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Combat Support

Shaping Air Force Logistics for the 21st Century

The Air Force is reexamining its CS infrastructure to focus on faster deployment, smaller footprint, greater personnel stability, and increased flexibility.

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Preface

Colonel Ronne G. Mercer, USAF, AFLMA
C. Robert Roll, Jr, RAND

In 1996, shortly after Operation Desert Strike,[1] concern about the long-term requirements of enforcing the no-fly zones, including covering *the carrier gap,* led to the initial concept of an air and space expeditionary force (AEF). At that time, the Deputy Chief of Staff (DCS), Operations, Lieutenant General John P. Jumper,[2] realized that transforming the Air Force to a more expeditionary footing was going to require comprehensive analytic study. The unique capabilities of both RAND Project Air Force and the Air Force Logistics Management Agency (AFLMA) were harnessed to take on this task. From the outset and continuing through today, our work has been jointly sponsored by the DCS, Operations and DCS, Installations and Logistics.

Early on, General Jumper asked the analytical team to do more than just observe from afar. He asked the analysts to walk in the Air Force's shoes and experience what the service was experiencing.[3] Our teams have been doing that ever since. RAND senior analysts, accompanied by experienced blue-suiters from AFLMA, have traveled across the globe to observe Air Force activities and to understand the grass roots problems airmen have faced. We have deployed with the early AEF wings and been alongside them as the Air Force transitioned to the expeditionary air and space structure. We have worked closely with a variety of organizations to gather lessons learned after each conflict, including the Air War Over Serbia and Operations Enduring Freedom and Iraqi Freedom, and to ensure those lessons were communicated to Air Force leadership and incorporated into our research. Oftentimes, we have found the lessons from actual experiences have validated our concepts. We have worked with members of the headquarters staff at the Pentagon and at most major commands, as well as numerous wing and unit-level individuals.

This compilation of articles is intended to communicate the essentials of the analyses completed over the last 6 years. The research was conducted to help the Air Force configure the Agile Combat Support (ACS) system in order to meet AEF goals. However, these articles also illustrate how analysis can, when properly accomplished, influence Air Force policy making. We hope the book can be used as a teaching document, illustrating the complexity of Air Force logistics systems and processes, as well as an archive of analytic methodology applied to military policy analysis. As a whole, the book can serve as a history of logistics during this 6-year period of extensive change, detailing where the Air Force has come from and why. Further, an examination of the entire collection of work can serve as an example of how to manage complex change and how to study large complex issues.

Many of you reading this may not remember the Air Force before it became expeditionary. Some of the ideas in the articles have been accepted and ingrained into the Air Force. Concepts such as forward support location and the new, smaller centralized intermediate repair facilities (CIRF) were foreign to the Air Force just a few years ago and are today an accepted, integral part of the ACS system. Our teams have played a key role in the design and execution of Title X wargames.[4] New ideas and concepts can be furthered in the games without impacting operational organizations. Our participation in the games as designers, assessors, or subject-matter experts has benefited us, the participants, and the directors. Aside from the games, we also affected future operations in numerous ways. The DCS, Installations and Logistics, after recognizing serious deficiencies with combat support command and control (CSC2), sponsored an effort to develop a CSC2 operational architecture, which is being implemented throughout the Air Force today. Our work on CIRFs outside the continental United States (CONUS) led to the transformational idea of CONUS CIRFs, which is under study by the Air Force.

We are proud of the work of our analytic teams, and by every indication, the work is thought-provoking, timely, and on target. We hope you benefit from this book. If you have questions or comments, feel free to contact the authors at our respective organizations or visit us on the Web at www.rand.org or www.aflma.af.mil.

Notes

1. Desert Strike was an Air Force response to the continued Iraqi violations of United Nations directives as they applied to the established no-fly zones in southern Iraq.
2. Many senior leaders in both the combat support and operations communities helped sustain, guide, and shape RAND/AFLMA research over the last 6 years. We thank them and numerous others for helping to further this work. Among the key leaders were General Patrick K. Gamble, General John W. Handy, General Gregory S. Martin, Lieutenant General Stewart E. Cranston, Lieutenant General William P. Hallin, Lieutenant General Lance L. Smith, Lieutenant General Michael E. Zettler, Ms Susan A. O'Neal, Mr Grover L. Dunn, Major General Scott C. Bergren, Major General Roger A. Brady, Major General Robert J. Elder, Jr, Major General Terry L. Gabreski, Major General Jeffery B. Kohler, Major General Quentin L. Peterson, Major General Teresa Marne Peterson, Major General Donald J. Wetekam, Brigadier General Patrick A. Burns, Brigadier General Michael A. Collings, Brigadier General Maury Forsyth, Brigadier General Peter J. Hennessey, Brigadier General William T. Lord, Brigadier General Robert A. Mansfield, Brigadier General Arthur B. Morrill III, Brigadier General Anthony F. Przyslawski, Brigadier General Arthur J. Rooney, Jr, Brigadier General Billy K. Stewart, Brigadier General James P. Totsch, Brigadier General(S) David Gillett, and Dr Robert Wolff.
3. At a conference in the RAND Washington DC facility in January 1997, General Jumper came into a logistics meeting and expressed his understanding of the problem and requested help.
4. Since 1997, AFLMA has had executive responsibility to inject Air Force logistics reality into the Title X wargame, Global Engagement. RAND and the AFLMA also participate in the Future Logistics Oriented Wargame and in Army and Navy wargames.

The end of the Cold War and the associated realignment of power centers placed the United States and its allies in a new environment with vastly different security challenges than those faced only a decade earlier. The early euphoria at the end of the Cold War was soon replaced with the realization that the United States, with the possible support of allied coalitions, would be expected to carry significant portions of security and peacekeeping responsibilities around the globe. In today's environment, US forces, in particular the Air Force, have been called on to make numerous overseas deployments, many on short notice—using downsized Cold War legacy force and support structures—to meet a wide range of mission requirements associated with peacekeeping and humanitarian relief, while maintaining the capability to engage in major combat operations such as those associated with operations over Iraq, Serbia, and Afghanistan.

Introduction

Shaping Air Force Logistics for the 21st Century

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US defense policy makers no longer can plan for a particular scenario in a specific region. One of the many lessons of the last decade has been the unpredictability of the nature and location of conflicts. In the conflict in Serbia, US and coalition air forces played a major role in driving the Serbian forces from Kosovo. A common thought of the day was that all future conflicts would be air dominated. The events of 11 September 2001 and the US reprisal against the Al-Qaeda in Afghanistan, Operation Enduring Freedom, resurfaced the importance of asymmetric warfare and the fundamental role of special forces. These events, however, have not lessened the need for a powerful and agile aerospace force as shown, once

The dramatic increase in deployments from the CONUS, combined with the reduction of Air Force resource levels that have spawned the AEF concept, equally has increased the need for effective combat support.

again, in Operation Iraqi Freedom. In that operation, the Air Force played a substantial role throughout the duration of the conflict, from its initial role to suppress and disable Iraqi command and control and air defense systems to providing close air support in urban environments.

Creation of the Air and Space Expeditionary Force

To meet current and anticipated challenges, the Air Force has developed an air and space expeditionary force (AEF) concept that has two primary goals.[1] The first is to improve the ability to deploy quickly from the continental United States (CONUS) in response to a crisis, commence operations immediately on arrival, and sustain those operations as needed. The second goal is to reorganize to improve readiness, better balance deployment assignments among units, and reduce uncertainty associated with meeting deployment requirements. The underlying premise is that rapid deployment from CONUS and a seamless transition to sustainment can substitute for an ongoing US presence in theater, greatly reducing or even eliminating deployments the Air Force would otherwise stage for the purpose of deterrence.

To implement the AEF concept, the Air Force created ten air and space expeditionary forces,[2] each comprised of a mixture of fighters, bombers, and tankers. These ten AEFs respond to contingencies on a rotating basis: for 90 days, two of the ten AEFs are *on call* to respond to any crisis needing airpower. The on-call period is followed by a 12-month period during which those two AEFs are not subject to short-notice deployments or rotations. In the AEF system, individual wings and squadrons no longer deploy and fight as a full or single unit as they did during the Cold War. Instead, each AEF customizes a force package for each contingency, consisting of varying numbers of aircraft from different units. This fixed schedule of steady-state rotational deployments promises to increase flexibility by enabling the Air Force to respond immediately to any crisis with little or no effect on other deployments.

The dramatic increase in deployments from the CONUS, combined with the reduction of Air Force resource levels that spawned the AEF concept, have also increased the need for effective combat support (CS).[3] Because CS resources are heavy and constitute a large portion of the deployments, they have the potential to enable or constrain operational goals, particularly in today's environment, which is so dependent on rapid deployment (Figure 1).[4] Consequently, the Air Force is reexamining its CS infrastructure, to focus on faster deployment, smaller footprint, greater personnel stability, and increased flexibility.

The AEF rapid, global force projection goals and associated sustainment requirements create a number of support planning challenges in such areas as munitions and fuel delivery, engines and navigational equipment maintenance, and forward operating location (FOL) development. Support is a particular challenge in expeditionary operations (dealing with conflicts in an expeditionary fashion and with little warning) since the traditional assumption associated with Cold War support planning was that scenarios and associated support requirements could be fairly well developed in advance and materiel prepositioned at anticipated FOLs. Much of the existing support equipment is heavy and not easily transportable; deploying all the support for almost any sized AEF from the CONUS to an overseas location would be expensive in both time and airlift. As a result, the Air Force has focused on streamlining deploying unit CS processes, leaning deployment packages, and evaluating different technologies for making deploying units more agile and quickly deployed and employed. Decisions on where to locate intermediate maintenance facilities such as the jet engine intermediate maintenance (JEIM) shop and nonunit heavy resources—those not associated with flying units, such as munitions, shelters, and vehicles—are significant drivers of employment time lines.

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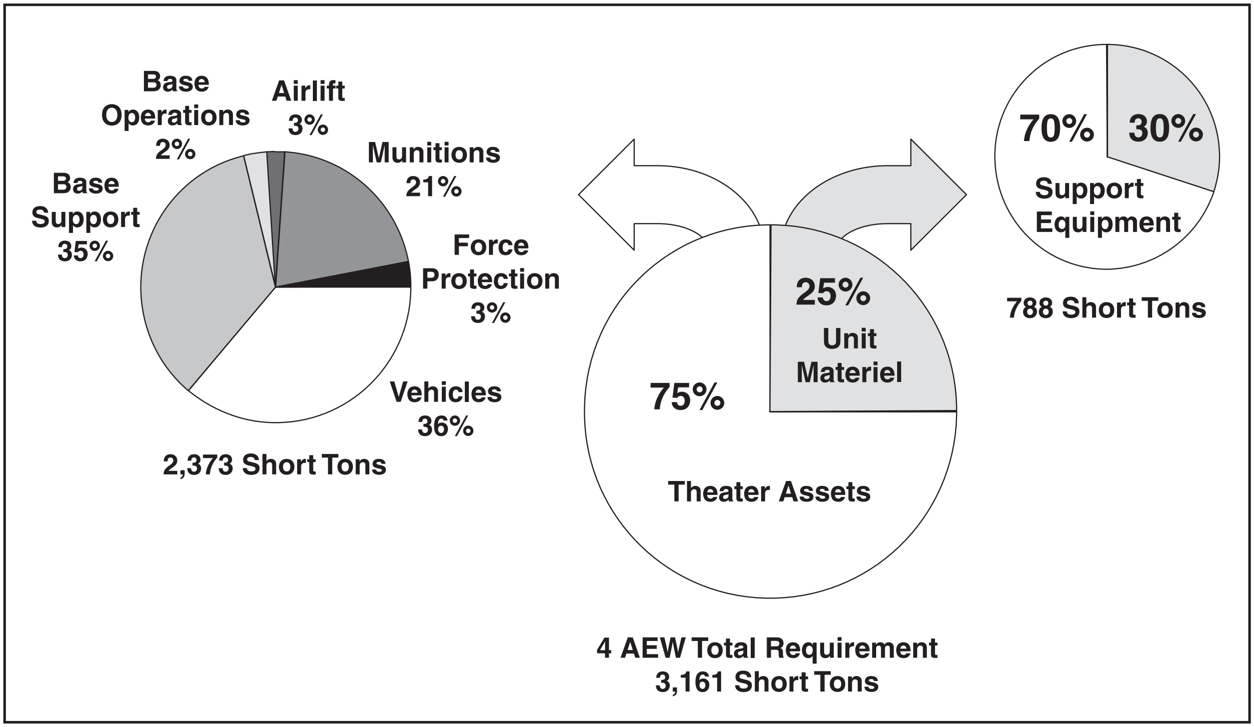

Figure 1. Support Footprint for Aerospace Power Is Substantial

Agile Combat Support—the Concept

Since the end of the Cold War and the inception of the AEF concept, RAND and the Air Force Logistics Management Agency have worked with segments of the Air Force to determine options for intermediate maintenance and for combat support, as a whole, that could meet the Air Force's changing needs.

This research[5] has resulted in what is most aptly called an Agile Combat Support (ACS) network, consisting of five principal elements.

This infrastructure can be tailored to the demands of any contingency.

- **Forward Operating Locations**. FOLs are sites in a theater, out of which tactical forces operate. FOLs can have differing levels of CS resources to support a variety of employment time lines. Some FOLs in critical areas under high threat should have equipment prepositioned to enable aerospace packages designed for heavy combat to deploy rapidly. These FOLs might be augmented by other, more austere FOLs that would take longer to spin up. In parts of the world, where conflict is less likely or humanitarian missions are the norm, all FOLs might be austere.
- **Forward Support Locations (FSL)**. FSLs are sites near or within the theater of operation for storage of heavy combat support resources, such as munitions or war reserve materiel, or sites for consolidated maintenance and other support activities. The configuration and specific functions of FSLs depend on their geographic location, the threat level, steady-state and potential wartime requirements, and costs and benefits associated with using these facilities.
- **CONUS Support Locations (CSL)**. CSLs are support facilities in the CONUS. CONUS depots are one type of CSL, as are contractor facilities. Other types of CSLs may be analogous to FSLs. Such support structures are needed to support CONUS forces should repair capability and other activities be removed from units. These activities may be set up at major Air Force bases, appropriate civilian transportation hubs, or Air Force or other defense repair or supply depots.
- **Theater Distribution System**. A transportation network connects the FOLs and FSLs with each other and with the CONUS, including en route tanker support. This is an essential part of an ACS system where FSLs need assured transportation links to support expeditionary forces. FSLs themselves could be transportation hubs.
- **Combat Support Command and Control (CSC2)**. CSC2 systems facilitate a variety of critical management tasks: (1) estimating support requirements, (2) configuring the specific nodes of the system selected to support a given contingency, (3) executing support activities, (4) measuring actual CS performance against planned performance, (5) developing recourse plans when the system is not within control limits, and (6) reacting swiftly to rapidly changing circumstances.

This infrastructure can be tailored to the demands of any contingency. The first three parts—FOLs, FSLs, and CSLs—are variable. The Air Force configures them as deployments occur to best meet immediate needs. In contrast, the last two elements—a reliable transportation network and CSC2— are indispensable ingredients in any configuration. Determining how to distribute responsibility for the support activities required for any given operation among CSLs, FSLs, and FOLs is the essence of strategic support decisions. For example, in determining the number of FSLs to support a given operation and their role, the Air Force must carefully evaluate such factors as the support capability of available FSLs and the risks and costs of prepositioning specific resources at those locations.

Organization of the Book

This book is divided into four sections, both in terms of categories of topics and chronology of the research. Section 1 covers early work done by RAND and the Air Force Logistics Management Agency that evaluates the CS portion of the expeditionary aerospace force concept, today known as the air and space expeditionary force. Articles in this section cover developing a vision for a global ACS system, developing a global infrastructure, and strategic planning for the combat support system. Clearly evident in the articles is the analytical framework to support the research.

Section 2 covers results of important maintenance support concept and challenges. In particular, this section presents our analysis of F-15 avionics support structure, low-altitude navigation and targeting infrared for night maintenance concepts, and JEIM options. In the area of consumables, an article on munitions discusses the alternative prepositioning strategies for this important commodity. Each analysis points to the value of a forward support location in supporting the warfighter and, thus, the importance of access to overseas bases. An article on global access strategies discusses the various options in selecting airbases. Finally, an article on footprint configuration maps a way to not only reduce the size of the footprint in terms of weight and volume but also develop a systematic concept to speed AEF deployment.

Section 3 deals with the demands of CSC2. The section begins with two introductory pieces, one by Lieutenant General Michael E. Zettler and the other by Major General Kevin Sullivan. Next is an article that examines the future CSC2 operational architecture. This article is followed by an analysis of CSC2 nodes and responsibility, mapping the relationships between the nodes and responsibilities. The benefits of maintenance FSLs or centralized intermediate maintenance (CIRF) became more evident by an ad hoc implementation during the conflict in Kosovo and as a result of Air Force formal testing of the CIRF in fall 2001. The last article in this section discusses command and control in the CIRF test as a proof of concept for the CSC2 operational architecture.

Section 4 contains three short articles . The first expands on the concept of Agile Combat Support. It is followed by articles that highlight the importance of leader development and doctrine.

Additional copies of *Combat Support: Shaping Air Force Logistics for the 21st Century* are available at the Office of the Air Force Journal of Logistics.

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The views expressed in the articles are those of the authors and do not represent the established policy of the Department of Defense, Air Force, Air Force Logistics Management Agency, or the organization where the authors work.

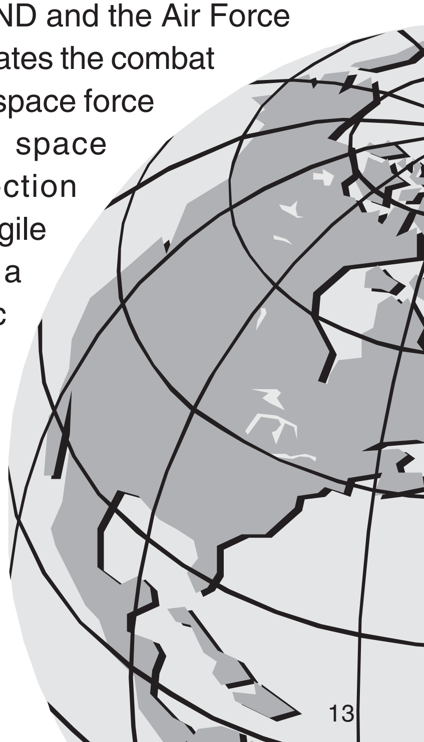
Notes

1. In the early genesis of the concept of expeditionary operations, the Air Force used the term expeditionary aerospace force (EAF) to define this new concept of force organization. In recent years, the term air and space expeditionary force or AEF has replaced EAF. To keep the historical perspective, the early sections of this book continue to use the term EAF.
2. Henceforth, when it is clear from the context, we will use AEF to represent both the concept and force package.
3. Air Force doctrine defines combat support to include "the actions taken to ready, sustain, and protect aerospace personnel, assets, and capabilities through all peacetime and wartime military operations."
4. Theater assets are provided by organizations outside the combat unit itself. In the case shown in Figure 1, most theater materiel was provided by US Central Command Air Forces.
5. From the beginning, RAND and the Air Force Logistics Management Agency developed a close partnership in the ACS research.

Section 1: Planning and Strategy

combat support

Section 1 covers early work done by RAND and the Air Force Logistics Management Agency that evaluates the combat support portion of the expeditionary aerospace force concept, today known as the air and space expeditionary force. Articles in this section cover developing a vision for a global Agile Combat Support system, developing a global infrastructure, and strategic planning for the combat support system. Clearly evident in the articles is the analytical framework to support the research.



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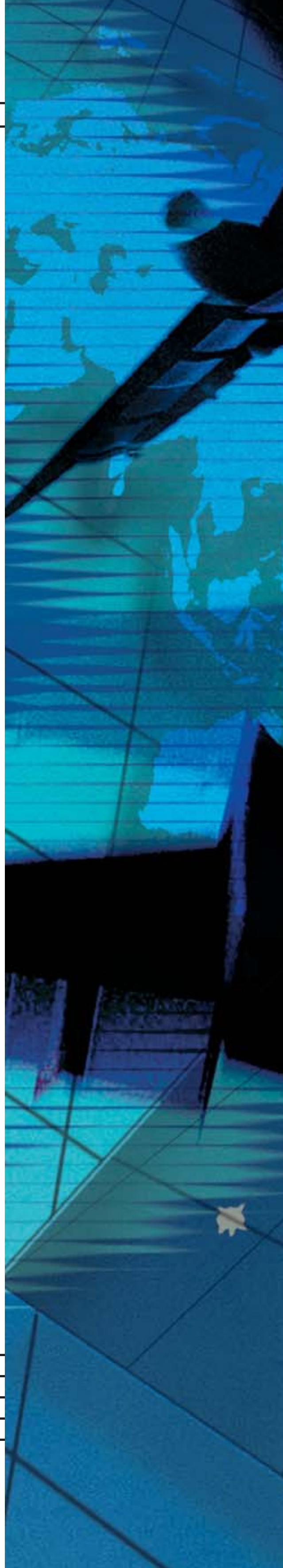
This article offers a vision of what the future ACS system might look like and how it could help the Air Force meet EAF operational goals. This vision draws from ongoing RAND and Air Force Logistics Management Agency research evaluating how ACS design options impact EAF effectiveness and efficiency. The ACS system will have to support EAF operations ranging from major regional contingencies, to small-scale contingencies, to peacekeeping missions.

Agile Combat Support

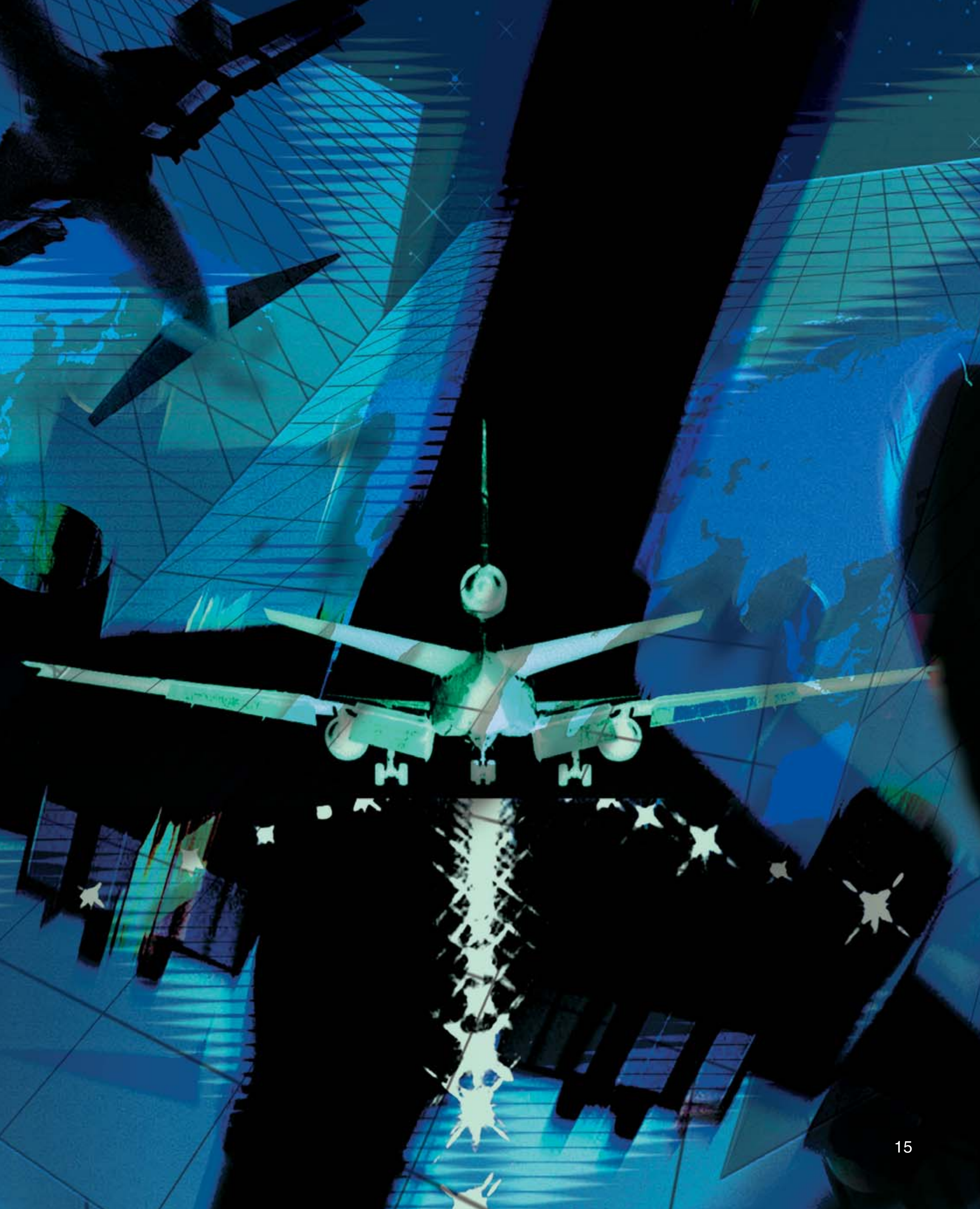
Vision for the Global ACS System



Introduction

The development of expeditionary aerospace force (EAF) operations[1] requires rethinking of many Air Force functions. This includes the combat support system. To a large extent, success of the EAF depends on turning the current support system into one that is much more agile. In recognition of this, the Air Force has begun transforming the current support system to the Agile Combat Support (ACS) system.[2] It has designated ACS as one of six essential core competencies for Global Engagement.

Developing the ACS system requires hard decisions concerning allocating the limited resources necessary for creating a system capable of meeting a wide range of uncertain scenarios. ACS requirements will vary with each scenario, and each scenario will require unique tradeoffs, such as that between speed and cost or, more generally, between different



Today, support resources must be designed to meet the needs of a smaller force facing a wide variety of scenarios in uncertain locations. The new planning environment also has limited resources for supporting multiple areas of responsibility.

characteristics valued by the Air Force. These tradeoffs will change as support technologies, policies, and practices change.[3] As a result, ACS planning must be a continuous effort. The system itself must evolve toward a flexible logistics infrastructure that makes the best use of resources and information.[4]

This article offers a vision of what the future ACS system might look like and how it could help the Air Force meet EAF operational goals. This vision draws from ongoing RAND and Air Force Logistics Management Agency (AFLMA) research evaluating how ACS design options impact EAF effectiveness and efficiency. The ACS system will have to support EAF operations ranging from major regional contingencies (MRC), to small-scale contingencies, to peacekeeping missions.

It will likely need to be a global network that will comprise:

- Forward operating locations (FOL), with resource allocations that support differing employment time lines
- Forward support locations (FSL), with differing support processes and resources
- Continental United States (CONUS) support locations (CSL)

These infrastructure elements need to be connected by a combat support command and control (CSC2, originally termed logistics command and control system—LOG C2) system and a very responsive distribution system to ensure support resources arrive when combat commanders need them.

ACS Decisions and Their *Trade Space*

The Air Force recognizes that it must change the current support system to meet the needs of the EAF. Some elements and processes of the current system are remnants of a Cold War system designed to support the needs of large overseas forces that would be employed simultaneously in major conflicts occurring in Central Europe and Northeast Asia. Specific resources were provided to FOLs for waging combat in known places. Planners assumed the resources needed for MRCs would suffice for all lesser conflicts. There was less uncertainty to consider in such a planning environment.

Today, support resources must be designed to meet the needs of a smaller force facing a wide variety of scenarios in uncertain locations. The new planning environment also has limited resources for supporting multiple areas of responsibility (AOR). This means the future support system must be flexible enough to move resources across AORs.

Aviation unit type codes (UTC) were developed to be self-sufficient for 30 days. For EAF operations, UTCs designed for more rapid deployment require a smaller footprint, in turn, requiring immediate resupply after deployment. There must be a shift from reliance on large stockpiles of resources at FOLs to an emphasis on fast resupply to replenish smaller forward stocks.

More generally, support resources must be considered strategically rather than tactically. In the past, support requirements determinations have been made to calculate specific requirements needed to meet commander-in-chief responsibilities. Now support resource calculations and considerations must take into account a wide range of scenarios. Resources need to be distributed to meet wide variations in scenarios. The resulting resource mix may not be the best for any one particular scenario, but it may be the most robust against the entire range of scenarios or the mix that holds up best in the face of uncertainty. Thus, the future ACS system must be flexible, with logistics processes in place to determine how to move limited resources from one place to another in meeting rapid deployment, employment, sustainment, and reconstitution needs.

Specific key variables affecting ACS system design include:

- Options for force composition, employment time line, and operation tempo
- FOL capabilities, including infrastructure and resources, as well as the political and military risks associated with prepositioning resources at specific locations
- Technology options affecting performance, weight, and size of test equipment, munitions, support equipment, and other support
- Resupply time, particularly as it affects initial operating requirements (IOR) and follow-on operating requirements (FOR)
- Alternative support policies, such as conducting repair operations at deployed or consolidated support locations
- Strategic and tactical airlift capacity

These and other variables form a rich array of decisions from which Air Force leaders will choose in designing the future ACS system. Generally, there are no right or wrong answers, but system tradeoffs will be required.

ACS design decisions will depend on how Air Force leaders value different criteria. Some system needs—such as rapid employment time lines, high operating tempos, and airlift constraints—favor forward positioning of resources. Others, such as the cost and risk of positioning resources at FOLs, favor positioning of resources at consolidated locations.

Figure 1 depicts the general tradeoffs. Investment costs are higher for an extensive support structure positioned at numerous forward locations. They decline as the number of support locations declines. Employment time is lower for an extensive support structure with numerous forward locations. It increases as the number of support locations decreases.

While the general direction of these relationships is fixed, the specific details are not. The arrow on the graph shows the effect of reengineering processes or implementing new technologies, such as developing lightweight munitions or support equipment. New technologies or processes can shift the time-line curve downward. This allows more rearward positioning of resources than would otherwise be possible.[5]

These models are employment-driven because they start from the operational scenario—or from the employment requirements—to provide time-phased estimates of support resource requirements.

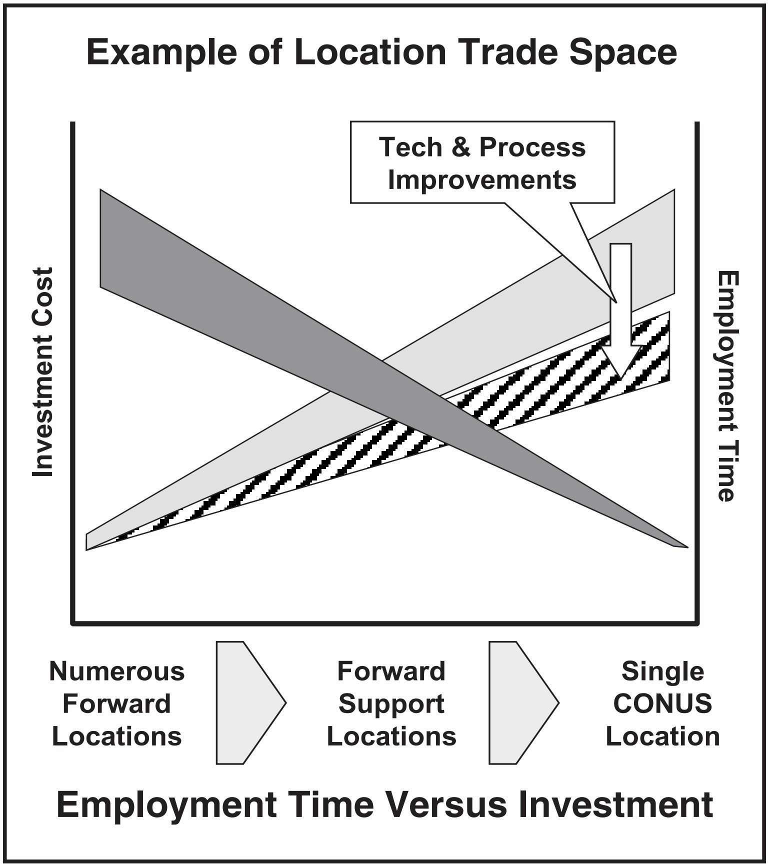


Figure 1. General Decision Trade Space by Location

An Analytic Framework for Strategic ACS Planning

How can Air Force leaders evaluate and choose among ACS options? We propose an employment-driven modeling framework. The core of this framework is a series of models for critical support processes that can calculate equipment, supplies, and personnel needed to meet operational requirements.[6]

These models are employment-driven because they start from the operational scenario—or from the employment requirements—to provide time-phased estimates of support resource requirements. Once support requirements are computed, the models can be used to evaluate options—such as prepositioning support resources or deploying from consolidated locations—for satisfying them. The evaluation includes metrics such as spin-up time, airlift capacity, investment and recurring costs, and political and military risks. Figure 2 depicts the modeling framework developed in the analyses.

This framework is designed to address the uncertainties of expeditionary operations. The models can be run for a variety of mission requirements. This includes the support needed for different types of missions (for example, humanitarian, evacuation, or small-scale interdiction); effects on support system requirements of different weapon mixes for the same mission; the impact of different support policies, practices, and technologies; and other operation support needs.

The models have been designed to run quickly and estimate mission requirements at a level of detail appropriate for strategic decisions. This detail should include the number of people and large pieces of equipment that account for most mission support airlift footprints. It should also include enough detail so that major changes to support processes can be reflected in the model and evaluated against all metrics.

The final output of the modeling framework is an evaluation of the effects of each support option on spin-up time, airlift footprint, investment and recurring costs, risks, and flexibility. This shows the details of the tradeoff between moving resources from centralized support locations or prepositioning them at FOLs.

ACS analyses may find that an option cannot be supported because of cost or process constraints. If so, then senior leaders can design an option

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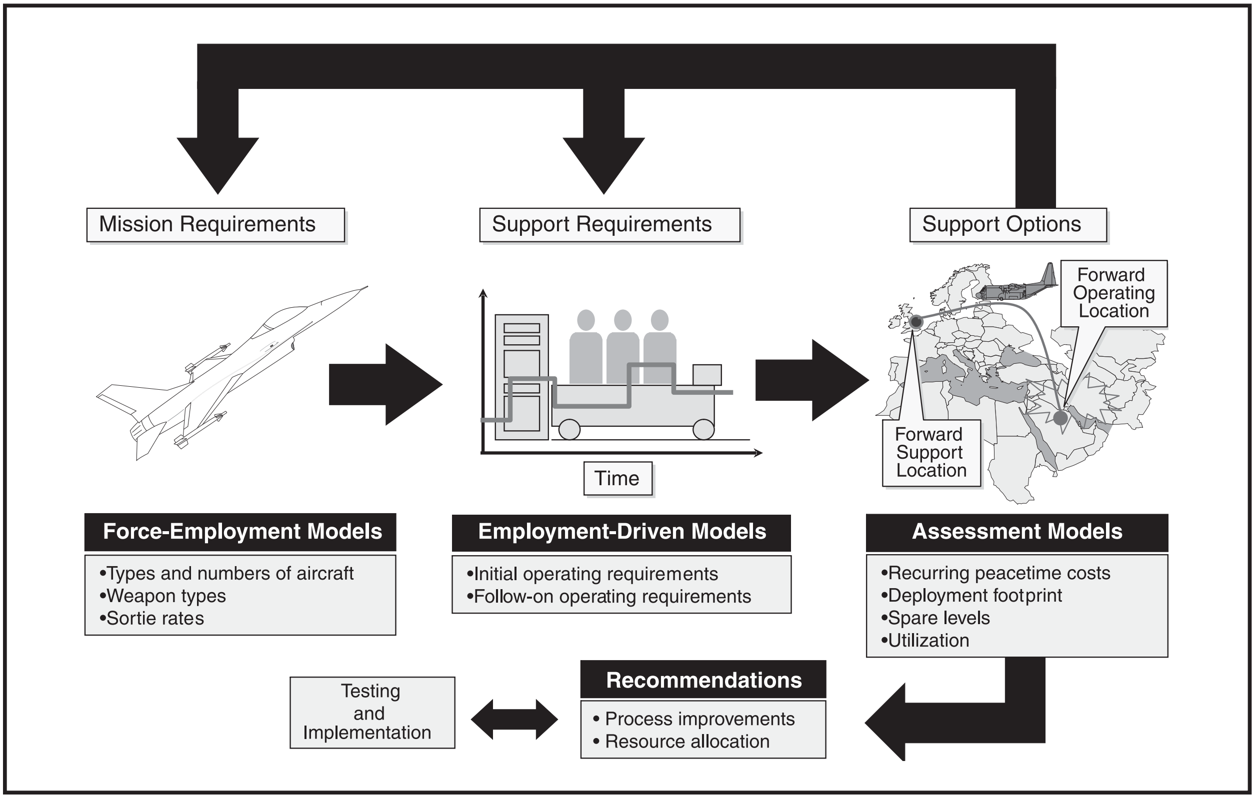

Figure 2. Employment-Driven Analytical Framework

with less cost or risk that would still achieve their goals. This framework thus can be used not only for ACS system analysis but also to support integrated analysis of operations, ACS, and mobility options.

Key Findings from ACS Modeling Research

Using an analytic framework and prototype models for some specific commodities has made clear the broad ACS system characteristics needed to support future expeditionary operations. An important finding of RAND/AFLMA research: the Air Force goal of deploying to an unprepared base and sustaining a nominal expeditionary force at a high operating tempo or a 36-ship package capable of air-defense suppression, air superiority, and ground attack aircraft cannot be met with current support processes. A 48-hour time line can be met only with judicious prepositioning and even then only under ideal conditions.

Using an analytic framework and prototype models for some specific commodities has made clear the broad ACS system characteristics needed to support future expeditionary operations.

Table 1 shows the results generated from using a preliminary integrating model to minimize support costs and meet the employment time line while satisfying resource requirements for a 7-day surge employment scenario. These results were obtained by using inputs from our commodity models for munitions, fuel, vehicles, shelter, F-15 avionics components, and low-altitude navigation and targeting infrared for night (LANTIRN) needs for the 36-ship force.

A 48-hour time line requires substantial materiel to be prepositioned at the FOL. A bare base can be used only if the deployment time line is extended to 144 hours and substantial materiel is prepositioned at a regional forward support location—or FSL—and if intra- and intertheater transportation is available to move resources to the FOL.

The reason for this conclusion is simple: current support resources and processes are heavy. They are not designed for quick deployments to FOLs

Time Line	Forward Operating Location	Forward Support Location	CONUS
Initiate & sustain at 48 hours	Bombs (IOR) Fuel Shelter Vehicles	Missiles (IOR & FOR) Bombs (FOR) Repair: F-15 avionics & LANTIRN	Unit equipment Two-level repair
Initiate & sustain at 48 hours	Bombs (IOR) Fuel Shelter Vehicles	Bombs (FOR) FMSE Repair: F-15 avionics & LANTIRN	Unit equipment Two-level repair Missiles (IOR &FOR)
Initiate & sustain ops at 144 hours	Fuel	Bombs (IOR &FOR) Repair: F-15 avionics & LANTIRN Shelter Vehicles	Unit equipment Two-level repair Missiles (IOR & FOR) Fuels Mobility Support Equipment

Table 1. ACS Modeling

having limited space for unloading strategic airlift. Significant numbers of vehicles and materiel-handling equipment—such as forklifts and trailers—are required to meet EAF operational requirements. The airlift required to move this materiel, not including munitions, is enormous, and it may not always be available.

Shelter needs place another constraint on options for quick deployment. The current Harvest Falcon shelter package for bare bases requires about 100 C-141 (72 C-17) loads to move and almost 4 days to erect using a 150-man crew. The construction time for the Harvest Falcon shelter package alone means it must be prepositioned to meet a 48-hour time line or even a 96-hour time line.

These results do not mean expeditionary operations are not feasible. Technology and process changes may reduce the need to deploy heavy maintenance equipment. For now, however, these results do mean that setting up a strategic infrastructure to perform expeditionary operations involves a series of complicated tradeoffs.

Expensive 48-hour bases may best be reserved for areas such as Europe or Southwest Asia (SWA), which are critical to US interests or are under serious threat. In other areas, a 144-hour response may be adequate. In still other areas, such as Central America, most operations will be humanitarian relief missions that could be deployed to a bare base within 48 hours since combat equipment would be unnecessary. For all these cases, the models and analytic framework being developed can help in negotiating the complex web of decisions.

One key parameter that affects ACS design is resupply time. If resupply time is cut, the initial operating requirements and initial deployment can also be cut. In addition to IOR, resupply time affects repair locations. If resupply time is long, more maintenance equipment and personnel must be deployed to keep units operating, and greater quantities of supplies will be needed to fill longer pipelines.

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Short resupply times can help in dealing with uncertainties caused by an inability to predict requirements or by changes in requirements resulting from enemy actions. A short resupply time provides the ability to react quickly to inevitable surprises, mitigating their impact.

The future ACS system needs to be designed around expected wartime resupply times, not peacetime resupply possibilities. To examine its constraints, resupply time was analyzed as it varies by delivery process and assumptions. Parts of these data were gathered from actual delivery times. Others were generated with models, using optimistic assumptions, which help show differences between possible and actual system performance.

The left most curve in Figure 3 (Air Mobility Express–Commercial [AMX-C]) shows the distribution of best expected resupply times for small items (less than 150 pounds) that could be shipped via express carriers to Southwest Asia from CONUS. This distribution includes the entire resupply time, from requisition to receipt, and has a mean of about 4 days, *During Noble Anvil, the resupply times to Europe using WWX averaged about 5 days, while more than 10 percent of the deliveries took more than 10 days.*

including weekends, holidays, and pickup days. This distribution was generated from a simulation model using very optimistic times for each part of the resupply process. It assumes the processes are perfectly coordinated with no delays because of weather, mechanical problems, or enemy actions. This curve represents a current process optimum to Southwest Asia.

The third curve (Air Mobility Express–Military [AMX-M]) shows the expected distribution of best resupply times to Southwest Asia for AMX-M, the system used for large cargo in wartime, under optimistic assumptions. Median resupply time for this system is about 7 days. The fourth curve (Southwest Asia) shows the current actual delivery times for high-priority cargo to Southwest Asia units. These data include delivery times for both small and large cargo. Note that half these requisitions took more than 9 days to deliver.

Operation Noble Anvil (ONA) provided extensive evidence of this challenge. The second left most curve (Nobile Anvil Worldwide Express [WWX]) shows the distribution of WWX deliveries during Noble Anvil. WWX is a Department of Defense (DoD) contract with commercial carriers to move small items within the CONUS and from the CONUS to the rest of the world. The contract specifies intransit delivery times for

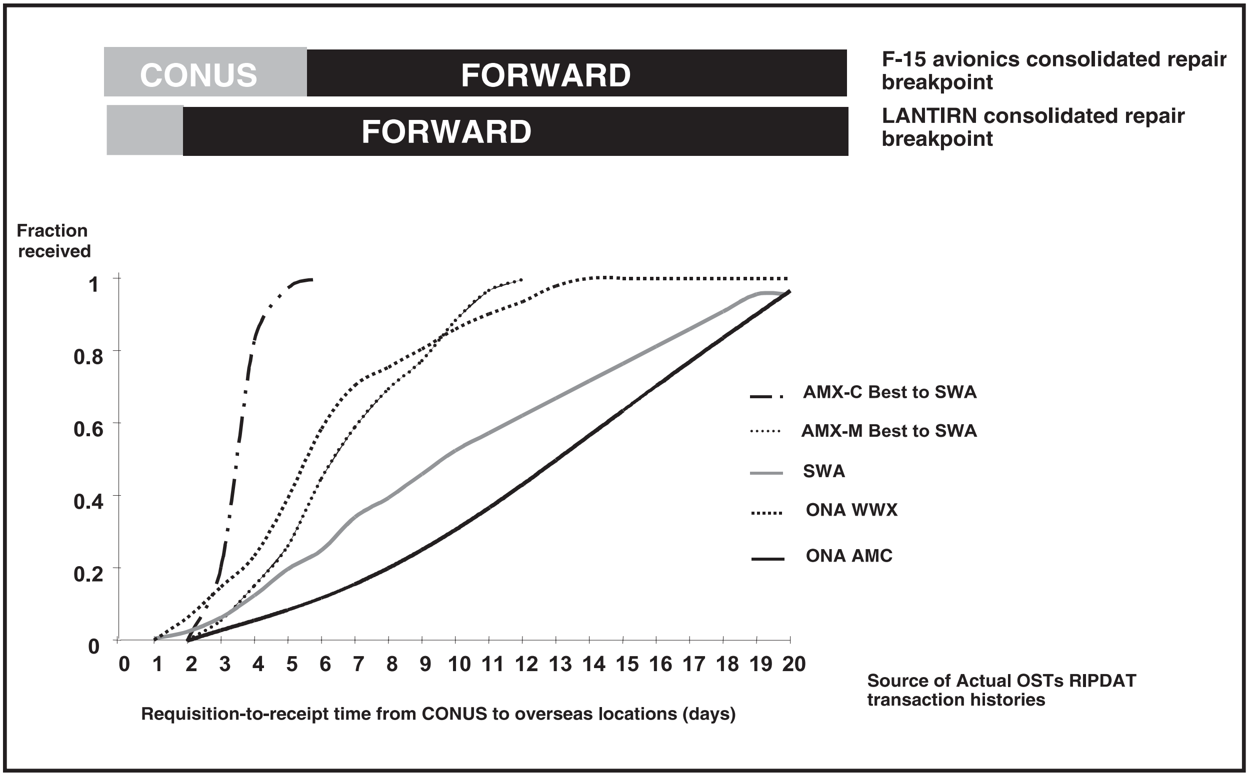

Figure 3. CONUS to SWA Resupply Times and Support Breakpoint Solutions

shipments between specific locations. Most intransit times to overseas theaters are about 3 days, but this excludes the day of pickup and weekends.

During Noble Anvil, the resupply times to Europe using WWX averaged about 5 days, while more than 10 percent of the deliveries took more than 10 days. As shown in Figure 3, the large items moved by military flights averaged more than 15 days to deliver.[7] Even in a highly developed theater, for a benign conflict environment, resupply times are lengthy.

The Department of Defense recently established a resupply goal of 5 days to overseas locations and ordered inventory levels to be reduced to reflect these new delivery goals. RAND/AFLMA research, however, indicates a resupply goal of 5 days to overseas FOLs may not be achievable for small items in all wartime environments. Such a goal probably is not achievable for large items since the median of the expected delivery time distribution for such items under optimistic assumptions is 7 days.

As mentioned above, resupply time affects repair location decisions. Separate studies on maintenance support for key equipment in an expeditionary environment are being completed. For two cases in which the analysis is complete, F-15 avionics[8] and LANTIRN pod repairs,[9] the breakpoints for locating repair facilities in the CONUS or forward locations are shown at the top of Figure 3.

For F-15 avionics, consolidating repairs at regional or CONUS facilities sharply reduces personnel needs, as well as the need for some upgrades currently being considered for repair equipment. Resupply time for any consolidated repair facility, however, must be less than 6 days, or the longer pipeline will require substantial investments in new spare parts. Figure 3 shows that achieving such delivery times from the CONUS may be difficult, although data from theater support of mission capable (MICAP) requisitions indicates that transportation times from regional FSLs can meet the 6-day breakpoint.[10]

For LANTIRN targeting pods, for which no new acquisitions are planned, the breakpoint time line is even shorter because of the lack of spares. Maintaining the availability of working pods in an MRC requires transportation times of less than 2 days from a consolidated repair facility. Figure 3 shows that this is out of reach from the CONUS, and it might even be difficult to achieve within theater. At the same time, however, deployment of LANTIRN repair to FOLs is not an attractive option. The test equipment is old, very heavy, and increasingly unreliable, so repair consolidation, reducing the need for test equipment deployment, may be required.

Models of individual support processes yield important insights for supporting processes for expeditionary operations. To plan an ACS system, outputs of models for different processes need to be integrated, and consideration should be given to the mixes of options. This may include a mix of prepositioning some materiel, deploying other materiel

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from FSLs, and deploying still other materiel from the CONUS. The research on this topic explores the use of optimization techniques to integrate options for several support processes.

From these analyses, it was concluded that performing expeditionary operations for the current force with current support processes and technologies requires judicious prepositioning of equipment and supplies at selected FOLs. This must be backed by a system of FSLs providing equipment and maintenance services. Such a system would require a transportation system linking FOLs and FSLs.

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The Air Force already makes some use of FSLs, particularly for munitions and war reserve materiel (WRM) storage. Consolidated regional repair centers have also been established to support recent conflicts. During Desert Storm, C-130 engine maintenance was consolidated at Rhein Main AB, Germany. During Noble Anvil, intermediate F-15 avionics repair capabilities were established at Royal Air Force Lakenheath, United Kingdom.

Overview of a Global ACS System

Based on the preliminary results, an evolving ACS system to support expeditionary operations can be envisioned. The system would be global and have several elements based at forward positions or at least outside the CONUS. Figure 4 gives a notional picture.

The system has five components:

1. FOLs. Some bases in critical areas under high threat should have substantial equipment prepositioned for rapid deployments of heavy combat forces. Other more austere FOLs with longer spin-up times might augment these bases. Where conflict is not likely or humanitarian missions will be the norm, the FOLs might all be of this second, more austere form.
2. FSLs. The configurations and functions of these would depend on geographic locations, presence of threats, and the costs and benefits of using current facilities. Western and Central Europe are presently stable and secure; it may be possible from European FSLs to support operations in areas such as Southwest Asia or the Balkans.
3. CSLs. CONUS depots are one type of CSL, as are contractor facilities. Other types of CSLs may be analogous to FSLs. Such support structures are needed to support CONUS forces, since some repair capability and other activities may be removed from units. These activities may be set up at major Air Force bases, convenient civilian transportation hubs, or Air Force or other defense repair depots.
4. A transportation network connecting the FOLs and FSLs with each other and with the CONUS, including en route tanker support. This is essential; FSLs need transportation links to support expeditionary forces. FSLs themselves could be transportation hubs.
5. A CSC2 system to organize transport and support activities and for swift reaction to changing circumstances.

The actual configuration of these components depends on several elements. These include local infrastructure and force protection, political aspects (for example, access to bases and resources), and how site locations may affect alliances. The analytical framework introduced here needs to be expanded and linked with methods for taking additional issues into account. The primary focus should be on areas of vital US interests that are under significant threat (Figure 4 shows clusters of FOLs in Korea, Southwest Asia, and the Balkans).

This potential structure and the key findings depend on the current force and support processes. As new policies are developed and implemented; the Air Force gains experience with expeditionary operations; and new technologies for ground support, munitions, shelter, and other resources become available, the system will need adjustment to reflect new capabilities. Improvements in transport times, weight, and equipment reliability may favor greater CONUS support and shrinking the network of FSLs.

An analytic framework helps focus research and attention on areas where footprint reductions could have big payoffs. Munitions is a key area where reductions in weight and assembly times could pay big dividends in deployment speed. For operations at bare bases, where shelter must be established, the development and deployment of more lightweight shelters

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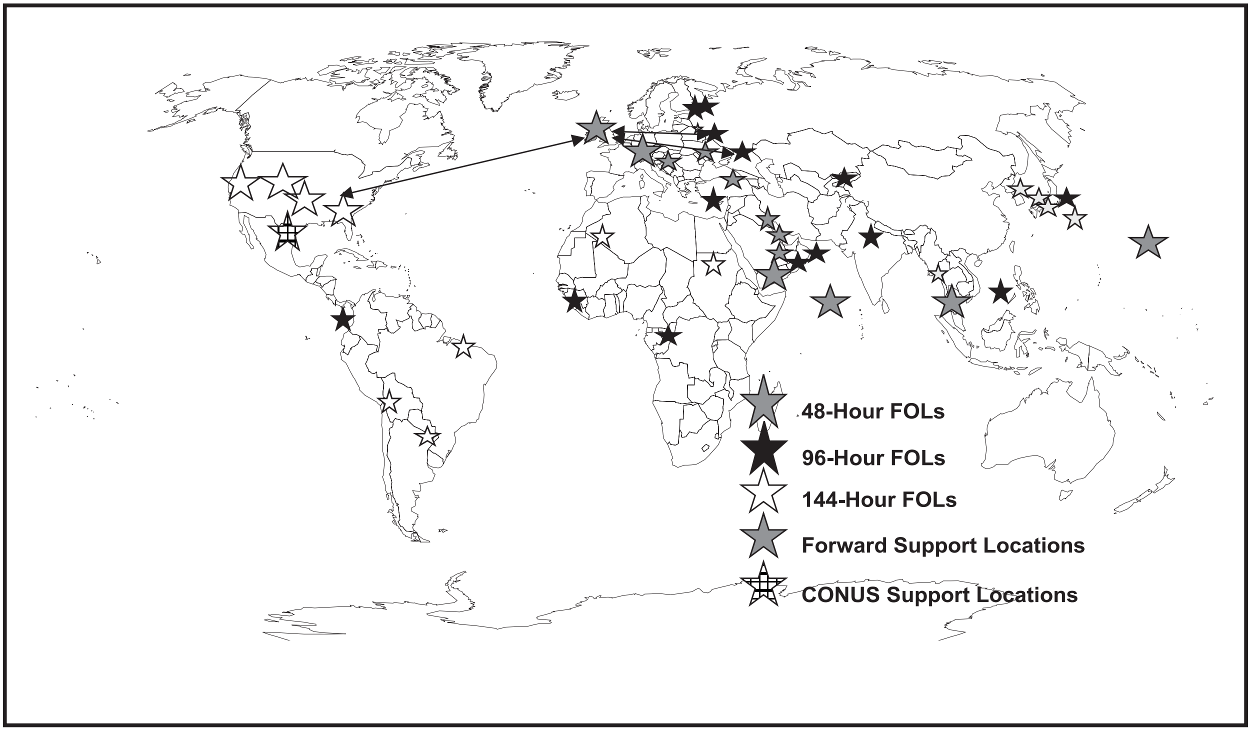

Figure 4. Potential Global ACS Network

Limited testing of the envisioned ACS occurred during Noble Anvil.

(for example, the small shelter program or AEF hotels) can also pay dividends in deployment speed and footprint. Changes in these areas will not be made immediately, but the structure outlined previously will enable expeditionary operations in the near term.

Peacetime cost is important for the analysis. The new support concept may help contain costs by consolidating assets: reducing deployments for technical personnel; using host-nation facilities; and possibly, sharing costs with allies. Considerable infrastructure, including buildings and large stockpiles of war reserve materiel, may already be available in Europe.

Limited testing of the envisioned ACS occurred during Noble Anvil. Before the war, the United States Air Forces in Europe, Director of Logistics consolidated WRM storage at Sanem, Luxembourg. During Noble Anvil, the USAFE Director of Logistics established consolidated repair facilities at Lakenheath and Spangdahlem. An intratheater distribution system was created to provide service between FSLs and FOLs. Munitions ships designated for use in another AOR were moved to support Noble Anvil munitions resupply. This transfer of assets between theaters raised several issues about how non-unit resources should be stored for use in multiple AORs.

Noble Anvil raises several general issues for those designing the future ACS system. Support design for Noble Anvil took time that may not always be available in other conflicts or war. Heroic efforts were required to overcome system, training, and concept of operation shortfalls. This raises questions as to what new efforts should be institutionalized in an ACS system. Some resources needed for Noble Anvil were tied to other AORs, and this leads to questions about logistics support becoming more of a strategic, rather than a tactical, asset.

Strategic and Long-term Planning for the ACS System

Building an ACS system requires many decisions about prepositioning and the location of support processes, including the categories of FOLs and FSLs. The prototype models developed and used deal with process characteristics and rough costs, but support decisions must also account for threat situations and political considerations that change over time.

Strategic planning for an ACS system must be global and evolving. A global perspective is needed because the combination of cost constraints, political considerations, and support characteristics may dictate that some support for a particular theater or subregion be provided from facilities in another region.

This is not a theoretical point. Much of Southwest Asia is politically volatile, and support there might better be provided from outside the region, as indeed, some is now from Europe and Diego Garcia. The configuration of FOLs and FSLs is critical in sizing the aircraft fleet and in setting up its refueling infrastructure to support all theaters.

Strategic planning must be evolving because the new security environment includes small, short-notice contingencies and continually changing threats. Geographic areas of critical interest will change over time, as will the specific threats within them. An expeditionary ACS system designed today would be oriented toward Southwest Asia and Korea, but within a decade, those regions could be at peace and new threats emerge elsewhere.

In addition to political changes, support processes and technologies may also change as the Air Force continues to move to a more expeditionary footing and seeks to reduce support footprints while maintaining effectiveness. Over the next 10 years, it is expected that many process and technology changes will force reevaluations of the ACS system.

The need for global and evolving planning will require centralized planning in which cost, politics, and effectiveness tradeoffs are made for the system as a whole and to ensure that each theater is appropriately protected and supported. This goes against the current practice of giving each theater commander control of all theater resources. Peacetime cost considerations alone require that facilities not be duplicated unnecessarily across theaters.

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Changes in the force structure will also require changes to the support structure. The F-22, for example, is designed to have one-half the support footprint of the F-15. The Joint Strike Fighter is also designed to reduce support requirements. Air Force wargames, particularly the Future Capabilities games, have experimented with radically different forces relying on standoff capabilities or space-based weapons. All these developments will lead to changes in both support requirements and in the options that are most attractive under peacetime cost constraints.

The advantage of an analytic framework is such that long-term changes can be handled in the same way as short-term modifications to policy and technology. New technologies, political developments, and budget changes require continual reassessment of the support system configuration, which we are designing our model to do. New force structures will require different support resources, in turn, requiring new support structures. For long-term decisions, the ability to perform quick-turn, exploratory analysis of different support structures becomes even more important.

Notes

1. In response to global concerns, the Air Force formulated a new concept of force organization, the expeditionary aerospace force or EAF. Under this concept, the Air Force was divided into several air and space expeditionary forces, each roughly equivalent in capability, among which deployment responsibilities were to be rotated. Each AEF would have the capability to project highly capable and tailored force packages, largely from the continental United States, on short notice to any point around the world. Rotating deployment responsibilities among units on an equitable and fairly predictable basis was expected to greatly decrease personnel turbulence. As this concept has evolved, some of the details were modified. As envisioned, the structure consisted of ten AEFs as described, two units for *popup* contingencies, and

five AEFs for humanitarian/evacuation operations. In recent years, the term air and space expeditionary force or AEF has replaced EAF. To keep the historical perspective, the early sections of this book continue to use the term EAF.

2. The Logistics Transformation Team, comprising Air Force and KPMG personnel, is leading much of this transformation work. The Logistics Transformation Team was previously the Agile Logistics Team, which was previously the Lean Logistics Team. Electronic correspondence from Lt Col Michael Menendez, HQ USAF Installations and Logistics, Logistics Transformation Team, to Robert S. Tripp, RAND, 5 Oct 99.
3. For a detailed discussion of how changing technology affects one part of the support system, see Eric Peltz, et al, *An Analysis of F-15 Avionics Options*, RAND, MR-1174-AF, Santa Monica, California, 2000.
4. For a more general discussion of this point, see Robert S. Tripp, et al, *An Integrated Strategic Agile Combat Support Planning Framework*, RAND, MR-1056-AF, Santa Monica, California, 1999.
5. *Ibid*.
6. This model is discussed in more detail in Tripp, et al.
7. Air Force Materiel Command Materiel-Handling Engineering Program Office Briefing, Wright-Patterson AFB, Ohio 6 Jul 99.
8. Peltz, et al, 2000.
9. Amatzia Feinberg, et al, *Expanded Analysis of LANTIRN Options*, RAND, MR-1225-AF, Santa Monica, California, 2001.
10. Data collected from the 4th Air Expeditionary Wing deployment to Doha, Qatar, from May 1997 to August 1997. MICAP requisitions that were processed at Prince Sultan AB in Saudi Arabia averaged less than 5 days. At that time, Prince Sultan AB and Doha were connected by scheduled military resupply flights.

Logistics

Understanding the elements of military power requires more than a passing knowledge of logistics and how it influences strategy and tactics. *An understanding of logistics comes principally from the study of history and lessons learned.* Unfortunately, despite its importance, little emphasis is placed on the study of history among logisticians. To compound matters, the literature of warfare is replete with triumphs and tragedy, strategy and tactics, and brilliance or blunders; however, far less has been written concerning logistics and the tasks involved in supplying war or military operations.[1]

General Mathew B. Ridgeway once observed, "What throws you in combat is rarely the fact that your tactical scheme was wrong…but that you failed to think through the hard cold facts of logistics." Logistics is the key element in warfare, more so in the 21st century than ever before. Success on the modern battlefield is dictated by how well the commander manages available logistical support. Victories by the United States in major wars (and several minor wars or conflicts) in the 20th century are more directly linked to the ability to mobilize and bring to bear economic and industrial power than any level of strategic or tactical design. The Gulf War and operations to liberate Iraq further illustrates this point.

> As the machinery of the Allied Coalition began to turn, armchair warriors addicted to action, and even some of the hastily recruited military experts, revealed a certain morbid impatience for the "real war" to begin. But long before the Allied offensive could start, professional logisticians had to gather and transport men and materiel and provide for the sustained flow of supplies and equipment that throughout history has made possible the conduct of war. Commanders and their staffs inventoried their stocks, essayed the kind and quantities of equipment and supplies required for operations in the severe desert climate, and coordinated their movement plans with national and international logistics networks. *The first victory in the Persian Gulf War was getting the forces there and making certain they had what they required to fight* [Emphasis added]. Then and only then, would commanders initiate offensive operations.[2]

Unfortunately, the historical tendency is for the political and military leadership to neglect logistics activities in peacetime and expand and improve them hastily once conflict has broken out may not be so possible in the future as it has in the past. A declining industrial base, flat or declining defense budgets, force drawdowns, and base closures have all contributed to eliminating or restricting the infrastructure that made rapid expansion possible. Regardless, modern warfare demands huge quantities of fuel, ammunition, food, clothing, and equipment. All these commodities must be produced, purchased, transported, and distributed to military forces. And of course, the means to do this must be sustained. Arguably, logistics of the 21st century will remain, in the words of one irreverent World War II supply officer, "The stuff that if you don't have enough of, the war will not be won as soon as."[43]

Notes

1. John A. Lynn, ed, *Feeding Mars: Logistics in Western Warfare from the Middle Ages to the Present*, San Francisco: Westview Press, 1993, vii.
2. Charles R. Shrader, *U.S. Military Logistics, 1607-1991, A Research Guide*, New York: Greenwood Press, 1992, 3.
3. Julian Thompson, *The Lifeblood of War: Logistics in Armed Conflict*, Oxford: Brassy's, 1991, 3

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The shift toward expeditionary operations presents numerous challenges, particularly in combat support. Here, we present analyses that indicate achieving the EAF goals with current support processes requires strategic preparation of a global support infrastructure.

Supporting the EAF

A Global Infrastructure

Introduction

In this article, we analyze two key aspects of that global infrastructure: forward operating locations (FOL) and forward support locations (FSL). A great deal of Air Force attention has been given to determining air and space expeditionary force (AEF) composition and scheduling when each AEF will stand ready for its deployment commitment. With respect to deployment responsibilities, much of the Air Force effort concerning support focused on the deployment execution—how to compress time lines for deploying a unit's support functions, given current processes and equipment. Figure 1 illustrates the significant progress made by the Air Force in meeting the expeditionary aerospace force's (EAF) demands to deploy and employ quickly.

Rather than addressing deployment execution activities, we have concentrated on the *strategic* decisions that affect the design of the logistics infrastructure necessary to support rapid deployments. Figure 2 depicts the relationship of strategic decisions to the deployment and redeployment execution decisions illustrated in Figure 1. The large ovals below the

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readiness-to-reconstitution time line indicate areas of strategic decision making that need to be addressed. While many of these are topics of ongoing research by RAND, the Air Force Logistics Management Agency (AFLMA), and others, this article focuses on global infrastructure preparation.

Global Infrastructure Preparation

The original EAF concept envisioned air expeditionary wings (AEW) [1] deploying to any airfield around the world that had a runway capable of handling the operational and airlift aircraft, regardless of whether the airfield was a fully equipped military base or a *bare base* with minimal facilities. Reliance on prepositioned assets was to be minimized, if not eliminated. Unfortunately, analyses show that, at present, prepositioned assets cannot be eliminated: the current logistics processes cannot support the timing requirements, and most equipment is too heavy to deploy rapidly. While new technologies and policies can improve this situation in the mid to long term, implementing the EAF over the next few years will require some judicious prepositioning at FOLs.

Global infrastructure preparation is, therefore, a central function of planning expeditionary support. Tradeoffs among several competing objectives must be analyzed. These include time line, cost, deployment footprint,[2] risk, flexibility, and sortie generation. In our analyses, we determined the resources necessary to meet the operational employment objectives—time-phased sortie generation goals. Prepositioning everything at the base from which operations will be conducted minimizes the deployment airlift footprint and time line required to begin operations, but it also reduces flexibility, adds political and military risk, and incurs a substantial peacetime cost if several such bases must be prepared. Bringing support from the continental United States (CONUS) or a support location near the area of operation, whether in the theater or outside the theater, increases flexibility and can reduce risk and peacetime cost for materiel. However, setting up support processes in this situation takes longer, and the deployment footprint is larger.

There are five basic components of the global infrastructure. These components are FOLs, FSLs, CONUS support locations (CSL), responsive resupply and transport system, and a combat support command and control (CSC2, originally termed logistics command and control system—LOG C2) system.

FOLs are the locations from which aircraft conduct their operations or missions. FOLs are divided into three categories based on their infrastructure and our derived time lines:[3]

A **category-3** FOL is a *bare base*. It meets only the minimum requirements for operation (runway, fuel, and water) of a small fighter package. Such a base would take almost a week (144 hours) to prepare to support AEW high-sortie generation rates.

A **category-2** base has the same support facilities as a category-3 base plus prepared space for fuel storage facilities, a fuel distribution system, general-purpose vehicles (host-nation support or for rent), and basic shelter. It may take up to 96 hours before a category-2 base could support AEW high-sortie generation rates.

A **category-1** base has all the attributes of a category-2 base plus an aircraft arresting system and munitions buildup and storage sites already set up and 3 days' worth of prepositioned munitions. Such a base could be ready within 48 hours of the execution order to support high AEW sortie generation requirements.

Each category requires differing amounts of equipment to prepare the base for operations and, as a result, has a different time line and transportation requirement. As the third and fourth components of global infrastructure, two options were considered for supplying these resources: FSLs in or near the theater of operations and CSLs. An FSL can be a storage location for US war reserve materiel, a repair location for selected avionics or engine maintenance actions, a transportation hub, or a combination thereof. It could be staffed permanently by US military or host-nation nationals or simply be a warehouse operation until activated. The exact capability of an FSL will be determined by the forces it will potentially support and by the risks and costs of positioning specific capabilities at its locations. The network of CSLs, FSLs, and FOLs needs to be coordinated to provide the resources necessary to meet operational goals.

The fourth and fifth components are assured resupply and transportation and a CSC2 system to coordinate the delivery of resources to FOLs. If AEWs must deploy with minimum support and depend on resupply from either CSLs or a set of FSLs, they will need to have an assured resupply link whose responsiveness is aligned with the support that is available at the FOL. The strategic infrastructure envisioned here will also require a more sophisticated CSC2 structure to coordinate support activities across FOLs, FSLs, and CSLs connected by a rapid transportation system. These last two components are the subject of current RAND and AFLMA research and are not treated further here.

The global infrastructure, then, is a combination of FOLs, FSLs, and CSLs connected by assured resupply and monitored and controlled by a CSC2 system. Our contribution in this article is to describe several tools and a prototype of the analysis and planning that the Air Force must do to prepare to deploy quickly under the EAF concept.

General Analytic Framework

To analyze basing structure decisions under extreme uncertainty, RAND and AFLMA developed logistics support models for five major resource categories and used them to assess how requirements change under different scenarios. These five categories—munitions, fuels support, unit maintenance equipment (the bulk of unit support equipment), vehicles, and shelter—make up the majority of support materiel for an air operation, as shown in Figure 3.[4] While these models focus on single commodities, they cut across organizational lines where necessary (for example, the

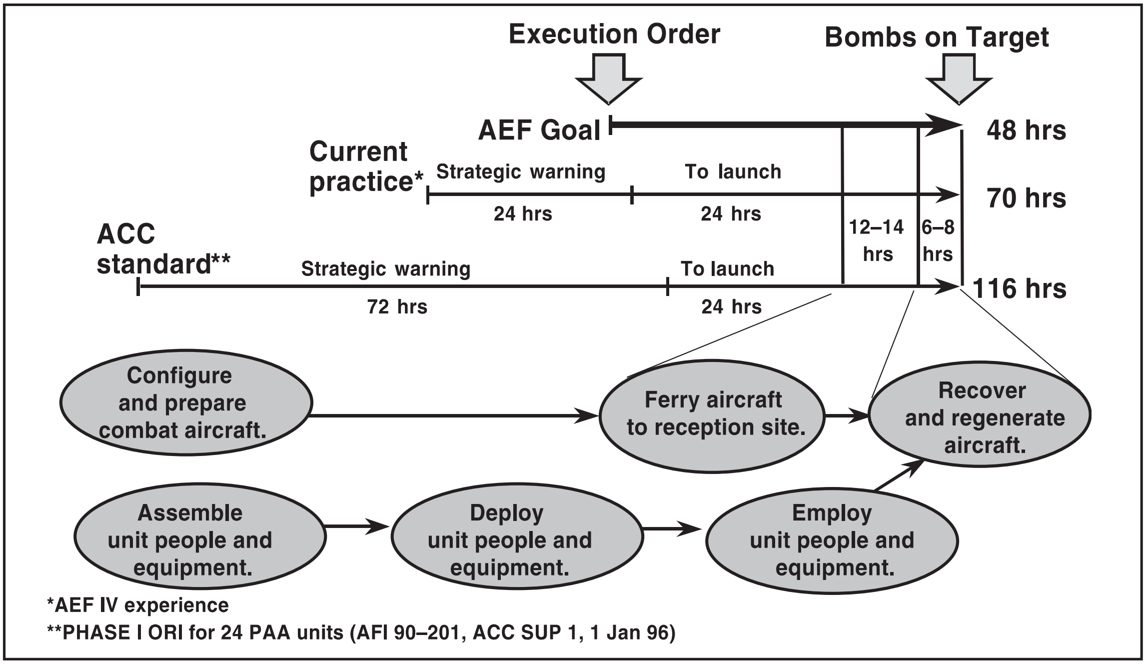

Figure 1. Deployment and Employment Planning

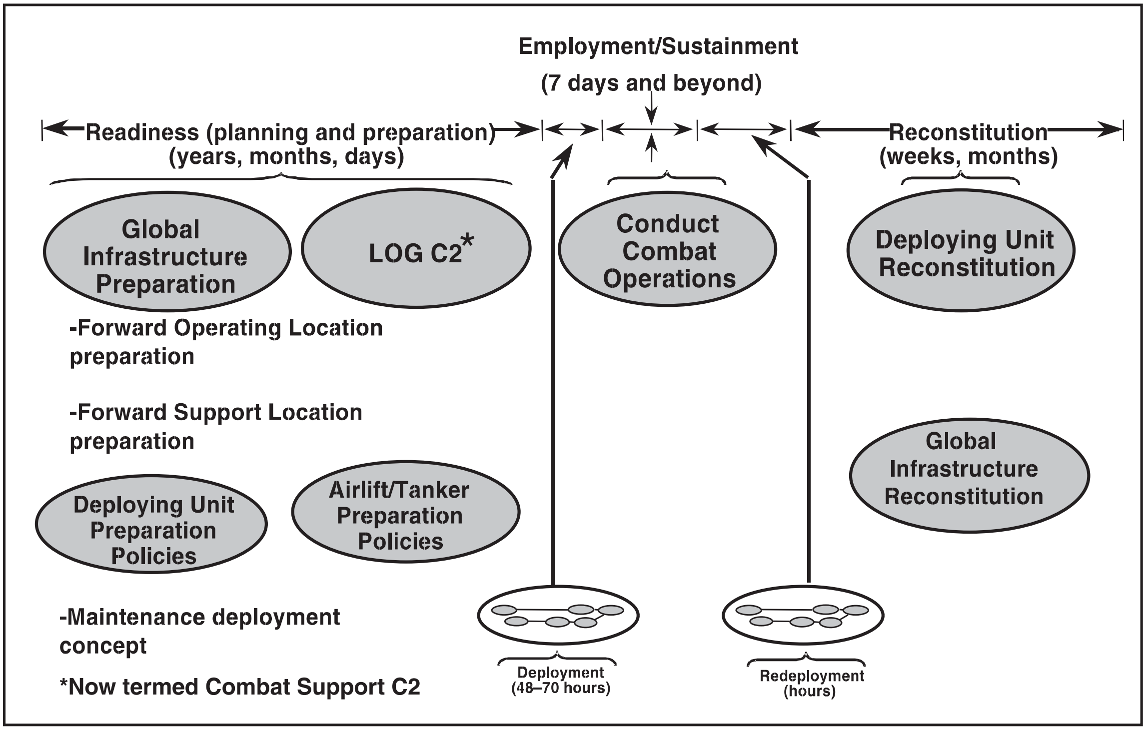

Figure 2. Strategic Decision Relationships

munitions support model covers both munitions buildup and aircraft loading processes).

As Figure 4 illustrates, our models have three components. First is a mission requirements analysis that specifies the critical mission parameters determining each support commodity's requirements based on the mission to be flown. The second component is a set of employment-driven logistics process models to determine time lines to set up the process and the materiel, equipment, and people to establish and operate the process. These models are high-level models created within Excel spreadsheets.[5] The support options analysis evaluates the performance of alternative infrastructure options in providing these requirements (as an example, prepositioning all munitions at an FOL versus moving air-to-air missiles from the CONUS or an FSL). The results of the model analyses comprise recommendations for infrastructure location, forward or CONUS, as well as changes in policies and technologies. Note the feedback arrows in Figure 4 from both of the evaluations to the mission analysis. Part of the support planning process is to inform operational planners about support feasibility, costs, and risks. In some cases, operational plans might need to be adapted as well.

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Expeditionary Deployment Performance

Our analytic method provides quantitative treatment of three key metrics: time line, deployment footprint, and cost. How well can FOLs with varying amounts of prepositioned equipment support expeditionary operations in terms of time line, footprint, and cost? What is the comparative performance of FSLs versus CSLs for supplying the materiel that is not prepositioned? Risk and flexibility are more difficult to quantify.[6] For now, decision makers must judge the quantitative tradeoffs provided by the logistics modeling with the subjective factors of risk and flexibility.

We illustrate this analysis[7] with some results from a scenario requiring a mission package of 12 F-15Cs, 12 F-16CJs, and 12 F-15Es conducting ground attack operations with guided-bomb unit (GBU)-10s (2,000-pound bombs). Figure 5 displays the estimates made with the employment-driven models for six different configurations of FOLs, FSLs, or CSLs (each of three categories of FOL in combination with the two options for supplying the remainder).

Time Lines to Deploy to Different Categories of FOL

The time line to have a given support capability up and running is the sum of times required to do a number of tasks (as an example, deploying people to theater, breaking out the deployed or stored equipment, and so forth). We get deterministic times for accomplishing tasks from either computations by the requirements models (for example, the time to build the first load of munitions) or from model rules that are based on judgment

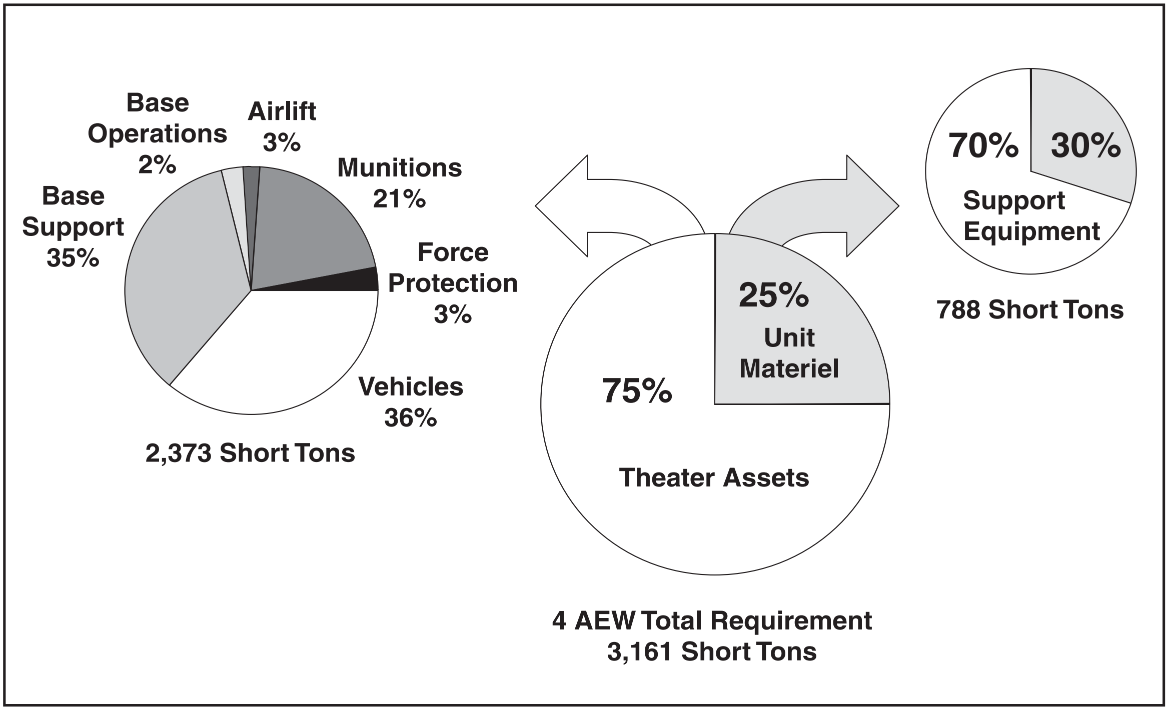

Figure 3. Support Materiel Requirements

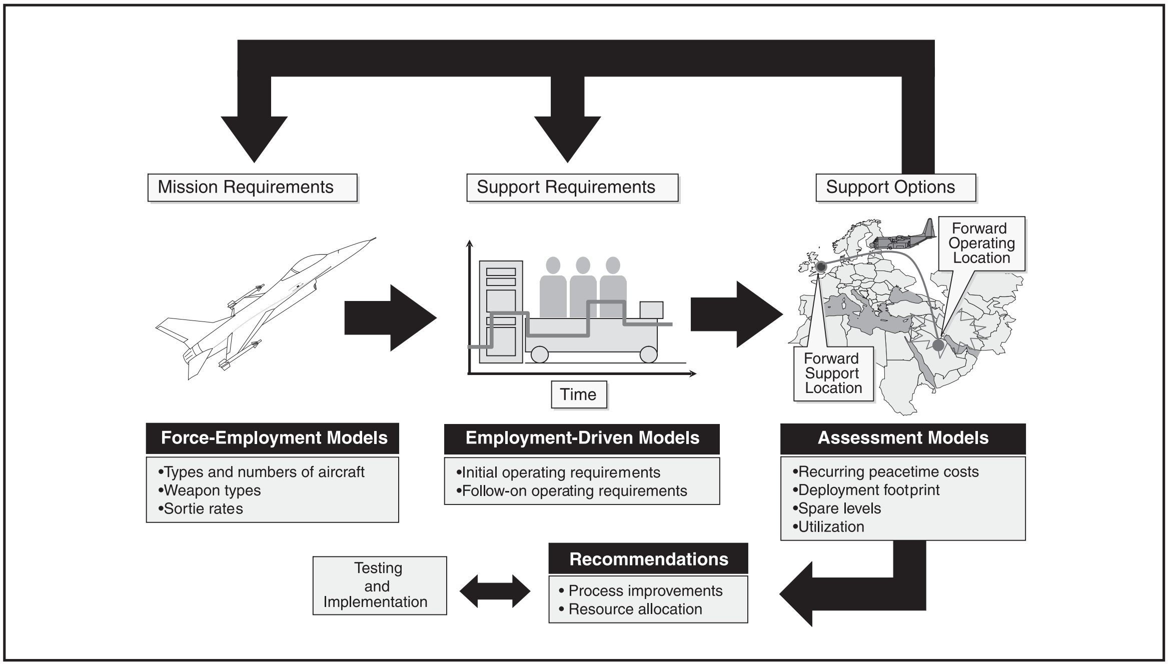

Figure 4. Model Components

(for example, it takes 22 hours to deploy personnel from the CONUS to the FOL). Some activities can be done in parallel, and in these cases, the time required is the maximum of the longest individual process times. For example, equipment may be moved to an FOL from an FSL and unloaded while unit personnel are deploying. In this case, if the time to deploy the personnel were longer than the time to deploy the equipment and have it ready for use when the personnel arrive, the personnel deployment time would be used to determine the minimum spin-up time for this particular process. The models estimate *pessimistic* time lines by adding to a selected set of tasks a somewhat subjective increment.

We have integrated the time lines for the various commodities by adding the times required to unload the airlift (subject to the maximum-on-ground [MOG] constraint) and then taking the maximum of that time and all the other times to set up the various commodity processes and produce the first sortie. This assumes an optimal integration of materiel arrival and process setup and, thus, is a rough estimate of the optimistic initial operational capability (IOC). For the pessimistic IOC, we use a similar method on the individual pessimistic IOCs for each commodity and its unloading.

The results of the time line analysis for the three FOL categories are shown in the upper left-hand panel of Figure 5. The optimistic time to set up a category-1 base is just under 2 days, even though most equipment is prepositioned. The time is primarily driven by the time to deploy the people from CONUS and setup times for munitions and fuel storage facilities.[8] For the other options, time lines are driven by the MOG. The difference in time line between a CSL and an FSL is minimal because the bottleneck is in unloading.[9] For category-3 bases, unloading the bulky Harvest Falcon package[10] pushes up the time lines.

The bottom line is that meeting the 48-hour time line will be virtually impossible with current processes and equipment unless most equipment is prepositioned, and even then the time line is extremely tight.

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Deployment Footprint

We define the deployment footprint as the amount of materiel that must be moved to the FOL for operations to commence. This is what we call the initial operating requirement (IOR). The upper right-hand panel of Figure 5 shows the initial footprint for the three categories of bases (the amount of airlift required to get the base operating).

Peacetime Cost Estimates

Current fiscal concerns require that the evaluation of options include the peacetime costs of setting up a given configuration of FOLs and FSLs (*investment*) and the peacetime costs of operating the system (*recurring*). Under our definition, a category-1 FOL will require prepositioning of the IOR of munitions (3 days); munitions assembly equipment; and petroleum, oil, and lubricants (POL) storage and distribution equipment.

Recurring costs have two components: the transportation cost for exercising AEW deployments and the cost for storage operations.

The equipment then must be maintained for use and be activated for AEW exercises or use in a real conflict. If the munitions are to be stored at an FSL for transport to a category-2 FOL, the FSL must contain enough sets of equipment to cover several AEW operations in its area.[11]

The lower left-hand panel in Figure 5 compares investment costs for our scenario for four commodities.[12] The baseline configurations are two regions, five bases per region (any one of which might have to support the 36-aircraft AEW), and two simultaneous AEW operations (each central stock location, if any, must be prepared to support two AEWs).[13]

As expected, providing for five category-1 FOLs per region is very expensive, and munitions are by far the greatest cost even though minimum IOR (only 3 days' worth) of munitions are prepositioned at each base. Drawing materiel back from the FOLs decreases the cost, increases flexibility, and (may) decreases risk because each FSL only requires two sets of equipment. However, the deployment footprint increases in terms of the number of transport aircraft needed to move the munitions upon execution of an AEF deployment.

Recurring costs have two components: the transportation cost for exercising AEW deployments and the cost for storage operations. The lower right-hand panel of Figure 5 shows our estimates of the recurring costs for these four commodities for the base configurations. These recurring costs show a different pattern. The category-3 bases supported from the CONUS are very expensive to operate, primarily because of the large costs of transporting munitions and the Harvest Falcon sets twice a year for exercises.

Looking at Figure 5 as a whole, we can see that category-1 bases give the fastest response but at high investment costs. Category-2 bases have a longer response time but at less investment cost, and FOLs have higher investment costs than stockpiling in the CONUS but have lower recurring costs. While the deployment footprint is roughly equal for FSL and CSL options, the type of airlift differs. Tactical or intratheater airlift could be used to provide resources from FOLs, whereas strategic airlift would be needed to provide the resources from CSLs.

Effects of Different Technologies on Deployment Performance

We can use our modeling to assess the impact of different technologies and policies on support option decisions. We explored the replacement of GBU-10s with the small bomb system (SBS), a 250-pound bomb that is effective against 70 percent of targets for which GBU-10s are used. Because the SBS is much lighter than the GBU-10, each F-15E can carry more of the former.[14] Thus, it takes fewer sorties to deliver the same amount of ordnance. This will, in turn, reduce POL requirements and, with the right scheduling of sorties, refueler requirements. However, these savings must be weighed against the higher investment costs of using this more expensive munition.[15] Figure 6 captures the analysis of this alternative support option.

The general pattern of each metric seems similar in this case, but closer comparison shows significant differences between the two cases. The SBS option seems to degrade the startup performance slightly because the increased bombload per sortie requires more bomb buildup work per flight. (If the SBS can be shipped in a full-up configuration, prebuilding the rounds on strategic warning at a storage site may reduce the time to IOC.) As expected, the deployment footprint is somewhat smaller, although the weight of munitions-handling equipment is still significant. Finally, the investment and recurring costs are lower for the SBS option. The investment decrease occurs because of fewer missile expenditures. In this scenario, there are fewer air-to-ground sortie requirements and, as a result, lower air-to-air requirements to provide suppression of enemy

The general pattern of each metric seems similar in this case, but closer comparison shows significant differences between the two cases.

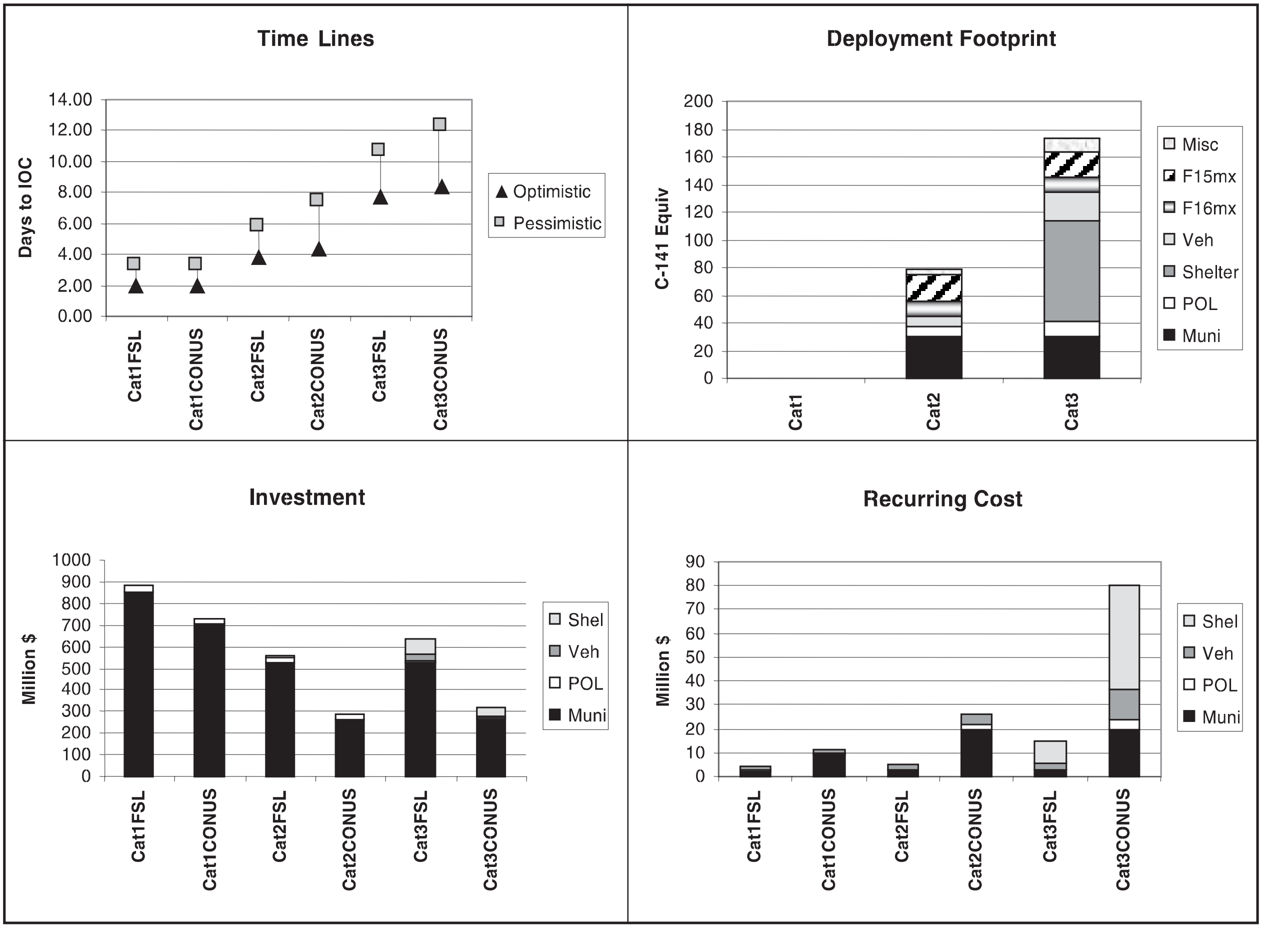

Figure 5. Employment-Driven Model, GBU-10 Scenario

The concept of the expeditionary air force has significant implications for two Air Force core competencies: Agile Combat Support and Global Mobility.

air defenses and air cover for the air-to-ground operations. The reduction in recurring costs comes from the reduced airlift needed to transport SBSs for exercises.[16]

Conclusions and Challenges

In looking at the current force structure and its current support processes, our analysis leads to several conclusions:

To get close to the execution order plus 48-hour deadline for placing the first bombs on target, AEWs must deploy to category-1 bases. Further, given that a flight halfway around the world takes approximately 20 hours, pushing the time line below 48 hours will require either having people deployed or materiel at an advanced state of preparation at the FOL or both.

Equipping numerous category-1 FOLs from scratch would be very expensive. Although much of the cost for current processes might well be sunk, maintenance and storage costs will still have to be paid. Anecdotal accounts of current (nonurgent) deployments to Southwest Asia indicate current maintenance arrangements there do not keep equipment ready for immediate use, suggesting that these costs might be larger than are paid now. Further, future munitions and improved support equipment not already in the inventory would have to be bought for the FOLs. Therefore, significant attention should be given to resourcing a number of FOLs in each category in order to provide a range of employment time lines for operational use. Within different regions, different employment time lines may be required. Not all regions may need to have category-1 FOLs or necessarily the same number of category-1 FOLs. The identification of various categories of FOLs throughout the world is important for supporting not only AEF operations but also major regional contingency operations. Attention should be given to pursuing host-nation support agreements to the extent possible to offset costs and lift requirements.

FSLs provide a compromise in cost between prepositioning at FOLs and deploying everything from CONUS.[19] They have little effect on the time line for initial capability, but they do avoid the necessity of having a tanker air bridge for the extra strategic lift from CONUS. Further, the strategic lift then becomes available for use in deploying additional combat units.

Category-2 bases represent another compromise between cost and time line. However, deploying to a category-2 base takes about 3.3 days (airlift flow and unloading airlift aircraft) and 2-3 days to set up munitions and fuels storage. Increased ramp space would not significantly speed up the deployment process. Plus, the agreements for vehicles, medical facilities, and so forth would probably require some time to finalize unless very complete arrangements had been completed well in advance.

Category-3 bases are not useful as FOLs for very quick crisis response given the time required for airlift offload operations and to set up the support processes. However, this is a function of the current processes, and the time line estimated here is for a stressing combat scenario. A less stressing combat scenario or a humanitarian operation might well be feasible from such a category-3 FOL within the 48-hour time line.

The concept of the expeditionary air force has significant implications for two Air Force core competencies: Agile Combat Support and Global Mobility. Rapid deployment places an emphasis on reducing the logistics support that must be deployed, but the current force structure and current logistics processes mandate a forward logistics structure that prepositions equipment and support packages to meet potential operating tempos. FSLs, CSC2, and very responsive resupply also can reduce the amount of materiel and number of people that need to be deployed to FOLs. New technologies and continuous process refinement also can reduce the deployment footprint over a period of years.

The deployment footprint could be reduced in three major areas: munitions, ground equipment, and shelters. Continued research is needed to reduce the weight and bulkiness of munitions and support equipment.[18] The weight and volume of the current bare-base shelter package could be

The deployment footprint could be reduced in three major areas: munitions, ground equipment, and shelters. Continued research is needed to reduce the weight and bulkiness of munitions and support equipment.

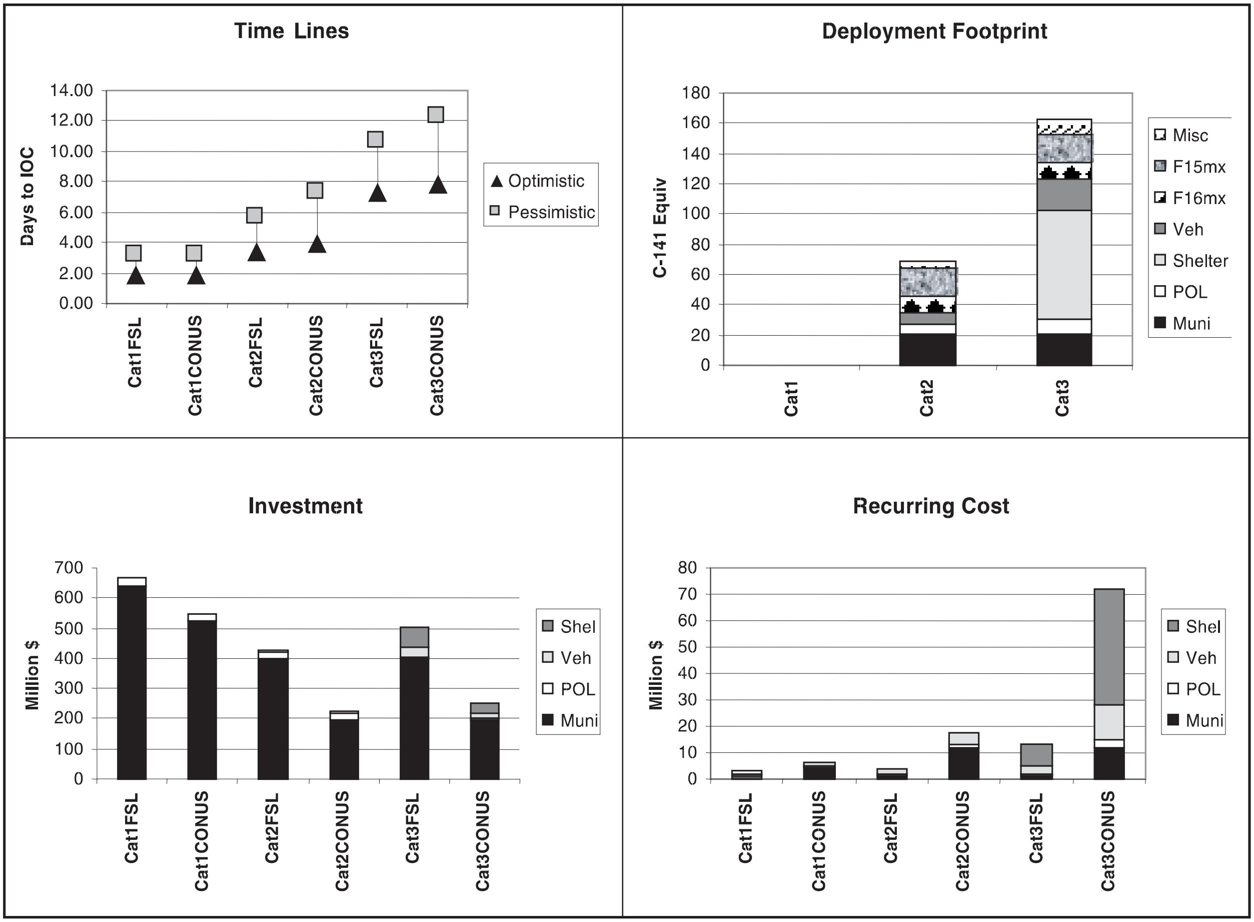

Figure 6. Employment-Driven Model, Small Smart Bomb Scenario

Our research argues for three major policy changes.

eliminated via commercial alternatives, some of which are being explored by the Airbase Systems Command at Eglin AFB, Florida.

The issues concerning FOLs, FSLs, and their location and equipping require some planning decisions be made centrally from a global and strategic perspective. Those decisions should be revisited on a regular basis as the global political situation changes and as technology offers new options.[19]

Our research argues for three major policy changes. First, storage and maintenance policies for prepositioned equipment should be carefully formulated and rigorously enforced, especially if third-party contractors are used to do some or all the work. Second, host-nation support should be considered in planning and execution. How much support can the Air Force expect from allies and how does this change US support requirements? Finally, the other Services could use support concepts similar to the FSL and FOL mixes described here. Indeed, they already have raised similar ideas, and it may prove advantageous to share locations and some resources with them.

Notes

1. With the end of the Cold War, the United States has entered an entirely new security environment. It is now the only global superpower in a world of many regional powers. The subsequent demands for US military presence or intervention required the Air Force to stage a large number of deployments—often on short notice and to far-flung locations—with a substantially smaller force than existed in the 1980s. The resulting increased workload and operational turbulence have been blamed for a decrease in retention and recent decreases in overall readiness. See, for example, Paul Richter, "The Tough Job of Keeping Soldiers Ready for War," *Los Angeles Times*, 22 Nov 98, and "Buildup in Gulf Costly: Expenses, Stress Surge for Military," *Los Angeles Times*, 17 No 98. Richter (17 and 22 Nov 98) and Matthew Williams, "Plea for Help (from the Air Force Secretary and the Chief of Staff): Better Pay, Bigger Budgets Called Key to Fixing Readiness Woes," *Air Force Times*, 28 September 1998. However, some research has shown that some deployments may improve retention (James R. Hosek and Mark Totten, *Does Perstempo Hurt Reenlistment?: The Effect of Long or Hostile Perstempo on Reenlistment*, RAND, MR-990-OSD, Santa Monica, California, 1998).

   In response to global concerns, the Air Force formulated a new concept of force organization, the expeditionary aerospace force or EAF. Under this concept, the Air Force was divided into several air and space expeditionary forces, each roughly equivalent in capability, among which deployment responsibilities were to be rotated. Each AEF would have the capability to project highly capable and tailored force packages, largely from the CONUS, on short notice, to any point around the world. Rotating deployment responsibilities among units on an equitable and fairly predictable basis was expected to greatly decrease personnel turbulence. As this concept has evolved, some of the details were modified. As envisioned, the structure consisted of ten AEFs as described, two units for *popup* contingencies, and five AEFs for humanitarian/evacuation operations. In recent years, the term air and space expeditionary force or AEF has replaced EAF. To keep the historical perspective, the early sections of this book continue to use the term EAF.

   There is no general term for the force package actually deployed, although AES (for squadrons), AEW (for wings), and AEG (for groups) have been used. In this article, we call the actual deployed force of whatever composition an AEW.
2. Footprint is the name given to the size of the materiel needed to deploy a specific force. If airlifted, the footprint is expressed in airlift equivalents (for example, 12 C-141 loads); if stored, in terms of warehouse space.

3. Planners at US Air Forces in Europe have independently developed a similar classification for bases in their theater. HQ USAF, Installations and Logistics, Maintenance has also proposed a division of bases for its planning analyses.
4. These data are from the 4th Fighter Wing's deployment to Qatar, but other deployments have similar patterns. This deployment was not done on short notice, and there was little reengineering of support processes although unit type codes (UTC) were extensively examined and tailored. However, our models capture individual processes in sufficient detail to permit evaluation of process modification and tailoring.
5. More details may be found in Robert S. Tripp, et al*, Integrated Strategic Support Planning for the Expeditionary Aerospace Force*, RAND, MR-1056-AF, Santa Monica, California, January 1999.
6. RAND is examining several issues germane to risk and flexibility (Wendt, 1998, unpublished research).
7. In our munitions modeling, we accounted for all munitions that would be used in support of this AEF force package, including air-to-air munitions, HARM missiles, chaff/flares, and 20mm gun ammunition.
8. We have assumed that US forces must set up temporary fuel storage on a prepared site so that fuel for US aircraft can have additives added independently of host base fuel.
9. This does not take into account the much more demanding air bridge (tankers, airlifters) that must be in place to use airlift from CSLs.
10. Setup requires 4.6 days with a dedicated 150-person crew in a temperate climate.
11. There are two omissions from the investment cost. First, we defer considering the cost of building FSLs or constructing new FOLs in a theater of interest because these installations may be provided by an ally's bases or by adapting existing facilities. Second, we present the total purchase price without considering the fact that some of the equipment and consumable costs could be sunk.
12. The aviation maintenance equipment is assumed to be brought with the unit.
13. Each FSL has two sets of equipment, but if there is reachback to the CONUS, the CONUS only needs two sets total.
14. In this analysis, we assumed that each F-15E carried six SBSs.
15. The SBS is only under test and has not been procured. The costs shown here are, therefore, money that must be programmed and expended, unlike the costs for the GBU-10, which are largely sunk.
16. Note that we have assumed that rapid transportation is available for movement of munitions to an FOL when they are stored in an FSL or in the CONUS.
17. Much of the difference in recurring costs occurs because of the expense of running exercises from CONUS and the form of the exercises.
18. The AEF Battlelab at Mountain Home AFB, Idaho is overseeing development of a combined compressor/air-conditioner for flight-line use, and the Aerospace Ground Equipment Working Group is investigating items such as collapsible maintenance stands. The Air Force Research Laboratory at Wright-Patterson AFB, Ohio is investigating modular support systems for both legacy and future weapons systems.
19. For a more complete description of an enhanced planning process for global support infrastructure, see Tripp, et al*,* 1999.

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The time horizon over which planning is done determines a number of key planning process characteristics. These include the response time required to construct a plan, level of detail of inputs, and flexibility of available resources.

EAF Strategic Planning

The Combat Support System

The EAF and Combat Support System Planning

To meet future operational requirements,[1] the combat support system should be designed to maintain readiness levels to support immediate deployments, provide responsive support to deal with unexpected events, provide support for the full spectrum of potential operations, transition support effectively as the units move along the spectrum of operations (transportation from one kind of operation to another), and be efficient and affordable. Moreover, maintaining readiness to meet potential major regional contingency (MRC) requirements, while a significant portion of the force is temporarily deployed to meet boiling peacetime commitments, presents additional support challenges. These challenges differ considerably from those posed by Cold War employment concepts and require a complete reexamination of the combat support system to determine how they can best be met. Strategic Agile Combat Support (ACS) design tradeoff and investment

While much of the Air Force's attention has been focused on the execution time horizon to support the EAF, this segment of research concentrates on an integrated planning framework that addresses strategic decisions.

decisions need to be made in the near term to create the ACS capabilities necessary to achieve the operational capabilities required in the future.

Focus on Strategic Planning

The time horizon over which planning is done determines a number of key planning process characteristics. These include the response time required to construct a plan, level of detail of inputs, and flexibility of available resources. Planning for the ACS system could operate on three different time horizons at the:

- Level of execution (days to weeks): the ACS system should support ongoing operations;
- Midterm or strategic level[2] (months to years): the system should acquire or construct resources to support the current force structure across the full spectrum of operations and in any location critical to US interests, subject to peacetime cost constraints; and
- Long-term level (decades): the ACS mobility system and its strategic infrastructure should be modified to support new force structures as they come online and to utilize new technologies.

While much of the Air Force's attention has been focused on the execution time horizon to support the expeditionary aerospace force (EAF), this segment of research concentrates on an integrated planning framework that addresses strategic decisions. These ACS system design and policy issue planning decisions made in peacetime affect the logistics footprint, closure time, peacetime costs, and other important metrics for evaluating support of expeditionary operations. The goal of this research is to begin formulating a strategic planning process that addresses how to make decisions about infrastructure development, resource positioning at forward or rear locations, and other policies and practices affecting logistics support.

An Enhanced Strategic ACS Planning Framework for the EAF

A detailed, continuous, careful end-to-end planning process focusing on strategic time horizons is required to develop the infrastructure necessary to transition to the EAF effectively and efficiently. Further, much, if not most, support effectiveness comes from planning and decisions made for these longer time horizons where options include redesigning support equipment, developing support processes and infrastructure, setting up prepositioned resources, and negotiating base access and relationships with coalition partners.

Characteristics of Strategic ACS Planning in the EAF Environment

Generally, a strategic ACS planning system for the new environment should assess how alternative logistics designs affect a number of important metrics. These include time lines to achieve the desired operational capabilities, peacetime costs, risks, and flexibility. It should also provide feedback as to how well the existing ACS system meets the spectrum of operational requirements. In comparing the current planning system with the ACS planning requirements for the EAF concept, enhancements should be made in the following areas:

- **Supporting the entire spectrum of operations.** The current planning system assumes that combat support capabilities designed for MRC scenarios can handle any situation. However, resources required to support peacetime operations (missions other than war) may be greater than or differ substantially from those required for MRCs.
- **Dealing with uncertainty.** Expeditionary operations are fraught with uncertainty. For example, denial of base access may require both preparation of several reception sites (forward operating locations) to support combat operations and minimal resource prepositioning at multiple sites to increase the probability of access. Moreover, there is great uncertainty surrounding the operational scenario, which will greatly affect support resource requirements. For instance, low operating tempos (OPSTEMPO) may require far less prepositioned resources to meet rapid employment time lines, whereas high OPSTEMPOs may create a need for much more prepositioning. The current planning system, which focuses on MRCs, needs to be enhanced in order to address these uncertainties as well.
- **Evaluating alternative designs for deployment and employment time lines and associated costs.** The EAF concept emphasizes rapid deployment time lines that should be accounted for in future ACS system design. Alternatives to achieve fast deployment (for example, prepositioning equipment, developing FOLs with adequate facilities and resources to support rapid deployments and immediate employment, and developing host-nation support agreements) have significant peacetime costs. On the other hand, the time lines might be slightly longer if materiel were held at regional storage sites. This would significantly lower costs. Assessing such tradeoffs between time line, cost, and risk is integral to future strategic ACS system planning. The current support planning system does not address these issues.[3]
- **Integrating ACS planning among support functions and theaters and with operations.** The current combat support planning system is stovepiped in several ways. Each commodity and its support processes are viewed largely independently in order to determine resource requirements. In this fragmented process, opportunities to develop consolidated support operations or other policies that may support more than one theater may be missed. Moreover, feedback needs to be provided among commodity managers (for example, engines and low-altitude navigation and targeting for night) so they may determine how the best support option for one commodity (for example, consolidated intermediate maintenance) may affect the *best* ACS design for the other. Additionally, feedback on support options and costs needs to be

EAF Strategic Planning: The Combat Support System

The approach to requirements generation and determination is called employment driven *because it starts with operational analysis: forces, weapons, OPSTEMPO, and required time lines.*

provided to operations planners for tradeoff analysis decisions. As an example, a deployment window of 96 hours versus 40 hours produces dramatic savings of resources.

- **Integrating the assessment and development process for technology and policy.** In the areas of technology and policy, many different organizations and agencies are pursuing initiatives that are part of the overall ACS system. However, these initiatives are formally uncoordinated below the level of the Air Staff. There has been little attention given to developing a capability that can evaluate options among those sets of competing policies and technologies that may be developed both to produce the most cost-effective global ACS capability and serve multiple theaters and operational scenarios.
- **Controlling variability and improving performance.** Ensuring that a redesigned support process is working and identifying areas for improvement will require monitoring the support system as it evolves, yet feedback for system design improvements is not routinely captured. A few critical parameters drive wartime and peacetime requirements for resources. While some of these parameters are measured, much improvement can be made in controlling their variability. Further, improvement may be made by developing a measurement system that can indicate when corrective action is needed or when the system may need redesigning.[4]

A Framework for Strategic ACS Planning Employment-Driven ACS Requirements Determination

The approach to requirements generation and determination is called *employment driven* because it starts with operational analysis: forces, weapons, OPSTEMPO, and required time lines. These key parameters determine most of the support requirements. This step is the leftmost panel in Figure 1, which depicts the overall approach to analyzing support requirements.

The middle panel represents the requirements determination model, which generates time-phased combat support requirements for each support resource as a function of the operational requirements and alternative logistics policies, practices, and technologies. ACS planning is beset by uncertainties and options. Some simple aggregated spreadsheet models were constructed to compute requirements for fuel, munitions, vehicles, support equipment, and shelters. As these models are easier to specify and run than the usual highly detailed models, they may be used to quickly screen several scenarios permitting a more thorough analysis of uncertainty. Yet, these relatively simple models provide enough detail to estimate the personnel, equipment, and commodity requirements to support alternative operational requirements and the timeframes required to assemble the production function for those commodities and operate them to sustain operations for an operational scenario.

For example, in the fuel model, the refueling system requirements (number of R-9 refuelers) are determined by the aircraft go sequence, aircraft fuel acceptance rates and capacities, and refueling system flow rates. For refueling by truck, the system flow rate would be determined by the truck acceptance rate, distribution system pumping rate (fill stand), and driving time to and from the fill stands. While not a detailed simulation of the fuels support operation, the model can be used to compute requirements for a number of fuel reception, storage, and distribution methods.[5]

As noted in the middle panel of Figure 1, two of the key outputs from the requirements determination models are the initial operating requirement (IOR) and follow-on operating requirement (FOR) for each resource (if applicable). The IOR is the number of resources necessary to initiate and sustain operations while resupply pipelines are initiated for that resource. In the case of munitions, it may be that 3 days are required to reestablish resupply of munitions. Thus, 3 days of munitions would be the IOR. The FOR is the projected number of resources required during the remainder of the planned operation. The FOR can be delivered periodically to keep the flow of resources into the forward operating location (FOL) easy to handle by a relatively lean forward support force. These parameters are the key to determining deployment resources and time lines and sizing the resupply capability, respectively.

As depicted in the rightmost panel of Figure 1, the support options for various commodities need to be evaluated across the different phases of

The FOR is the projected number of resources required during the remainder of the planned operation. The FOR can be delivered periodically to keep the flow of resources into the FOL easy to handle by a relatively lean forward support force. These parameters are the key to determining deployment resources and time lines and sizing the resupply capability, respectively.

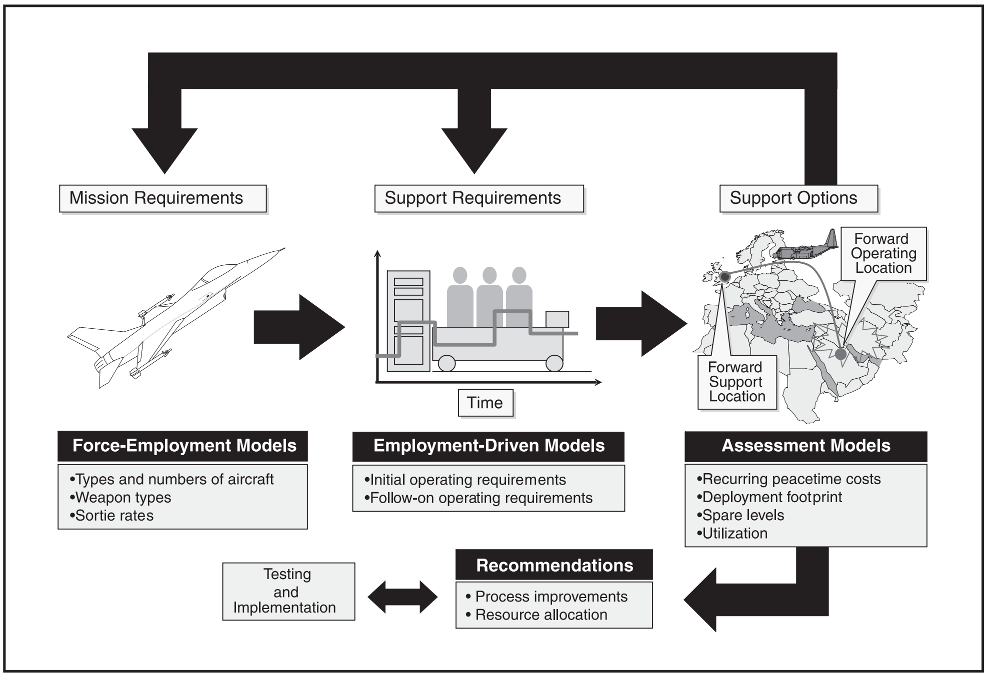

Figure 1. Employment-Driven Combat Support Requirements Generation

The model accounts for such issues by allowing each option to be given a subjective rating with respect to its robustness. It then requires options with low robustness (but high initial deployability) to be replaced by more robust options within a specified period of time.

operation. As with operational analysis, the aim is to identify support options that provide good performance (in terms of the set of metrics) across all phases of operation and across a range of potential scenarios (the number and range depending on the time horizon under consideration). Again, tradeoffs may have to be made across the scenarios and the metrics (for example, a low-cost option may have a large risk). Additionally, support options may be evaluated for different mixes and for continental United States versus forward-based logistics. This approach allows these tradeoffs to be made with a clear picture of the effects across different options and scenarios.

Integration of Individual Commodities Options into an ACS System

The next step is to select options in each of the commodity areas to create candidate AEF support concepts. As shown in Figure 2, preliminary work was done on an *integrating model* to choose among the options analyzed. This is a mixed-integer optimization model that selects combinations of the options that meet the objective function subject to several constraints and thereby quickly identifies feasible support concepts. Taken together, these options represent a possible support concept for AEFs that could then be looked at more closely to consider additional issues, such as the flexibility of the concept and its transportation feasibility.

For each commodity considered, the model can select from as many as six alternative ways to provide the resources needed to support operations. Each option has different fixed (investment) and variable (recurring) costs and varies according to its robustness and suitability for long-term use.[6]

The model accounts for such issues by allowing each option to be given a subjective rating with respect to its robustness. It then requires options with low robustness (but high initial deployability) to be replaced by more robust options within a specified period of time.

While the model allows the identification of potential EAF support concepts, it is also useful in answering a range of questions that give insight into the robustness of the concepts. For example, by varying the costs of certain aspects of a concept of operation (CONOP), the *breakpoints* could be identified that would motivate a switch to another CONOP. This allows a number of important questions to be explored; for example, the maximum desirable cost associated with the opening of a new forward support location or how sensitive a CONOP might be to annual transportation costs. Another important issue that can be analyzed by the model is the effect of various levels of airlift availability, which is a key make-or-break assumption associated with each AEF support CONOP. Finally, the payoff of improved technology to lower the deployment footprint of a resource option could be explored. In this way, the effect of an improvement in the deployability of a particular resource on the overall AEF deployment could be gauged.

As the Air Force extends its analysis of support structures beyond single theaters of operation, the complexity of issues will make the application of automated techniques, such as the integrating model, essential. The complex interactions between the region-specific security challenges, mutually supporting theaters, geography, and required levels of responsiveness will create an almost overwhelming number of possible support structures. Automated models such as the integrating model are needed to manage this complexity in order to identify low-cost global support structures for the EAF.

Integration of ACS and the Mobility System

Executing AEF deployments requires that a multitude of mobility-related actions be set in motion. These include forward positioning of tankers, deploying aerial port personnel, placing mobility crews in crew rest, and so forth.

Mobility processes comprise a substantial portion of the overall AEF deployment time line. As interweaving mobility processes with logistics support processes are a key aspect of future AEF Agile Combat Support structures, there should be a way to test the mobility and logistics interfaces for any candidate AEF support structures devised. Toward this end, a high-level simulation model of the air mobility system, called the AEF Deployment and Planning Tool, was developed.[7]

This model provides insight into the chain of mobility-related events that makes AEF deployments possible and can test the transportation feasibility of possible AEF support structures.

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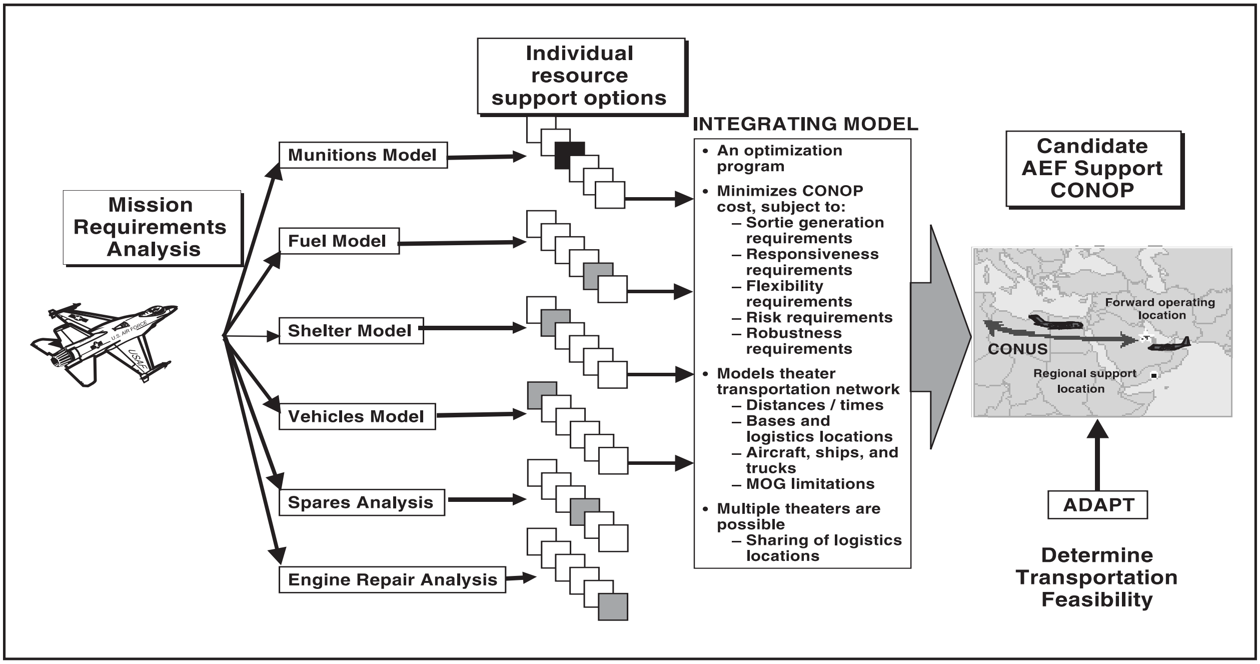


Figure 2. The Integration Model Assists in Choosing Among EAF Support Options

The final element of the proposed planning framework is feedback, which provides indications that there are discrepancies between plans and reality. Information on deviations from plans can be used to initiate correctional actions to solve the problems. Two primary feedback loops are envisioned in the planning framework.

Feedback Loops for Control

The final element of the proposed planning framework is feedback, which provides indications that there are discrepancies between plans and reality. Information on deviations from plans can be used to initiate correctional actions to solve the problems. Two primary feedback loops are envisioned in the planning framework.

The first feedback loop is between logistics planning and operations planning as shown at the top of Figure 1. Operational analysis can provide alternative force packages that can accomplish *equivalent* goals. This is important because the alternative force packages can have very different support requirements.[8]

In some circumstances, logistics constraints may not be removable because some logistics resources may be strongly tied to an expensive and relatively fixed infrastructure that has limited flexibility. For example, fuel resources available within a given country and distribution capabilities to forward operating bases may not be available to support a sustained, high EAF OPSTEMPO. Operational plans may have to be modified to deal with this constraint. This requires close interaction between logistics and operations in designing the ACS system of the future. With these strategic time horizons, the interaction needs to be continuous but not real time. Time is available to plan and acquire a logistics infrastructure that can support more ambitious operational plans if the costs and risks are judged to be acceptable.

The second feedback loop is between logistics planning and the control of the logistics infrastructure. First, there is a diagnostic loop in which logistics constraints identify areas of the ACS system where enhancement is needed. The diagnostic results are used to focus modifications on the logistics infrastructure to enhance its capabilities at the points where such improvement is needed to support operational plans.

A tracking and control feedback loop is needed to monitor the performance of logistics processes that are not (currently) constraints and ensure their performance remains adequate. These feedback loops and control system ensure the logistics system evolves as needed to support current and future operational plans and the system achieves and maintains the required support capability.[9] The result is a continuous cycle of planning, diagnostics, improvement, and replanning.

Planning Process Modifications and Organizational Development to Support Continuous Expeditionary ACS System Planning

The proposed support planning system likely requires integration across Air Force organizations and across commodities with one agency endowed with responsibility and authority to integrate and rationalize this global strategic planning from an Air Force perspective. While each major command (MAJCOM) and appropriate numbered air force would be responsible for developing ACS requirements based on its own area of focus, appropriately supplemented by other internal and external organizations, the requirements should be analyzed and integrated at a system level, ensuring tradeoffs are made and resources are directed appropriately. There are several ways the Air Force could organize to develop the future combat support system using the process described above.

One option for integration is that the Deputy Chief of Staff, Installations and Logistics could initiate organizational and process changes needed to support the new strategic ACS planning framework by creating a director for ACS Design and Development. Each of the functional areas would be represented in this organization.

Another method to integrate the development of combat support requirements across all command lines is to include them in an ACS Technology Planning and Policy Integrated Process Team (TPPIPT), which would formally review the MAJCOM outputs on a periodic basis. Membership of this TPPIPT might also be expanded to include coalition partners, academics, and *think tanks* to help ensure policy alternatives receive due attention.

There are several ways the Air Force could organize to develop the future combat support system using the process described.

A third option for accomplishing this integration would be to continue the functioning of the Air Force Directorate of Expeditionary Aerospace Force Implementation and extend its charter to evolve the ACS system of the future, along with developing new employment concepts.

With regard to implementation, the Air Staff could delegate most of these responsibilities to the MAJCOMs in a system of centralized control but decentralized execution. The integrating agent, either the Director of ACS Development, the TPPIPT, or the Director of Expeditionary Aerospace Force Implementation would provide direction and guidance to the MAJCOMs to ensure multiple area-of-responsibility infrastructure developments are considered. As requirements are approved for development, they could be approved for funding and delegated to the MAJCOMs. Alternatively, the responsibility for acquisition and maintenance of the global support infrastructure could be the responsibility of a system program office for infrastructure at Air Force Materiel Command, which would be responsible for building the infrastructure and ensuring its performance meets the needs of operators.

Specific Elements of an ACS Planning Framework for the EAF

Based on the foregoing, the following elements can be seen to be integral components of an enhanced ACS planning framework:

- A closed-loop strategic ACS planning process to develop alternative strategic designs for the EAF concepts of the future. This planning framework would be provided to the MAJCOMs for development of specific AOR ACS designs in concert with the warfighting commander in chief's A3.

The EAF concept is a radical departure from past Air Force employment concepts. It holds promise for enhancing the Air Force's ability to deal with a new and uncertain international environment while alleviating some of the serious readiness problems being caused by lengthy overseas deployments. An integrated, continuous strategic ACS planning process will enable the realization of the full potential of EAF capabilities.

- Use of employment-driven end-to-end requirements generation models to specify requirements as a function of operational requirements and logistics policies, practices, and technologies for important logistics commodities and processes.
- Use of support options assessment models to compute metrics to compare alternative approaches for satisfying the requirements for individual commodities and processes across the phases of operations—peacetime operations and readiness preparation, deployment, employment and sustainment, redeployment, and reconstitution.
- Use of an integration model to evaluate integrated commodity ACS structures and processes.
- Evaluation of the impacts of uncertainty and alternative transition paths to MRC operations.
- Use of measurements and assessments of actual process performance and resource levels with those that were planned.
- Designation of ACS planning and assessment responsibilities to direct and advocate the strategic system design and evolution.

The EAF concept is a radical departure from past Air Force employment concepts. It holds promise for enhancing the Air Force's ability to deal with a new and uncertain international environment while alleviating some of the serious readiness problems being caused by lengthy overseas deployments. An integrated, continuous strategic ACS planning process will enable the realization of the full potential of EAF capabilities.

Notes

1. In the early genesis of the concept of expeditionary operations, the Air Force used the term expeditionary aerospace force or EAF to define this new concept of force organization. In recent years, the term air and space expeditionary force or AEF has replaced EAF. To keep the historical perspective, the early sections of this book continue to use the term EAF. Under the EAF concept, the Air Force is divided into several air and space expeditionary forces or AEF, each roughly equivalent in capability, among which deployment responsibilities will be rotated. Each AEF is required to be able to project highly capable and tailored force packages, largely from the continental United States, on short notice, anywhere around the world in response to a wide range of possible operations. This concept requires the ability to deploy and employ quickly, adapt rapidly to changes in the scenario, and sustain operations indefinitely. To meet the demanding time lines, units must be able to deploy and set up logistics production processes quickly. Deploying units will, therefore, have to minimize deployment support. This, in turn, demands the support system be able to ensure the delivery of sufficient resources when needed to sustain operations. As this concept has evolved, some of the details have been modified. At the time of writing, the structure consisted of ten AEFs, including two units for popup contingencies and five AEFs for humanitarian/evacuation operations.
2. The term strategic is used because these decisions are affected by not only time horizons but also the geopolitical strategic situation, technology, and fiscal constraints. As will be argued, these decisions have to be made by complex tradeoffs of risk and benefits using criteria that are strategic in the broadest sense.
3. Logistics planners in US Central Command Air Force have had to develop their own methods to address these questions since they may host many deployments.

4. Raymond Pyles and Robert S. Tripp, *Measuring and Managing: The Concept and Design of the Combat Support Capability Management System*, RAND, N-1840-AF, Santa Monica, California, 1982.
5. To determine munitions support and avionics repair requirements and associated personnel and equipment workload, new algorithms and modeling technology had to be developed. In other cases, suitable models exist or can be modified to generate requirements for resources. Such is the case for spare parts. In this case, the Aircraft Equipment Model provides requirements for spares as a function of OPSTEMPO, force module size, maintenance concept, resupply times, and so forth.
6. For example, an austere shelter option may be permissible during the first few days of a deployment but may be replaced by a more robust option as time goes on and the airlift capacity is available.
7. The model is programmed using ithink Analyst software. (ithink Analyst Technical Documentation, High-Performance, Inc, Hanover, New Hampshire, 1997).
8. For instance, an AEF operational analysis might indicate that, under some scenario variations, an AEF composed of 12 F-15Es, 12 F-16Cs, and 6 F-16CJs could produce the same results as an AEF composed of 18 B-1 bombers and 6 F-16CJs. The support requirements and corresponding support alternatives are very different for these force packages. They also may have different deterrent implications. The fighter package may involve bedding down the force closer to the adversary. Using the reception sites of a neighbor may have a greater deterrent impact than indicating to an adversary that punitive strikes may be inflicted from bomber bases located farther away. These alternatives also have different costs and risks.
9. Pyles and Tripp, 1982.

Technology

Technology (to include technological change and technological innovation) as a subject covers a lot of ground and often enjoins heated debate. It has proven to be one of the major tools for dealing with problems, more so in the last century than at any other time in history. However, critics of technology argue that it often causes as many problems as it solves and the new problems are often far worse than the old ones. Further, they question its validity as a major tool for solving complex problems rooted in ethical, philosophical, political, or other nontechnical areas.[1] These are certainly, by no means, all the criticisms of technology, but they serve to frame the basic objections. The counter argument to these criticisms would answer that technology is not unique in creating new and, often, more difficult problems while solving old ones. Very much the same criticism could be aimed at all approaches to problem solving. No problem-solving approach yields simple, final answers to the basic problems of humankind.[2] One could even argue that philosophical and other nontechnical approaches have done little when measured against the same standards; they fail just as abjectly as technology.[3] Further, the fact that technological solutions are inappropriate in certain situations does not mean that technology is always unsuited to problem resolution. Technology cannot be viewed as a separate entity within either the military or society in general. This illusion of discreteness simply does not exist. It is and will remain an integral part of both. The real issue is to recognize that technology is a tool with limitations, and these limitations should be considered in reacting to particular situations. Technology does not offer a *silver bullet* for all situations.

A variety of human and cultural factors still impedes full-scale adoption of many new technologies—complexity and difficulty in their use, loss of control, changes in fundamental power relationships, uselessness of old skills, and changes in work relationships. Change and instruments of change, as apparent as they seem once implemented, often elude understanding before they enter the mainstream.[4] As an example, Chester Carlson, the inventor of the photocopy machine (often referred to as the Xerox machine) was told by business that his invention was unnecessary because libraries and carbon paper already filled the need. This was a technology that drastically altered the way people approached information, yet finding interested businesses and investors in the beginning proved elusive.

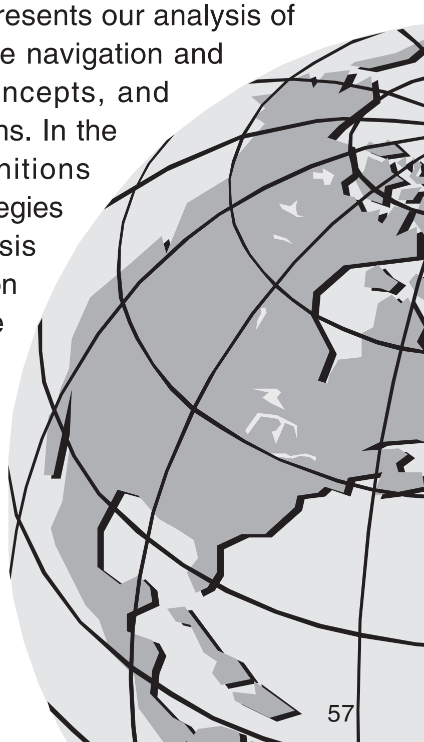
Notes

1. John E. Jordan, Jr and Thomas C. Lobenstein, "Technology Overview" from *Low-Intensity Conflict and Modern Technology*, ed. Lt Col David J. Dean, Maxwell AFB, Alabama: Air University Press, 1986, 105.
2. *Ibid*.
3. Jordan and Lobenstein, 106.
4. Norma R. Klein, "Technology Trends and Logistics: An Interrelational Approach to Tomorrow," *Air Force Journal of Logistics*, Vol XIII, No 2, 36.

Section 2: Support Challenges

combat support

Section 2 covers results of important maintenance support concepts and challenges. In particular, this section presents our analysis of F-15 avionics support structure, low-altitude navigation and targeting infrared for night maintenance concepts, and jet engine intermediate maintenance options. In the area of consumables, an article on munitions discusses the alternative prepositioning strategies for this important commodity. Each analysis points to the value of a forward support location in supporting the warfighter and, thus, the importance of access to overseas bases. An article on global access strategies discusses the various options in selecting airbases. Finally, an article on footprint configuration maps a way to not only reduce the size of the footprint in terms of weight and volume but also develop a systematic concept to speed AEF deployment.



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The level of support consolidation and proximity to the fighting units, ranging from the current decentralized practice of deploying intermediate maintenance with the deploying unit to a small network of support locations (or even a single location), characterizes the alternative structure options. Technologies, policies, and capabilities combine with the structure options to form a rich array of possibilities from which the Air Force may choose the best ACS system to meet uncertain scenarios.

F-15 Support Analysis

Alternative Support Structures

Introduction

The F-15 weapon system will play an important role in the expeditionary aerospace force (EAF) for several years in the future. This article examines how alternative F-15 support structures shape the effectiveness and efficiency of EAF Agile Combat Support (ACS).

RAND and Air Force Logistics Management Agency researchers have been exploring promising alternative support concepts to support the EAF operational strategy. Comparisons of these concepts to each other and to the current system have been based upon six air and

F-15 Support Analysis: Alternative Support Structures

The analysis centers on the level of consolidation chosen for support operations.

space expeditionary force (AEF) logistics metrics: spin-up time, airlift footprint, operational risk, operational flexibility, investment, and recurring costs. Analyses indicate that varying the structure according to support location proximity to operations—with the operational unit at another forward location in theater or in the Continental United States (CONUS)—creates tradeoffs among logistics metrics. In some instances, technologies and process methods can change the tradeoffs inherent in a given structure, reducing negative features while preserving positive ones.

This article specifically examines alternative F-15 avionics intermediate maintenance structures and explores how different technology and process capabilities affect the likely cost and performance of the structures. The level of support consolidation and proximity to the fighting units, ranging from the current decentralized practice of deploying intermediate maintenance with the deploying unit to a small network of support locations (or even a single location), characterizes the alternative structure options. Technologies, policies, and capabilities combine with the structure options to form a rich array of possibilities from which the Air Force may choose the best ACS system to meet uncertain scenarios. Our goal is to highlight the key issues affecting the possible decisions and to illustrate some of the tradeoffs the Air Force faces in these decisions.

Support Structures, Policies, and Technology Create the *Trade Space*

The analysis centers on the level of consolidation chosen for support operations. The Air Force currently decentralizes F-15 avionics maintenance by deploying testers from home bases to forward operating locations (FOL) with aircraft. A variation of this system is the *decentralized no deployment* option in which the avionics intermediate shop (AIS) would not deploy with its squadron to FOLs during combat operations. Other options rely on varying levels of consolidation. These range from using a single CONUS support location (CSL) to using a CSL in network with two to four forward support locations (FSL).

While structure decisions may focus on support locations, they should not do so exclusively. Adopting new procedures or technologies can affect how different support structures compare to each other. Considering faster order and ship times (O&ST) than those achieved today can provide insights into the logistics system that can justify a push for new transportation concepts or processes. Implementing new technology such as the new electronic system test set (ESTS) is also likely to affect the six AEF support metrics.

In analyzing different support structures for the AEF, an employment-driven modeling approach or an approach shaped by mission and support requirements and options was used.[1] The first step in this approach is shown in the left panel of Figure 1. In analyzing mission requirements, force employment models are used to determine the force package and operating tempo necessary for anticipated missions.

This information is used to estimate initial deployment and subsequent sustainment requirements, as shown in the middle panel of Figure 1. The demand for avionics components then drives the requirements for maintenance equipment and personnel, spare parts, and transportation resources. The last step in this process is to determine the spin-up time, airlift footprint, cost, risk, and flexibility of each option, as shown in the right panel of Figure 1. In some cases, this will show that all the alternatives are incapable of meeting operational needs. If this is the case, it should guide modification of mission planning or development of new alternatives. In this way, logistics and operations planners can work together in an iterative process until the best solution, given resource constraints, is reached. At the end of the process, mission requirements and logistics capabilities should be consistent and well understood.

Costs

The study examined several types of costs across six support structures for F-15 intermediate avionics maintenance. These costs include those for testers, personnel, spare parts, and transportation. As mentioned, the six support structures analyzed are defined primarily by level of consolidation. These are (1) the current decentralized system, (2) a *decentralized no deployment* system, (3) a network of four FSLs and one CSL, (4) a network of three FSLs and one CSL, (5) a network of two FSLs and one CSL, and (6) use of only one CSL for avionics maintenance.

Tester Costs

For the current decentralized system, $12M is needed for additional Tactical Electronic Warfare Intermediate Support System (TISS) testers. Analysis shows the Air Force currently lacks the six TISS stations needed to meet wartime requirements for two coincident major regional contingencies (MRC). This cost would not be incurred for the centralized structures, because these structures would require fewer total testers. In this case, the current decentralized inventory is more than sufficient. In fact, with the current testers, analysis indicates consolidated support would cut worldwide tester requirements by 50 percent.

For the ESTS configuration, costs include remaining program funds and, for the decentralized structure, $22M for the additional procurement of three ESTS units and six TISS testers. With ESTS, consolidation would cut total tester requirements by about a third. As with current testers, this reduced tester requirement does not produce savings, because existing tester inventory (including funds already expended for ESTS) is a sunk cost.

Personnel Costs

Based on fully burdened Air Force personnel costs[2] for the authorized grades and skill levels planned for staffing and supervising test stations,[3] personnel costs are estimated to be about $42K per person. Expressed in 8-year, net present value (NPV) terms,[4] total personnel costs necessary to satisfy two MRC demands, using the current testers, range from about

F-15 Support Analysis: Alternative Support Structures

F-15 Support Analysis: Alternative Support Structures

Spare parts costs increase as consolidation increases, because the length of the resupply pipeline increases.

$450M with complete consolidation to nearly $900M for the decentralized structure. Personnel costs using the ESTS range from about $400M with consolidation to about $650M for the decentralized structure. The model suggests the need for a slight increase in Air Force avionics maintenance personnel if the Air Force adopts ESTS under the current structure, while consolidation would allow a reduction in personnel.

Spare Parts Costs

Spare parts costs increase as consolidation increases, because the length of the resupply pipeline increases. While consolidation yields some economy-of-scale *savings* for shop replaceable units, these savings are overwhelmed by the demands of longer pipelines for line replaceable units (LRU). To support the consolidated options, new spares concepts were developed, including a buffer stock at the consolidated sites to help ensure serviceable spares are available when requisitioned by a deployed unit. This is more cost effective than further increasing the depth of readiness

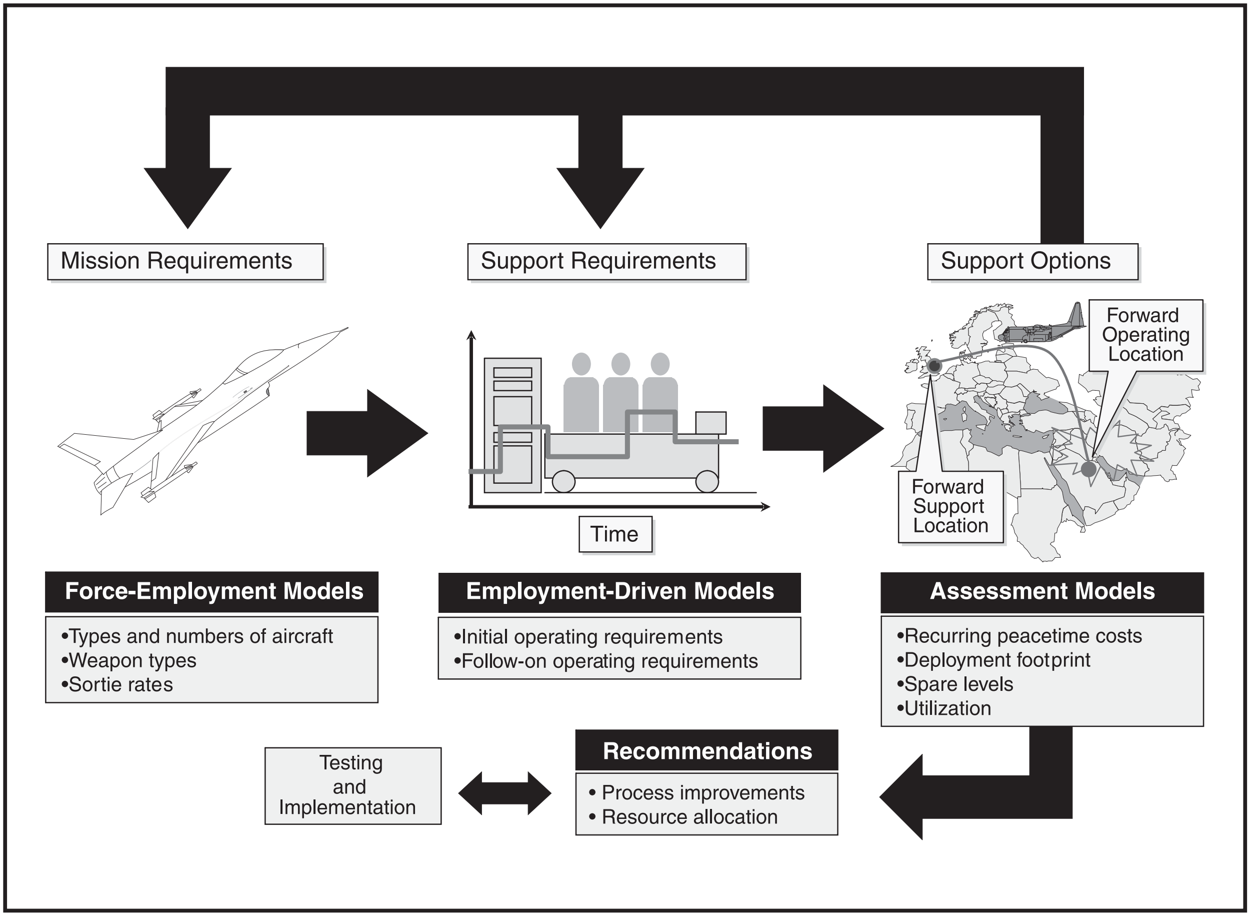

Figure 1. Employment-Driven Modeling Approach for Evaluating ACS Systems

spares packages (RSP). These buffer stocks are referred to as consolidated spares packages. In addition, the RSP that would support deployed options was changed to contain LRUs only, since avionics intermediate maintenance would not be deployed under the consolidated options. Finally, peacetime operating stocks were adjusted to support the pipelines between operating and repair locations.

Using today's order and ship times would require an additive spare parts inventory cost of nearly $100M for the CSL/4 FSL option and more than $350M for the CSL-only option. Reducing O&ST, thereby reducing the pipeline length, greatly reduces these additive spare part requirements. For example, with O&ST 2 to 3 days shorter than current times, additive spare parts costs for the CSL/FSL combinations are about $50M. For the CSL-only option, the cost is about $250M.

Transportation Costs

In the current decentralized system, unserviceable three-level (remove-repair-replace) items are repaired on base and do not require transportation to a repair facility. In a remove-and-replace system used for consolidation, all unserviceable items must be shipped from FOLs or home bases to an FSL or CSL, and a serviceable part must be shipped back. Again, as consolidation increases, parts transportation costs increase, because fewer operating bases are colocated with repair facilities, producing an increasing reliance on transportation. Estimates, based on analysis, show the 8-year NPV of these transportation costs to vary from $28.1M for CSL/4 FSL structure to $44.4M for a single CSL.

Total Costs

The sum of 8-year NPVs for equipment, personnel, spares, and transportation equals the total costs for each option and test set, as shown in Figure 2. With baseline OSTs and the current tester configuration, the decentralized deployment option and the CSL/4 FSL option are nearly equal in total cost. The two options essentially trade off personnel and spare parts costs.

For the ESTS configuration with baseline OSTs, shown on the right side of Figure 2, the decentralized option costs slightly less than the CSL/4 FSL option, because the ESTS itself reduces personnel requirements.

Improved OSTs reduce the requirements for spare parts while keeping other costs constant. This makes the CSL/4 FSL option the low-cost option for using current testers. For ESTS with improved OSTs, the CSL/4 FSL option and the current decentralized support structure are about equal in costs.

The sum of 8-year NPVs for equipment, personnel, spares, and transportation equals the total costs for each option and test set. With baseline O&STs and the current tester configuration, the decentralized deployment option and the CSL/4 FSL option are nearly equal in total cost. The two options essentially trade off personnel and spare parts costs.

Other Requirements by Structure

There are other critical dimensions beyond cost to consider in making support structure decisions. These include deployment personnel requirements and quality-of-life issues, deployment footprint, and operational risks.

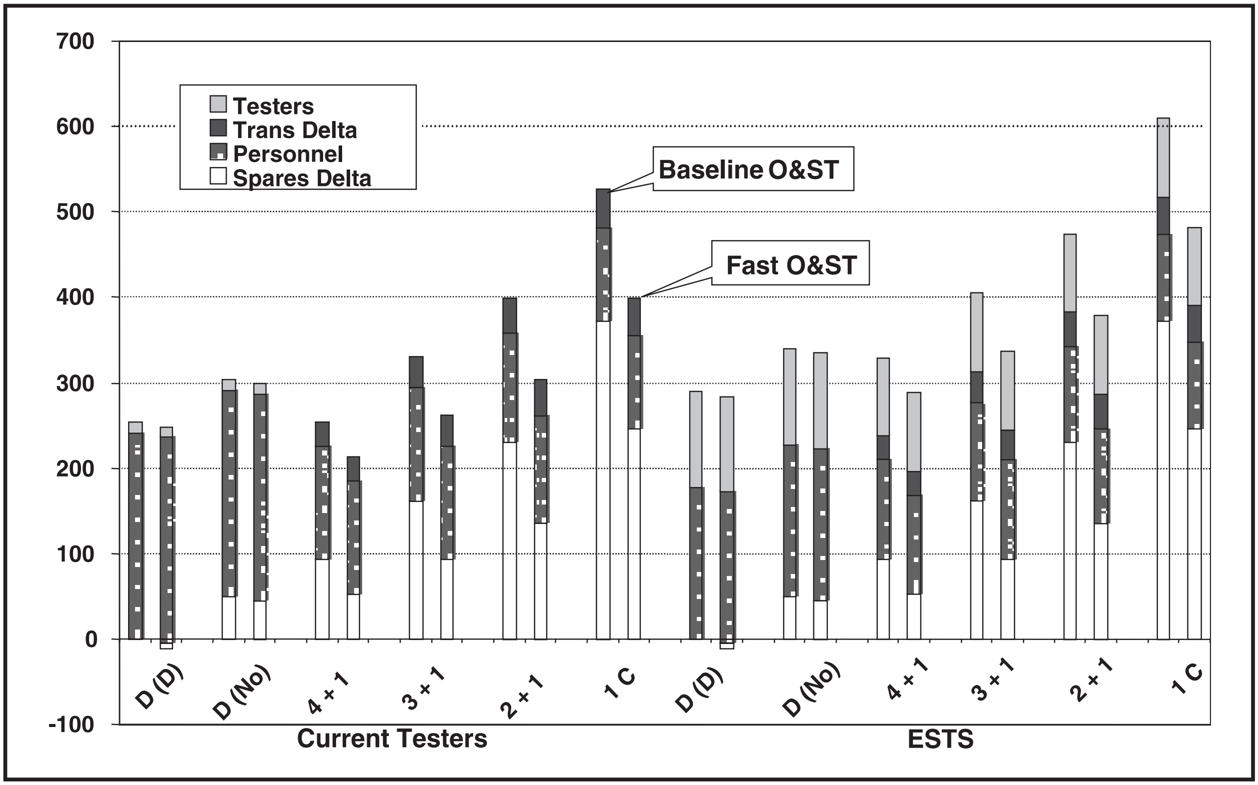

Figure 2. Total Cost by Structure, O&ST, and Tester Configuration

The current decentralized deployment option has high deployment personnel requirements, while the decentralized no deployment option eliminates deployment personnel requirements. The consolidated structures eliminate deployments for small-scale contingencies and require just a small number of people to shift from CSLs to FSLs during major regional contingencies.

Deployment Personnel Requirements

Among the goals of the AEF is deployment predictability to provide stability for Air Force personnel. In this analysis, this goal is taken one step further by analyzing how to reduce deployment personnel requirements, not just how to make the requirements more predictable. The current decentralized deployment option has high deployment personnel requirements, while the decentralized no deployment option eliminates deployment personnel requirements. The consolidated structures eliminate deployments for small-scale contingencies and require just a small number of people to shift from CSLs to FSLs during major regional contingencies.

Deployment Footprint

A key element in successful quick-hitting expeditionary operations is the rapid deployment of strong combat forces. This puts a premium on reducing the deployment footprint or the amount of initial airlift space needed to transport initial operating requirements and combat equipment. For an MRC deployment, consolidated and decentralized no deployment structures reduce deployment footprint requirements for avionics intermediate maintenance by up to 60 C-141 (43 C-17) load equivalents.

The adoption of the much smaller ESTS would reduce these savings to a maximum of 12 C-141 (9 C-17) load equivalents.

Reducing the deployment footprint provides a vivid picture of an objective that can be achieved in different ways. Either new technology, such as the ESTS, or policy changes, such as those for consolidation, can help reduce the deployment footprint. The key point is Air Force leaders often can choose from a variety of options to meet their operational goals.

Operational Risks

If resupply times for a given support structure do not meet the performance assumptions used to set spare parts levels, then aircraft availability may suffer. In a decentralized structure, the greatest operational risk is tester downtime. If a single set of testers is deployed, a breakdown of just one will temporarily eliminate resupply for a large group of LRUs. This is termed the *single string* risk.

In a consolidated structure, the greatest operational risk is O&ST and retrograde time performance. While the single string risk can greatly affect a small group of LRUs, O&ST and retrograde time risk is broader but also likely to be more moderate and gradual. In effect, single string risk cuts off resupply while a tester is down, while O&ST risk lengthens the pipeline. The severity of the effects of subpar O&ST and retrograde performance depends on how actual resupply time differs from the assumptions used to plan readiness spares packages.

If resupply times for a given support structure do not meet the performance assumptions used to set spare parts levels, then aircraft availability may suffer. In a decentralized structure, the greatest operational risk is tester downtime. If a single set of testers is deployed, a breakdown of just one will temporarily eliminate resupply for a large group of LRUs. This is termed the single string risk.

Support Option Advantages and Disadvantages

The *current decentralized system*, in which the AIS deploys to FOLs, has the advantages of low relative cost, greater certainty in resource requirements, and an existing infrastructure. Its disadvantages, however, are precisely the difficulties that have led to examination of alternatives and have caused many deploying units to modify their procedures informally.

Personnel under the current system are likely to face continued, frequent deployments, further contributing to retention problems among avionics technicians. Further, to meet operational objectives, the current structure requires more highly skilled personnel than currently available in the Air Force. Besides the deployment of personnel, the current system of AIS deployment consumes valuable initial airlift space that might otherwise be used to close additional forces. When the AIS is deployed in a single string for small-scale contingencies, as specified by current doctrine, LRU resupply faces a high tester downtime risk.

Modifying the current structure to eliminate AIS deployment—or the *decentralized no deployment* option—eliminates the personnel deployment and airlift requirements. Moving to this system would be relatively easy since no new infrastructure would be needed, although an increase in the serviceable inventory of spare parts would require a one-time investment that makes this structure more costly than the current structure. The risk for this structure would be in resupply from CONUS.

Consolidated structures also reduce the personnel turbulence and deployment footprint concerns associated with the current structure while being cost competitive with the current structure. Like the decentralized no deployment option, consolidated repair depends upon consistently available transportation, but its transportation requirements are limited to shorter intratheater lift and present less management complexity.

Conclusion

This article focuses on *pure* structures to emphasize tradeoffs created by the alternatives. The pure models help illustrate the sensitivity of the system to individual design parameters. From the pure models, Air Force logistics personnel may be able to develop hybrids, capturing the advantages of different structures to create even better alternatives or to improve implementation feasibility.

In fact, the 48th Component Repair Squadron at Royal Air Force Lakenheath, United Kingdom, implemented a hybrid strategy to support F-15 operations against Serbia in Operation Noble Anvil. Building upon their experience providing partial support for AEF operations in Southwest Asia over the last 5 years, they supported initial F-15 Noble Anvil operations in Europe and continuing operations in Southwest Asia from Lakenheath with their existing assets. When deployment plans for additional aircraft were projected to exceed their support capabilities, they developed an augmentation plan with CONUS organizations. This plan, executed for logistics support even though the conflict ended prior to the deployment of the additional aircraft, cut airlift footprint and deployed personnel by more than 50 percent than would have been necessary had support deployed to the FOLs. In the long run, this method would reduce the additive spare parts requirements of consolidation, because it does not lengthen the peacetime pipeline. This hybrid plan struck a balance between the benefits of consolidation and decentralized support. For example, about half the deployment airlift benefit was achieved with just a small increase in spare parts levels.

This is representative of the decisionmaking needed to make the EAF work. First, the Air Force must determine how it values the AEF logistics metrics. Then, it should choose ACS options that best strike a balance between these values. The Lakenheath example provides an option with some reduced airlift and a limited increase in spare parts requirements, while a permanent FSL would further reduce airlift but require more spare parts (and fewer personnel).

The Air Force should carefully examine this ad hoc planning and implementation, which served as a concept test, as well as similar events occurring for other contingencies and for other commodities. Then, the Air Force should select and begin implementing its doctrine of the future. Thorough peacetime planning will allow a more seamless, effective transition to wartime operations.

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Notes

1. Robert S. Tripp, et al*, Integrated Strategic Support Planning for the Expeditionary Aerospace Force*, RAND, MR-1056-AF, Santa Monica, California, January 1999.
2. Application of Military Standard Composite Rate Acceleration Factors for Fiscal Year 1998, AFI 65-503*, Cost and Planning Factors*, Table A32-1, 23 Apr 98.
3. Manning Statistics by (Grades 33-39) HQ ACC/DPAA, Jul 99 (Provided authorized and assigned numbers for each AIS).
4. An 8-year net present value of personnel costs is used, because test equipment is estimated to have a lifespan of 8 years.

The LANTIRN system consists of two pods (navigation and targeting) employed by F-16s and F-15Es. The alternative support structure options range from the current decentralized practice of deploying intermediate maintenance with the fighting units to a network of consolidated (or even single) support locations.

LANTIRN Support Challenges

Intermediate Maintenance Concepts

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LANTIRN Support Challenges: Intermediate Maintenance Concepts

During the study, expected warfighter capability levels relative to a range of deployment and transportation times were computed by combining scenarios, support structures, and investments. Additionally, system cost implications—in terms of equipment, spares, and infrastructure investments, as well as transportation and labor expenditures—over a 15-year time horizon, the expected life of the program, were assessed.

This article examines alternative low-altitude navigation targeting infrared for night (LANTIRN) intermediate maintenance operations and explores the implications of support equipment investments in conjunction with various logistics concepts. The LANTIRN system consists of two pods (navigation and targeting) employed by F-16s and F-15Es. The alternative support structure options range from the current decentralized practice of deploying intermediate maintenance with the fighting units to a network of consolidated (or even single) support locations. Support equipment upgrades, policies, and capabilities combine with these structure options to form a rich array of possibilities from which the Air Force may choose the best ACS system to meet uncertain scenarios.

Scenarios, Support Structures, and Equipment Upgrades Create the *Trade Space*

The Air Force currently maintains LANTIRN pods using a decentralized logistics structure, deploying full sets of testers from home operating bases to forward operating locations (FOL) with the aircraft. Other options rely on varying levels of consolidation. These range from using a single continental United States (CONUS) support location (CSL) to using a CSL in network with two to four forward support locations (FSL). This analysis centers on the implications of various levels of consolidation chosen for the LANTIRN intermediate-level support operations relative to operational scenarios ranging from peacetime to two coincident major regional contingencies (MRC).

While structure decisions may focus on support locations, they should not do so exclusively. Adopting new procedures or technologies can affect how different support structures compare in terms of capabilities and costs. While the Air Force does not plan on upgrading pod performance or purchasing additional LANTIRN pods, three investment options to upgrade the support equipment used to repair these pods—including zero investment, advanced deployment kit (ADK,) and midlife upgrade—were evaluated. The upgrades offer a reduced footprint and enhanced support equipment performance and reliability. The current intermediate-level LANTIRN mobility shelter set and proposed upgrades are shown in Figure 1.

During the study, expected warfighter capability levels relative to a range of deployment and transportation times were computed by combining scenarios, support structures, and investments. Additionally, system cost implications—in terms of equipment, spares, and infrastructure investments, as well as transportation and labor expenditures—over a 15-year time horizon, the expected life of the program, were assessed. Analysis showed that the decision to centralize or decentralize LANTIRN repair operations hinges not on the expected system costs but on the capability and risk levels the Air Force is willing to accommodate in its operational plans.

Analysis of the Fundamental Factor—Time

When weighing the implications of centralized or decentralized support, one must consider the deployment and inter- and intratheater transportation times associated with each option. Whereas forecasting this time element for MRC scenarios is difficult, the expected capability levels relative to a range of both deployment and transportation times were assessed. Figure 2 illustrates the results of targeting pod analysis for a two-coincident MRC scenario. Only the targeting pods are shown since they are more mission essential and generate greater demands on the maintenance system.

Given the inherent pod inventory constraint, a pod availability goal was set for both engaged and nonengaged aircraft. Availability is defined as the number of serviceable pods available for use on aircraft for specific missions. Since the Air Force currently does not have a specific availability goal for LANTIRN pods on aircraft, a value (80 percent) somewhat higher than that used for the entire aircraft fully mission-capable rate was chosen.

Next, the expected pod availability for the nonengaged aircraft (trainers) was computed as a function of deployment or transportation time. Deployment time was defined as the number of days it takes repair to set up functional operations at the forward operating location once surge missions begin, in other words, the number of days *after* flying begins when repair comes on line. If deployment takes longer than 7 days during the second MRC, there will be no pods available to fly training missions. Furthermore, if deployment times increase beyond this breakpoint, then the Air Force will risk degrading pod availability to the *engaged* aircraft.

The centralization options introduce a different time factor in the analysis. Now, transportation time (defined as order and ship time [O&ST]) becomes the critical system sensitivity. Since equipment and some people are prepositioned near areas of potential conflicts, deployed

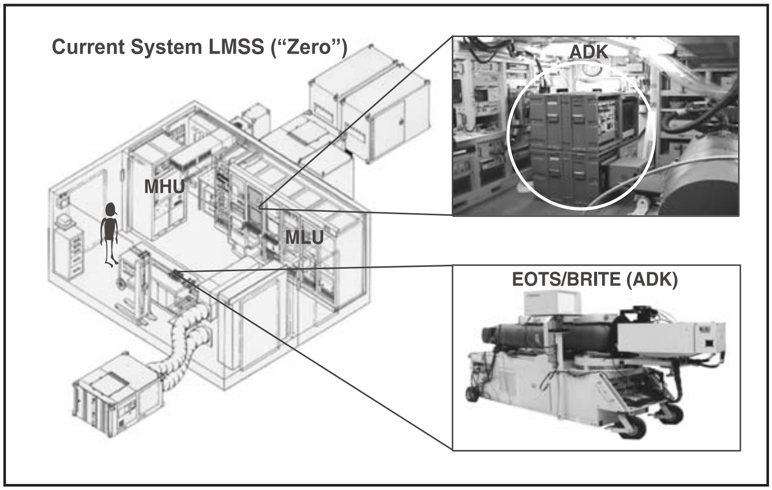

Figure 1. Current and Proposed LANTIRN Support Equipment

LANTIRN Support Challenges: Intermediate Maintenance Concepts

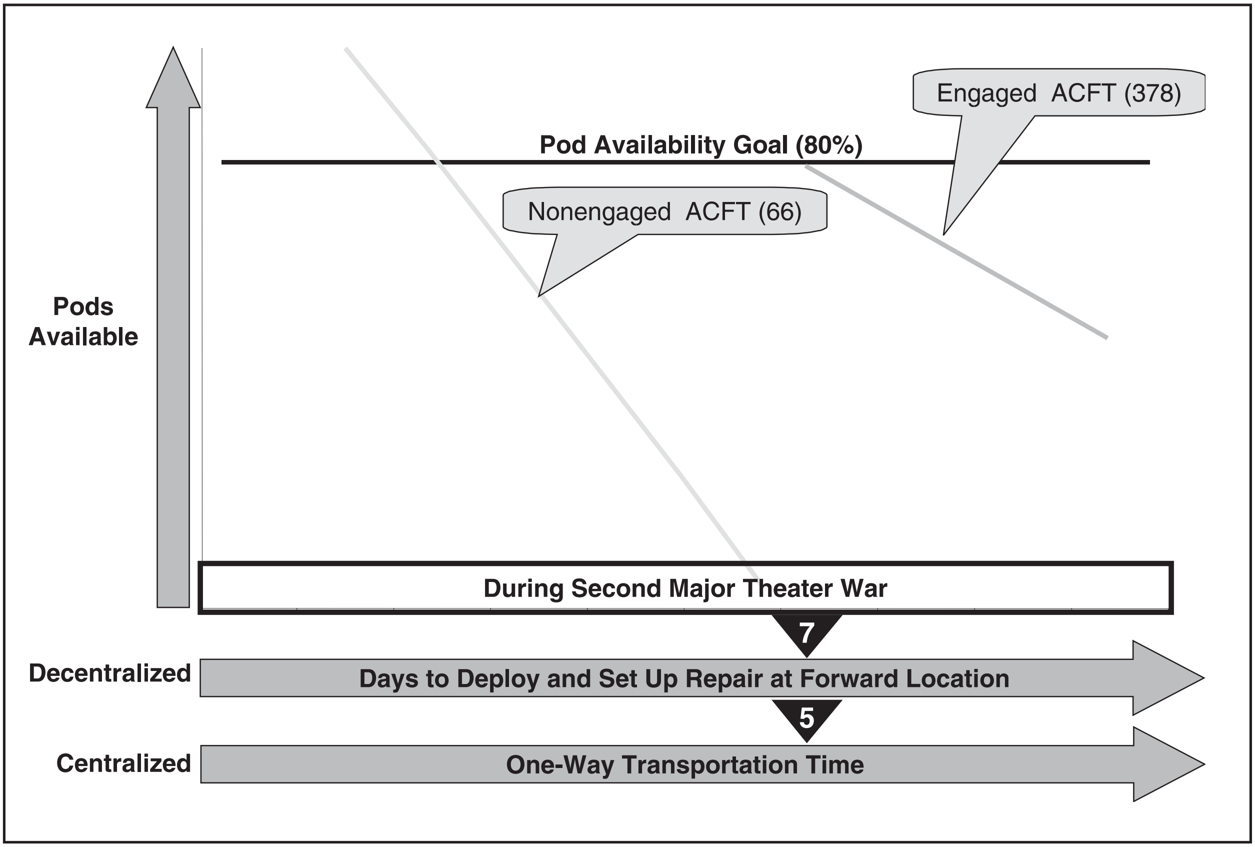

Figure 2. Expected Pod Availability Relative to Deployment or Transportation Time

units must transport unserviceable pods to the regional repair operation. Again, the targeting pod availability was computed during the second MRC as a function of the one-way transportation time from an FOL to a regional repair facility. Here, the critical breakpoint is 5 days, beyond which *engaged* aircraft capabilities may degrade.

While centralized operations may be more susceptible to terrorist attacks or may be located too far from yet unforeseen contingencies, the decentralized support structure is extremely sensitive to the availability of deployment airlift during the early phases of large-scale missions.

Structure Tradeoffs

Strategic and Operational Risks. While centralized operations may be more susceptible to terrorist attacks or may be located too far from yet unforeseen contingencies, the decentralized support structure is extremely sensitive to the availability of deployment airlift during the early phases of large-scale missions. Both structures may suffer if resupply times do not meet the performance assumptions used to set spare parts levels. Operationally, a decentralized structure is very sensitive to tester downtime. If a single set of testers is deployed, a breakdown by just one will temporarily eliminate repair capabilities. In a consolidated structure, the greatest operational risk is O&ST. The severity of the effects of subpar performance depends on how actual resupply time differs from the assumptions used to plan readiness spares packages and pod kits for a specific deployment package.

Deployment Footprint. Among the goals of the expeditionary aerospace force are quick-hitting expeditionary operations and deployment predictability to improve stability in the personal lives of Air Force personnel. These goals require rapid deployment of strong combat forces, putting a premium on reducing footprint or the amount of initial airlift space needed to transport operating materiel and combat equipment. While consolidation options may reduce the number of people needed in regional operations by up to 150, requiring smaller personnel deployments (under 60), the greatest footprint reduction is realized through the elimination of equipment movement. Conversely, decentralized support of a two-MRC contingency would require movement of 85 to 252 people and more than 180 equipment pallets, depending on upgrade investment.

Organizational Issues. Although the thrust of this analysis focuses on the quantitative issues associated with various logistics structures, one cannot overlook the less tangible cross-organizational implications of the dipole options space. Decentralized support requires that individual squadron or wing commanders compete for valuable airlift early in the campaign. This includes competing not only with other LANTIRN units but also with other commodities. As a result, mobilization plans may need to be modified to prioritize deployment time lines. While centralized support requires minimal tactical airlift (pods are relatively small), commanders would have to share a global asset pool. This pool includes not only personnel and repair equipment but also tactical transport and the pods themselves.

Support Option Advantages and Disadvantages

While the centralized option requires fewer test sets and fewer highly skilled people, the annual transportation costs may be higher. The analysis shows that these annual costs, coupled with labor expenses, are virtually the same across the seven options analyzed. So the recurring peacetime costs and, consequently, present value of *all* costs are essentially equal, as shown in Figure 3.

Another advantage of the regional support structure is the drastically reduced deployment footprint. Specifically, very few people need to deploy to support the two MRCs. Furthermore, since FSLs are removed from theater operations, both the support equipment and people face lower risks. Although regional operations may become more vulnerable to attack (both conventional and cyber), proper preparations and communications design can alleviate these threats.

Colocation of test equipment not only reduces the effects of single-string failures but also eliminates the need to transport repair equipment to support various contingencies. Since test set transport and setup times can be quite long and equipment readiness is unpredictable once it is unloaded in theater, the regional structure offers a much more stable support system. However, daily pod transportation risks increase with the

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The consolidated intermediate repair structure will require new organizational processes. Unit commanders will have to relinquish some of their control over LANTIRN pods. They will also have to communicate very closely with the support centers and other bases serviced by the same regional facility. Performance metrics and incentive systems may also need to change to support a system focused on customer (warfighter) satisfaction, on-time delivery, and quality workmanship.

consolidated options. Since pods must be moved off base for repair, the system's sensitivity to transportation delays is amplified. Pods will pass through additional transportation channels, and more people will be involved with the loading and unloading process. While there are no data indicating pod sensitivity to transport, rough handling in the new channels may become an issue in the proposed regional structure. Standardized training procedures and tools can mitigate this potential problem.

The analysis also shows that the decentralized structure requires greater support equipment investment, thus increasing the financial risks to the Air Force. However, the present value analysis indicates that, in the long term, recurring costs outweigh investment costs, making the financial difference among the seven options negligible.

Most important, the consolidated intermediate repair structure will require new organizational processes. Unit commanders will have to relinquish some of their control over LANTIRN pods. They will also have to communicate very closely with the support centers and other bases serviced by the same regional facility. Performance metrics and incentive systems may also need to change to support a system focused on customer (warfighter) satisfaction, on-time delivery, and quality workmanship.

Conclusions

Analyses show that—given today's planning scenarios and deployment and transportation processes—the Air Force must invest in support equipment upgrades regardless of support structure. Furthermore, centralized support exclusively from CONUS facilities may reduce warfighter capabilities because of extended pipelines. Thus, it can be

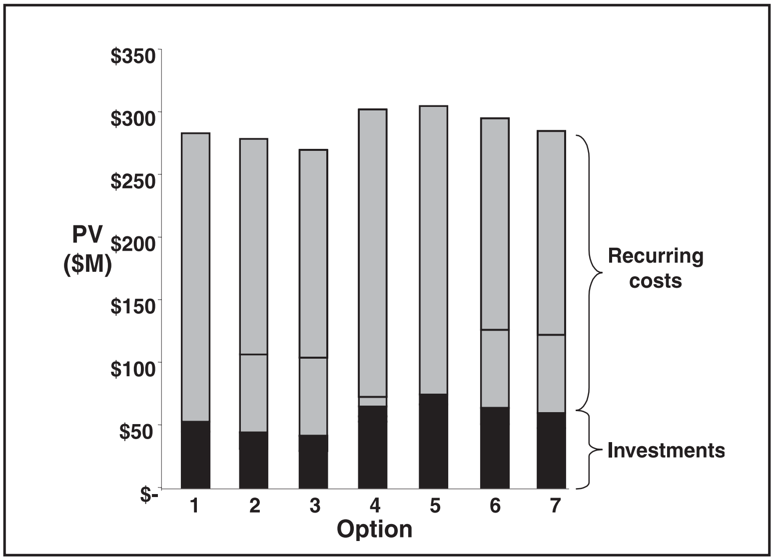

Figure 3. Present Value of Investment and Recurring Costs by Option

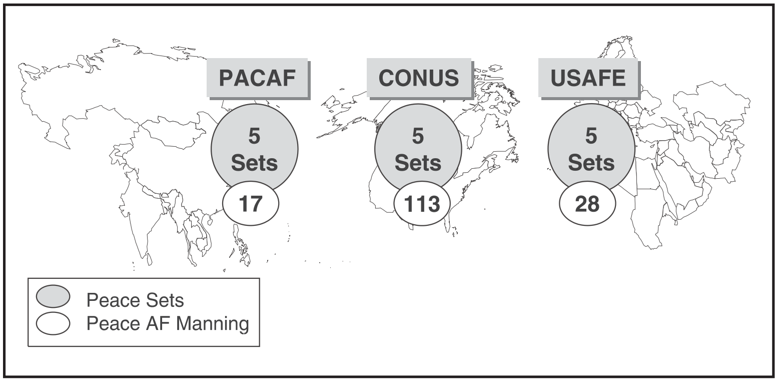

Figure 4. Notional Beddown of Equipment and People for a Regional Repair Structure

asserted that in assessing centralized repair alternatives the Air Force should only consider networked FSL and CSL structures.

While the FSL structure introduces new risks to the Air Force, it also offers some distinct advantages over the current system. The most viable structure the analyses identified would use two FSLs and one CONUS facility. Figure 4 shows a notional implementation of such a structure with five prepositioned sets in each region and the peacetime manning indicated in the white bubbles.

Analyses show that—given today's planning scenarios and deployment and transportation processes—the Air Force must invest in support equipment upgrades regardless of support structure.

This system requires that pods be shipped from FOLs to the centralized repair facilities. While this analysis was based on Defense Planning Guidance flying program expectations, other mission profiles (like Operation Noble Anvil) may change the resource requirements. However, since the options analysis focused on relative differences, the overall strategic outcomes would not change.

Based on the analysis, the Air Force should invest in the ADK upgrade and conduct a proof-of-concept experiment of the regional repair option. However, a centralized system will be sensitive to transportation times and may suffer from poor cross-organizational cooperation and communication. Viable locations to conduct this test include Aviano AB, Italy; Royal Air Force Lakenheath, United Kingdom; or another US Air Forces in Europe installation. This test offers an opportunity to assess transportation system capabilities (and shortfalls) in an international environment and with more stringent operating tempos than within the United States.

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This study evaluated several maintenance policies for F100-220, F100-229, and TF-34 engines. FSLs for wartime support of fighter engines, with removal rates in the range experienced by the F100 engines, seemed to offer the most attractive policy in terms of serviceable engine availability and their effect on fighter capability. However, the development of any consolidated maintenance structure will require considerable planning from a global, strategic perspective.

Expeditionary Operations

Intermediate Engine Maintenance Alternatives

Introduction

The reorganization of the Air Force into an expeditionary aerospace force (EAF) requires reexamination of many combat support areas. One such area is engine maintenance. Traditionally, the jet engine intermediate maintenance shop (JEIM) has been located where the aircraft were flown from (for example, at the forward operating location [FOL] during deployments) and was under the overall command of the operational commander, a concept that was compatible with Cold War conflicts since units planned to operate from relatively fixed locations. Recent EAF support studies show that, in some cases,

Expeditionary Operations: Intermediate Engine Maintenance Alternatives

With the advent of the EAF, interest in centralization has been renewed because of difficulties in moving a complete airbase structure to a bare base within a very short period of time. Recent experience showed that centralization is useful in some circumstances.

centralized repair can provide better performance and allow quicker deployments by reducing initial transportation requirements.[1]

The Air Force has attempted centralized jet engine intermediate repair for various engines several times, albeit with varying success. It centralized JEIM for the Pratt & Whitney F100-220 engine at the San Antonio Logistics Center under the control of the Air Force Logistics Command (later Air Force Materiel Command). Operating units opposed this experiment, and it was ended within 2 years. Nevertheless, reduced fleet sizes and problems in recent years in retaining skilled personnel has led to JEIM centralization for the F110 engine at Misawa AB, Japan; the B1-B engine at Dyess AFB, Texas, and McConnell AFB, Kansas; and the TF-34 engine at Shaw AFB, South Carolina, and several Air National Guard (ANG) units.

With the advent of the EAF, interest in centralization has been renewed because of difficulties in moving a complete airbase structure to a bare base within a very short period of time. Recent experience showed that centralization is useful in some circumstances. Examples are Operation Noble Anvil (the air operation in Kosovo) when logisticians established centralized engine repair facilities at European bases to support forces deploying to new operating locations (southern Italy) or those with limited or overtaxed facilities (Aviano AB, Italy). The JEIM at RAF Lakenheath, United Kingdom, supported several F-15E deployments to other bases. Centralized JEIM at Spangdahlem AB, Germany, supported ANG A-10s operating in Italy and stood ready to supply additional F100 engine repair as needed.

However, working against centralization is the fact that transporting engines for repair is more difficult than shipping other commodities such as avionics whose support might also be centralized. Also, jet engines are subject to numerous time change technical orders, some requiring attention that a centralized repair structure might not be able to perform immediately for a large fleet. Further, the issue of control over maintenance assets remains a significant, if unarticulated, concern to wing commanders.

RAND evaluated several engine maintenance alternatives in support of expeditionary operations:

- The current decentralized-deployed system, in which part of the JEIM at each base deploys with its unit to an FOL to form a deployed JEIM (DepJEIM).
- Decentralized no-deployment, in which there is no JEIM deployment and repairs are done at the home base, even during contingencies.
- A decentralized forward-support-location (FSL) structure, in which each base has its own JEIM but, during war, some personnel from each deploy to a single FSL to support all units in theater.
- A structure combining FSLs with a continental United States (CONUS) support location (CSL) supporting all units in peacetime with JEIM personnel deploying to a theater FSL during war (CSL-FSL).

- CSL-only, in which JEIM is done at a CSL in both peace and war (CSL).

In evaluating these options, a primary consideration was system performance and the ability to respond to unforeseen events. The major elements involved in system performance include spare engines, personnel, and transportation resources. The major focus, however, is on spare engines as a key measurement because sufficient spares ensure that sorties are being executed and provide a hedge against uncertainty and surprises in operating demands.

Simulating Demand and Need

Although helpful for insight into past problems and in choosing alternatives to evaluate, data from previous centralization efforts cannot be used to evaluate the alternatives. This is true for several reasons. First, data on system performance, particularly during conflict and pre- and post-centralization efforts, are limited. Second, several previous centralization efforts faced unique external constraints that may not apply in general situations. Finally, some of the centralization alternatives have not been tried for particular engine types; that is, for engines with repairs that were never centralized (for example, the F100-229), only partially centralized (for example, the TF-34), or not centralized during conflict (for example, the F100-220).

As a result, simulation techniques were used. Engine repair has special characteristics making a simulation model useful for analysis. Sortie requirements change over time, and many measurements such as sorties missed, current spare levels, and queue sizes at key shop points are inherently dynamic. Further, evaluation of alternative systems also requires dynamic analysis of transportation times, capacity, schedules, and management decisions. A simulation model allows analysis of such dynamic variables and how they change during an operation.

Each simulation model is based on the following sequence of events: aircraft are flown from home bases and FOLs to meet peacetime (training) and wartime flying schedules, respectively. After each mission, engines are checked on the flight line, and some maintenance is done. When engines accumulate enough flying hours or when unscheduled maintenance is required, they are removed from the planes and sent to a JEIM facility. Bases and FOLs use spare engines to replace those sent to intermediate maintenance but can miss some daily required sorties if not enough engines are available to meet demands.

In the intermediate shop, engines wait in a repair queue until space and labor are available. Once parts and labor are available, JEIM personnel repair the engines. The labor and physical equipment to work on an engine comprise a *rail team*.[2] The model also accounts for delays in receiving parts that may render an engine not mission capable because of supply (ENMCS).

The model for the F100 engines simulates 2 years of operations, with a single MRC beginning after 1 year of peace and ending in 100 days, after which all units return to their home bases and resume a peacetime flying schedule. Resources needed to give equal performance, as measured by missed sorties, are used to compare JEIM alternatives.

After repair, the engine is reassembled and flows to a queue for the test cells. After testing, it is moved to final inspection and then returned to the flight line where it is available as a serviceable spare that can be installed on aircraft as needed.

The model makes some further modifications to simulate wartime demand and need. It allows deployed aircraft to fly at rates that vary daily, assumes wartime work hours, and gives priority to deployed units.

The model uses data from the Comprehensive Engine Management System and the Reliability and Maintainability Management Information System and from interviews with personnel at a number of units.

Assessing Repair by Engine Type

For each of the engines examined, intermediate maintenance performance during a single major regional contingency (MRC) scenario was simulated. The focus was on wartime demand because each structure in peacetime must include the excess capacity needed for war.

F100 Engine Analysis

The F100 series engine is divided into several modules that are designed to be interchanged in the field and can be repaired separately. This article presents results from the analysis of F100-229 and F100-220 engines. The F100-229 is the newest version of the F100 and comprises a rather small fleet. The F100-220 preceded the 229, entering service in the 1980s; this fleet has more than 1,200 engines.

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For modeling purposes, during peacetime, the F-15s fly at a utilization (UTE) rate of 18 and the F-16s at a UTE rate of 19.[3] At the beginning of the conflict (1 year into the model run period), 48 F-15s and 24 F-16s with F100-229 engines deploy to single mission-series-design bases in a theater of conflict. The larger F100-220 fleets are deployed in stages. The F-15s deploy on day 4 of the contingency, with 12 each going to two F-15 bases and 36 going to a third base. F-16 aircraft deploy for the MRC in four waves, 24 each on days 4, 8, 12, and 16 to four separate bases.

The wartime flying schedule has a 10-day surge, during which the F-15s fly approximately 1.6 sorties per day and the F-16s fly approximately 2.0 sorties per day, followed by a 90-day sustainment period, in which both the F-15s and the F-16s fly about 1.0 sortie per day.

For ENMCS times, historical data from 1997 to 2000 were used. The peacetime total removal rate for the 220 is about 5.0 per 1,000 engine hours on F-15s and 7.5 per 1,000 engine hours on F-16s. For wartime, a single removal rate of five per 1,000 hours was assumed.[4] The removal rate for 229 engines is about five per 1,000 hours in both peace- and wartime. In general, each unit takes all its designated war reserve engines (WRE) when it deploys.

For each alternative, the throughput capacity of the JEIMs involved is set to be just adequate so that no sorties are missed during the MRC because of lack of engines . The number of rail teams, as defined above, represents the throughput capacity of a JEIM shop in the model. A comparison is then made of alternatives both by the rail teams required[5] to ensure no sorties are lost and the average stock of serviceable spare engines that are available over the course of the war.

For the *deployed-JEIM alternative,* the trace of average serviceable F100-229 spares at each day of the conflict is shown in Figure 1. In this case, 16 total rail teams (12 deployed at the respective FOLs and 4 at home) are sufficient to provide the maintenance needed for simulated MRC operations. The reason for the decline in serviceable spares up to day 60 (negative spares means that engines are not available for all aircraft) occurs because, under the current repair structure, JEIM personnel deploy to an FOL by day 30 of the war and begin work immediately. Test cells, however, are not planned to be ready until day 60, because the concrete slab needed as a foundation to resist the thrust of engines at full power must set for 30 days after pouring. Although no wartime sorties are missed, the number of available engines comes very close to dropping below the threshold needed to maintain sorties.

Deploying more rail teams cannot solve this problem since there are too few WREs for the period when the deployed JEIM is not operating. However, deploying all available spares can improve the situation somewhat. The thicker lines in Figure 1 represent the performance when all spares are deployed for F100-229 engines.

For the *decentralized no-deployment structure (*home support), the JEIM remains at the home base and supports deployed forces from there. Some units currently use this method to support operations enforcing no-fly zones over Iraq. To analyze this structure, one-way transportation for

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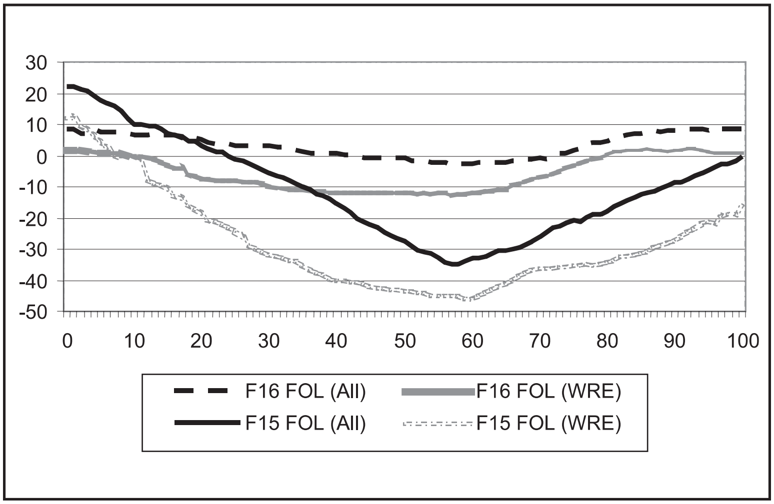

Figure 1. F100-229 Decentralized, Deployed MRC Spares Performance

	Rail Teams (CONUS/Dep)	Test Cells (CONUS/Dep)
DepJEIM	16 (4/12)	6 (4/2)
HOME	20 (20/0)	5 (5/0)
Dec-FSL	12 (4/8)	6 (4/2)
CSL-FSL	11 (3/8)	3 (1/2)
CSL	12(12/0)	3 (3/0)

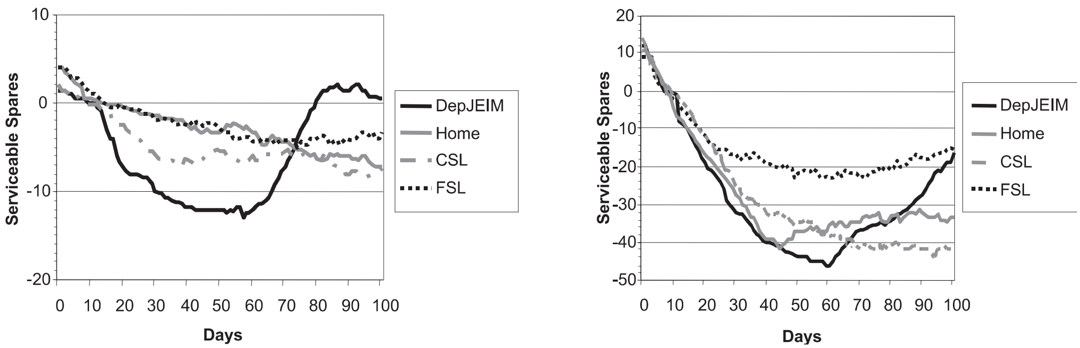

Figure 2. Spares Performance by Repair Structure in MRCs for F100-229 Engine

	Rail Teams (CONUS/Dep)	Test Cells (CONUS/Dep)
DepJEIM	60 (32/28)	34 (22/12)
HOME	61 (61/0)	22 (22/0)
Dec-FSL	52 (29/23)	26 (22/4)
CSL-FSL	30 (7/23)	8 (4/4)
CSL	35(35/0)	8 (8/0)

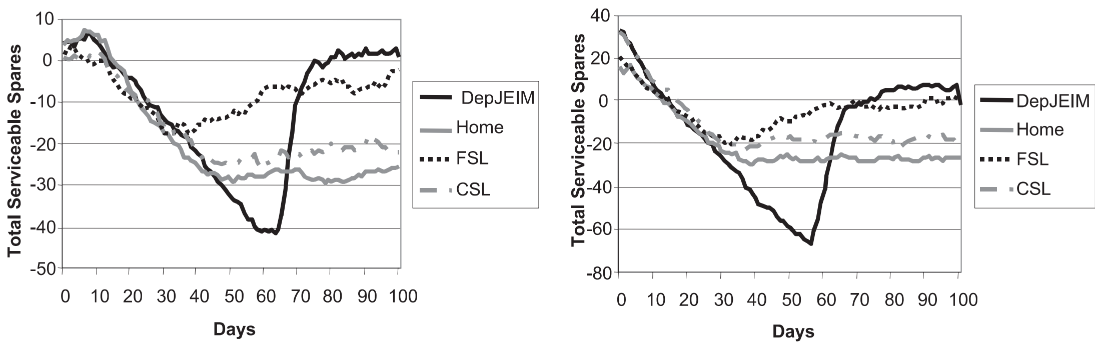

Figure 3. Spares Performance by Repair Structure in MRCs for F100-220 Engines

engines between an FOL and JEIM was assumed to be about 15 days.[6] The JEIM moves to a wartime schedule when forces deploy, and deployed forces get first priority for repairs. The resources required and the spares performance are illustrated in Figure 2 (which also shows the WRE curves from Figure 1).

Another variation of decentralized support is the *decentralized FSL structure.* In this structure, a JEIM shop is located at an FSL in theater and supports engaged forces. During conflict, each home unit deploys some people to an FSL ready to begin operations when the JEIM personnel arrive. Transportation between FOLs and the FSL takes about 2 days.[7]

An alternative FSL arrangement is the *CSL-FSL structure* with some CSL staff performing peacetime JEIM and some deploying to an FSL during war. Total staffing and resource requirements for this case are derived from those identified for the FSL above, plus those needed at the CSL during war to support nonengaged forces. The performance of this alternative is the same as that of the decentralized FSL alternative since the source of resources has no effect on the repair process once established and running.

The final alternative is *complete centralization* in a single CSL. The CSL would be 2 to 4 days from each CONUS location and about 15 days from forces engaged in an MRC. The simulations for this case also show that using only the specified WRE will leave spare levels dangerously low.

Figure 2 illustrates the results for F100-229 engines for all alternatives. For the deployed JEIM scenario, as many as 12 F-16s and 22 F15s can be without serviceable engines. In contrast, in the worst day of the conflict, only a few F-16s and about 11 F-15s are with holes in an FSL scenario. The table in the figure indicates the total number of resources (rails teams and test cells), retained resources, and deployed resources for all the scenarios.

These results indicate that FSLs are superior for supporting a fast-breaking conflict. Other structures do not perform as well because of their time requirements. Those with more centralization require too much transportation time for maintaining adequate thresholds for sorties. Those with less centralization develop a large backlog of engines during MRCs and, hence, a dangerously low level of spares before a deployed JEIM can begin repairs. Note that, although recovery is ultimately more complete over the war for the deployed JEIM, it requires more resources.

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Figure 3 shows similar spares analysis for the 220 engines. The performance for the decentralized system declines through the first 60 days of the contingency but recovers following DepJEIM establishment. Performance for the consolidated options degrades for about the first 30 days and then stabilizes, after which spares performance for the FSL option becomes better than that for the other consolidated options.

Transportation Requirement for F100 Engines

It is somewhat difficult to determine the transportation requirements for the decentralized-deployed case. The latest Air Force unit type code (UTC)

The transportation requirement for the FSL scenario is the same for the decentralized no-deployment scenario. The decentralized FSL structure, however, can meet this requirement with intratheater assets or about 10 per week for the 229 engines and about 24 per week for the 220 engines.

list describes several different F-15 and F-16 independent (that is, capable of operating by themselves) JEIM UTCs ranging in weight from 25 to 50 short tons.[8] A very conservative assumption that 50 short tons must be moved to the F-16 FOL and 100 short tons to the F-15 FOL means that the airlift requirement for this option is 1.2 C-5 sorties for the aircraft with F100-229 engines during the first 30 days of the MRC.[9] JEIM deployment for the 220 engine requires movement of 250 short tons or 3.8 C-5 equivalents.

The decentralized no-deployment structure requires intertheater transportation between FOLs and JEIM shops. It is estimated that an average of 40 F100-229 engines would be returned during the first 2 weeks of the MRC and 10 engines per week would be returned during sustainment operations. This equates to a lift requirement that would need 1.7 C-5s each way during the first 2 weeks of the war and 6.8 C-5s for the remainder of the war. Fighters with 220 engines require an average of 1.6 C-5 transportation equivalents per week during the MRC. These numbers reflect the gross capacity needed, presumably supplied by an ongoing airlift operation that shares transportation space with other needs.

The transportation requirement for the FSL scenario is the same for the decentralized no-deployment scenario. The decentralized-FSL structure, however, can meet this requirement with intratheater assets or about 10 per week for the 229 engines and about 24 per week for the 220 engines. The complete result of the transportation analysis is shown in Table 1.

TF-34 Engine Analysis

As part of the study, the usefulness of alternatives for repair of the TF-34 were also examined. The T-34 is a nonmodular engine that entered service in the late 1970s. The aircraft it powers, the A-10, has been retained in greater numbers than planned following its performance in Iraqi and Kosovo operations. Because of its smaller thrust and lack of an afterburner, it has a lower removal rate than the F100 engines analyzed.

Current repair for the TF-34 features both centralized and decentralized structures. JEIM for Spangdahlem AB and for Pope AFB, North Carolina, for example, moved to Shaw AFB when A-10s were withdrawn from Shaw, freeing JEIM capabilities. As with the other engines, a comparison was made with the performance of centralized and decentralized

		Transportation a/c Equiv (Surge/Sustain)	
Peace	War	F100-220	F100-229
Decentralized	Deploy	3.8 C-5 (once)	1.2 C-5 (once)
Decentralized	No Deploy	2.8/19.9 (1.6/wk) C-5	1.7/6.8 C-5
Decentralized	FSL	43/299 (24/wk) C-130	32/122 C-130
CSL	FSL	43/299 (24/wk) C-130	32/122 C-130
CSL	CSL	2.8/19.9 (1.6/wk) C-5	1.7/6.8 C-5

Table 1. F100 Series Wartime Transportation Requirement

alternatives in a scenario featuring a single MRC, using current spare levels and empirical ENMCS and repair times from the Shaw JEIM.[10]

A similar MRC scenario was used for this engine. Simulated JEIM performance showed a slowly declining number of spares available over the course of the conflict. This pattern is primarily due to an interaction between the number of available spares and the relatively long time needed to repair the TF-34. Repair at consolidated locations or at home bases functions best, providing the highest number of spares throughout the conflict.

A deployed JEIM for the TF-34 requires 3.5 C-5 equivalents to meet requirements. The options in which repair takes place in CONUS require an average of .25 C-5 equivalents weekly throughout the MRC. The options in which repair takes place at an FSL require an average of three C-130 equivalents weekly throughout the MRC. Total transportation resources needed for these options are only slightly higher than those needed for the DepJEIM and are concentrated after the first month when airlift is more available.

Dealing with Uncertainty

The previous analyses assume relatively fixed removal rates, repair and ENMCS times, spare levels, and sortie rates with values, in most cases, corresponding to current experience. These values will not always be fixed. Different scenarios may require different flying profiles. Removal rates may change. As a result, the effects of changes in some of these variables were explored.

Transportation assumptions may be the most critical and subject to the most contention, particularly as the Air Force uses more joint transportation and defense agencies expand transportation contracts with private carriers.

Transportation

Transportation assumptions may be the most critical and subject to the most contention, particularly as the Air Force uses more joint transportation and defense agencies expand transportation contracts with private carriers. Figure 4 shows how transportation time affects missed sorties in an FSL repair structure for the F100-229. If the one-way transportation time is 2 days or less, as assumed, sorties missed because of transportation delays are negligible. For each additional day required for transportation, however, missed sorties increase, especially for the F-15 unit.

Figure 5 shows similar effects for the home-base repair performance for the F100-229. If transportation between FOLs and home exceeds 15 days, missed sorties increase substantially.

TF-34 repair is less sensitive to transportation times because of its low removal rates and different repair structure.

Removal Rate

Removal rates may increase as engines age or decline and as new maintenance practices such as reliability-centered maintenance take effect.

For the F100-229, comparatively few sorties are missed if removal rates remain below ten per 1,000 flying hours or twice that assumed. Figure 6

Expeditionary Operations: Intermediate Engine Maintenance Alternatives

The basic scenario assumes that surge operations will last 10 days. MRCs with longer surges will miss sorties if other operation parameters remain unchanged.

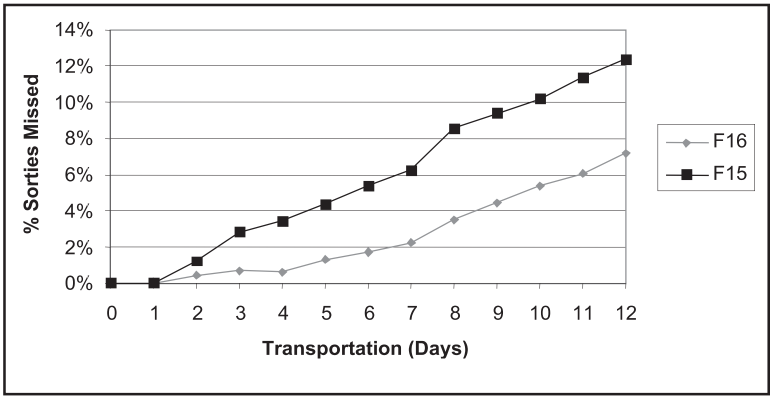

Figure 4. Effects of Transportation Time on FSL JEIM Performance for Deployed F100-229 F-15 and F-16 Units

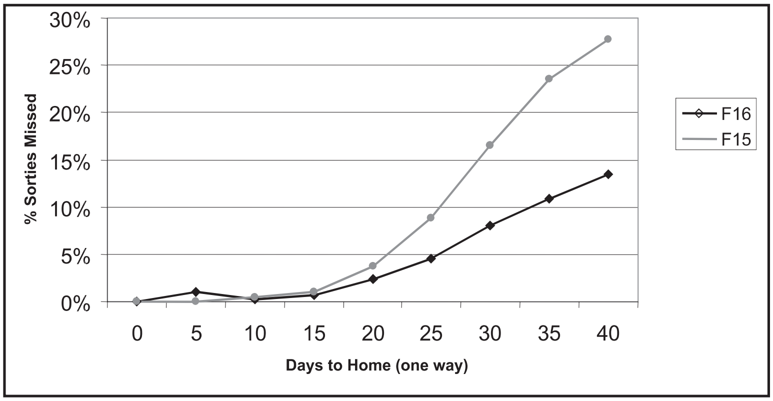

Figure 5. Effects of Transportation Time on Home-Base JEIM Performance for Deployed F100-229 F-15 and F-16 Units

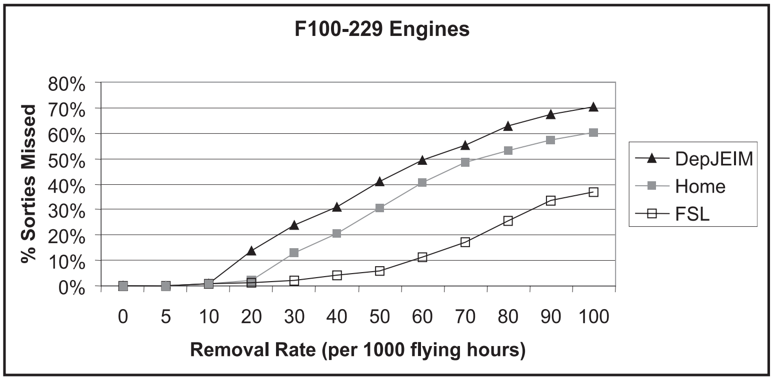

Figure 6. Effects of Removal Rate Variation on JEIM Structures for All F100-229 Engines

shows that, at higher removal rates, the FSL alternative continues to perform better than the other alternatives.

To avoid missed sorties, the removal rate for the F100-220 cannot exceed the assumptions by much. In fact, if the removal rate for the F-16 during war remains at its current peacetime level of 7.5 per 1,000, only an FSL JEIM structure will avoid missed sorties. System performance will be worse and missed sorties highest with the DepJEIM.

Even with removal rates substantially lower than those assumed, the DepJEIM cannot perform as well as an FSL structure. Figure 7 shows available spares for the 220 engines on F-15s in an FSL structure with a baseline removal rate of five per 1,000 hours, for a DepJEIM with the baseline rate, and for a DepJEIM with lower removal rates. Even at a removal rate of two per 1,000 engine hours, the DepJEIM performance is worse than that for the baseline FSL case in days 50 to 65 of the MRC. The results for the F-16 are similar; however, only at the lowest removal rates does DepJEIM become competitive with the baseline FSL case.

Conflict Intensity

The basic scenario assumes that surge operations will last 10 days. MRCs with longer surges will miss sorties if other operation parameters remain unchanged. For example, for the F100-229 engine being repaired by the decentralized-deployed alternative resourced for the scenario, a 20-day surge will lead to a missed sortie rate of about 10 percent, while a 40-day surge will lead to a missed sortie rate of about 20 percent. The model indicates the FSL alternative would better adapt to longer surge operations with fewer sorties missed.

Conclusions and Recommendations

This study evaluated several maintenance policies for F100-220, F100-229 and TF-34 fighter engines. For an MRC, deploying the JEIM to an FOL is too slow. For each engine, the deployed JEIM had the worst performance during the first part of the war because of the time it takes to establish a JEIM shop, particularly the test cell. Constructing test cells at potential FOLs could reduce this time but would reduce flexibility for expeditionary operations since it is not feasible to carry out this program for all possible FOLs. A deployed JEIM also requires transportation resources that may be needed for other parts of the deployment, especially in the early stages of a conflict.

FSLs for wartime support of fighter engines, with removal rates in the range experienced by the F100 engines, seemed to offer the most attractive policy in terms of serviceable engine availability and their effect on fighter capability. The speed with which FSL repair can begin wartime operations and its short transportation pipeline are well-suited for expeditionary missions. An FSL JEIM also requires fewer people in the critical early days of combat and performs better in the face of uncertainties.

However, consolidating repair operations for F100 engines will require a dedicated, responsive, and substantial intratheater transportation system

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The low removal rates for the TF-34 make centralization of its maintenance operations easier. Continued centralization of TF-34 repair seems to be the best policy, supported by both analysis and experience at Shaw AFB, even to the extent of using CSLs to support MRCs. However, as a hedge against transportation uncertainties, some TF-34 repair capability might be included in an FSL.

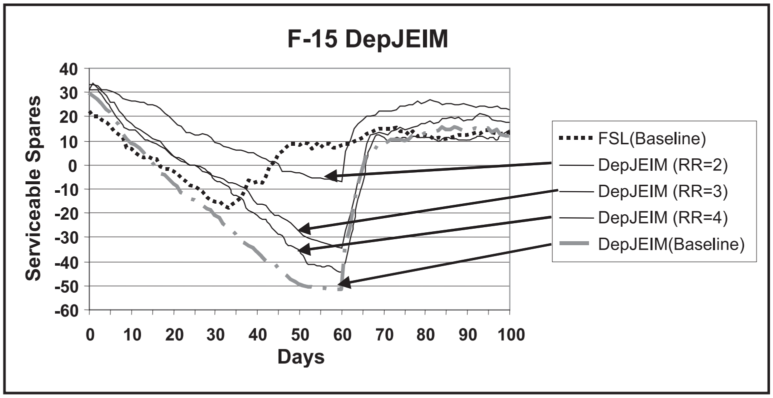

Figure 7. Effects of Removal Rate Variation on JEIM Structures for F100-220 Engines on F-15 Aircraft

during an MRC, particularly during surge operations. Transportation delays will lead to loss of capability. The development of any consolidated maintenance structure will require considerable planning from a global, strategic perspective.

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Finally, there are a number of qualitative considerations to bear in mind when considering centralized engine repair.

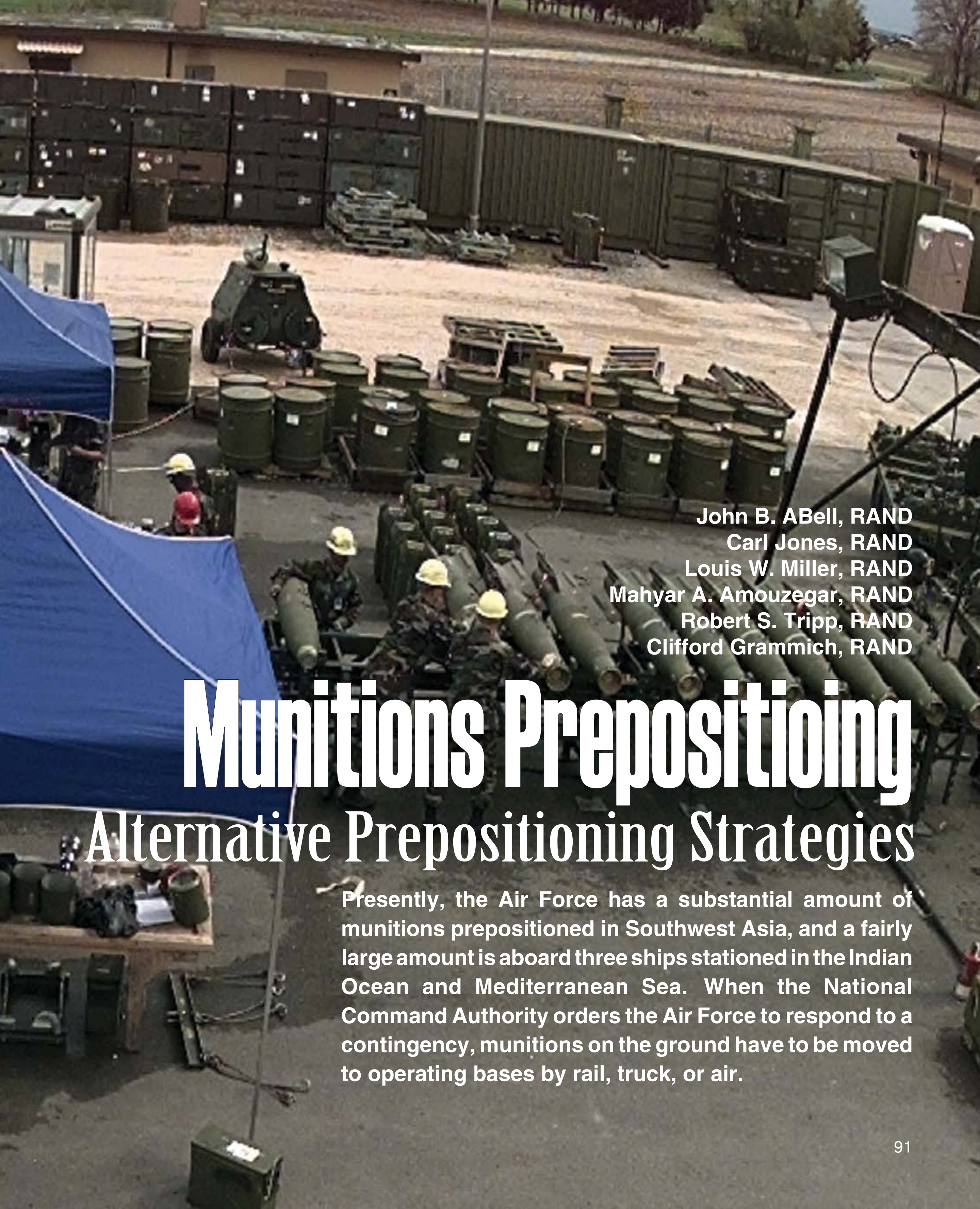
- Past centralization attempts have had a mixed record on responsiveness to units. Other questions of organizational control are also contentious. Such issues must be settled early and clearly for any centralization effort to succeed.
- JEIM consolidation will require attention to flight-line experience so that flight-line diagnosis is not compromised. If the flight line requires relatively more experienced personnel when not collocated with JEIM, this will offset some of the resource economies of scale suggested by the analysis. Alternatively, since the JEIM currently backs up the flight line, if flight-line experience is not maintained or increased, removal rates may increase.
- If support is centralized for wartime but not for peace, the Air Force will have to ensure that the transition from one structure to another is smooth. This will require rethinking areas such as information systems, command relationships, and communication requirements and, most important, practicing real centralized maintenance in exercises and deployment.

- There are several other potential advantages to centralization such as improved training and reduced ENMCS times. In these areas, this analysis has been conservative in that centralized alternatives have used the same skill levels and ENMCS performance as the decentralized ones.

Notes

1. The work reported in this article is described in more detail in Mahyar A. Amouzegar, et al, *Alternatives for Jet Engine Intermediate Maintenance*, RAND, MR-1431-AF, Santa Monica, California, 2000.
2. Engines are mounted on *rails* for repairs. A rail team is defined as a minimum number of people needed to work on an engine in a two-shift day. For example, for F100-229 engines, a rail team is five people per shift or a total of ten people.
3. These usage rates are the current Air Combat Command (ACC) targets. As of this writing, other factors were forcing the actual usage for ACC units below this target. Recent research suggests that the ACC target may be too low to maintain pilot proficiency and allow newer pilots to acquire needed skills. See William W. Taylor, et al, *The Air Force Pilot Shortage: A Crisis for Operational Units?* RAND, MR-1204-AF, Santa Monica, California, 2000.
4. With higher removal rates, there would not be enough spares to support an MRC in all but one of the repair structures studied.
5. The relative rankings of the alternatives are valid because each alternative faces the same scenario. These numbers do not represent an absolute size of a real-world JEIM shop because they do not take into account various factors such as sickness, other duties, and so forth. The model is not a maintenance-sizing model.
6. This assumption has stimulated considerable comment at briefings to various audiences. Some argue that current transportation times to locations outside CONUS can be substantially longer than 15 days, particularly for large items like engines. Others argue that planned changes to DoD transportation policies will result in shorter times. Given current constraints on military airlift and assumptions of how an MRC would likely stress the airlift system, the assumption of 15 days for one-way transportation time is retained.
7. This is more of a requirement than an assumption since more than 2 days of transportation time will affect the sortie generation.
8. Manpower and Equipment Force Packaging System Summary Report, 27 Oct 99.
9. This does not include the resupply transportation for spare parts and modules required for support of deployed JEIM shops.
10. Shaw JEIM was used because a large number of engines are repaired there and the distributions across all JEIMs of repair and ENMCS times were largely similar. Intermediate repair for the TF-34 is a mixture of *quick turn* and more comprehensive repair.


AMMO RULES



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Munitions Prepositioing

Alternative Prepositioning Strategies

Presently, the Air Force has a substantial amount of munitions prepositioned in Southwest Asia, and a fairly large amount is aboard three ships stationed in the Indian Ocean and Mediterranean Sea. When the National Command Authority orders the Air Force to respond to a contingency, munitions on the ground have to be moved to operating bases by rail, truck, or air.

Munitions Prepositioning: Alternative Prepositioning Strategies

Decisions about prepositioning assets affect employment time lines and lift requirements associated with contingencies and determine the Air Force's capability to respond to contingencies around the globe.

A maxim has it that we seldom fight the war for which we plan. Recent history strongly suggests that it is likely the next contingency we face will be one we have not considered explicitly. Facing up to this likelihood requires planning that is robust against the widest possible range of scenarios, including things that can go wrong. Robustness results from actions taken both before and during a contingency. To achieve robustness, investment levels and prepositioning assets must be determined during peacetime. Strategies for prepositioning war reserve materiel (WRM) include placing materiel at forward operating locations (FOL), forward support locations (FSL), or continental United States locations. FSLs can be established at fixed sites on land, or they can use afloat prepositioning ships (APS). Decisions about prepositioning assets affect employment time lines and lift requirements associated with contingencies and determine the Air Force's capability to respond to contingencies around the globe.[1]

Robust planning for war reserves can be distilled into three issues:

- What kinds and quantities of resources should the Air Force acquire and have on hand to meet continuous peacekeeping roles, as well as major regional contingencies (MRC)?
- Where should these resources be stored in peacetime?
- What strategies should be employed in crises for supporting deploying units with war reserve assets?

This article does not address the full range of questions implied by these three points. Rather, it focuses on aspects of the second point and illustrates how this issue can be approached by evaluating air munitions against a range of scenarios. The scenarios are variations on a Desert Storm-sized campaign occurring in one of five geographic locations, with differing amounts of warning, and in the face of several kinds of disruptive, unexpected events. Prepositioning air munitions on the ground and in ships and the use of transportation assets were considered. Outcomes were evaluated according to the adequacy of munitions stocks to meet 30 or more days of operations.

JICM and Exploratory Modeling

The evaluations were accomplished using the Joint Integrated Contingency Model (JICM).[2] JICM is a comprehensive, deterministic simulation in which higher level decisions and actions are specified by the user. Execution details are left to the adaptive logic of the program, which employs an extensive database of information about geography, military activities, and objects such as ships and aircraft. Although JICM can adjudicate battles on land, sea, and in the air, only its capabilities to simulate mobility operations leading to estimates of the day-by-day quantities of munitions delivered to operating bases were used.

One approach to dealing with uncertainty is to plan against a single scenario that is so demanding it encompasses all other cases that might eventuate (normally an erroneous assumption). *Exploratory modeling* takes the opposite view. Rather than deny the existence of uncertainty, it provides an approach to confront both uncertainty and a lack of knowledge head on. Operationally, it entails examining a broad range of cases that cover the extremes of beliefs about the possibilities that could eventuate, combined with a broad range of choices. Instead of choosing a policy that is in some sense *optimal* for a fixed environment or scenario, the objective is to find alternatives that are robust against a wide range of conditions.[3]

Although there has been criticism that exploratory modeling is just old-fashioned sensitivity analysis, it encourages a valuable and possibly novel approach to planning. Exploratory modeling generally requires that many cases be evaluated. This only has become possible with modern computing environments (the number of cases run in this study was close to 180,000).

That exploratory modeling projects typically involve running a large number of cases raises the question of how to go about analyzing the results. The solution lies in having some kind of computer-generated graphical display appropriate to the problem. This study employed a program called DataView.[4]

Scenarios and Alternative Prepositioning Strategies

Presently, the Air Force has a substantial amount of munitions prepositioned in Southwest Asia (SWA), and a fairly large amount is aboard three ships stationed in the Indian Ocean and Mediterranean Sea.[5] When the National Command Authority orders the Air Force to respond to a contingency, munitions on the ground have to be moved to operating bases by rail, truck, or air. At the same time, ships begin moving toward ports. After ships dock and unload at ports with limited berthing and unloading capacity, the munitions must be moved to bases. Transporting munitions can be an immense task in itself, involving issues such as the availability of equipment, host-nation approval, qualification of personnel to prepare munitions packages for pallets, and so forth. The analysis focused explicitly on the number and position of APS and their effect on WRM stocks throughout the first month of a contingency.

In generating the results, it was assumed that the requirement for munitions would depend on the planned arrival of forces in theater according to current deployment plans for Southwest Asia and a specified target set. It was also assumed that the mix of munitions both on the ground and in APS would be carefully chosen, so only the aggregate tonnage of munitions was considered during the course of the study. Of course, the quantity of munitions required for a contingency may vary, so cases were examined where the WRM requirement varied 25 percent from planned levels.

The main sources of uncertainty considered were warning time (the time between the decision to act [C-day] and the commencement of hostilities [D-day]) and the theater of operations (location of the contingency). The five theaters considered were Southwest Asia (Saudi Arabia), South Asia (Myanmar), North Africa (Tunisia), the west coast

Munitions Prepositioning: Alternative Prepositioning Strategies

The five theaters considered were Southwest Asia (Saudi Arabia), South Asia (Myanmar), North Africa (Tunisia), the west coast of Africa (Congo), and west South America (Chile). Among these, only Southwest Asia has approved data on targeting, force beddown, and time-phased force and deployment.

of Africa (Congo), and west South America (Chile). Among these, only Southwest Asia has approved data on targeting, force beddown, and time-phased force and deployment.

In addition to these uncertainties, a variety of other things can go wrong, so seven *surprises* were included in the evaluation.[6]

- Aero. *AeroPort* danger, in which enemy action poses a danger to aircraft delivering munitions to operating bases, resulting in delivery by land (and not air) from rearward bases.
- Late. Ship late, in which the ship that is supposed to arrive first is delayed by 5 days.[7]
- Land lines of communication (LLOC). LLOC curtailed, in which enemy action reduces the throughput capacity of the surface transportation network by 75 percent.
- Port. Seaport attack, in which an attack on a seaport halts operations at the primary port until damage can be repaired.
- Sabo. Sabotage, in which 5,000 tons of munitions on the ground are destroyed before combat begins.[8]
- Sunk. Ship sunk, in which the ship that is supposed to arrive first to a theater is lost, along with its cargo.
- Horm. *Hormuz* chokepoint, in which enemy action delays passage through the Strait of Hormuz (the surprise affects only the Southwest Asia scenario).

In combination with this range of scenarios and surprises, several initiatives to promote robustness and responsiveness were evaluated. The most important of these was to change the prepositioning of WRM, primarily by increasing the number of APS. For the study, a shipload of munitions was taken to be 17,000 tons. At the time of the study, there were about three shiploads of munitions prepositioned on shore in Southwest Asia, in addition to the three ships. Alternatives considered involved adding one or two additional ships, while reducing the number of munitions on land accordingly, to maintain the 102,000 (six times 17,000) tons overall.[9]

Alternative APS positioning was also investigated. The National Command Authority, for example, may have advance indications of the need to deploy, and APS could move accordingly to a *forward leaning* posture. Further, the option of replacing break-bulk APS—which would take 4 days to unload, with roll-on, roll-off (RORO) ships that were faster and could be unloaded in a single day—was tested. The assumption was made that one APS would always be a lighter aboard ship, or LASH, to ensure deep-water unloading capabilities. The study also considered increasing the airlift for moving munitions by the equivalent of 30 C-17s operating for 30 days for greater responsiveness.

Table 1 presents the locations of the APS, regardless of where the contingency takes place. The middle column gives the locations assumed in the base case. The right-hand column depicts modified basing used in analyzing a forward-leaning (FWD) option for this scenario.

In the non-Southwest Asia scenarios, forward basing means that two ships begin moving in order to be 1 day from docking on C-day.

Demand for Air Munitions and Scoring Scheme

A natural way to evaluate the performance of logistics support for an operation is to compare the availability of material to the demand. A planner would want to ensure adequacy of supply by providing for safety stocks above the projected demand while recognizing that supplying materiel beyond a reasonable level of protection is wasteful. The daily requirement for munitions was established by using the Air Force's Conventional Targeting Effectiveness Model (CTEM) for munitions that are strictly target-driven. For munitions requirements that the CTEM does not estimate, requirements were developed using estimates of the regional commander in chief. These requirements were translated into tons of munitions required for each day of operation.

Evaluations of alternatives against scenarios with JICM were based on the worst days in terms of munitions on hand over the first 30 days of operation. Specifically, at the end of each day, the tonnage of munitions on hand was compared with the demands for succeeding days. For example, having at least 5 days of supply on hand every night for each of the first 30 days would be satisfactory. On the other hand, it will be highly unsatisfactory if there are as many as 3 occasions out of the 30 when the inventory is inadequate to meet the following day's requirements. Expanding the foregoing, a straightforward system involving a nine-point scale for conditions between and including these extremes was adopted. Table 2 indicates the nine-point scoring scale and the color codes employed. The abbreviation *DOS* is short for *days of supply*. For example, 7 DOS means the amount of munitions required for the following 7 days.

Evaluations of alternatives against scenarios with JICM were based on the worst days in terms of munitions on hand over the first 30 days of operation.

Scenarios in which there was excess movement of stock were not explicitly considered, but it was obvious that too much WRM ashore in Southwest Asia adversely affects support system performance elsewhere.

Analysis of Prepositioning Options with DataView

The study explored variations of these nine factors:

- First surprise, if any
- Second surprise, if any

Number of Ships	Normal Basing	Forward Basing
2	IO, IO	PG, MI
3	IO, IO, MED	PG, MI, IO
4	IO, IO, MED, SP	PG, MI, IO, MED
5	IO, IO, MED, SP, LA	PG, MI, IO, MED, SP

IO—Indian Ocean (Diego Garcia)
MED—Mediterranean Ocean (Rome)
LA—continental United States (CONUS) Pacific Coast (Los Angeles)
PG—Persian Gulf (United Arab Emirates)

Table 1. Locations of Afloat Prepositioning Ships

Since DataView produces three-dimensional displays, a user can (interactively) choose three factors for the X, Y, and Z axes and pick specific values for the remaining factors.

Color Guide	Score	Condition
Green	9	At least 7 DOS on hand every night
Green	8	At least 5 DOS on hand every night
Yellow-Green	7	At least 3 DOS on hand every night
Yellow	6	At least 1 DOS on hand every night
Yellow	5	Less than 1 DOS on one or more nights; never stocked out
Orange	4	Stocked out 1 night
Orange	3	Stocked out 2 nights
Red	2	Stocked out 3 nights
Red	1	Stocked out more than 3 nights

Table 2. Colors and Scores Based on Days of Supply

- Theater (Southwest Asia, South Asia, North Africa, West Africa, and South America)
- Warning time (C-day to D-day) of 10, 20, or 30 days
- Shiploads (17,000 tons) of air munitions ashore in Southwest Asia
- Number of afloat prepositioning ships
- Whether FWD is in effect
- Whether all APS but the LASH are RORO
- Whether additional airlift is used to move munitions

To fully appreciate the power of DataView, one must work with it interactively. Since DataView produces three-dimensional displays, a user can (interactively) choose three factors for the X, Y, and Z axes and pick specific values for the remaining factors. For the figures in this article, the three axes were associated with the first three factors in the list above. Each figure is the result of setting specific values for the remaining six factors. Figure 1 is the DataView presentation for the case of 20 days' warning, three shiploads of munitions ashore in Southwest Asia, and three prepositioning ships. None of the options represented by the last three factors is in effect.[10]

The five squares in the lower left corner (None and None) indicate outcome scores with no surprises for the five scenario locations. For the Southwest Asia and North Africa contingencies, green indicates there are always at least 5 days of supply on hand. For the South Asia and West Africa scenarios, yellow means that there was at least 1 night with less than 3 days' supply on hand but there were no days with stock outs either. The South American war is just too far away to be satisfactorily supplied by the munitions we assumed to be available, and red means there are at least 3 nights with stock outs. (Were the United States to become involved in a war in Chile, alternative sources of munitions might be available.)

Because all the munitions are near the Southwest Asia theater, none of the surprises, or even combinations of surprises, causes that case to be worse than green (although, with less warning, the Hormuz and other surprises cause Southwest Asia outcomes to be colored differently). The worst set of surprises comes when a ship is sunk and the port is contaminated or munitions on the ground are lost to sabotage.

That all the Southwest Asia outcomes are colored green suggests that munitions are well-positioned to fight an MRC there. But that level of performance is unachievable in any of the other theaters considered. This suggests that achieving a more robust posture might be possible if less tonnage were kept on the ground in Southwest Asia and more put in afloat prepositioning ships.

Figure 2 shows the outcomes under all the same conditions as above, except that two of the three shiploads of munitions are placed on ships located according to the last line in Table 1. Observing the color shifts between the two figures suggests there are some improvements in the non-Southwest Asia scenarios.[11]

The forward-basing strategy outlined in the right-hand column of Table 1 additionally improves responsiveness. The results are in Figure 3 where,

The data suggest that munitions are well-positioned to fight an MRC in Southwest Asia. But that level of performance is unachievable in any of the other theaters considered. This suggests that achieving a more robust posture might be possible if more tonnage was put in afloat prepositioning ships.

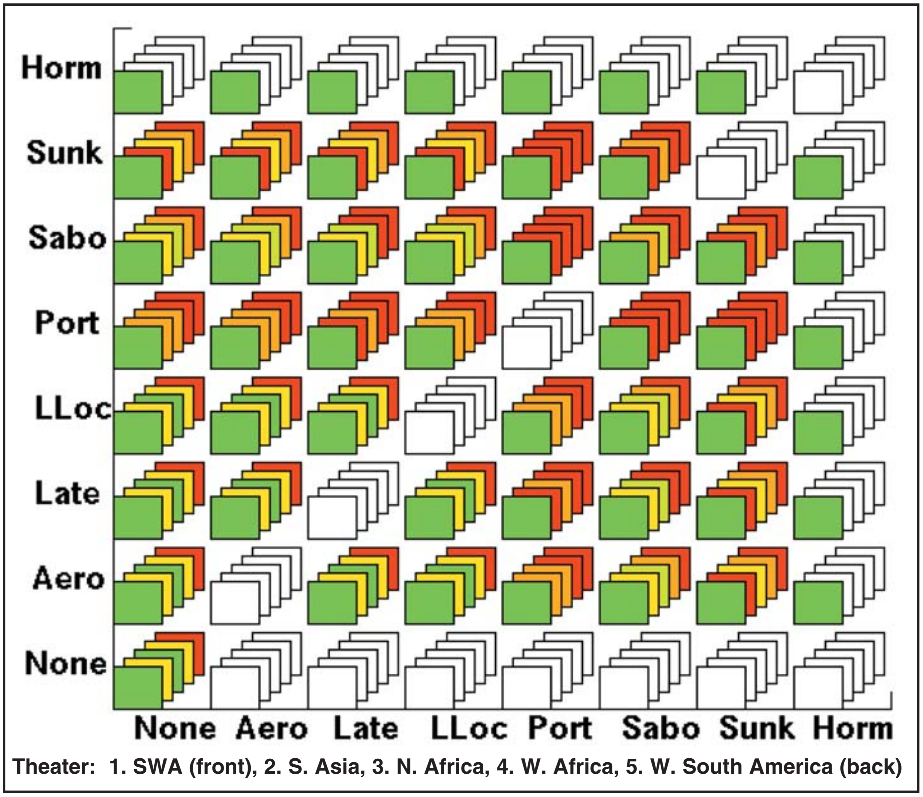

Figure 1. 20 Days, 3 Ashore, 3 Afloat

Since only total tonnage was considered in this analysis, the mix of munitions to be stowed aboard ships was not explicitly considered.

at worst, there are a few cases showing stock outs on 1 or 2 nights when the port is attacked.

Proceeding with additional improvement measures, replacing break-bulk ships with RORO ships eliminates all the orange squares. If, in addition, the extra strategic airlift is provided for moving munitions, all cases are green.

Since only total tonnage was considered in this analysis, the mix of munitions to be stowed aboard ships was not explicitly considered. Optimal mixes of munitions required for different theaters can vary considerably.[12] This suggests the Air Force should load munitions prepositioning ships homogeneously, lest a ship loaded for a particular scenario is the first to arrive at a scenario for which its load was not intended. Current loading of Air Force munitions prepositioning ships indicates that such a policy is already in effect.

Experiences with APS During Operation Noble Anvil

During Operation Noble Anvil, the Air Force flew about 2,000 bombing runs (with a total of about 6,000 sorties) and dropped about 16,000 short

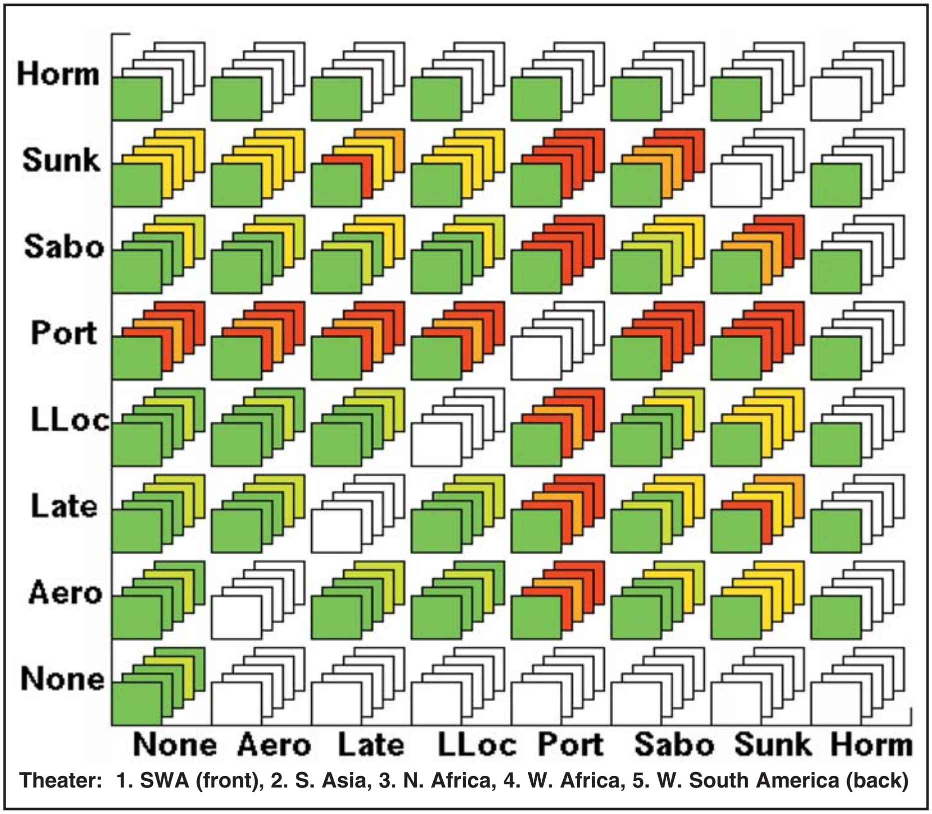

Figure 2. 20 Days, 1 Ashore, 5 Afloat

tons of munitions. Because of the unique aspects of Noble Anvil—rich infrastructure of the theater, proximity of well-developed FOLs, duration and intensity of the conflict, and the enemy's strength—one should be circumspect about drawing too many conclusions from it. It is worthwhile, however, to reflect on what the experience suggests about potential strengths and weaknesses of the Air Force's preparations to face future (and different) conflicts.

As outlined, the ammunition prepositioning fleet is an important asset because, in many conceivable scenarios, the munitions requirements cannot be met with in-theater assets alone. Yet, it took about 9 weeks from the United States Air Forces in Europe (USAFE) request that munitions on the *MV Captain Stephen L. Bennett* be made available and arrival of the final trainload at its destination. Figure 4 shows the time line of events associated with the *Bennett*. The horizontal scale indicates weeks from the start of air operations. The initial delay between the USAFE request and Joint Chiefs of Staff (JCS) authorization might be attributed to the lack of urgency in resupplying munitions, given the quantity of the prepositioned materiel in the theater and initial expectations that the campaign would not be a long one. The *Bennett* sailed from its station in

It took about 9 weeks from the USAFE request that munitions on the MV *Captain Stephen L. Bennett be made available and arrival of the final trainload at its destination.*

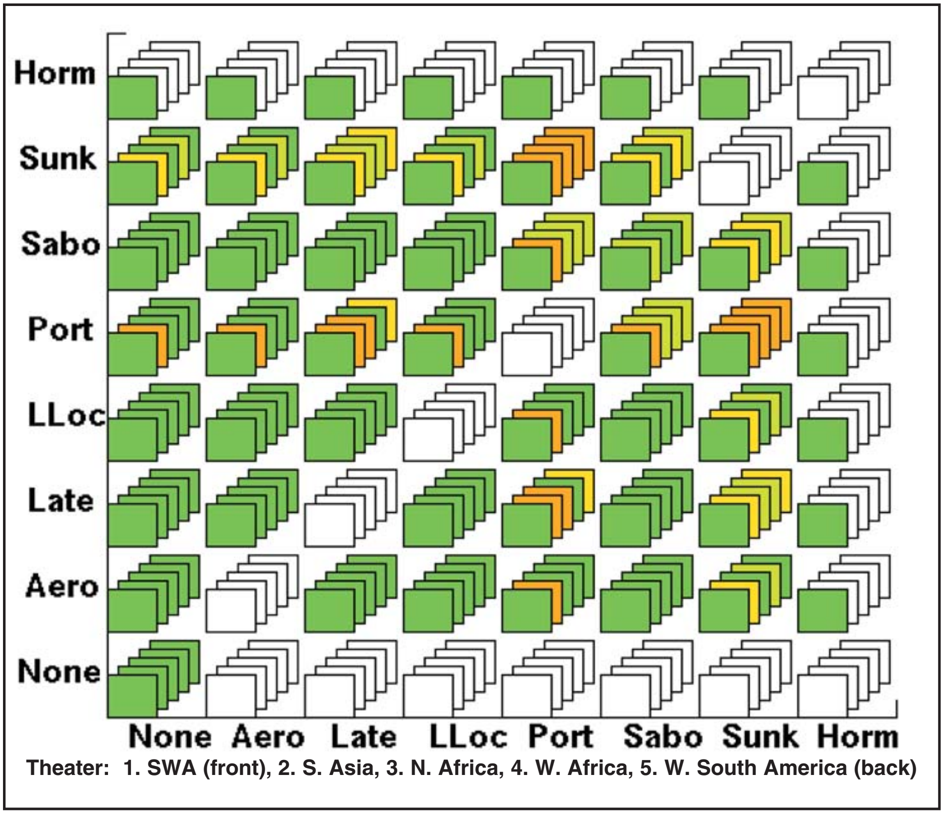

Figure 3. 20 Days, 1 Ashore, 5 Afloat, FWD

...locations required selected munitions that were spread throughout the entire ship. As a result, all the containers had to be offloaded, opened, and sorted and then either shipped forward or repacked and put back on the ship

the Mediterranean to Spain and then to Nordenham, Germany, to be offloaded. At this point, about 2 weeks had elapsed since the initial request was sent out by USAFE. The deep-water port is only one constraint for an APS. Host-nation restrictions, as well as availability of equipment and experienced personnel for munitions offloading, also play major roles in the selection of the port. The offloaded munitions from the *Bennett* were then sent to three different locations. A portion was sent on barges to the United Kingdom, and the rest were sent to Italy and Germany. These locations required selected munitions that were spread throughout the entire ship. As a result, all the containers had to be offloaded, opened, and sorted and then either shipped forward or repacked and put back on the ship (Figure 4).

It took about 2 weeks to complete the offload and delivery to Germany and the United Kingdom and upwards of a month to complete the delivery to Italy. Some of this delay may be attributed to the hazardous nature of munitions and the rules and regulations governing its transportation.

Could smaller, faster ships alleviate some of the problems outlined above? For example, expeditionary air and space force (EAF)

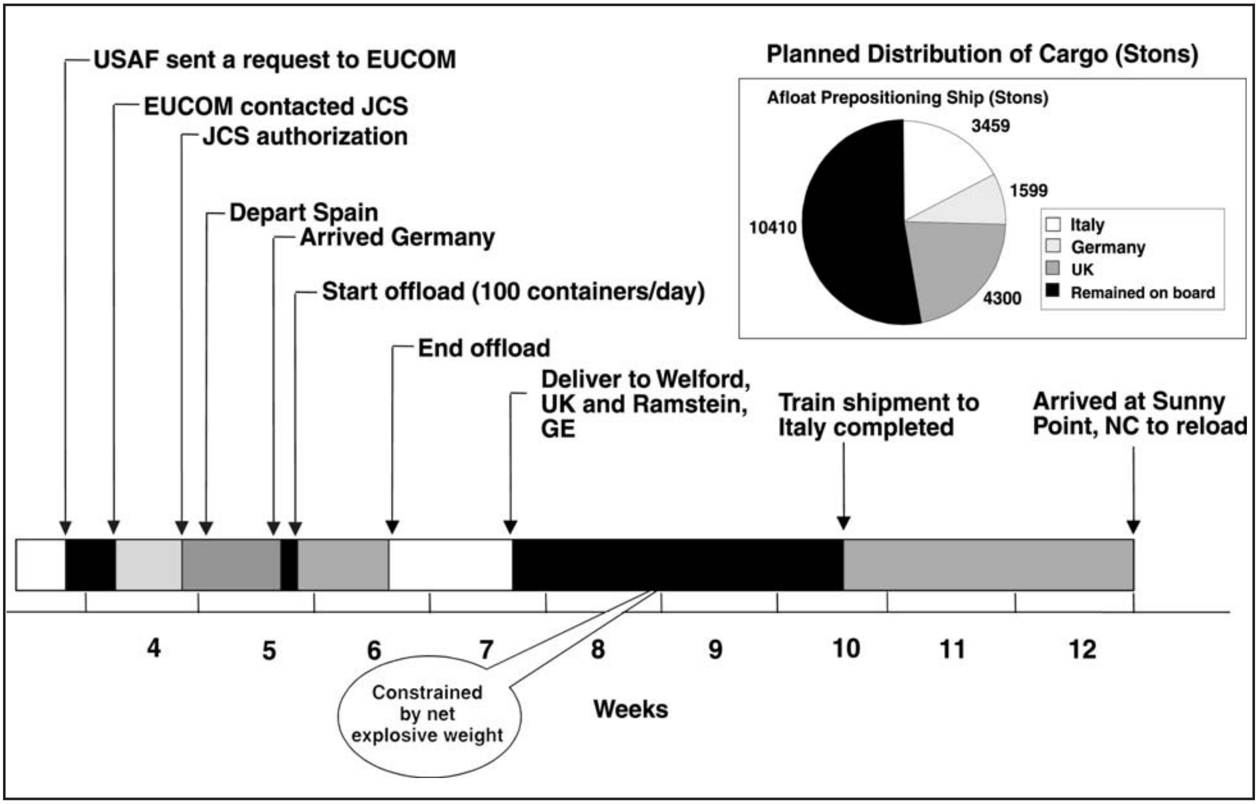

Figure 4. Time Line of Munitions Delivery by *MV Stephen L. Bennett*

peacekeeping scenarios, as well as many other smaller conflicts, may not require as many munitions as an MRC, and yet the requirement for munitions in a multiple-conflict scenario across large distances can overwhelm two or three large APS.

The Air Force should start examining smaller, faster sealift capability. One particularly attractive option includes the high-speed sealifts (HSS)—such as the 91-meter wave-piercing ferry INCAT 046 and Revolution 120, a 120-meter wave-piercing RO/Pax Catamaran—both built by the International Catamaran (INCAT) Australia Shipyard. These boats combine three attributes: light weight, high performance, and large payload. The INCAT 046 *Devil Cat*, Figure 5, with a surface-piercing catamaran hull 91 meters long and beam of 23 meters, is capable of carrying 500 metric tons and reaching speeds of up to 43 knots. In fact, the Army, as part of the Center for the Commercial Deployment of Transportation Technologies High-Speed Sealift program and in cooperation with the US Transportation Command and Maritime Administration, has sponsored an evaluation of the 91-meter INCAT 046[14]. The newest INCAT design, Revolution 120, with turbine-powered jets, is 120 meters long with a beam of 30 meters. It can achieve speeds of more than 60 knots lightship (400 metric tons) and 50 knots fully loaded (1,200 metric tons). In fact, the Australian Navy used an INCAT-built catamaran, the *HMAS Jervis Bay*, to carry troops and vehicles to and from East Timor.

There is no doubt that an afloat prepositioned fleet (APF) of larger ships can meet the need for sustainment or, when time lines allow, for longer transportation delay. Moreover, HSS ships do not obviate the need to preposition munitions at some FOLs that require a very short time line. Although the transit time for sealift can be substantially decreased, ground transportation can still add delays to the delivery of munitions to FOLs. For example, one can imagine a hypothetical situation where HSS ships would be deployed to ports in the three countries where the *S. L. Bennett's* cargo was sent. It would have taken eight HSS ships to do the job, but substantial savings might have been achieved in terms of sealift transit time, loading and offloading, and surface transportation.

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Conclusions and Recommendations

The initiatives evaluated—reducing WRM munitions on the ground in Southwest Asia, increasing the size of the afloat prepositioned fleet, and changing its composition—have the potential to improve the Air Force's ability to respond to crises worldwide. However, the deep-water nature of the ships presents some problems in finding suitable ports. During Noble Anvil, considerable time was taken to unload and transport the munitions to their final destinations. These initiatives do provide benefits for meeting operational requirements in contingencies with relatively long warning times and substantial uncertainty. These results suggest both specific and general policies for the Air Force to consider in increasing operational robustness.

Munitions Prepositioning: Alternative Prepositioning Strategies

Planning processes should focus more explicitly on the levels of flexibility, adaptability, and robustness needed in resource investments, asset postures, and prepositioning strategies. Planners for EAF operations may need to think outside conventional bounds and canonical scenarios.

Specifically, the Air Force may want to pursue positioning a mix of WRM on fast, smaller HSS, such as the 91-meter INCAT 046 *Devil Cat* or Revolution 120 and other larger ROROs. The Catamarans can travel up to 50 knots and carry 500 to 1,200 tons of equipment and people. In comparison, the larger ships can carry about 20,000 tons of cargo at a speed of 18 to 22 knots. If the Air Force needs to meet very rapid employment time lines, prepositioning munitions at selected FOLs may still be necessary. Difficult tradeoffs need to be made. More generally, the Air Force should undertake further exploratory modeling of the type used in this analysis. Such modeling is ideal for developing the dynamic and responsive system needed to support expeditionary operations.

Uncertainty dominates planning for war. It affects virtually every decision related to war reserve policy, requirements, investment levels, prepositioning, transportation capacity and priorities, and campaign planning. In the face of so many variables, for which there is so much uncertainty, it is no surprise that planners may wish to rely on canonical scenarios. A canonical scenario can be a constructive approach to the problem of matching logistics resource investment levels with budgetary constraints, but it is less useful for determining resource mixes or specific military capabilities needed for operations. Rather than a canonical scenario, what is needed is a methodical approach for:

- Evaluating alternative strategies under a variety of scenario assumptions,
- Exploring a large number of alternative resources, and
- Choosing among strategies in a way that yields a robust mix of resources positioned to be most responsive to the widest possible variety of scenarios.

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The RAND analysis of only a few variables for WRM prepositioning, for example, shows the key question is not where on land WRM ought to be positioned but how its positioning can become more flexible for greater support responsiveness. There are likely other areas of EAF planning where the key questions are not how best to use existing materiel, technology, and support structures but how to design a support system that stretches the current boundaries posed by existing materiel, technology, and support structures. Exploratory modeling can contribute significantly to identifying and answering such questions.

Notes

1. See “Further Reading” in this Publication..
2. Bruce W. Bennett, et al, *JICM 1.0 Summary,* RAND, MR-383-NA, Santa Monica, California, 1994.

3. Steven C. Bankes, "Exploratory Modeling for Policy Analysis," *Operations Research*, Vol 41, No 3, May-Jun 93.
4. DataView was implemented by James Gillogly, formerly of RAND.
5. According to current doctrine, munitions needs for a two-MRC scenario are determined by the Nonnuclear Consumable Annual Analysis process. Munitions allocated amongst the theater munitions stocks (USAFE, Pacific Air Forces, and Central Air Forces) and swingstock. The latter includes the CONUS munitions stocks, Standard Air Munitions Packages, and the afloat prepositioned fleet; the Air Force presently has three ships as part of the APF program: the *MV Buffalo Soldier*, *MV Major Bernard F. Fisher*, and *MV Captain Stephen L. Bennett*. *Buffalo Soldier* is a break bulk, and the other two are container ships. At the time this analysis was done, there were two break bulk ships and one LASH.
6. Scenarios were analyzed in which there are no, one, or two surprises. In scenarios in which there are two surprises, it is assumed, with one exception, that the same surprise cannot occur twice. That exception is for sabotage, which can occur twice.
7. In cases where both *ship sunk* and *ship late* surprises occurred, the first ship expected to arrive in theater was the one assumed lost.
8. If sabotage was simulated to occur twice, it was assumed that 10,000 tons of munitions were lost.
9. It was assumed that one shipload of munitions would always be kept in Southwest Asia. For other scenarios, if more than one shipload was in Southwest Asia, it was assumed that one shipload could be airlifted directly from Southwest Asia to the theater. If three shiploads were in Southwest Asia, the second load would be moved by sea.
10. White squares indicate cases not run. Off-diagonal squares are for combinations of surprises, but sabotage of munitions on the ground is the only surprise that can happen twice. The *Hormuz* surprise only affects the Southwest Asia scenario. Except for the first position, the bottom row is empty because it would be just like the first column.
11. The exception is that performance is worse in the North African scenario when there is an enemy attack on the port (the port surprise). Understanding this requires an analysis of the interaction between the ship arrival schedule, what we assumed about unloading processes, and our model of the effects of an attack on a port.
12. Using CTEM, for example, we estimated munitions requirements for scenarios in Southwest Asia and Korea, finding the optimal mixes of munitions required for these two theaters to be quite different.
13. Courtesy of INCAT Australia.
14. Martin J. Dipper, Jr, "91-meter Wave-Piercing Ferry INCAT 046 Transit from Hobart, Tasmania, Australia, to Yarmouth, Nova Scotia, Canada," Naval Surface Warfare Center Carderock Division, West Bethesda, Maryland, 20817, CRDKNSWC/HD-1479-01, 1998.

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A global access strategy that includes maintaining core assets and developing new political and technological opportunities can help the United States manage and develop access and basing options both now and in future years.

Global Access

Basing and Access Options

Introduction

Defense basing decisions reflect both military needs and political conditions. For much of its history, the Air Force has relied heavily upon forward basing, maintaining a substantial portion of its *tactical* forces[1] at permanent bases outside the United States. The primary purpose of this strategy was to counter a possible attack by the Soviet Union and its allies, but this strategy also had political dimensions. However, it was only possible with political support at home and in host nations. It would not have been possible had the United States and its allies disagreed on the need to or means of containing Soviet power. Ultimately, the collapse of the Soviet Union and the implosion of the Warsaw alliance removed the military and political conditions for extensive foreign basing.

Despite the subsequent drawdown from a global to a US-based force in the past decade, the Air Force has waged a growing number of operations of various scales on every continent

Global Access: Basing and Access Options

All branches of the US military must confront access and basing questions for operations abroad. The Army and Air Force are equipped and configured primarily to fight within theater. The Marines' raison d'etre *is conducting expeditionary operations "from the halls of Montezuma to the shores of Tripoli." Even Navy ships, largely free from the need for foreign bases, require access to foreign ports and facilities for resupply and other support.*

in the same decade. It has done so while maintaining its role as a deterrent to attacks and preparing to respond wherever US interests are challenged.

The growing number of operations in locations around the world has led the Air Force to reconstitute itself as an expeditionary aerospace force, or EAF. The EAF goal is to deploy forces anywhere in the world and begin sustained operations within 48 hours. However, such goals will be difficult to meet with current processes and technologies, particularly where resources are not prepositioned at forward operating locations (FOL). RAND and Air Force Logistics Management Agency (AFLMA) research has shown that the level of resources at FOLs affects employment time lines. Naturally, greater prepositioning at FOLs reduces employment time lines. This research has also shown that forward support locations (FSL) can help reduce the need for prepositioned materiel and aid the shift from surge to sustainment operations in a contingency when used for intermediate maintenance activities and for storage of munitions, supplies, or other war reserve materiel.[2]

The continuing need for forward basing of the logistics infrastructure, even as more operational forces are based in the continental United States, means that logisticians must be involved in addressing questions of access to bases and other facilities outside the United States. To address such questions, logisticians must understand both operational and political constraints. As the scenarios change in nature and location, so do political and logistical needs and conditions. These may see the warfighting ally of today refuse to cooperate tomorrow, even to the point of denying the United States access to its resources located at FOLs and FSLs abroad.

What are the conditions that would lead a potential ally to permit or resist US access and basing? Given these, what strategies should the United States use to manage its future needs for access and basing? We reviewed some expeditionary operations that encountered substantial political difficulties and how the difficulties affected access and basing. These operations demonstrate the variables that lead other nations to grant or resist US requests for access and basing, as well as how the United States can maintain and develop new access and basing options.

All branches of the US military must confront access and basing questions for operations abroad. The Army and Air Force are equipped and configured primarily to fight within theater. The Marines' *raison d'etre* is conducting expeditionary operations "from the halls of Montezuma to the shores of Tripoli." Even Navy ships, largely free from the need for foreign bases, require access to foreign ports and facilities for resupply and other support.

Nevertheless, access and basing issues are most salient for the Air Force. Fighters and attack aircraft like the A-10, F-15, F-16, and F-117 have operating ranges of 300 to 500 nautical miles. While aerial refueling can extend the operating ranges for these aircraft, they cannot operate effectively when based thousands of miles from theater.[3] The Air Force also has suffered the most pronounced limitations because of access problems, most recently in operations against Iraq.

The Politics of Recent Expeditionary Operations

Expeditionary operations in the 1970s, 1980s, and 1990s illustrate the political issues that must be confronted in access and basing. Access difficulties may not halt operations outright, but they do impede effectiveness.

Operation Nickel Grass. In 1973, the Air Force conducted an airlift to support Israel during the Yom Kippur war. This operation was severely hampered by the refusal of nearly all the European allies to permit US aircraft to cross European airspace or use their facilities while en route to or from Israel. Only Portugal cooperated, grudgingly granting access to Lajes Air Base in the Azores. Without this assistance, the airlift, which Egyptian president Anwar Sadat cited as one of the reasons he requested a cease-fire, might have been impossible.[4]

European allies refused to cooperate with this mission because they feared reprisals from Israel's enemies. Indeed, the subsequent Arab oil embargo was targeted toward both the United States and Portugal but not other European allies. Portugal, however, was willing to curry the favor of the United States by supporting Nickel Grass since, at the time, it was isolated globally because of its colonial war in Africa.

Operation El Dorado Canyon. In 1986, the United States launched airstrikes against Libya in retaliation for alleged terrorist activities. These operations included F-111 and EF-111 aircraft flying from the United Kingdom (UK). France and Spain refused to permit flyovers, thus forcing US aircraft to fly from the UK around the Iberian Peninsula to Tripoli in a one-way journey of 2,700 nautical miles. Flying over France would have cut this journey to 1,500 miles, and flying over Spain and around France would have cut it to 1,900 miles (Figure 1). The refusal of France and Spain to permit flyovers for this operation nearly doubled the distance aircraft had to travel to perform the mission. Upon reaching Libya, many US aircraft had difficulties with their targeting systems, and tired aircrews made errors in aiming ordnance. While on a strategic level the attack may have succeeded, on a tactical level, the access problems prevented it from accomplishing as much as had been hoped.

The UK supported this mission, in part, because of the special relationship the United States and United Kingdom have nurtured. This included the sharing of intelligence that persuaded the United Kingdom of the need for the mission. France and Spain refused support because they feared being targeted by terrorist reprisals.

Persian Gulf Operations. In 1990, the Iraqi invasion of Kuwait galvanized a coalition sharing interests in preventing further Iraqi aggression, ousting Iraq from Kuwait and, if possible, toppling Saddam Hussein. US diplomatic pressure, coupled with American intelligence convincing Riyadh of an Iraqi threat to Saudi Arabia, persuaded the Saudis to permit an enormous deployment of US forces there. Following the Gulf War, several nations in the region, including Saudi Arabia, broke with tradition and permitted the United States to maintain some presence. Yet

...refusals arose as the political climate changed from one in which regional allies needed US help to contain and reverse Iraqi aggression to one in which they questioned whether US strategy against Iraq would prevent ultimate reprisals by Saddam Hussein. Domestic politics also limit how much regional allies are willing to cooperate with US actions against an Arab state.

the United States has been unable to formalize its security relationship with Saudi Arabia. Continued US involvement in the region has led to conflicts between the United States and its regional allies. These conflicts have caused serious problems for military planners many times since 1996. Saudi Arabia and Turkey have refused to support US actions against Iraq or permit the use of US forces for such actions, forcing the United States to rely on less effective cruise missile strikes rather than land-based airpower. These refusals arose as the political climate changed from one in which regional allies needed US help to contain and reverse Iraqi aggression to one in which they questioned whether US strategy against Iraq would prevent ultimate reprisals by Saddam Hussein. Domestic politics also limit how much regional allies are willing to cooperate with US actions against an Arab state.[5]

Operations in the Former Yugoslavia. US responses to crises in Bosnia and Kosovo have involved US airstrikes against Serbian forces. Although the North Atlantic Treaty Organization (NATO) authorized and conducted these operations, Greece, a longstanding member of the alliance, refused to allow NATO flyovers or use of bases in Greece for

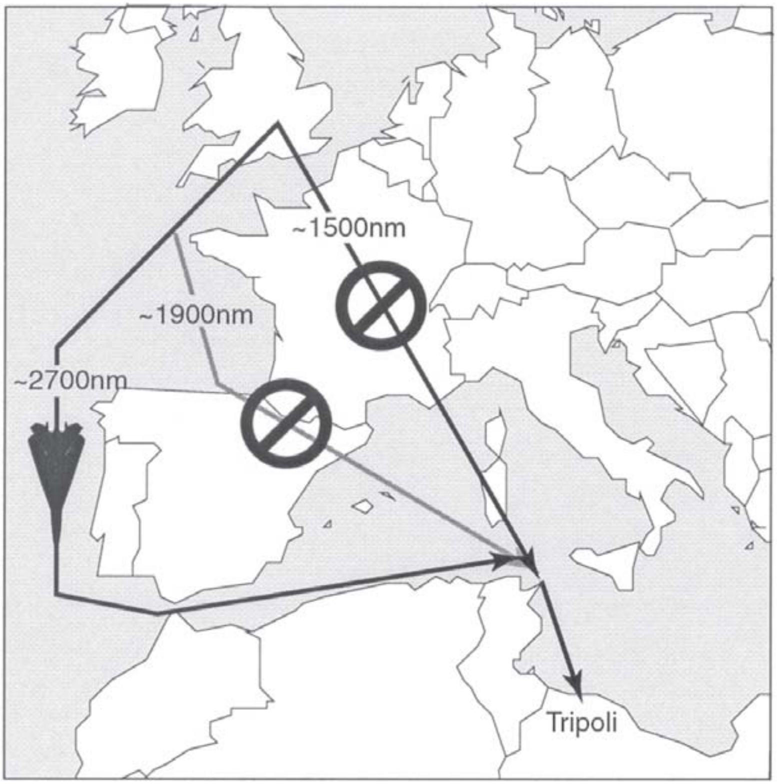

Figure 1. Schematic Mission Profile for *El Dorado Canyon*. The refusal of France and Spain to permit flyovers for this operation almost doubled the distance aircraft had to travel to perform the mission.

these operations (Greece did provide logistical support and allowed humanitarian overflight). In contrast, Albania and Bulgaria, which are not NATO members, and Hungary, which became a NATO member only recently (after Bosnian operations but before the Kosovo crisis), cooperated with NATO in Kosovo. All three nations permitted flyovers, and Hungary and Albania hosted both NATO and US forces.

Albania had the most compelling reasons for supporting the United States since ethnic Albanians in Kosovo were suffering the most. Hungary was interested in strengthening its new ties to the alliance, despite domestic political concern that its support could endanger the large ethnic Hungarian community within Serbia. Greece, whose position in the alliance was longstanding and secure, faced no such incentive to ignore the opposition of its predominantly orthodox population to NATO operations. Bulgaria, while facing the same ethnic political considerations, was willing to ignore these in hopes of building stronger ties to the United States and NATO.

The Political Variables of Access

The recent history of Air Force expeditionary operations points to six key variables affecting the options available to logisticians and planners when confronted with access and basing decisions. Logisticians can neither affect nor ignore these variables. An optimal location with a mix of resources for an FOL or an FSL is worthless if political constraints prevent its use. Logisticians, therefore, must take into account the political variables that affect access and basing possibilities. Three that work to favor cooperation from other nations are:

- Close alignment and sustained military connections,
- Shared interests and objectives, and
- Hopes for closer ties with the United States.

Three that work against cooperation are:

- Fear of reprisals,
- Conflicting goals and interests, and
- Adverse domestic public opinion.

Understanding these variables can help logisticians devise an optimal access-and-basing strategy for supporting expeditionary operations.

Close Alignment and Sustained Military Connections. States that have longstanding security relations with the United States are more likely to support its actions. The best example of this is the *special relationship* shared by the United States and the United Kingdom over the last 60 years. The United Kingdom was the only US ally to support *El Dorado Canyon,* and UK aviators flew alongside US forces against Iraq and Serbia. Nevertheless, close alignment does not guarantee cooperation in access and basing. Many NATO allies have denied access and basing for US

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States sharing identical interests and objectives with the United States are more likely to support its operations and grant access and basing.

operations, and even the United Kingdom refused to support *Nickel Grass*. Still, the formal alliances, treaties, and diplomatic understandings the United States has developed around the world will remain an integral part of its global access strategy.

Shared Interests and Objectives. States sharing identical interests and objectives with the United States are more likely to support its operations and grant access and basing. Even allies as reluctant as the Saudis will provide access and basing when they perceive common interests and objectives. For agreement on interests and objectives to lead allies to grant access and basing to the United States, it must cover both ends and means. The Saudis, for example, may agree with the United States on an ultimate goal of toppling Saddam Hussein, but they will not cooperate with means that they see as ineffectual, counterproductive to their long-term interests, or possibly stimulating an ultimate reprisal. The United States can, however, use its intelligence to develop cooperation on access and basing. American intelligence on the threat Iraq posed to Saudi Arabia helped persuade that nation to accept the presence of American forces in 1990. It also persuaded the United Kingdom to support *El Dorado Canyon* in 1986.

Hopes for Closer Ties to the United States. States looking to improve their relationships with the United States or perceiving their security to depend on the United States are likely to cooperate with US military actions, including access and basing. Portugal in 1973 and Hungary in 1999 had unique interests leading them to support military operations that other more *reliable* US allies refused to support. Kuwait has perceived its security to depend on the United States and, hence, has cooperated with US actions against Iraq.

The United States may be able to develop future access and basing options with other nations hoping for closer ties. The Philippines, for example, has expressed renewed interest in closer ties with the United States, likely because it seeks support in its dispute with China over the Spratly Islands. The United States has expressed no interest in reestablishing a permanent military presence there and has stated that its only interest in the Spratlys is to keep open sealanes. Nevertheless, this political situation offers the United States a means of solving many of its access and basing problems in Southeast Asia.

Fear of Reprisals. Fear of reprisals nearly changed the course of Middle East history by almost thwarting *Nickel Grass*. French and Spanish fears of terrorist attacks, were they to support *El Dorado Canyon,* greatly limited the effectiveness of that operation. Fear of reprisals also figures in the reluctance of many regional states to provide the United States with access and basing for actions against Iraq. In many cases, there is little the United States can do to assuage these concerns. US forces can help protect a host country from direct military retaliation, but the United States has had little success battling terrorism, and it is usually not in a position to insulate its partners from the effects of economic sanctions. The fear of reprisal among US allies will continue to be a barrier for access and basing.

Conflicting Goals and Interests. Conflicting interests can eliminate prospects for cooperation. They made Turkey reluctant to support US retaliation against Iraq for the latter's offensive against Kurdish rebels in 1996. Greece and Macedonia refused to support the US-led response to the Kosovo crisis, in part because of their differing views on what constitutes Balkan stability.

Domestic Public Opinion. Domestic public opinion can limit access and basing options. It led Greece to oppose the US-led response to the Kosovo crisis by refusing NATO access to Greek airspace. It has made the Saudis sensitive to Islamic complaints that a continuing US military presence is incongruous in the nation of Mecca and Medina. In 1986, it forced the United States to remove a tactical fighter wing from Spain in the face of rising anti-American sentiment, exacerbated by the participation in *El Dorado Canyon* of two KC-10 refueling stations that had been based there. Domestic public opinion may yet force the United States to reduce or eliminate its military presence in Okinawa, Japan.

Basing and Access Options

Each of these political variables affects the five different approaches the Air Force has for managing access and basing issues to the point that none, by itself, is adequate for a complete global access strategy. Logisticians must recognize how the political variables affect the five *pure* basing alternatives in developing a hybrid access-and-basing strategy that helps the United States exploit favorable variables and control unfavorable ones.

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The five *pure* alternatives for access and basing are:

- Expanding the number of major operating bases abroad to increase the likelihood that forces will be present where and when needed;
- Identifying one or more reliable allies in each region of the world and counting on them to cooperate when asked;
- Proliferating security agreements and alliances to broaden the set of potential partners in any given contingency;
- Negotiating and securing long-term extraterritorial access to bases, such as that gained by leasing Diego Garcia from the United Kingdom; and
- Relying on extended-range operations from US territory.

Expanding Major Operating Bases Abroad. To contain the Soviet threat, the Air Force built and stationed dozens of major operating bases around the world. After the Cold War, the Air Force reduced this network. Expanding the current network of major operating bases by rebuilding the former one is, theoretically, an option for supporting operations around the globe.

There are, however, several barriers to such a strategy. There are no popular constituencies for it, either domestic or foreign. Unless host countries assume some of the costs for these bases, finding the money to build or reopen these facilities would be extremely difficult. Even if these facilities were built or reopened, there is no guarantee that they will always be of use in expeditionary operations. Having forces stationed in another nation does not ensure they can be used how and when the US desires.

Identifying More Reliable Allies. The United Kingdom has been a stalwart to the United States, particularly in supporting El Dorado Canyon and in policing no-fly zones over Iraq. Can the United States identify other such allies around the world whose cooperation almost always will be forthcoming for expeditionary operations? Unfortunately, this is unlikely. Candidates for such relationships are rare. The special relationship between the United Kingdom and the United States includes a strong cultural attachment, a common history, and a very close security alliance dating back to World War II. There is no other nation that shares such strong ties and common perspectives with the United States. This relationship does not exist with nations in Asia and the Mideast, where access and basing problems are most pronounced.[6] Furthermore, even the reliable United Kingdom has refused to cooperate with US operations such as Nickel Grass. The United States can and should try to nurture close relationships with other countries, but it should not build its overall access strategy on this single option.

Proliferate Security Agreements and Alliances. By expanding its network of alliances and other security arrangements, the United States has been able to expand its access and basing options for expeditionary operations. The recent expansion of NATO, for example, helped convince Hungary to support the US-led response to the Kosovo crisis. The success of the Partnership for Peace program has also given the United States new options for access and basing.

There is not, however, consistent domestic support within the United States for expanding foreign alliances. Support for recent NATO expansion may have been a one-time occurrence, based more on public familiarity with the role of the alliance in US security than any desire to expand security arrangements more generally. Isolationism in American politics is a recurring theme that can limit global engagement.

Furthermore, much of the benefit to access and basing from expanding security arrangements comes before such arrangements are formalized or when they are still new. A desire for improved relations with the United States may motivate a potential partner more than a longstanding formal alliance, just as such a desire led Hungary, a new NATO member, to support the US-led response to Kosovo while long-time NATO member Greece did not.

Negotiate and Secure Long-Term Extraterritorial Access for Bases. The 99-year lease for Diego Garcia Island, which the United States gained from the United Kingdom as part of the lend-lease arrangement of 1940, has been invaluable in supporting operations in the Persian Gulf. It might be possible to lease from the Philippine government one of the many desolate, uninhabited islands in the archipelago and build a major operating base there. Such a base would be ideal for supporting military operations in Southeast Asia.

The possibilities for acquiring such extraterritorial access, however, are rare. The United States gained Diego Garcia only when the United Kingdom faced its darkest hour against Nazi Germany. The United States also enjoys extraterritorial access at Guantanamo Bay in Cuba, but this is a remnant of a colonial past. Many *available* locations might be uninhabitable because of unhealthy climates, flooding, lack of livable land, or an absence of fresh water. These problems can be overcome, but the costs can be high.

Relying on Extended-Range Operations from US Territory. A final option for access abroad is to eliminate the need for it by relying on US-based airpower. B-52 bombers operating from Louisiana and B-2s operating from Missouri were used in attacks against Iraq and Serbia. The growing capabilities of the Air Force heavy bomber fleet will make it more important in future operations.

There are, however, two problems with exclusive US basing for expeditionary operations. First, the Air Force currently has almost 2,000 fighter and attack aircraft with small operating ranges and less than 200 long-range bombers. It plans no new procurement of long-range combat aircraft in the next 20 years. Exclusive US-basing means that about 90 percent of the Air Force combat aircraft would be useful in only the most exceptional scenarios. Furthermore, the larger payloads of heavy bombers flying 30- to 40-hour missions that begin and end in the United States generate less than one sortie per day. Their heavier payloads do not always match the number of weapons that smaller planes flying more sorties can place on target.

Second, for many expeditionary missions, operating mainly from a US territory is not a practical option. The goal of some expeditionary operations is not to put ordnance on target but to support complicated and intensive peacekeeping or humanitarian operations on the ground. Such operations could not be accomplished without regional access and basing. US territory should become increasingly important as a base for operations abroad, but it cannot be a complete solution to the access problem.

Designing an Effective Global Access Strategy

None of the *pure* strategies above can, by itself, provide the Air Force, in particular, and the military, in general, with all their access and basing needs. Nevertheless, planners can select elements of these individual approaches to develop a hybrid strategy, meeting present and future needs. The four components of this strategy are maintaining core assets, developing new processes and technologies that expand access and basing options, exploiting new opportunities for access and basing, and addressing immediate concerns in Southwest Asia and the Pacific Rim.

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Maintaining Core Assets. We offer three recommendations for the Air Force to make the most of its core assets for access and basing. First, the

Global Access: Basing and Access Options

Improvements in process and technology can help the Air Force expand its access and basing options.

United States should maintain its current major operating bases in Europe and Asia for use as FOLs. These are fairly secure and reliable bases for operations in nearly all regions of interest to the United States. These bases have been helpful in providing rapid response to past contingencies, and they should be in the future, particularly since the Air Force cannot currently meet expeditionary deployment time lines without substantial prepositioning of resources at FOLs.

Second, in establishing FSLs to support FOLs, logisticians should select locations where access is guaranteed or most likely. These locations could serve as strategic and theater airlift hubs as well as repair facilities for key components such as engines or critical avionics units. Current RAND analysis also suggests that forward support locations can greatly improve logistics processes for EAF operations.[7]

A small number of forward support locations in Alaska, Guam, Puerto Rico, Diego Garcia, and the United Kingdom could put most of the world within range of a C-130 carrying a 12-ton payload of supplies and equipment (Figure 2). Those in Alaska, Guam, and Puerto Rico, being on sovereign US territory, would offer assured access. Assured access is available on Diego Garcia until at least 2039. FSLs in the United Kingdom do not offer completely assured access, but they would be on the territory of the most reliable US ally. All would be outside the range of the offensive capabilities of likely future adversaries.

A third core asset the United States can exploit in a broader access-and-basing strategy is its relationships with key security partners worldwide. Training exchanges, joint exercises, and temporary deployments help maintain the relationships that can be of great value in a crisis. Because deployments for training and exercises often include facility improvement, they offer opportunities to enhance an access-and-basing infrastructure as well as relationships.

Developing New Processes and Technologies. Improvements in process and technology can help the Air Force expand its access and basing options. Increases in crews and tanker support could permit an expeditionary unit to operate with about the same effectiveness at ranges of 1,000 to 1,500 nautical miles as it would have operating about 500 miles from a contingency. Developing and acquiring aircraft with longer operating ranges would help the Air Force avoid future access difficulties. Aircraft able to operate over a range of 2,000 nautical miles without refueling, for example, could support contingency operations in most of the world while operating exclusively from the five forward support locations preciously identified. Small, *smart* munitions could improve the rates at which aircraft could deliver ordnance, in turn, permitting the Air Force to consider a wider variety of options for access and basing. By adopting processes or technologies that expand its options for access and basing, the Air Force will hedge against risks of future *access lockout*. By identifying and implementing process and technology innovations that improve expeditionary operating range, logisticians will also overcome many of the political constraints on their options.

Exploiting New Opportunities. There are two types of opportunities for access and basing that may be exploited for future operations. The first is extraterritorial access. We cannot identify a future host country, but the United States possibly could work now to develop such opportunities. The Air Force should survey one or more key areas of interest, starting in the western Pacific, to identify potential sites for such access. If some are found, then logisticians can consider the cost, feasibility, and development of facilities there. This preparation will help should theoretical possibilities become actual opportunities.

A second area of opportunity for access and basing is in the currently rapid pace of geopolitical change. The changes of the last decade may have created new opportunities for access and basing that have not yet been realized. Many nations of Central Asia have shown an interest in closer ties with the United States. Their help could be crucial in access and basing for responses to crises involving China or Iran. Several Southeast Asian nations have also expressed interest in expanding ties with the United States; their help could be crucial for US responses to crises there.

Addressing Immediate Concerns. In both Southwest Asia and the Pacific Rim, current access arrangements are insufficient, and the risk of contingencies is high. Both these regions should command the most attention in managing and developing access and basing options.

In Southwest Asia, flexible planning will be critical to maintaining Air Force capabilities to respond to contingencies. Such planning should focus on how to maintain current capabilities if basing options are not optimal. This might include planning to base aircraft at one regional location and support processes at another to minimize risks and create more basing options. The United States may wish to develop more strategic partners

Figure 2. Coverage Available from Five FSLs. Most of the world is within a 3,000-mile radius from one of these five potential FSLs, putting most of the world within the operating range of a C-130.

There are two types of opportunities for access and basing that may be exploited for future operations. The first is extraterritorial access. A second area of opportunity for access and basing is in the currently rapid pace of geopolitical change.

Continuing changes in military technology may eliminate many access and basing problems. Space-based surveillance and attack systems may someday enable the Air Force to strike any target in the world without deploying aircraft or personnel. Still, it is unlikely that such changes will completely eliminate expeditionary operations in general and the need for access and basing in particular. Peacekeeping and humanitarian operations will continue to require local access and basing.

in the region. Israel is a prime candidate for such a role should a broad peace accord permit its *normalization* in the region.

The Asian Pacific Rim outside Korea presents daunting access and basing problems to the United States. Particularly problematic is the lack of bases available near the Taiwan Strait. Facilities in the northern Philippines would solve this problem if they could be used in a Taiwan crisis. Identifying and developing extraterritorial access would also help. In Southeast Asia, the United States would improve its options by expanding its presence in Singapore, continuing to build its relations with Thailand, and possibly, developing Malaysia as a site for access and basing.

In both Southwest Asia and the Pacific Rim, the development of new, longer range combat aircraft could ameliorate access and basing concerns.

Future Access and Basing Needs

Continuing changes in military technology may eliminate many access and basing problems. Space-based surveillance and attack systems may someday enable the Air Force to strike any target in the world without deploying aircraft or personnel. Still, it is unlikely that such changes will completely eliminate expeditionary operations in general and the need for access and basing in particular. Peacekeeping and humanitarian operations will continue to require local access and basing.

There is no single solution that the United States can apply for its access and basing needs now or in the future. Traditional problems for access and basing will persist, and new ones, including new threats posed to US forces based regionally, may develop, further complicating a global access strategy. Nevertheless, a global access strategy that includes maintenance of core assets and development of new political and technological opportunities can help the United States manage and develop access and basing options both now and in future years.

Notes

1. *Tactical* forces are those not committed primarily to the nuclear retaliatory mission performed until the early 1990s by Strategic Air Command.
2. For more information on the resources that must be prepositioned to meet a 48-hour deployment and operation time line, see Lionel A. Galway, et al, *New Agile Combat Support Postures*, RAND, MR-1075-AF, Santa Monica, 1999.
3. The next planned generation of tactical aircraft, including the F-22 and the joint strike fighter, will have similar operating ranges.
4. In 1973, the Air Force fleet of C-141A transport aircraft was not fitted for aerial refueling and could not have flown nonstop from the United States to Israel. The C-5A, which was equipped for refueling but was prohibited from doing so because of difficulties with its wing structure, could have made the trip without refueling, but its maximum payload would have been reduced to 33 tons. By stopping at Lajes AB, the C-5s were able to carry an average of 68 tons per sortie. See J. Lund, 1990, "The Airlift to Israel Revisited," unpublished manuscript, and US General Accounting Office, 1975, *Airlift Operations of the Military Airlift Command During the 1973 Middle East War*, LCD-75-204, 10, 30.
5. The research for this article predates the most recent operations in the Persian Gulf—Operation Iraqi Freedom. In the Spring of 2003, Iraqi Freedom removed the Saddam Hussein regime and created a new security environment in the Persian Gulf.

6. Israel might be said to have a special relationship with the United States, but it currently cannot help the United States solve its access and basing problems in the Mideast. Using Israel for access and basing in an operation against another state in the region—for example, against an Arab state—is, at best, problematic. This could change if the position of Israel in the region continues to improve. For more on the political dynamics and military implications of improving Arab-Israeli relations, see Zalmay Khalilzad, David Shlapak, and Daniel Byman, *The Implications of the Possible End of the Arab-Israeli Conflict for Gulf Security*, RAND, MR-822-AF, Santa Monica, California, 1997. We also recognize that Australia shares many of the cultural bonds that the United States has with the United Kingdom. There are, however, several reasons why these bonds will not yield a special relationship with the United States. London and Washington share many of the same perspectives on regional and global issues, but Canberra and Washington do not. A significant number of Australians would likely oppose greatly expanded ties with the United States. Even if a special relationship were possible, Australia still would not be ideally located for supporting operations away from the far southeastern portion of Asia.
7. For an overview of the role of FSLs in EAF logistics processes, see Lionel A. Galway, et al, *New Agile Combat Support Postures*, RAND, MR-1075-AF, Santa Monica, California, 1999, and Eric Peltz, et al, *An Analysis of F-15 Avionics Options*, RAND, MR-1174-AF, Santa Monica, California, 2000.

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The EAF concept requires the Air Force to be able to deploy combat aircraft to bases with a range of infrastructures, from Cold War warm bases (fully equipped with prepositioned materiel and often in active use) through international airports with little military infrastructure, down to bases that have no more than water and fuel, a bare base. Further, because of uncertainties in the location and scale of future conflicts, a major part of deployment planning must be *generic*, unlike Cold War planning that developed detailed plans for specific bases.

Footprint Configuration

A New Concept to Speed EAF Deployment

Introduction

The expeditionary air and space force (EAF) concept requires the Air Force to be able to deploy combat aircraft to bases with a range of infrastructures, from Cold War warm bases (fully equipped with prepositioned materiel and often in active use) through international airports with little military infrastructure, down to bases that have no more than water and fuel, a bare base. Further, because of uncertainties in the location and scale of future conflicts, a major part of deployment planning must be *generic*, unlike Cold War planning that developed detailed plans for specific bases.[1]

Footprint Configuration: A New Concept to Speed EAF Deployment

The primary goal in developing expeditionary support concepts is to speed the deployment of aerospace capability so it can be employed quickly and sustained.

However, quickly deploying the support structure for operations is not as easy as moving the aircraft themselves. Under current concepts of operation, all the materiel and personnel to initiate and sustain operations, the deployment *footprint*, must be present for operations to commence. The support processes constitute the major portion of any deployment, and the speed and agility of deployment hinge on the size of this logistical requirement.[2]

Given that most of the current combat platforms and their support systems were developed during the Cold War, it is not surprising that little of the support equipment was explicitly designed for rapid deployment to austere operating locations. In a series of reports, RAND and Air Force researchers examined the deployability of various specific support capabilities, including flight-line maintenance, avionics repair, low-altitude navigation and targeting infrared for night pod maintenance, and jet engine intermediate repair, as well as munitions, fuel support, and billeting.[3] The consensus of the research was that moving all the support for an aerospace expeditionary task force (ASETF)[4] package to a forward operating location (FOL) within the notional timeframe of 48 hours was almost certainly infeasible given the current support process, organization, and equipment.

One result of this work—and of experience in Kosovo—was a call for *footprint reduction*, reducing the amount of materiel and number of people actually deployed to FOLs. According to *Air Force Vision 2020*, "We will streamline what we take with us, reducing our forward support footprint by 50%." In line with this statement of the problem, much effort and attention has been directed at the reduction of support equipment. For example, new and smaller F-15 avionics testers were developed, and new, lighter shelters and billeting equipment are being proposed. However, for many areas such as munitions, significant mass reduction will require substantial investment in new technology and development, and for some areas such as civil engineering, large reductions in the size of earth-moving equipment seem infeasible.

The primary goal in developing expeditionary support concepts is to speed the deployment of aerospace capability so it can be employed quickly and sustained. While it is certainly plausible that there is scope for physical footprint reduction as defined above and that reduction is one important tool in achieving the deployment goal, the research previously cited and the current activities of several Air Force functional communities have recognized that the key to fast deployment is not only the physical reduction of weight but also the restructuring of the footprint and time and space phasing appropriate parts of it.[5]

To include these other strategies, we need a broader concept for the amount of support that can be used to analyze the time and resources needed to deploy support processes.

Beyond Footprint: Footprint Configuration

Footpint Hierarchy

The first step in examining a footprint from a broader perspective is to recognize that logistics planners work with a footprint at three different levels, illustrated schematically in Figure 1:

- Unit-type code (UTC) level: a specific support or operational capability, including both materiel and personnel
- Force or base level: all capabilities needed to initiate and sustain operations for a given force at an individual base (a set of UTCs)
- Theater level: all capabilities needed over an entire theater given a specific mix of forces and bases to perform a campaign (set of force or base packages, plus other theater support facilities)

UTC Level. The UTC is the basic deployment unit of materiel and personnel in all branches of the military. For example, the UTC 3FQK3 represents an 18-primary aircraft authorized (PAA) F-15E squadron, consisting of 449 people and 417.3 short tons of materiel. It does not include a jet engine intermediate maintenance shop, so if this is required, an HFQK3 UTC must be deployed with 40 people and 55.3 short tons of additional equipment. In some cases, the entire capability of a standard UTC may not be needed, in which case the UTC is *tailored* by functional area personnel. [6]

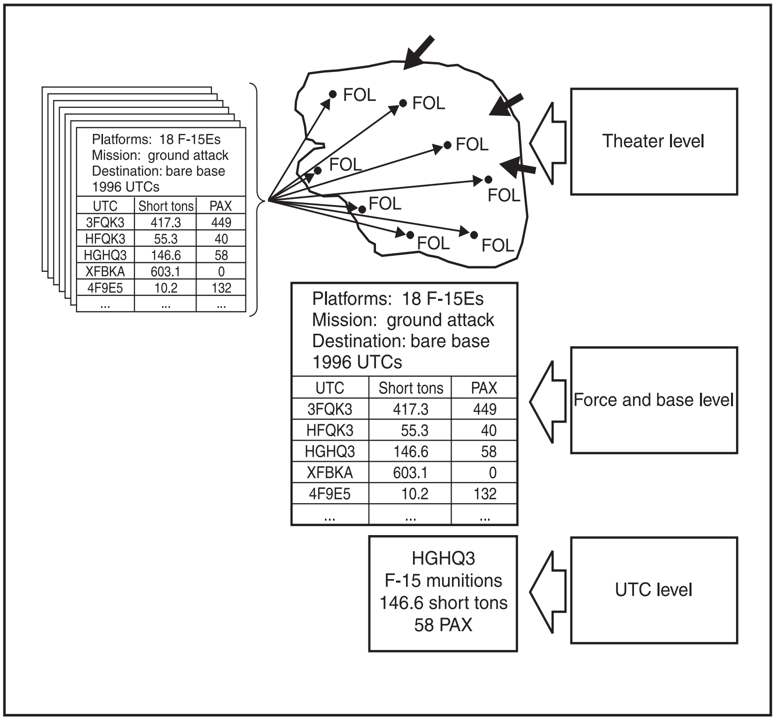

Figure 1. Footprint Hierarchy Schematic

Footprint Configuration: A New Concept to Speed EAF Deployment

Footprint Configuration: A New Concept to Speed EAF Deployment

Working at either the UTC or theater level can reduce the footprint, facilitating improvements in rapid and flexible deployment. But the keystone to reducing time to deployment lies in examining the second hierarchical level: the requirements for transforming a base that does not have a full military infrastructure to one that is completely equipped to launch the required combat missions.

The Desert Storm experience,[7] the development of the EAF concept, and further experience in Kosovo spurred a large-scale effort to rework all Air Force UTCs.[8] These efforts include *right sizing* UTCs (redefining standard UTCs to support smaller expeditionary forces in a range of conflicts). A parallel and complementary focus has been to break individual UTCs into modular building blocks so capabilities can be fit more precisely to specific circumstances. In addition, there are also simultaneous efforts by pilot units and functional area managers to physically reduce UTCs.

Force or Base Level. The second level of the footprint hierarchy, the force or base level, is the list of required UTCs that depend on the combat force and mission (for example, an 18-PAA squadron of F-15Es flying air-to-ground bombing missions), the state of the base, and the threat level.

Theater Level. The third and highest level of footprint hierarchy is the sum of all deployed materiel and personnel needed in an entire theater of operations. In the simplest case, where each base is completely self-contained, this would be the sum of individual force or base footprints. But some support capabilities and supplies can be placed in forward support locations (FSL).[9] Therefore, analysis on the theater level must take into account economies of scale that alleviate redundancies of capability among bases, create efficiencies in distribution of materiel, and reduce airlift requirements in the crucial initial phase of a deployment.

Focus on Force or Base Level

Working at either the UTC or theater level can reduce the footprint, facilitating improvements in rapid and flexible deployment. But the keystone to reducing time to deployment lies in examining the second hierarchical level: the requirements for transforming a base that does not have a full military infrastructure to one that is completely equipped to launch the required combat missions.

Evaluating the progress of footprint reduction at the base level provides a unique vantage point of the levels above (theater) and below (UTC). For example, base-level analysis will accurately assess the reduction of one UTC by jettisoning materiel available in another UTC.[10] Base-level analysis also reveals which UTCs provide the best payoff in reduction for a given expenditure of resources, rather than requiring each individual *functional* to achieve equivalent degrees of reduction. Finally, understanding the requirements at a base level provides the basic data needed to plan for the capabilities and materiel that might best be positioned in FSLs to exploit economies of scale in a theater composed of many FOLs.

Comprehensive UTC Lists for Force or Base Packages

Expeditionary force or base packages are *generic* UTC lists not tied to specific bases. Unfortunately, such UTC lists for bare bases do not seem to exist for any current or proposed force packages outside the popup air expeditionary wings (AEW).[11] Although clearly *virtual,* generic lists exist in the skill base of the functional experts at major command

(MAJCOM) headquarters, the lack of a canonical list of support for a given force package leaves logistics planners with few means of coordinating footprint changes on a level higher than the UTC.

It has been suggested that the various deliberate planning and historical time-phased force deployment data (TPFDD), such as those from Noble Anvil, could be used in lieu of such generic lists. While such efforts provide valuable insight for the construction of generic lists, in general, these data are not adequate for strategic logistics planning. First, very few of these deployments are to true bare bases, so they do not directly answer the question of defining the total package required to support any given force. Further, for each historical or planned base and force package, there are specific circumstances and assumptions unique to each situation that must be taken into account.[12] In most cases, drawn from planning data, each base has prepositioned materiel and assumptions about resources available on the local economy in that specific location. Finally, many of the UTCs in either deliberate planning or in historical data are heavily tailored.

The EAF will have to develop the capability to assemble lists of UTCs for different force packages to deploy to any operating location. The determining parameters would also include components of destination infrastructure and threat level, among others. Such capability-based lists could be used for strategic planning of transportation resources, a starting point for footprint changes (identifying large UTCs that are natural candidates for reduction or restructuring, accounting for materiel shifted out of one UTC to another without acknowledging that no total reduction has been achieved), and a template against which deliberate and crisis planning for specific locations could be compared.

Footprint Configuration: A New Concept to Speed EAF Deployment

Footprint configuration provides a framework for visualizing and assessing the broader array of strategies for decreasing the deployment time line.

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FOL Versus Remote Support Processes. Researchers have observed that support processes[13] can be divided into those that must be done at an FOL from where aircraft fly and those that can be done remotely, either at FSLs or even at continental United States (CONUS) support locations.[14] The footprint in terms of equipment (or personnel) can, therefore, be initially divided into two pieces as illustrated in Figure 2.

The FOL Segment. The FOL segment can, in turn, be subdivided into the following three pieces, as shown in Figure 3:

- The initial operating requirement (IOR) is required at the FOL to initiate combat operations.
- The follow-on operating requirement is needed at the FOL to sustain combat operations at the desired tempo.
- The on-call segment is required at an FOL only in specific circumstances and is deployed only when needed.

Figure 2. Division of Footprint into FOL and Remote (Not at FOL) Pieces

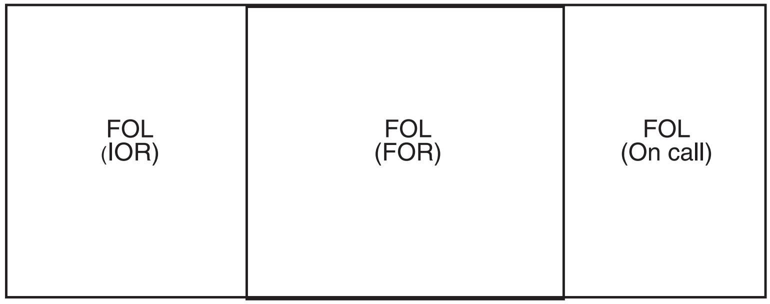

Figure 3. Subdivision of FOL Footprint Portion into Initial and Full Operating Requirements (FOR) and On Call

For example, the IOR for munitions would consist of an initial stockpile of munitions, fins, and fuses, plus the munitions assembly and movement equipment. The follow-on requirement, in this case, would be the resupply of munitions necessary to continue carrying out operations. The on-call category can be specialized fuses that can be used only for a very specific mission.

The Remote Segment. The remote segment can be subdivided further into two pieces as in Figure 4.

- FSLs are facilities that can support FOLs with selected maintenance or supply processes linked to the FOLs by intratheater transport.
- CONUS support locations are support facilities in the CONUS linked to FOLs by using intertheater transportation.

FSLs were established during the Kosovo conflict as centralized intermediate repair facilities at locations such as Royal Air Force Lakenheath and Spangdahlem Air Base, Germany, to support FOLs in Italy and Turkey with avionics and engine repair and phase maintenance. Currently, many F-16 avionics line-replaceable units are repaired by CONUS facilities no matter where the aircraft are located around the world.

Putting It All Together: Footprint Configuration. Putting these subdivisions together gives a time and space phasing of the different segments of this process in this potential configuration. Figure 5 is a comprehensive picture of what is prepositioned (shaded region), what needs to be moved and when, and what need not be moved at all for this process.

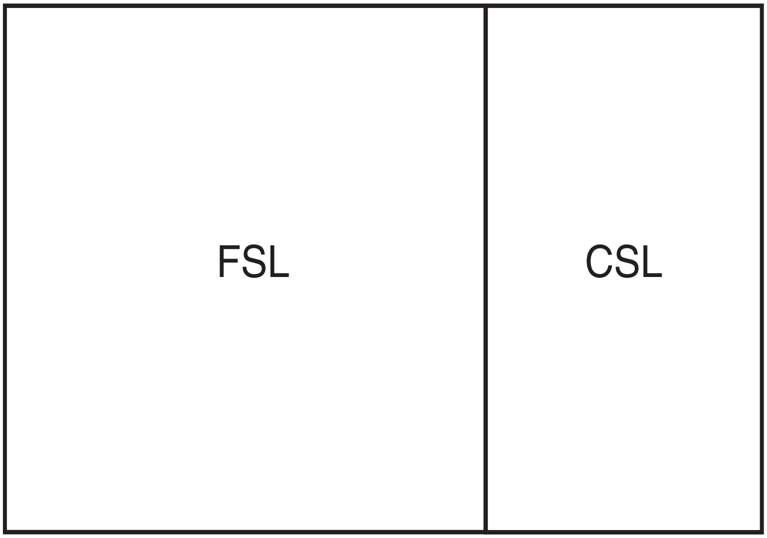

Figure 4. Subdivision of Remote Footprint Portion into Subdivisions at Forward and CONUS Support Locations

We have presented the discussion this far in terms of a single support process. However, the real interest is in combining all support processes into a force or base package as shown in Figure 6.

Some processes may be required to be entirely at the FOL, with no part that can even be on call (for example, notional support process B). Others may not have any part at a CONUS support location (process E), while for others, the proportion in each segment may vary, along with what can be prepositioned. But the real value is that it provides a framework for explicit decisions about what parts of individual support processes need to be moved and, if they do, when they are needed. The concept of footprint configuration also allows for the traditional reduction in weight and personnel while encompassing other strategies.

Footprint configuration also recognizes that different process configurations can interact, either at the force, base, or theater level. If an FSL can be established with robust transportation for jet engine intermediate repair, then an FSL for avionics at the same location can use the transportation links already established. So in making decisions about how to reconfigure a process, all levels of the footprint hierarchy need to be considered.

Evaluating Footprint Configurations: Metrics

Because the basis of footprint configuration is to structure support process arrival across space and time, the characteristics of footprint configuration are multidimensional.

There are four primary metrics:

- Time to initial operating capability (IOC)
- Time to FOC for the desired capability

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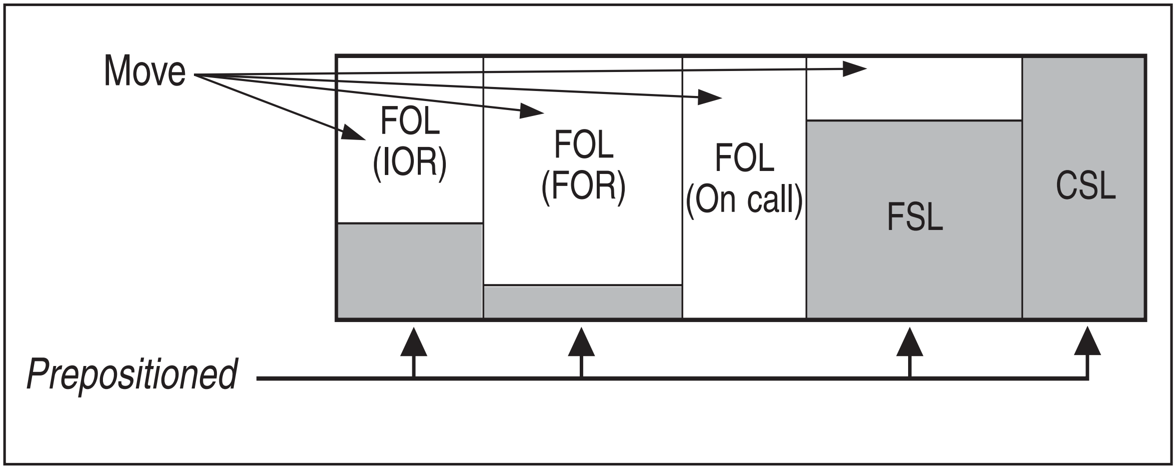

Figure 5. Footprint Configuration for a Notional Individual Support Process

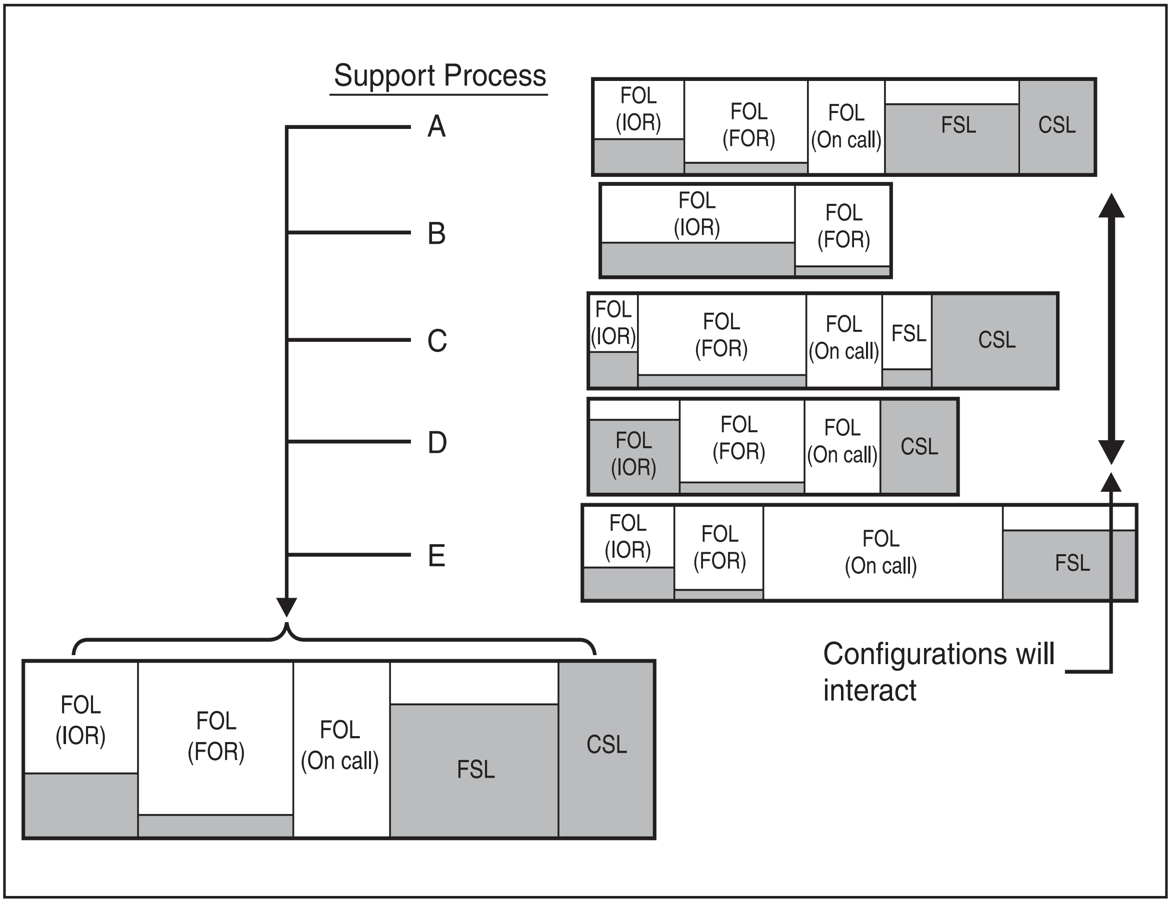

Figure 6. Combining Footprint Configurations for Multiple Support Processes

- Transportation resources required to move the IOR
- Transportation resources required to move the follow-on operating requirement[15]

Achieving desired values on these four metrics requires trading off or controlling several other key metrics:

- Materiel mass and personnel moved.
- Cost—investment and operating costs are both important.
- Flexibility—is the configuration chosen capable of supporting different kinds of operations under varying circumstances? Too much prepositioning could reduce the flexibility to use other FOLs.
- Risk—there are a series of risk analyses that need to be done for any configuration, including risks of depending on transportation; the vulnerability of FOLs with prepositioned materiel and centralized facilities; and political, cost, and technical risks.

For many of these metrics, input from the operations side of the Air Force will be required. How much flexibility is needed and how much can be traded for speed and robustness? Which risks are acceptable and which are unacceptable? What is IOC and, hence, IOR? What are the missions and operational rates needed? The close linkage between operations and logistics required by expeditionary operations presents a new challenge for the Air Force.[16]

Developing and Evaluating Alternative Footprint Configurations

When there are a number of different metrics and goals to be simultaneously satisfied, inevitably, there will have to be tradeoffs and compromises.[17] First, we need to be sure all aspects of support are accounted for. This is the role of parameterized UTC lists discussed previously. Second, for any proposed configuration, we need the capability to evaluate defined metrics (and any additional ones deemed necessary). Third, we need to be able to rank and weight the metrics so we can make tradeoffs for decisionmakers for alternatives based on the metric values (for example, some high costs may be paid to get a substantial decrease in deployment time). The primary focus should be on evaluating key force or base combinations since these are the fundamental building blocks of expeditionary deployments.

Evaluating Force or Base Packages

Building on the list of UTCs for a given force or base package, an evaluation tool can allow decisionmakers to modify the deployment list by selecting new or alternative UTCs or by allowing pieces of UTCs to be time phased, prepositioned, or deployed to an FSL instead of an FOL. Such decisions would change the ultimate package deployed and would be reflected in the key metrics of time to IOC and deployment resources

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Footprint Configuration: A New Concept to Speed EAF Deployment

computed by the tool. Figure 7 shows the notional structure of the broader tool. A set of requirements models for different support processes sits at the center (and interacts) so that changes in personnel in one support area, for example, are reflected in billeting. Requirements parameters (force and mission characteristics, technological changes, and so forth) are inputs to the model, and the outputs are the size and movement requirements.[18]

After evaluating different configurations, a selection must be made about which configuration (choice of FSL functions, prepositioning,

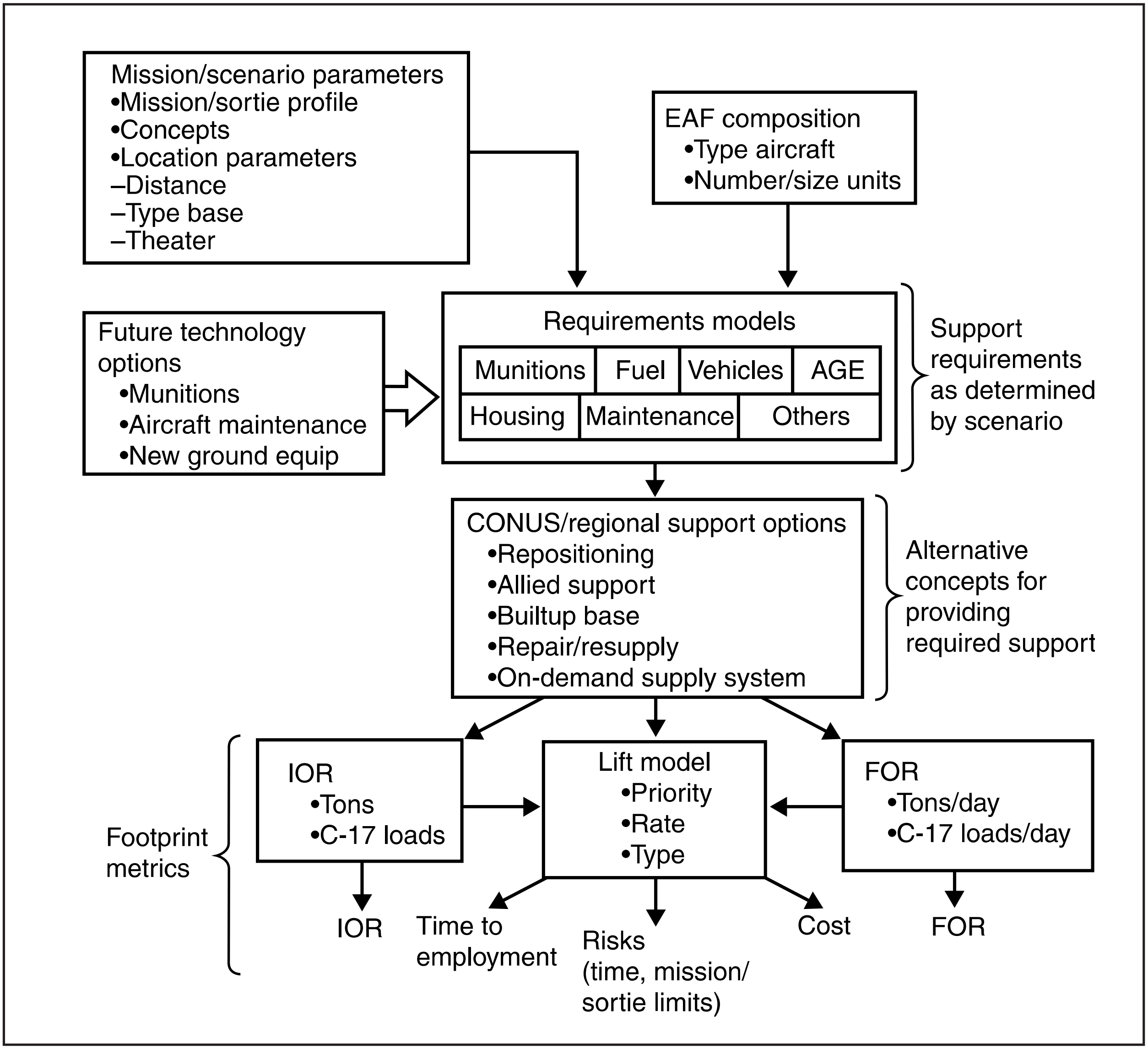

Figure 7. Evaluation Tool for Force or Base Package

technological development) will be implemented. To identify a configuration that performs well across the multiple metrics proposed, the RAND-developed DynaRank Decision Support System[19] could be used. This tool, an EXCEL add on, is a scorecard-development tool, which allows the user to specify a hierarchy of metrics and options to be compared. Scorecard manipulation functions allow multiple options to be sorted, ranked, and displayed by individual metric performance or aggregate weighted performance as selected by the decisionmaker (who, thus, has control over which metrics are most important).

For the near future, the two most important types of base infrastructures are the warm base and the *international airport* type base. Current planning suggests the following force packages are the most important for fighter operations:

- Full squadrons of F-15Es (ground attack), F-16CJs (Suppression of Enemy Air Defenses), and either or both F-15s and F-16s for air-to-air
- The *canonical* ASETF: 12 each of F-15Es, F-15Cs, and F-16CJs, for a small, balanced package of capability
- A six-ship, single-mission design series package of F-15s and/or F-16s for air-to-air[20]

The combination of the two base infrastructures with the force and mission packages above should provide a comprehensive view of how well the Air Force could carry out expeditionary operations over a wide spectrum of situations. One final point of emphasis: this evaluation should be done in terms of *generic* deployments, not specific ones. In this way, attention is focused on the strategic problems of expeditionary support, not on details of specific bases and units.

Evaluating Individual UTCs and Theater Configurations

Most of the work in reengineering and reconfiguring specific UTCs will reside with the functional area experts at the MAJCOMs and pilot units. In most cases, evaluating UTCs will be diagnostic to help identify promising areas of research for improving the performance at the force or base level. For example, initially, interest might focus on the heaviest UTCs: munitions, civil engineering, Harvest Falcon, and vehicles. High-technology areas such as medical and communications are also important to track because of the ongoing opportunities for technology insertion.

Some critical support processes are *not* organic to the Air Force, such as ground-based air defense and theater missile defense. However, these systems can be heavy and, by our definition, are part of the support of an airbase in that they are required, in some circumstances, to commence and sustain operations. It may, therefore, be in the interest of the Air Force to track their deployability as well.

Operational commanders and support planners at the theater level are interested in the deployment and beddown of a large force at multiple sites throughout a theater and being prepared for several different scenarios. However, with the force or base level understood (including the presence

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Operational commanders and support planners at the theater level are interested in the deployment and beddown of a large force at multiple sites throughout a theater and being prepared for several different scenarios. However, with the force or base level understood (including the presence of theater-level facilities such as FSLs), evaluating and tracking the theater-level performance of footprint configurations is then a matter of aggregating the performance at the relevant individual bases.

of theater-level facilities such as FSLs), evaluating and tracking the theater-level performance of footprint configurations is then a matter of aggregating the performance at the relevant individual bases.

Recommendations

- Adopt the concept of footprint configuration as an organizing principle for restructuring support processes. By being able to organize all the strategies in a common framework with a clear set of metrics, the selection of appropriate strategies for individual support processes will be clearcut and rigorous.
- Develop parameterized UTC lists to generate a comprehensive list of UTCs needed to deploy given force capabilities to different base infrastructures. This capability is central to expeditionary planning in that it allows evaluation of speed of deployment for a range of forces and destinations.
- Exercise more centralized control of UTC development. Because there is a primary global metric and deployment time and different support processes have different sizes and reconfiguration options, we believe more centralization to direct and evaluate efforts is important. Currently, most of the responsibility for making process changes resides at the pilot unit for each UTC. While involvement of process experts is critical, there needs to be central oversight of the allocation of the reengineering effort because the goal is the deployment of a complete force package.[21]
- Evaluate changes in deployment speed and other major metrics for selected force packages and base infrastructure combinations to track progress.
- Set up a system to aggregate the force or base evaluations to theater level for current warplans and for strategic support planning for proposed plans. As with the force or base evaluations, this would evaluate changes in deployment speed, time to IOC, and deployment resources but theater-wide plan for basing and employing expeditionary forces. In the current defense structure, these evaluations are clearly of interest to the MAJCOMs supporting the several geographic combatant commanders, who would probably wish to set up their own tracking systems based on actual theater plans. But recent events, such as the operations in Kosovo and Afghanistan, have indicated many major operations will draw operational forces and support from several combatant commanders, so corporate tracking to evaluate all warplans for review, as a whole, by senior Air Force leadership may be an emerging necessity. As with coordinating UTC development centrally, this will be a move toward a more centralized overview of a support system that is increasingly seen in global terms.[22]
- Develop tools to help decisionmakers evaluate and select among alternative footprint configurations. Such tools, together with the parameterized UTC lists advocated above, would allow analysts to evaluate many different footprint configurations quickly and

rigorously. Because we do not expect there to be a configuration that dominates in all metrics simultaneously, decisionmakers also will need to organize the results of evaluating different configurations to allow them to weight the results of individual metrics to come to a final decision. This is in line with the view that logistics must become a strategic planning function in an expeditionary world.[23]

Notes

1. Since the end of the Cold War, the Air Force has been required to perform numerous overseas deployments, many on short notice, in support of crises, ranging in size from humanitarian relief to Operation Desert Storm, and maintain a permanent presence in several areas to act as a deterrent to potential adversaries. To meet these challenges, it has reorganized itself into an EAF. That reorganization is replacing the forward presence of airpower with a force that can deploy quickly (within 48 hours) from the CONUS in response to a crisis anywhere in the world, commence operations immediately upon arrival, and sustain those operations as needed.

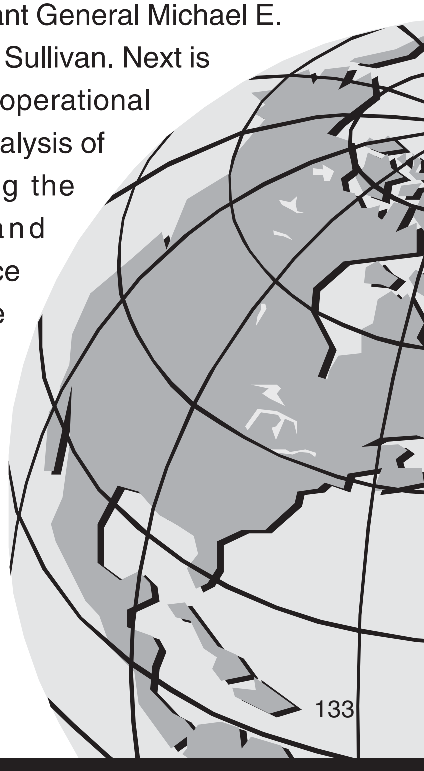
   For deployment time lines see, US Air Force, *Vision 2020: Global Vigilance, Reach, and Power*, Washington DC, 2001.
2. Lionel A. Galway, et al, *Supporting Expeditionary Aerospace Forces: New Agile Combat Support Postures for the EAF*, RAND, MR-1075-AF, Santa Monica, California, 2000.
3. See, for example, Tam T. Vo, *Exploratory Analysis of the Deployment Feasibility of United States Air Force Air Expeditionary Forces*, Air Force Institute of Technology, Wright Patterson AFB, Ohio, Sep 97; Frank C. O'Fearna, *Reduction of the Aircraft Ground Equipment: Footprint of an Air Expeditionary Force*, master's thesis, AFIT/GOR/ENS/99M-14, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, Mar 99; Galway, et al, 2000; Robert S. Tripp, et al, *Supporting Expeditionary Aerospace Forces: A Concept for Evolving to the Agile Combat Support/Mobility System of the Future*, RAND, MR-1179-AF, Santa Monica, California, 2000; Eric Peltz, et al, *Supporting Expeditionary Aerospace Forces: An Analysis of F-15 Avionics Options*, RAND, MR-1174-AF, Santa Monica, California, 2000; Paul Killingsworth, et al, *Flexbasing: Achieving Global Presence for Expeditionary Aerospace*, RAND, MR-1113-AF, Santa Monica, California, 2000; Amatzia Feinberg, et al, *Supporting Expeditionary Aerospace Forces: Expanded Analysis of LANTIRN Options*, RAND, MR-1225-AF, Santa Monica, California, 2001; and Mahyar A. Amouzegar, et al, *Supporting Expeditionary Aerospace Forces: An Analysis of Jet Engine Intermediate Maintenance Options*, RAND, MR-1431-AF, Santa Monica, California, 2001.
4. Terminology surrounding the EAF has changed over the 5 or so years of its existence. As it stood during research reported here, EAF denoted the overall operational concept, AEFs were the ten subdivisions of Air Force forces (two of which are on call at a time), and ASETF was used for whatever force was actually being deployed. Subsequently, two units were designated to initially handle very fast deployments, and these were designated AEWs. However, the acronym AEF was originally used for the deploying force, and it is possible that an entire on-call AEF would be deployed for a major conflict. In this document, we will use ASETF for the deploying force.
5. For examples of Air Force functional thinking, see "Civil Engineer Expeditionary Combat Support," AF/ILE, briefing dated 24 Jul 00, and "Medical Aspects of Dispersed Expeditionary Operations," ACC/SG, briefing dated 1 Apr 01. For a review of similar Army thinking, see Eric Peltz, John Halliday, and Steven Hartman, *Combat Service Support Transformation: Emerging Strategies for Making the Power Projection Army* a Reality, RAND, Santa Monica, California.
6. Jeffrey M. Hess and Merry D. Wermund, *Analysis of Standard Type Unit Development*, Thesis, AFIT/GLM/LSM/92S-23, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, 1992.

7. In Operation Desert Storm, it was noted that many Air Force UTCs arrived with as much as a 40-percent increase in personnel and a 300-percent increase in equipment over their nominal values and, further, some UTCs did not have their stated capability. See Stephen J. Hagel, "Capturing Logistics Data, Part II," *Air Force Journal of Logistics*, Air Force Logistics Management Agency, Maxwell AFB, Gunter Annex, Alabama, Vol XXVI, Winter, 1992.
8. Briefing, "United States Air Force UTC Refinement Effort," AF/XOXW, undated.
9. See Robert S. Tripp, et al, *Supporting Expeditionary Aerospace Forces: An Integrated Strategic Agile Combat Support Planning Framework*, RAND, MR-1056-AF, Santa Monica, California, 1999, and Killingsworth, et al, 2000.
10. For example, the medical community initially elected to drop power generation capability from its expeditionary facilities in the expectation of hooking into the bare base power grid. However, the latter was being reduced because it was assumed several functional areas had their own power sources. See *Bare Base Annual Report 2000*, ACC/LGXW, 1 Dec 00, Rev A 26 Dec 00.
11. The 366th Wing, Mountain Home AFB, Idaho, is one of the popup AEWs charged with being ready to deploy instantly to a warm base worldwide. As part of its planning process, the 366th has developed a list of 120 plus UTCs to augment the support resources at a generic warm base and expects to use the list as a template TPFDD to be completed when it actually deploys.
12. For example, total deployment figures for bases used in Noble Anvil do not shed much information on resources needed to commence operations, and they may be contaminated by the *Poppa Bear* buildup (in which resources but not aircraft were deployed). Also, the TPFDD for Noble Anvil also may not include some intratheater movements in Europe carried out by civilian transport.
13. In this project, we focused on support processes, but much of the subsequent discussion holds true for the operational part of the footprint as well.
14. Peltz, et al, 2000, and Galway, et al, 2000.
15. Unless these are feasible (in the sense of being acceptable to the theater combatant commander or CINC) under a variety of circumstances, expeditionary aerospace forces will not be used.
16. Tripp, et al, 2000.
17. Galway, et al, 2000, and Tripp, et al, 2000.
18. Tripp, et al, 1999.
19. Richard J. Hillestad and Paul K. Davis, *Resource Allocation for the New Defense Strategy: The DynaRank Decision-Support System*, RAND, MR-996-OSD, Santa Monica, California, 1998.
20. This stems from the parallel interest of the Air Force for dispersed operations. See the output of the Dispersal Conference, 20-21 Feb 01, in Washington DC, sponsored by AF/XOX.
21. Hess and Wermund.
22. Tripp, et al, 1999.
23. Tripp, et al, 2000.

Section 3: Command and Control Needs

combat support

Section 3 deals with the demands of combat support C2. The section begins with two introductory pieces, one by Lieutenant General Michael E. Zettler and the other by Major General Kevin Sullivan. Next is an article that examines the future CSC2 operational architecture. This article is followed by an analysis of CSC2 nodes and responsibility, mapping the relationships between the nodes and responsibilities. The benefits of maintenance FSLs or centralized intermediate maintenance (CIRF) became more evident by an ad hoc implementation during the conflict in Kosovo and as a result of Air Force formal testing of the CIRF in fall 2001. The last article in this section discusses command and control in the CIRF test as a proof of concept for the CSC2 operational architecture.



Lieutenant General Michael E. Zettler

the new Global Vision

All combat support must be managed in unison to create desired operational effects. We must be ready to measure actual performance constantly against planned performance and adjust accordingly.

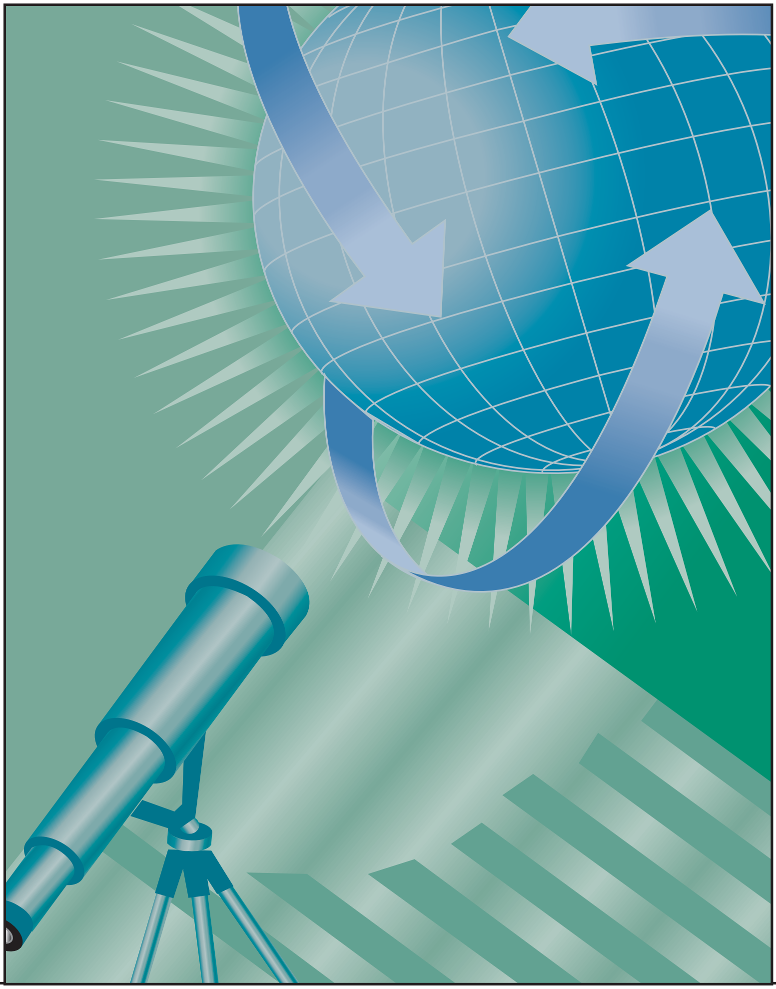
For the last 7 years, the Air Force, in response to ever-changing geopolitical events, has been working toward becoming a more expeditionary force. We have shifted from a Cold War-based system, where we concentrated on certain enemies and planned with great detail the type and nature of any conflict, to a much more flexible and responsive force. During the Cold War era, we prepositioned massive amounts of combat support (CS) at bases and in theaters. Much of that support was managed by commodity or type. Today, we find ourselves deployed to global places, many on short notice, and as a result, many of our resources are stretched to their breaking point. In this new environment, we can no longer afford to manage in stovepipes; rather, all combat support must be managed in unison to create desired operational effects.

We must understand the impact that any one resource or subsystem can have on the entire system. This overarching global view is essential for enabling today's air and space expeditionary force. For the last couple of years, Air Force people in both the operations and CS communities have worked with and led RAND Project Air Force analysts to define our current combat support command and control (CSC2) AS-IS state and develop a TO-BE operational architecture. Because the Air Force operates in a dynamic environment, defining the AS-IS state is valid only for that

The cornerstone of our TO-BE vision is a global view of combat support.

moment in time. However, our recognition and understanding of the processes and disconnects in the current system facilitated the definition and boundaries of the TO-BE vision. Once defined, the vision provides us a roadmap as we move forward.

The cornerstone of our TO-BE vision is a global view of combat support. While there is a requirement for the A-4 or J-4 staffs to maintain much of the operational control, there is also a requirement for resource allocation arbitration above the engaged component command. As an example of this requirement, I would like to describe the world, from the Air Force point of view, shortly after 11 September 2001. We had combat forces deployed in support of Operations Northern and Southern Watch supporting the no-fly zones in Iraq. Additionally, we were



Combat support must be aligned closely with operations, both in planning and at execution. Operations cannot achieve the desired effects and capability without adequate combat support.

building up forces in support of Operation Enduring Freedom in Afghanistan. At the same time, many continental United States-based forces—including the Air Force Reserve Command, Air National Guard, and active-duty Air Force bases—were flying in support of Operation Noble Eagle. Concurrently, we continued our day-to-day vigilance over the skies of South Korea. Arguably, any of these missions could be seen as a top priority. However, when everything is priority one, nothing is priority one. Compounding the problem of the number of missions was the fact they crossed all major commands. Our vision puts in place standing organizations that can deal with these complex issues.

First and foremost, combat support must be aligned closely with operations, both in planning and at execution. Operations cannot achieve the capability and desired effects without adequate combat support. Nor can the supporter provide required resources without a thorough understanding of the requirement. While this explanation may seem contrite and obvious to some, when we examined the current C2 system, we found disconnects that created misunderstanding. Our implementation plan is designed to eliminate as many disconnects as possible.

CS systems need feedback loops and the ability to reconfigure an infrastructure to meet changing needs in a constantly changing environment. While we continue to improve forecasting models, many factors cannot be modeled with desired accuracy. The major deterrent when computing requirements is not our inability to design consumption models but our inability to inject wartime factors—such as enemy actions, weather, and other variables—into the model. For this reason, we must be ready to measure actual performance constantly against planned performance and adjust accordingly. The vision provides for measuring and adjustment processes.

There is no such thing as an Air Force-centric CS system. We operate in a world supported by and supporting the other services, as well as coalition partners. In fact, some argue for a theater logistics commander reporting to the combatant commander who would control all logistics requirements for all services. While I do not advocate this, we must have a vision that provides the ability to understand and leverage the individual capabilities of each.

Finally, I should emphasize that one of the keys to achieving many of the successes the Air Force has enjoyed throughout its history has been our people. Energetic, adaptable, never tiring airmen are at the core of the Air Force. I argue flexibility is inherent in airpower, and many ad hoc organizations have been put together, most functioning with some measure of success because of the ingenuity of the airmen who ran those organizations. Our challenge has been to harness the best of these organizations, delete redundancy, and bridge disconnects. I believe the TO-BE operational architecture described in the following pages will do just that. There is always room for improvement, and I encourage each of you connected to the processes to review our vision with a critical eye. Help us move forward. This vision is intended as a roadmap to change. Adjustments will be required. As I stated earlier, we live in a dynamic world. With your help, we will continue to enable the Air Force to deliver the required capabilities to combatant commanders anywhere in the world.

There is no such thing as an Air Force-centric CS system. We operate in a world supported by and supporting the other services, as well as coalition partners.

Major General Kevin J. Sullivan

Concept to Reality

CSC2 concepts and an analysis of CSC2 processes drive an assessment of required changes in doctrine, training and education, materiel, leadership, and personnel.

As the Air Force transitions to a more expeditionary force, combat support command and control (CSC2) will have an essential role. The responsiveness required by today's operational forces can be achieved better through a CSC2 construct that is focused on creating operational effects. CSC2 is a subset of the overarching command and control (C2) within the operational planning and execution process, developing integrated operations and CSC2 processes. It is the means through which a designated commander plans, assesses, directs, and controls CS forces and resources to achieve operational effects. This article will lay the groundwork for taking the CSC2 operational architecture from a concept to a reality. The CSC2 concepts and an analysis of the required processes drive an assessment of required changes in doctrine, organization, training and education, materiel, leadership, and personnel (DOTMLP). Some of these changes are already underway and evolving from lessons learned in Operations Noble Anvil and Enduring Freedom.

To implement this work in a constructive fashion, we have set up an implementation team that has been patterned after the approach taken in the Chief's Logistics Review

Core process changes will serve as guiding principles for developing transition plans to implement a CSC2 operational architecture.

and Spares Campaign. It will be their charge to take the operational architecture; solicit comments from Air Force component commands, Air Staff, and major commands (MAJCOM); and integrate lessons learned from previous and ongoing operations to develop and refine an executable implementation plan. This plan will be time phased and focus on specific objectives. There will be a roadmap with associated metrics to indicate current status and progress toward capability-based goals. We intend to assess the progress at regular milestones. Where appropriate, we will leverage Air Force-wide efforts in command and control and communicate the status to MAJCOM commanders and at Corona conferences. All Air Force elements will be informed of

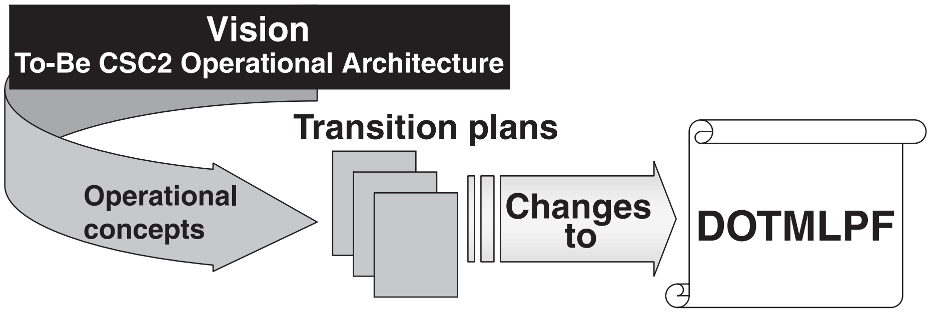
the CSC2 implementation plan. In this article, I will briefly outline some of the specifics of our plan.

We also must codify a standing organizational framework to facilitate the process of resource arbitration at various command levels when triggering events identify competing requirements.

Changes in DOTMLP

The joint services framework for analyzing processes and implementing new concepts in both material and nonmaterial solutions has been applied to the CSC2 operational architecture. This framework, DOTMLP, is a tool to manage the evolutionary changes required to meet operational requirements and is designed to be a comprehensive assessment of all applicable aspects of the process or concept. We have used it to assess changes required to enable core CSC2 processes (Figure 1). From this analysis, we believe there are several broad areas in which change is required. It is imperative that CS planners become active participants in operations planning processes and that the CS capability is integrated into all planning cycles, from early campaign planning to air tasking orders. In all cases, we should be able to interject timely CS capability information in operationally relevant terms. We also must codify a standing organizational framework to facilitate the process of resource arbitration at various command levels when triggering events identify competing requirements. Further, we need to strengthen our communications processes between supporting and supported functions. Finally, we must further develop closed-loop feedback and control processes to incorporate execution results and forward-looking assessments into the CS decision cycle—often called CS battlespace awareness.

These core CSC2 process changes will serve as guiding principles as we develop transition plans to implement a CSC2 operational architecture.



- Improvements are needed in the following areas to improve C2 for combat support:
  - Processes
  - Doctrine and policy
  - Organizational structure
  - Training and education
  - C2 systems integration and decision support tools

Figure 1: Implementation Process

Doctrine

Part of the implementation plan will be to institutionalize best practices and evolve organizations through doctrine. A couple of examples of best practices are the logistics sustainability analysis process, validated during the preparations for Operation Iraqi Freedom and led by the Air Force Combat Support Center Agile Combat Expeditionary Support Analysis Team, and the centralized intermediate-level repair facility (CIRF) test. These planning, assessment, and

Air Force policy and procedures also will be written or modified, where appropriate, to further detail doctrinal concepts.

The alignment of C2 responsibilities must be clearly defined and assigned to standard CS nodes.

execution processes are being written into doctrine to capture and institutionalize lessons learned. We also have initiated a review of current Air Force doctrine and policy and started revisions to reflect the core processes and required organizational framework for CSC2. Changes are already in work with the revision of Air Force Doctrine Document (AFDD) 2-4, *Combat Support*. Further, as AFDD 2, *Organization and Employment of Aerospace Power;* AFDD 2-6, *Air Mobility Operations;* and AFDD 2-8, *Command and Control,* come up for revision, we will be deeply involved in incorporating revised CSC2 concepts into these documents as well. Air Force policy and procedures also will be written or modified in Air Force instructions in tactics, techniques, and procedures format, where appropriate, to further detail the doctrinal concepts.

Organization

The organizational framework is an important part of the implementation plan. We endorse the CSC2 nodal construct found in *An Operational Architecture for Combat Support Execution Planning and Control*, RAND Project Air Force Report MR-1536, 2002. A reader familiar with the report will notice that we have modified some of the names and grouped functions somewhat differently than those outlined in the report. The alignment of C2 responsibilities must be clearly defined and assigned to standard CS nodes.

Specific organizations will be designated to fulfill the responsibilities of each of the nodes. The organizational template allows for variations in organization assignments by theater, while retaining standard *grouped* responsibilities. It may serve as a guide to configure the C2 infrastructure, based on the current requirements. Along with the template, having standing CSC2 nodes that operate in both peacetime and wartime can ease the transition from daily operations to higher intensity operations and allow us to train and work the way we intend to fight.

We have made several decisions on the names for standing CSC2 organizations and the chains of communication between them and identified initial responsibilities and information flows to better facilitate integrated operations. Our TO-BE CSC2 architecture outlines changes in three key organizations: the commander, Air Force forces (COMAFFOR) operations support center (OSC), commodity control points, and Air Force Combat Support Center.

Within the MAJCOMs, operations support centers have evolved as a matter of necessity for handling day-to-day contingency support. Air Combat Command has an operations support center, United States Air Forces in Europe (USAFE) calls its organization the USAFE Theater Air Support Center, and Pacific Air Forces (PACAF) has the PACAF Operations Support Center. These organizations are at various stages of evolution, and we will work with each of the MAJCOMs to institutionalize the roles and responsibilities of combat support within their operations support centers. We have made progress in the spares area by establishing C2 capabilities in the regional supply squadrons. The C2 features of the regional support squadron can be accessed *virtually* by the OSC CS personnel on the A4 staff. As an example of the process of resource arbitration, there is a success story from Noble Anvil with the CIRFs in USAFE. CIRF operations in Operations Iraqi Freedom and Noble Anvil were directed from the regional support squadron, which, during

CIRF operations will provide further capability, as they become a standardized part of the CSC2 nodal construct with automated tools to prioritize repairs and distribute serviceable assets.

As organizations and their C2 responsibilities become institutionalized, they must be staffed with highly effective CSC2 personnel who have been purposefully developed through training, leadership, and education opportunities.

Enduring Freedom and Noble Anvil, was acting as envisioned in the TO-BE architecture as a virtual component of the operations support center. As an illustration, the regional support squadron would direct the next serviceable asset repaired at the CIRFs to the unit that would best maximize the warfighting capability. CIRF operations will provide further capability as they become a standardized part of the CSC2 nodal construct with automated tools to prioritize repairs and distribute serviceable assets. Work is underway to formalize roles and responsibilities for the CIRFs as a part of the CSC2 organizational framework.

RAND's operational architecture report addresses organizations designed to manage the supply of resource commodities to supported forces. Commodity control points (called virtual inventory control points in the report) exist within different organizations, but their processes remain the same. According to maintenance concepts of operation, spares management is being organized along weapon system lines by a commodity control point at Air Force Materiel Command (AFMC). This function is being aligned with weapon system supply chain managers. Thus, supply chain managers will manage their resources until they cannot resolve competing demands. Then resource arbitration will be elevated to the supported operations support center or further to the Air Force Combat Support Center, if required. In practice, the Combat Support Center, located in the Pentagon, is making arbitration decisions for allocations among competing areas of responsibility and COMAFFORs when demands exceed supply. The Combat Support Center allocates resources in accordance with theater and global priorities. Some of these decisions may be aided by information systems that carry combatant commander priorities and priorities among the various combatant commanders. Some of this logic has been worked into the centralized Execution and Prioritization of Repair Support System algorithms being run at the AFMC commodity control point; that is, the AFMC Supply Management Division. In light of the global nature of air and space expeditionary forces, worldwide commitments, and limited resources, other commodities should be considered for management in the same manner.

Training

As organizations and their C2 responsibilities become institutionalized, they must be staffed with highly effective CSC2 personnel who have been purposefully developed through training, leadership, and education opportunities. This can be done through expanding CSC2 training objectives in operations-focused wargames and exercises. These training objectives should reinforce revised CSC2 doctrine and policy, as well as address recent C2 lessons learned. We will take advantage of joint services logistics wargames (for example, the Focused Logistics Wargame) to evaluate new concepts and expand training in tactical-level venues (for example, Eagle Flag). There will be an education working group, as part of the implementation team, to address the development and enhancement of formal education programs. The Advanced Maintenance and Munitions Officers School at Nellis AFB, Nevada, already has implemented significant C2 instruction in its curriculum. Additional opportunities will exist as we develop the Expeditionary Combat Support Executive Warrior Course and Advanced Logistics Readiness Officer

The CSC2 implementation effort will be fully integrated with our Future Logistics Enterprise and other CS enterprise architectures.

Within the systems architecture will reside the CSC2 tools that provide responsive capability analysis and decision support for the resource arbitration process, CS execution feedback (equivalent of battle damage assessment for operators), and forward-looking assessments.

Course and expand the Air Command and Staff College curriculum to include an Agile Combat Support specialized study course. We also can develop job performance aids for CS personnel who routinely step into one-deep positions at a numbered air force, a MAJCOM, or the Air Staff. The curriculum in both the operations and CS disciplines should be updated to address the impact of combat support in operations planning.

Material

The implementation of a responsive CSC2 operational architecture must include a review of the material, in this case information systems, required to support it. The CSC2 implementation effort will be fully integrated with our Future Logistics Enterprise and other CS enterprise architectures. We will develop systems and technical architecture views, as shown in Figure 2, that are Enterprise Architecture Initiative compliant.

Within the systems architecture will reside the CSC2 tools that provide responsive capability analysis and decision support for the resource arbitration process, CS execution feedback (equivalent of battle damage assessment for operators), and forward-looking assessments. These tools should strengthen communication channels between supporting and supported functions. Air Force CS functional communities will work together to integrate CSC2 architectures and the Future Logistics Enterprise to build the foundation for making combat support truly agile.

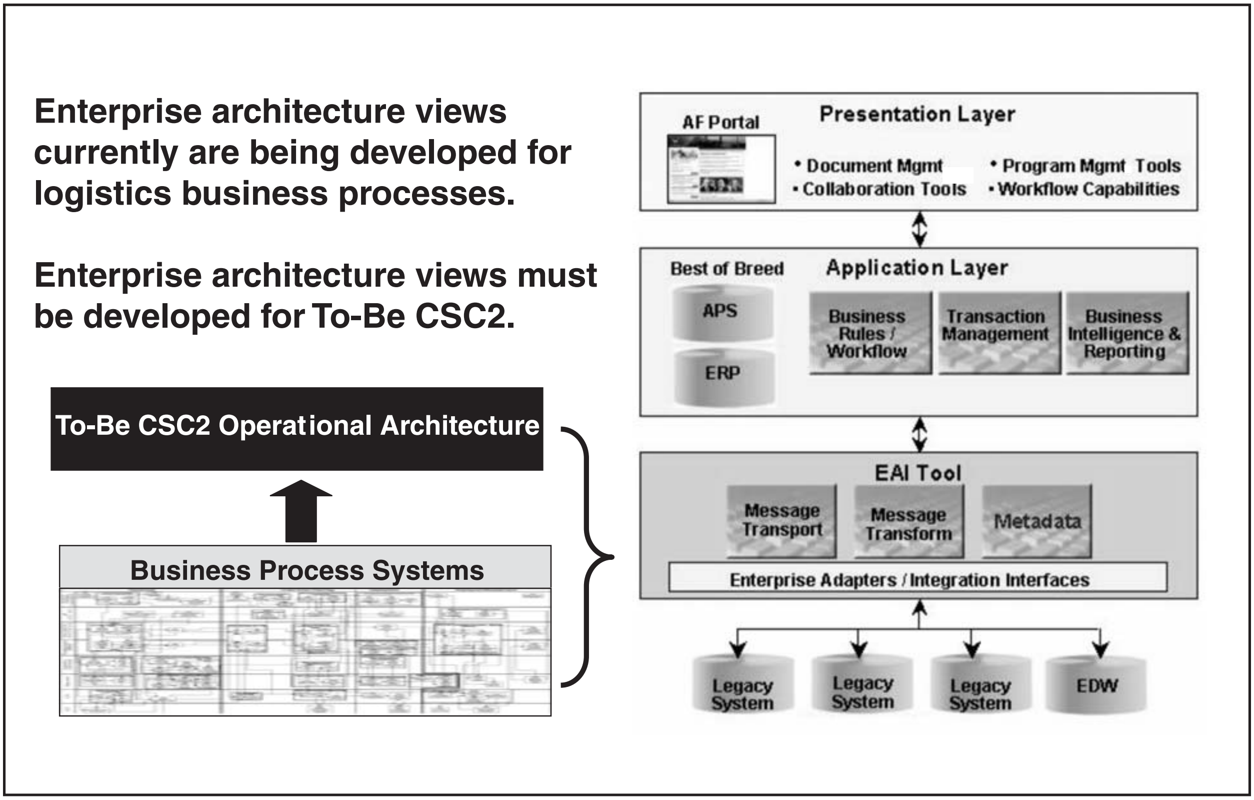


Figure 2. Enterprise Architecture

Leadership and Education

As indicated earlier, the key to actualizing this vision is leadership. The success of CSC2 will rest on the shoulders of those tasked to implement the concepts. Efforts toward implementing the concepts already have begun through the Air Staff-led implementation team. They cannot operate in a vacuum; every one of you touched by these processes has an obligation to help. At the Air Staff, we are

To manage these changes, we have chartered a formal change management team in the Air Force Planning, Doctrine, and Wargames Division.

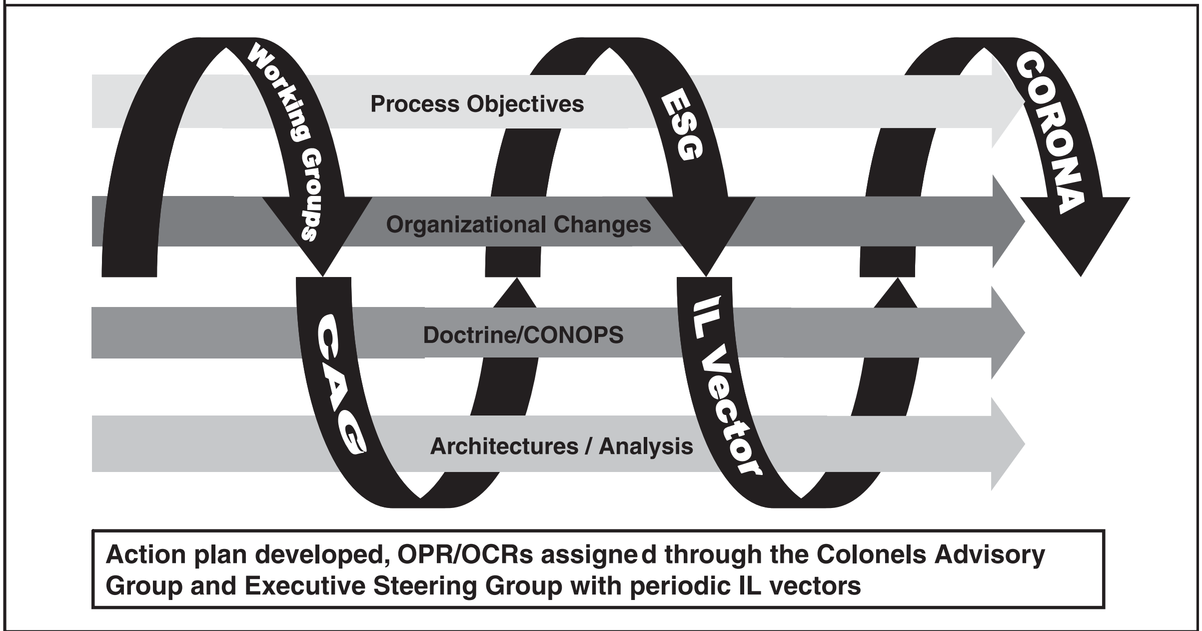


Figure 8. Managing Change

The Executive Steering Group will review issues and recommendations before they are sent for approval.

well aware there is much to be done, and we appreciate the work RAND and others have done to help us start down this path.

Managing the Way Ahead

As discussed, achieving the required capabilities of the TO-BE CSC2 architecture will require significant changes in DOTMLP. We have chartered a formal change management team in the Air Force Planning, Doctrine, and Wargames Division to oversee and manage these changes. The process we will use is shown in Figure 3. We have designed this process to be open to input and will begin with working groups that have MAJCOM representatives to refine process changes contained in the operational architecture. Specific milestones and actions have been identified for these working groups, and they include validation and refinement of the TO-BE processes to ensure corporate buy-in of the end states. The end states will be used to establish specific plans for changing processes, organizational changes, doctrine, and system architectures. The ACS Colonels Advisory Group has representatives from across the Air Force and is chaired by the Chief, Planning, Doctrine, and Wargames Division. The Colonels Advisory Group will advise and direct the issue working groups and elevate appropriate decisions to the Executive Steering Group, which is composed of general officers and Senior Executive Service personnel. The Executive Steering Group, chaired by the Director of Logistics Readiness, with broad ACS representation, will review issues and recommendations before they are sent to the Deputy Chief of Staff, Installations and Logistics for approval. As necessary or desired, actions and issues will be sent to the Deputy Chief of Staff, Installations and Logistics for approval to present to Air Force senior leaders at Corona conferences or other forums. CSC2 is increasingly important for creating and sustaining Air Force capabilities. The implementation process will remain a high priority as we continue to build consensus, assign resources, and guide the implementation work groups toward our desired end state. It will take all of us to get there.

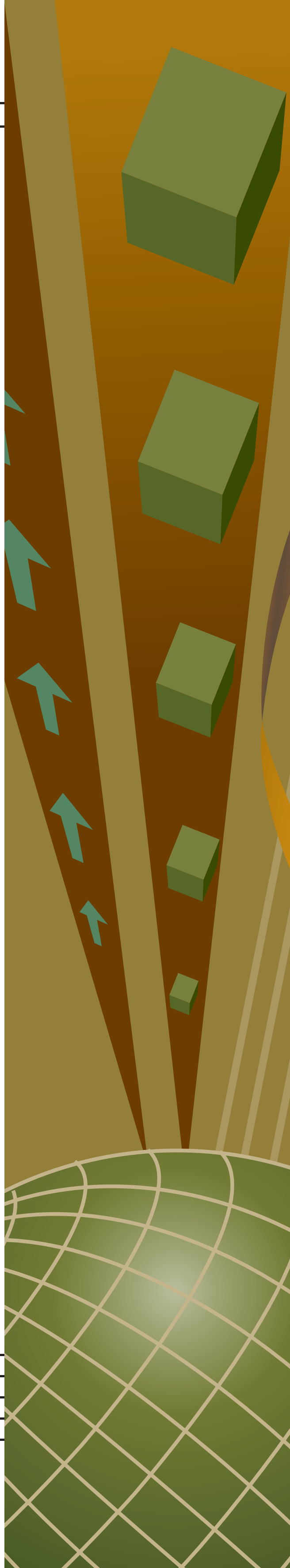
CSC2 is increasingly important for creating and sustaining future Air Force capabilities. The implementation process will remain a high priority as we continue to build consensus, assign resources, and guide the implementation work groups toward our desired end state.

Robert S. Tripp, RAND
Patrick Mills, RAND
Amanda Geller, RAND
C. Robert Roll, Jr, RAND
Major Cauley von Hoffman, AFLMA
Lieutenant Colonel David L. Johansen, RAND Fellow
James A. Leftwich, RAND

The shift toward expeditionary operations presents numerous challenges, particularly in combat support. To meet these challenges, the Air Force requires a *global* CS infrastructure.

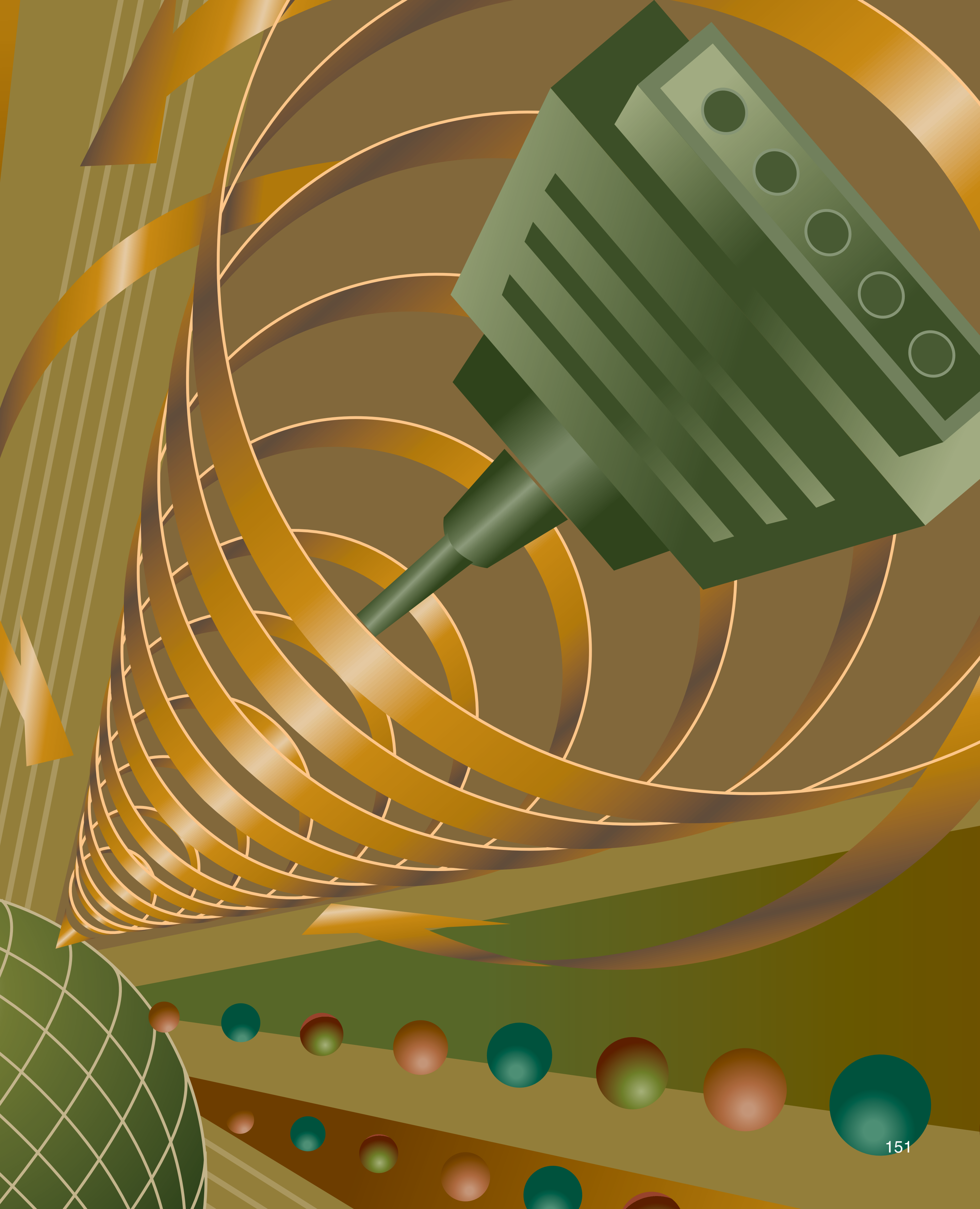
Combat Support C2 Architecture

Supporting Expeditionary Airpower

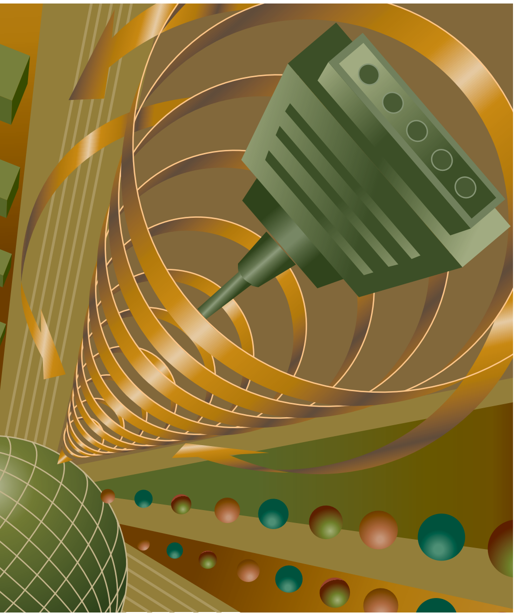


Introduction

Since the end of the Cold War, the US security environment has undergone extensive transitions. Combat has evolved from a theater-centric perspective, which focused on well-understood enemies in well-known locations, to a global perspective that requires preparations for conflicts at any time and in any part of the world. During the Cold War, the United States had a large force presence permanently positioned at established bases, but more recent demands for US military presence or intervention have required the Air Force to stage a large number of deployments, often on short notice and to unanticipated locations, with a substantially smaller force than existed in the 1980s. In response to this changing environment, the Air Force formulated a new concept of force organization, the air and space expeditionary force (AEF). The expeditionary concept is based on the premise



Combat Support C2 Architecture: Supporting Expeditionary Airpower



The shift toward expeditionary operations presents numerous challenges, particularly in combat support (CS). To meet these challenges, the Air Force requires a global *CS infrastructure.*

that forces tailored rapidly to support anything from a small-scale contingency to a major theater war—deployed quickly from the continental United States (CONUS) to locations around the globe and employed immediately—can serve as a viable alternative to the permanent forward presence established in the Cold War.

The shift toward expeditionary operations presents numerous challenges, particularly in combat support (CS). To meet these challenges, the Air Force requires a *global* CS infrastructure. RAND and Air Force Logistics Management Agency (AFLMA)-partnered analyses offer recommendations for such an infrastructure, which include developing forward operating locations (FOL) from which missions are flown, forward support locations (FSL) and CONUS support locations (CSL), regional repair and storage facilities, a transportation system for distribution, and a combat support command and control (CSC2) system.

At the request of the Air Force Deputy Chief of Staff, Installations and Logistics (Lieutenant General Michael E. Zettler), RAND Project Air Force (PAF) and AFLMA began an indepth analysis of the CSC2 system in October 2000. This article briefly summarizes their work in this area. In this work, we presented concepts for guiding the development of architecture for CS execution planning and control activities within an integrated operations and CSC2 framework.[1] We use CSC2 as a shortened name but stress that this architecture is part of the integrated operations and CS framework. This architecture is intended for use in transforming the current Air Force CSC2 system into one more capable of supporting expeditionary forces.

Implementing the AEF: Expeditionary Combat Support

Initially, the Air Force gave a great deal of attention to determining AEF composition and scheduling. With respect to deployment responsibilities, much of the effort and progress concerning expeditionary combat support focused on the deployment execution—how to compress time lines for deploying a unit's support functions, given current processes and equipment.

To complement Air Force progress in these areas, we have concentrated on strategic decisions that affect the design of the CS infrastructure necessary to support rapid deployments. The original AEF concept envisioned packages deploying to any airfield around the world that had a runway capable of handling the operational airlift aircraft, regardless of whether the airfield was a fully equipped base or a bare base with minimal facilities. Reliance on prepositioned assets was to be minimized, if not eliminated. However, analyses have shown[2] that, at present, prepositioned assets cannot be entirely eliminated: the current logistics processes cannot support the timing requirements, and most equipment is too heavy to deploy rapidly. While new technologies and policies can improve this situation in the mid to long term, implementing the AEF concept currently requires judicious prepositioning overseas. Global CS infrastructure preparation is, therefore, a central function of planning expeditionary support. There are five basic components of the global infrastructure: forward operating locations, forward support locations, CONUS support locations, a responsive distribution system, and a CSC2 system.

FOLs are locations from which aircraft conduct their operations or missions. Each FOL requires different amounts of equipment to prepare the base for operations and, as a result, has a different time line and transportation requirement. Two options are available for supplying these resources: FSLs in or near the theater of operations and CONUS support locations. An FSL can be a storage location for US war reserve materiel (WRM), repair location for selected avionics or engine maintenance action, transportation hub, or combination thereof. The exact capability of an FSL will be determined by the forces it will support and by risks and costs of positioning specific capabilities. The network of CSLs, FSLs, and FOLs needs to be coordinated to provide the resources necessary to meet operational goals.

The configuration of these components will depend on several elements, including local infrastructure and force protection, political aspects (for example, access to bases and resources), and how site locations may affect alliances. It is, therefore, important to consider tradeoffs between several competing objectives, such as time line, cost, deployment footprint, risk, flexibility, and sortie generation. Prepositioning everything at bases from which operations will be conducted minimizes the deployment airlift footprint and time line required to begin operations, but it also reduces flexibility, adds political and military risk, and incurs a substantial peacetime cost if several such bases must be prepared. Bringing support from the CONUS, on the other hand, increases flexibility and can reduce risk and peacetime cost for materiel. However, setting up support processes in this situation takes longer, and the deployment footprint is larger. FSLs provide a compromise between prepositioning at FOLs and deploying everything from CONUS. They have little effect on the time line for initial capability, but they do avoid the necessity of having a tanker air bridge for the extra strategic lift from CONUS. Further, the airlift that would have been used to deploy support equipment from the CONUS will be available for deploying additional combat units.

The global infrastructure and its network of operating and support locations are also dependent on an assured distribution system and a CSC2

Combat Support C2 Architecture: Supporting Expeditionary Airpower

This article and accompanying articles focus on the command and control (C2) framework required for effective CS execution planning and execution.

EAF Operational Need	CSC2 Requirements
Rapidly tailor force packages to achieve desired operational effects	Estimate CS requirements for suitable force package options; assess feasibility of alternative operational and support plans; create CS performance parameters necessary to achieve operational effects
Deploy rapidly	Determine FOL beddown capabilities for force packages and facilitate rapid TPFDD development
Employ quickly	Configure distribution network rapidly to meet employment time lines and resupply needs
Shift to sustainment smoothly	Execute resupply plans and monitor performance
Allocate scarce resources to where they are needed most	Determine impacts of allocating scarce resources to various combatant commanders and prioritize allocations to users
Adapt to changes quickly	Indicate when actual CS performance deviates from planned performance parameters and initiate and implement get-well plans

Table 1. CSC2 Functionality Required to Meet EAF Operational Goals

system to orchestrate every facet of FOL beddown and sustainment. If units must deploy with minimal support and depend on resupply from CSLs and FSLs, they will need to have an assured resupply link whose responsiveness is aligned with the support available at the FOL. The strategic infrastructure envisioned here also will require a more sophisticated CSC2 structure to coordinate support activities across the components of the network and phases of operations.[3] This article and accompanying articles focus on the command and control (C2) framework required for effective CS execution planning and execution.

Defining CSC2

To begin, a definition of CSC2 is needed. Joint and Air Force doctrine defines command and control as the exercise of authority and direction, by a properly designated commander over assigned and attached forces in the accomplishment of the mission.[4] Specifically, command and control includes the battlespace management process of planning, directing, coordinating, and controlling forces and operations. It involves integration of the systems, procedures, organizational structures, personnel, equipment, information, and communications designed to enable a commander to exercise command and control across a range of military operations.[5] The definition of an operational architecture encompasses many of the same elements. It is a description of tasks, operational elements, and information flows required to accomplish or support a Department of Defense function or military operation. In our study, we used these definitions, applied to Air Force CS activities, to identify and describe processes involved in CSC2 at each echelon and across the phases of operations.

Developing an Operational Architecture for CSC2

The objective of our analysis was to develop a set of concepts the Air Force can use to establish a CSC2 operational architecture capable of supporting the AEF. The analytic approach used in developing the TO-BE architecture is shown in Figure 1. The first step in this approach was to define expected CSC2 functionality. The objectives of CSC2 are dictated primarily by AEF operational needs summarized in Table 1, along with the CSC2 functionality required to meet them.

The objective of our analysis was to develop a set of concepts the Air Force can use to establish a CSC2 operational architecture capable of supporting the AEF.

Based on the desired CSC2 functional characteristics and analysis of the *AS-IS* architecture, we developed *TO-BE* concepts and an associated operational architecture. The *TO-BE* operational architecture is

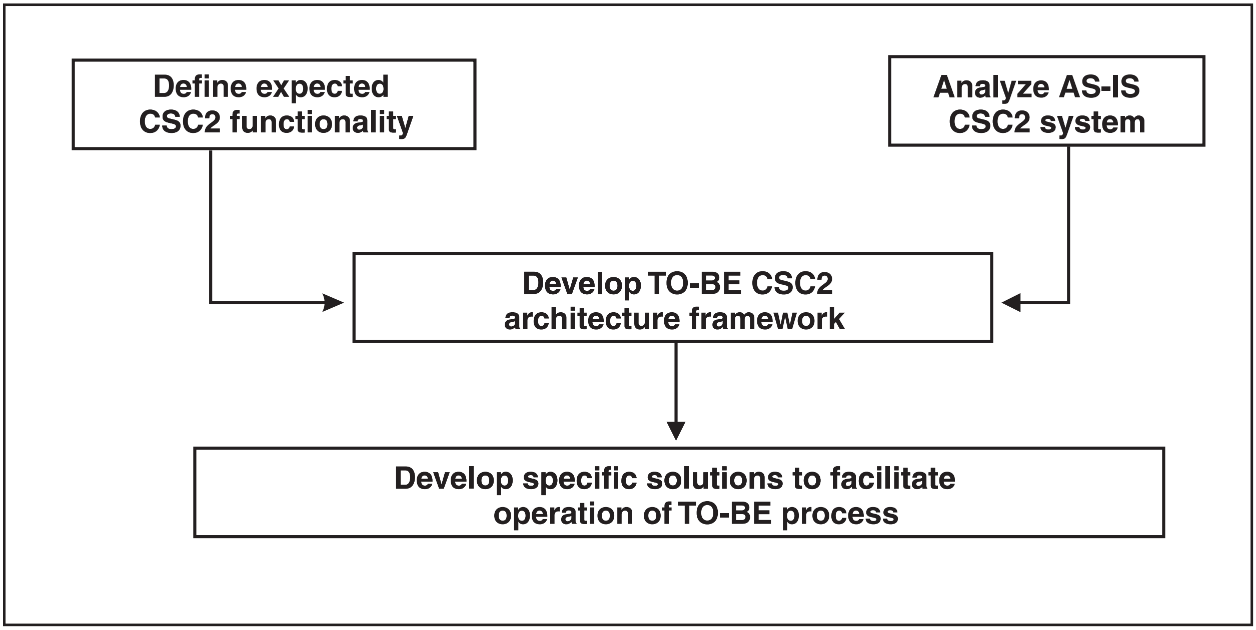


Figure 1. Analysis Approach

Our analysis of the Air Force CSC2 process revealed critical process *shortfalls in the* AS-IS *architecture.*

documented in a database containing process activities and tasks in a hierarchical structure. It also contains information required to perform the tasks and information source; products produced by each activity and recipient of the product; and finally, the identification of the organizational node responsible for performing the activities and tasks.

Our analysis of the Air Force CSC2 process revealed critical *process* shortfalls in the *AS-IS* architecture; these can be grouped into four categories:

- Poor integration of CS input into operational planning
- Absence of feedback loops and the ability to reconfigure the CS infrastructure dynamically
- Poor coordination of CS activities with the joint community
- Absence of resource allocation arbitration across competing theaters

In the report, we propose a *TO-BE* CSC2 system that would enable the Air Force to meet its operational goals by relying on proven process elements. The future architecture would:

- Enable the CS community to estimate requirements quickly for force package options, assess the feasibility of operational and support plans, and establish performance parameters needed to achieve desired operational effects;

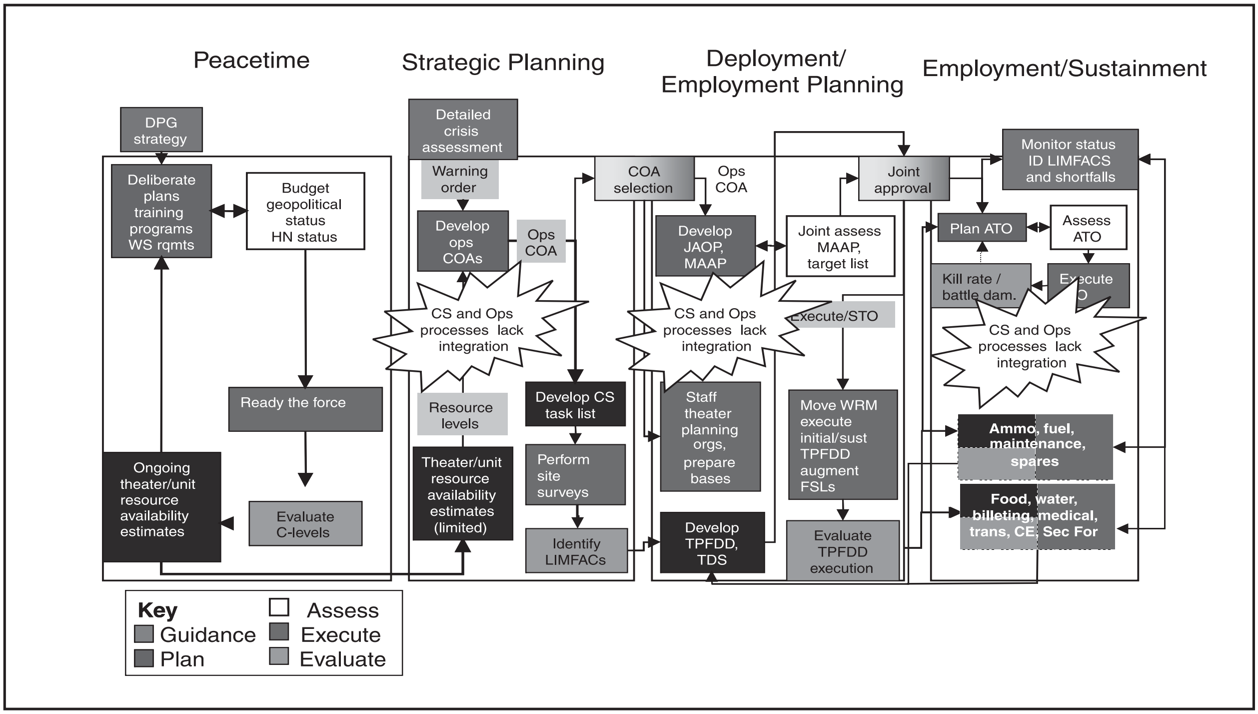


Figure 2. CS and Operations Process Integration Shortfalls

- Quickly determine beddown capabilities, facilitate rapid time-phased force and deployment data (TPFDD) development, and configure a distribution network to meet employment time lines and resupply needs;
- Facilitate execution resupply planning and monitor performance;
- Determine impacts of allocating scarce resources to various combatant commanders; and
- Indicate when CS performance deviates from the desired state and facilitate development and implementation of get-well plans.

Finally, the report offers recommendations to help transition the Air Force CS community from the current CSC2 architecture to the future concept. The recommendations are as follows:

- Clarify Air Force CSC2 doctrine and policy
- Evolve to standing CSC2 organizations
- Emphasize enhanced training for both operations and CS personnel on CSC2
- Enhance capabilities by fielding appropriate CSC2 information systems and decision support tools

The article by Major General Kevin Sullivan on page 6 provides details on implementation actions.[6]

Process Shortfalls

Poor Integration of CS Input into Operational Planning

The conventional roles of the operations and CS communities entail separate and relatively independent activities. Operational plans often are developed without adequate regard to CS feasibility.[7] Figure 2 identifies where some of these disconnects impact the planning and execution process. Early in the planning process, the strategy cell, consisting of A-3 and A-5 planners, is responsible for recommending courses of action to the Joint Forces Air Component Commander. CS personnel are then tasked with supporting the operational plans and must generate the appropriate resources to support a particular TPFDD or air tasking order. This serial approach can result in prolonged development of unsupportable plans, requiring major restructuring when CS factors are eventually brought to light. When attempts are made to incorporate CS input into operational planning, the traditional separation between these communities hinders effective integration. Most logisticians, for example, are not trained in and do not participate in air campaign planning and, therefore, may not have a full understanding of how and when CS considerations are used in the planning process.[8] In many of the CS functional areas, people are not equipped to communicate essential aspects of CS options in operationally understood metrics. As a result, information is not always provided to planners in operationally relevant terms; for example, forward operating location, initial operating capability, and sortie generation capability.[9] Furthermore, when plans are discovered to be unsupportable,

The conventional roles of the operations and CS communities entail separate and relatively independent activities. Operational plans often are developed without adequate regard to CS feasibility.

An additional hindrance to the incorporation of CS input into operational planning is a lack of capability assessments driven by the general shortage of up-to-date and reliable CS resource information.

CS personnel are generally not familiar enough with operational objectives to contribute to the development of alternative plans.

At the same time, operators lack CS training and, hence, tend not to consider the effect support capabilities have on the performance of planned missions. Part of planning effects-based operations must include the CS metrics that will enable them; for example, the sortie generation capability by day for each mission design series. When CS aspects of plans are overlooked, the importance of reliable information throughout the operational planning process is not valued. This delays plan development, slows the response to changing plans, and increases vulnerability to failure for want of adequate support.

An additional hindrance to the incorporation of CS input into operational planning is a lack of capability assessments driven by the general shortage of up-to-date and reliable CS resource information. Assessments may be available for some high-priority situations as a part of the deliberate planning process, but they are made for specific circumstances and, hence, are not conducted with a systematic methodology. Therefore, when information and assessments are needed quickly for nonstandard contingencies, the process is slow and ad hoc, with data requirements and organizational responsibilities being ambiguous and inconsistent. In other cases, assessment techniques may exist—for example, readinesss spares package assessment techniques—but information on the projected operations tempo may not be made available to supply analysts. There are no ready sources or a standing organization where this information can be found. One of the most commonly described shortcomings of the crisis action planning process is that operators have to make plans with insufficient and unreliable logistics data.[10] As a result, aspects of plans often are based on outdated information and assumptions with CS information requested piecemeal as it becomes necessary.

Absence of Feedback Loops and the Ability to Reconfigure the CS Infrastructure Dynamically

In the outlined *TO-BE* concept, CS and operations activities must be monitored continuously for changes in performance and regulated to avoid failures. This requires monitoring, assessment, and intervention capabilities more sophisticated than now employed. Currently, asset visibility is limited, and intransit visibility is incomplete.[11] Thus, it is difficult to estimate resource levels and arrival times. Rates of critical processes (component failure, repair, munitions buildup, cargo transportation, and civil engineering) are recorded sporadically. Even when these resource and process data are available, they are typically the focus of planning and deployment activities, but less so for employment and sustainment. Because operations can change suddenly, these data must be continuously available throughout operations in order to make adjustments. Currently, no process or organization exists to support this functionality.

When monitoring reveals a mismatch between desired and actual resource and process performance levels, the ability to assess the source of this discrepancy is often lacking. This is particularly true for activities acting across multiple theaters, such as depot repair, or multiple services, such as a theater distribution system. With limited monitoring and fault assessment, the ability to intervene and adjust CS activities in real time is limited.

Poor Coordination of CS Activities with the Joint/Allied/ Coalition Communities

Ultimately, most CS activities entail some degree of coordination among the services and with the joint community. Examples include fuels management, distribution and storage of munitions and housekeeping sets, and transportation. Nowhere is such coordination more important and troublesome than in transportation management. Inter- and intratheater transportation relies on the combined efforts of the regional combatant command and its service components, all of which maintain separate responsibilities and depend on each other for successful operation. Nominally, the Air Force is responsible for providing airlift, the Army is responsible for providing surface lift and port management, and the combatant commander manages theater distribution, through the appointment of one service component as the executive agent.[12]

Although, in principle, the transportation system can operate smoothly when all components are involved, troubles arise when the relative roles of the different contributors in an operation vary substantially. If the Air Force plays a much larger role than the Army, as it did in Operation Noble Anvil, distribution can suffer for lack of clearly defined responsibilities. Despite the mature infrastructure available in Europe, the transportation system during Noble Anvil was slow to start and relied on ad hoc solutions that bypassed standard procedures.[13]

This reflects a disconnect between AEF goals and Air Force efforts to implement them. While the Air Force has gone to great lengths to better tailor force packages and deploy them, it has focused largely on unit-based resources and activities and much less so on the equally important theater-based CS aspects. Effective combat support for the AEF relies on rapid and reliable transportation, and efforts must be implemented to establish theater distribution systems under all circumstances—taking full advantage of cooperation with the Army, joint community, and allied and coalition forces, when available, and having the ability to configure alternative systems in situations where these resources are not available.[14]

Just as CS needs and capabilities must be communicated to operations planners, so, too, must they be communicated with other service, joint, and allied or coalition forces. In considering intratheater movement, the Air Force must be capable of determining transportation requirements based on anticipated sortie production goals and understand in what form those requirements should be communicated to the agency responsible for the theater distribution system.

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The current process does not include activities and procedures for formally allocating scarce resources across competing demands. To meet increasing support needs in a theater preparing for or engaged in a contingency, resources reserved for use in other regions often must be diverted.

Similarly, CS personnel should clearly define base capability information needed to conduct beddown assessment and be prepared to provide those requirements to coalition or allied forces that may host Air Force forces in a contingency. Such communications with allied and coalition forces could accelerate the site survey and beddown planning activities during the time-critical crisis action planning process.

Absence of Resource Allocation Arbitration Across Competing Theaters

The current process does not include activities and procedures for formally allocating scarce resources across competing demands. To meet increasing support needs in a theater preparing for or engaged in a contingency, resources reserved for use in other regions often must be diverted. However, the capability to assess quickly the impact to readiness, from a global perspective, of moving resources from one theater to another does not exist. For example, the Ammunition Control Point at Hill AFB, Utah, controls the global prepositioning and movement of munitions. However, there are no processes or automated decision tools in place that can provide an operational impact assessment based on the losing theater's operational requirements outlined in its operations plan.[15] While the Execution and Prioritization of Repair Support System has algorithms that can distribute spares from repair depots to different regions based on maximizing aircraft availability, current contingency operations tempo data may not be updated on a timely basis, which could affect allocation decisions. Joint Chiefs of Staff (JCS) project codes, which determine priority for spares distribution, are established to help move highest priority cargo more

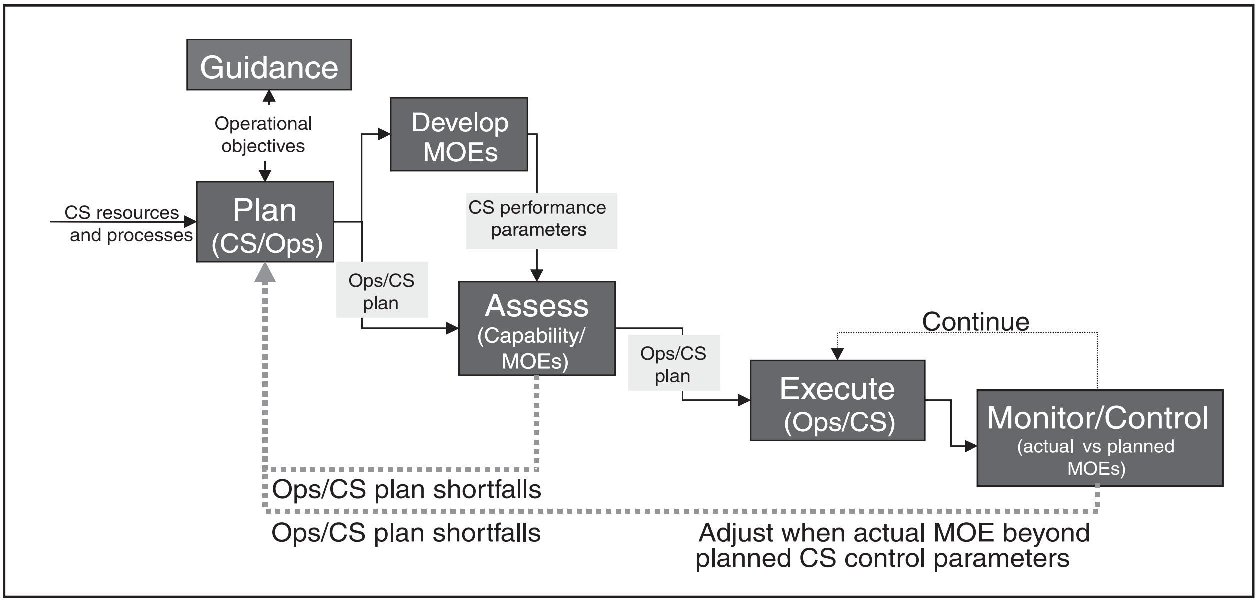

Figure 3. CSC2 *TO-BE* Concept

quickly. However, most important cargo for the contingency carries these designators, and thus, the priority system reverts to a first-in first-out system. This can be particularly detrimental when high-demand, low-density spares are considered. While the Centralized Intermediate Repair Facility (CIRF) concept[16] has great potential for more effectively managing constrained resources, it is important to note that no formal process or tools exist to prioritize the repair sequence and allocation of these assets from a global perspective. Other commodities lack even a central authority for resource allocation. In this instance, competing resource issues are resolved in an ad hoc fashion that eventually must be settled at the JCS level.

CSC2 Concept for the Future—The *TO-BE* Concept

The High-Level CSC2 Process Template

The *TO-BE* concept integrates operational and CS planning in a closed-loop environment, providing feedback on performance and resources.[17] Figure 3 illustrates the elements of these concepts in a process template, which can be applied through all phases of an operation, from readiness through deployment, employment, and sustainment, as well as redeployment and reconstitution. It centers on integrated operations and CS planning and incorporates activities for continually monitoring performance and dynamically making adjustments.

The TO-BE concept integrates operational and CS planning in a closed-loop environment, providing feedback on performance and resources.

Some elements of the process, on the left side of Figure 3, are accomplished in planning for operations. The process centers on integrated operations and CS planning and incorporates activities for continually monitoring and adjusting performance. A key element of planning and execution in the process template is the feedback loop that determines how well the system is expected to perform (during planning) by developing and monitoring measures of effectiveness or is performing (during execution) and warns of potential system failure. It is this feedback loop that tells CS planners to act when the CS plan and infrastructure should be reconfigured to meet dynamic operational requirements, during both planning and execution. The CS organizations will need to be flexible and adaptive to make changes in execution in a timely manner.

The feedback loop not only drives changes in the CS plan but also might call for a shift in the operational plan. For the CS system to provide timely fee3dback to the operators, it must be tightly coupled with their planning and execution processes and systems and provide options that will result in the same effects yet cost less in CS terms. Feedback might include notification of missions that cannot be performed because of CS limitations.

Integrating the CSC2 Process Across All Phases of Operational Planning

The planning activities reflected in Figure 3 occur across the spectrum of operations, as illustrated in the mid-level *TO-BE* processes shown in

Combat Support C2 Architecture: Supporting Expeditionary Airpower

From readiness through redeployment and reconstitution, the core process remains the same, but individual information flows vary, and plans and assessments become more refined through each phase.

Figure 4.[18] During day-to-day operations, planning supports programmed flying hours to achieve training objectives and prepare for combat. Planning products are flying schedules and air campaign plans for the operators. Similar products for CS personnel would include such products as depot maintenance repair plans, spares allocation plans, and WRM distribution to support the flying program and air campaign plans. On the installation support side, planning products center on infrastructure operation and maintenance, utility operations, and personnel service activities like lodging, dining, and mortuary affairs. During wartime or contingency operations, combat execution is prepared in the crisis action planning process, with similar products and plans produced in a time-compressed environment. For both peacetime and wartime planning, the focus of combat support should be production of installation support and sorties.

From readiness through redeployment and reconstitution, the core process remains the same, but individual information flows vary, and plans and assessments become more refined through each phase. For example, theater and unit capability assessments are performed constantly, beginning in peacetime. The assessment results feed the budgeting and planning processes that allocate funds to programs and redistribute other resources as required for the Air Force to fulfill its Defense Planning Guidance responsibilities. In this example, the assessment results are at a global level and will be used to make strategic resourcing decisions. As a world situation develops, the relationship between CS and operations

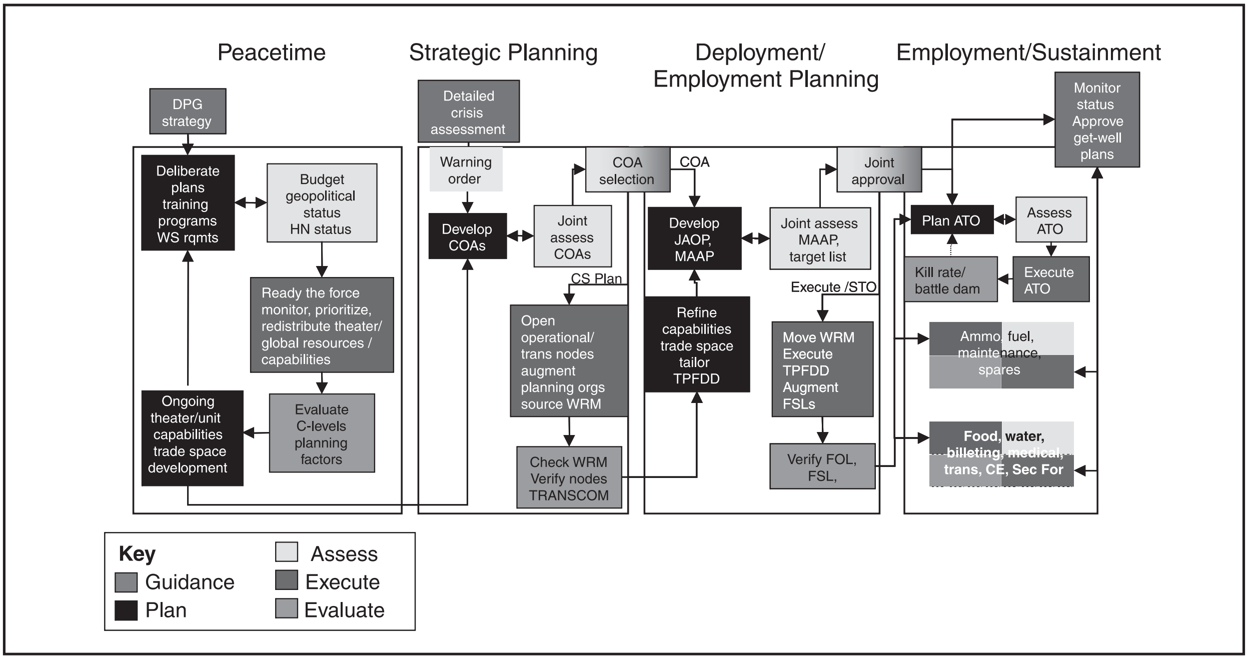

Figure 4. Midlevel Detail of *TO-BE* Process

capabilities feeds into the crisis action planning process and contributes to the development of a suitable course of action. Based on new information (for example, refined operations requirements, known threats, better known theater capabilities), assessments are reaccomplished, the CS plan is refined, and infrastructure configured as necessary to support new courses of action. As a result of the course of action and these CS configuration actions, the relationship of CS capabilities to operations capabilities is again refined to feed into the development of the joint air operations plan; master air attack plan; and eventually, air tasking order. The assessment capabilities and feedback loop enable the iterative planning with operations. This process continues into employment and sustainment and can be observed for the other blocks in the planning and execution process.

Recommendations to Meet the Future State

The *TO-BE* concept presents CSC2 process elements designed around the needs of the AEF: operationally relevant, rapid, and responsive. To improve the existing process performance and achieve process changes necessary to implement the *TO-BE* CSC2 concept, fundamental modifications to several *enabling mechanisms*—including doctrine and policy, organizational responsibilities, information systems, and training and education—must be made. Some of the specific implementation actions are outlined in "CSC2 Architecture: Supporting Expeditionary Airpower," in this publication.

The TO-BE concept presents CSC2 process elements designed around the needs of the AEF: operationally relevant, rapid, and responsive. To improve the existing process performance and achieve process changes necessary to implement the TO-BE CSC2 concept, fundamental modifications to several enabling mechanisms—including doctrine and policy, organizational responsibilities, information systems, and training and education—must be made.

Notes

1. James A. Leftwich, et al*, Supporting Expeditionary Aerospace Fores: An Operational Architecture for Combat Support Execution Planning and Contro*l, RAND, MR-1536-AF, Santa Monica, California, 2002.
2. Research at RAND has focused on defining the vision and evaluating options for an ACS system that can meet AEF operational goals. See Galway, et al*, Supporting Expeditionary Aerospace Forces: New Agile Combat Support Posture*s, RAND, MR-1075-AF, Santa Monica, California, 2000. Additional research has identified the importance of CSC2 within the AEF ACS system. See Tripp, et al*, Supporting Expeditionary Aerospace Forces: An Integrated Strategic Agile Combat Support Planning Framework*, RAND, MR-1056-AF, Santa Monica, California, 1999.
3. The phases of operations include peacetime operations and readiness preparation, deployment, employment and sustainment, redeployment, and reconstitution.
4. Joint Pub 1-02, *DoD Dictionary of Military and Associated Terms*, 12 Apr 01.
5. Air Force Doctrine Document 1, *Air Force Basic Doctrine*, 1 Sep 97.
6. See Maj Gen Sullivan's article in this publication.
7. Col Ed Groeninger, PACAF 502/CC, 8 Mar 01.
8. Lt Col Stephen Luxion, HQ CENTAF A3/A5, 9 Feb 01; Van Hazel, Seventh Air Force operations analyst, 10 Dec 01; Maj Parker Northrup, Seventh Air Force Air Operations Group, 10 Dec 01; Maj Steen, PACAF/XPXX, 17 Dec 01; Lt Col Levault, Thirteenth Air Force A3/5, 13 Dec 01.
9. Luxion, et al. In some CS areas, such as those dealing with supply of spare parts, the community has been able to express how a lack of spares impacts weapon system availability or engine and pod availability. This community also can assess how spares availability may impact projected weapon system availability.

10. Luxion, et al, and Joint Expeditionary Forces Experiment 99 and 00 final reports.
11. Regional supply squadrons (RSS) have visibility of spares, with the exception of bench stock, of all units deployed to their area of responsibility (AOR). There are seams, however, in this visibility. As an example, consider a bomber island, Diego Garcia, located in the PACAF AOR but supporting CENTAF operations. The PACAF RSS had visibility of tankers deployed to Diego Garcia but not bombers deployed from ACC. Thus, two reachback systems were used. Furthermore, the status and condition of support equipment held as war reserve materiel at an FOL is not as well known.
12. Joint doctrine specifies that the component with the preponderance of force may be delegated the responsibility for developing and managing the theater distribution system (TDS). In Enduring Freedom, the Air Force was formally delegated TDS responsibility. It long has been the assumption that the Army would have responsibility for TDS, but joint doctrine allows the combatant commander to delegate this responsibility as outlined above. There are current efforts underway to allow the Defense Logistics Agency to assume executive agent responsibility for establishing end-to-end distribution responsibilities for medical, construction, fuels, and subsistence commodities. Other options would call for USTRANSCOM to assume end-to-end distribution responsibilities. This is an area that requires a great deal of attention because of the Air Force's reliance on rapid resupply.
13. Feinberg, et al, *Supporting Expeditionary Aerospace Forces: Lessons from the Air War Over Serbia*, RAND, MR-1263-AF, Santa Monica, California, 2002.
14. USAFE has created a theater distribution management center in cooperation with EUCOM to expedite shipments to end users through USAFE APODs.
15. Lt Col Carl Puntureri, JCS/J4 Munitions and NBC Defense Equipment, 23 Feb 01.
16. Robert S. Tripp, et al, *Supporting Expeditionary Aerospace Forces: An Integrated Strategic Agile Combat Support Planning Framework*, RAND, MR-1056-AF, Santa Monica, California, 1999.
17. Elements of these concepts were described in the Air Force C2 CONOPs, Vol III, and the AFMC C2 CONOPS, as well as Pyles and Tripp, *Measuring and Managing Readiness: The Concept and Design of the Combat Support Capability Management System*, RAND, N-1840-AF, Santa Monica, California, 1982.
18. More details can be found in Leftwich, et al.

Notable Quotes

Martin van Crevald, *Technology and War*

…technology and war operate on a logic which is not only different but actually opposed, nothing is less conducive to victory in war than to wage it on technological principles—an approach which, in the name of operations research, systems analysis or, cost/benefit calculation (or obtaining the greatest bang for the buck), treats war merely as an extension of technology. This is not to say . . . that a country that wishes to retain its military power can in any way afford to neglect technology and the methods that are most appropriate for thinking about it. It does mean, however, that the problem of making technology serve the goals of war is more complex than it is commonly thought to be. The key is that efficiency, far from being simply conducive to effectiveness, can act as the opposite. Hence—and this is a point which cannot be overemphasized—the successful use of technology in war very often means that there is a price to be paid in terms of deliberately *diminishing* efficiency.

Since technology and war operate on a logic, which is not only different but actually opposed, the very concept of "technological superiority" is somewhat misleading when applied in the context of war. It is not the technical sophistication of the Swiss pike that defeated the Burgundian knights, but rather the way it meshed with the weapons used by the knights at Laupen, Sempach, and Granson. It was not the intrinsic superiority of the longbow that won the Battle of Crécy, but rather the way which it interacted with the equipment employed by the French on that day and at that place. Using technology to acquire greater range, firepower, greater mobility, greater protection, greater whatever, is very important and may be critical. Ultimately, however, it is less critical and less important than achieving a close *fit* between one's own technology and that which is fielded by the enemy. The best tactics, it is said, are the so-called *Flaechenund Luecken* (solids and gaps) methods which, although they received their current name from the Germans, are as old as history and are based on bypassing the enemy's strengths while exploiting the weaknesses in between. Similarly, the best military technology is not that which is "superior" in some absolute sense. Rather, it is that which "masks" or neutralizes the other side's strengths, even as it exploits his weaknesses.

The common habit of referring to technology in terms of its capabilities may, when applied within the context of war, do more harm than good. This is not to deny the very great importance of the things that technology can do in war. However, when everything is said and done, those which it cannot do are probably even more important. Here, we must seek victory, and here it will take place—although not necessarily in our favor—even when we do not. A good analogy is a pair of cogwheels, where achieving a perfect fit depends not merely on the shape of the teeth but also, and to an equal extent, on that of the spaces which separate them.

In sum, since technology and war operate on a logic which is not only different but actually opposed, the conceptual framework that is useful, even vital, for dealing with the one should not be allowed to interfere with the other. In an age when military budgets, military attitudes, and what passes for military thought often seem centered on technological considerations and even obsessed by them, this distinction is of vital importance. In the words of a famous Hebrew proverb: The deed accomplishes, what thought began.

Robert S. Tripp, RAND
C. Robert Roll, Jr, RAND
Major Cauley von Hoffman, AFLMA

Transitioning from the *AS-IS* to the *TO-BE* CSC2 system requires changes to current doctrine and policy. Both doctrine and policy should emphasize the importance of the CSC2 role; describe the basic objectives, functions, and activities of a CSC2 system; and define organizations to perform these functions and activities.

Combat Support C2 Nodes

Major Responsibilities

Introduction

We have presented a *TO-BE* combat support command and control (CSC2) operational architecture[1] that would help the Air Force meet its air and space expeditionary force (AEF) operational goals. The future architecture would:

- Enable the combat support (CS) community to quickly estimate requirements for force package options needed to achieve desired operational effects and assess the feasibility of operational and support plans;

To help the Air Force CS community transition from the current CSC2 operational architecture to the future concept, we identified several actions that should be taken. Because these changes are significant and will require time to implement, the Air Force will use the joint doctrine, organization, training and education, materiel, leadership, and personnel (DOTMLP) process to evaluate and incrementally implement required changes.

- Quickly determine beddown capabilities, facilitate rapid time-phased force deployment data (TPFDD) development, and configure a distribution network to meet employment time lines and resupply needs;
- Facilitate execution resupply planning and performance monitoring;
- Determine impacts of allocating scarce resources to various combatant commanders; and
- Indicate when CS performance deviates from the desired state and implement replanning and get-well planning analysis.

To help the Air Force CS community transition from the current CSC2 operational architecture to the future concept, we identified several actions that should be taken. Because these changes are significant and will require time to implement, the Air Force will use the joint doctrine, organization, training and education, materiel, leadership, and personnel (DOTMLP) process to evaluate and incrementally implement required changes. Furthermore, the Air Force has created a change agent at the Air Staff, in the Logistics Readiness Directorate, to oversee these changes. This change agent will work with the Agile Combat Support (ACS) Colonels Advisory Group to develop and coordinate changes across all CS functional areas.[2] Some of the major changes include the following:

- Summarizing and clarifying Air Force doctrine and policy. The objectives and functions of CSC2 must be recognized and codified in doctrine. The functions of concurrent development of plans among operators and CS personnel, assessment of plan feasibility, use of feedback loops to monitor CS performance against plans, and development of get-well planning need to be articulated and understood.
- Creating standing CSC2 organizations. The Air Force has been supporting one contingency after another for the last decade. The area of responsibility (AOR) shifts from time to time, as does the operations tempo in various areas of responsibility, but there has been continuous deployment and employment of AEF packages during the last 12 years. Standing organizations are needed to conduct CSC2 functions and reduce turbulence and transition issues associated with transitioning from supporting one contingency to reshaping support processes to meet the needs of future contingencies.
- Training both operations and CS personnel on each other's roles. Understanding each other's responsibilities and methods can facilitate incorporation of both aspects into operational plans.
- Fielding appropriate information systems and decision support tools. Improved information and decision support tools are needed to translate

CS resource levels and process performances into operational capabilities or effects to improve operational understanding of CS constraints or enabling characteristics for any given operational planning option.

In this article, we primarily address the second area in the actions needed above, creating standing CSC2 organizations. Again, we emphasize that organizational development activities are only one of the DOTMLP areas that need to be addressed to achieve comprehensive improvements in linking ACS capabilities to operational effects through CSC2.

CSC2 Nodes and Responsibilities

In the TO-BE architecture, we establish a CSC2 nodal template with clearly defined responsibilities for each CSC2 node. Table 1 shows some of the important CSC2 nodes and their associated roles and responsibilities.

This nodal template is a key element of the *TO-BE* CSC2 operational architecture. The template can ease the transition to a wartime structure. Specific organizations can be designated to fulfill the responsibilities of each node. The template allows for variations in organization assignments by theater and may even serve as a guide for configuring the C2 infrastructure, while retaining standard responsibilities. Along with the template, having standing CSC2 nodes that operate in both peacetime and wartime also can ease the transition from daily to higher intensity operations and allow the Air Force to train the way it intends to fight.

The need for standing CSC2 organizations is driven by the AEF environment. In responding to threats globally, AEF CS resources may need to be allocated from one theater to another to make the best use of available resources. Currently, some resources are primarily confined to individual theaters and are managed by theater-based organizations. These include theater-based munitions and war reserve materiel, intratheater distribution resources, and physical and operational infrastructures. For a large number of resources, this arrangement still may prove effective, but the ability to relocate and allocate these resources to other areas of responsibility needs to be streamlined. Other CS resources currently are managed by units; however, with the advent of the centralized intermediate repair facility and to deal with allocating scarce resources, there may be a need to manage these resources more centrally and from a global perspective. Examples of scarce resources that may need to be managed centrally include spare parts, fuel, munitions, aerospace ground equipment, fuels mission support equipment, and consumables, as well as maintenance and intertheater distribution resources.

Combat Support C2 Nodes: Major Responsibilites

CSC2 Nodes	Roles/Responsibility
Joint Staff	
Logistics Readiness Center	Supply/demand arbitration across combatant commanders
Combatant Commander	
Combatant Commander Logistics Readiness Center	Combatant commander logistics guidance and course of action analysis
Joint Movement Center	Combatant commander transportation supply/demand arbitration
Joint Petroleum Office	Combatant commander POL supply/demand arbitration
Joint Facilities Utilization Board	Combatant commander facilities/real estate supply/demand arbitration
Joint Materiel Priorities and Allocation Board	Combatant commander materiel supply/demand arbitration
JTF	
JTF J-4 and Logistics Readiness Center	JTF logistics guidance Supply/demand arbitration within JTF among service components
JFACC	
Joint Air Operations Center CS reps	JAOP/MAAP/ATO production support
JFACC Staff Logisticians	JFACC logistics guidance
Air Force	
Air Force Combat Support Center [1]	Monitor operations—execute C2 Represent Air Force CS interest to Joint Staff Conduct/review integrated weapon system and base operating support assessments Arbitrate critical resource supply/demand shortages across AFFORs
AFFOR	
Air operations center CS element	JAOP/MAAP/ATO production support
AFFOR A-4 Staff (forward)	Site surveys/beddown planning Liaison with AOC CS element
AFFOR A-4 staff (rearward) at an operations support center [2] that supports AFFOR A-4 staff forward	Mission/sortie capability assessments Beddown/infrastructure assessment AETF force structure support requirements Supply/demand arbitration within AETF among AEFs/bases Theater distribution requirements planning Force closure analysis Liaison with Air Mobility Division in AOC Liaison with theater TRANSCOM node
Deployed Units	
Wing operations center	Disseminate unit tasking Report unit status
Combat Support Center	Monitor and report performance and inventory status
Supporting Commands (Force and Sustainment Providers)	
Logistics Readiness Center/Combat Support Center	Monitor unit deployments Allocate resources to resolve deploying unit shortfalls
Deploying Units	
Wing operations center	Report unit status Disseminate unit tasking
Deployment control center	Plan and execute wing deployment Report status of deployment
Commodity Control Points [3]	
Munitions, spares, POL, bare base equipment, rations, medical materiel, etc	Monitor resource levels Perform depot/contractor capability assessments Work with the GIC to allocate resources in accordance with theater and global priorities
Sources of Supply (Depots, Commercial Suppliers, etc)	
Command centers	Monitor production performance and report capacity

1. Some of the functions performed by the Combat Support Center were associated with an organization referred to as the Global Integration Center (GIC) in MR-1536-AF. The Air Force will not use the GIC name in implementation efforts but rather associate GIC functions with the Combat Support Center.
2. The functions performed by the AFFOR A-4 need to be standardized. What a given AFFOR A-4 chooses to do forward and rear can be different for a given theater or region, depending on circumstances. The idea is to codify the responsibilities by COMAFFOR in each region before contingencies begin. Operational Support Center A4 could have virtual RSS representation at the operations support center. Many of the spares-related C2 functions could be conducted at the RSS with Operational Support Center A4 input and coordination. The same is true for ammunition control points.
3. The commodity control point was referred to as a virtual inventory control point in the MR-1536-AF and in several transformation articles associated with the Spares Campaign and Depot Reengineering and Transformation. The Air Force had decided to replace the virtual inventory control point with commodity control point.

Table 1. *TO-BE* CSC2 Nodes and Responsibilities

Regardless of how CS resources are managed, CS resource assessments and allocation management tasks and responsibilities should be assigned to permanent organizational nodes dedicated to resource monitoring, prioritization, and reconfiguration. Additionally, having a standing integration function for all CS resource management will facilitate the incorporation of relevant resource data into capability assessments and raise the visibility and importance of these assessments in the eyes of the operational community.

In the past, organizational structures were established and responsibilities assigned at the start of a conflict. Responding to continual threats globally places new demands on CSC2. First, the rate of continuing operations is such that organizations seldom desist after supporting a contingency operation; instead, they transfer focus from one conflict to another. Second, CS resources are consumed continually and reconstituted from one contingency only to be used immediately by the next. Many times, demands outpace supply, driving reallocation of resources from one theater to another in order to meet the most urgent demand. As discussed, the ability to relocate and allocate these resources across and among areas of responsibility needs to be streamlined, and an arbitration function must be accomplished. To accomplish an arbitration function, CS resource assessments and allocation management tasks need to be assigned to permanent organizational nodes dedicated to resource monitoring, prioritization, and reconfiguration. An integration function for all CS resource management will facilitate the incorporation of relevant resource data into capability assessments and raise the visibility and importance of these assessments in the eyes of the operational community.

In the remainder of this article, we address three *new* standing organizations and their roles in the TO-BE CSC2 operational architecture: the operations suppo3 CS center.

The Operations Support Center

Integral to implementation of the CSC2 operational architecture is the evolution of operations support centers. Operations support centers will provide air component commanders theater-wide, daily, situational awareness and command and control of air and space, intelligence, surveillance, and reconnaissance, information operations, mobility, combat, and support forces. The operations support center will have the capability to direct deliberate planning and crisis response actions to deploy and sustain forces across the spectrum of operations. Within the operations support center, the A-4 division will act as a regional hub for monitoring, prioritizing, and allocating theater-level CS resources and be responsible for mission support, base infrastructure support, and establishing movement requirements within the theater. The OSC A-4 will be the theater integrator for commodities managed by commodity control points discussed below. To be effective, it must have complete visibility of theater resources and authority to reconfigure these resources. It should

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Combat Support C2 Nodes: Major Responsibilites

Commodity control points should be responsible for the management of supplying needed resources to the MAJCOMs and deployed forces. This is essential for management and distribution of critical resources.

have the capability to receive commodity-specific information from commodity inventory managers and perform integrated capability assessments, both sortie production and base, and report those capabilities to the CS personnel supporting air campaign plan, master air attack plan(MAAP), and air tasking order (ATO) production in the air operations center. In this role, it will make resource allocation decisions when there are competing demands for resources within the theater. In the spares area, the Air Force has made progress in establishing some of these capabilities in the regional supply squadrons. The C2 features of the regional supply squadrons can be accessed *virtually* by the Commander, Air Force Forces (COMAFFOR) A4 within the operations support center. Similarly, in the ammunition area, the theater ammunition control points can provide virtual assessment capabilities to the COMAFFOR A4. As prescribed in Air Force Doctrine Document (AFDD) 2-8, the OSC A-4 could perform these reachback functions.[3] It could be devoted to incorporating mission, base infrastructure, and movement capability assessments into operational plans and support the deployed AFFOR A-4 staff during a contingency, minimizing the number of personnel required to deploy forward. It would also alleviate problems associated with an undermanned numbered air force staff currently trying to perform the functions listed above, as well as their roles under the unified command structure. One example of an operations support center has already been established in the United States Air Forces in Europe (USAFE), the USAFE Theater Air Support Center. Another one has been established in the Pacific Air Forces (PACAF), the PACAF Operations Support Center.

Operations support centers would have all A-staff positions, including A-1, 2, 3, 4, 5, 6, and 7 if civil engineering is split out from the A-4. This organization could concentrate on day-to-day execution activities within a major command (MAJCOM) area of responsibility, when not engaged in contingency operations. The MAJCOM staff could concentrate on organizing, training, and equipping headquarters functions. The operations support center could be led by an air operations group (AOG) or squadron commander with the A-3/5 assuming the AOG responsibilities. If the peacetime workload is too small to keep the operation support center active, codification and training become even more important.

Commodity Control Point and Combat Support Center

Commodity control points should be responsible for the management of supplying needed resources to the MAJCOMs and deployed forces. This is essential for management and distribution of critical resources. For example, spares management should be accomplished, along weapon system lines, by a commodity control point at Air Force Materiel Command (AFMC). This standing C2 node at AFMC would operate spares management along the continuum of operations, having immediate access to both the data and analytical tools needed to exercise capability assessments and manage distribution of resources to MAJCOMs and theaters. The commodity control points will take guidance from the operations support centers and, when required, take direction from the Air Force Combat Support Center—a neutral integrator for arbitrating resource allocations among competing areas of responsibility and COMAFFORs. The spares commodity control point would be responsible for monitoring resource inventory levels, locations, and movement information and, using these data to assess contractor and depot capabilities, meet throughput requirements. The Combat Support Center, located at the Pentagon, would use weapon system operational capability assessments and coordinate with the joint community and theater operations support centers to prioritize and allocate resources in accordance with theater and global priorities. These integrated assessments will support allocation decisions when multiple theaters are competing for the same resources and can serve as the Air Force voice to the Joint Staff when arbitration across services is required. In light of the global nature of AEFs and worldwide commitments, other commodities should be considered for management in the same manner.

At both the operations support centers and the Combat Support Center, individual resource prioritization will be guided by a common set of rules: given a required operational capability, the operations support centers will manage the CS resources to meet their area of responsibility needs. When there are multiple ways to achieve the same goals, this will be considered in resource prioritization. Resources then will be assessed and allocated to meet the operational capability requirements set at higher levels (for example, the Joint Chiefs of Staff and Combat Support Center). These resources thus will be allocated according to the need for an overall level of operational capability, rather than on an individual commodity basis.

Based on these assessments and allocations, the commodity control points (within authorized parameters) will direct purchases, repair operations, and distribution of components and spares and will assess the capability to meet combatant commanders' requirements. Theater operations support centers will advise of infrastructure capabilities, needed resources to implement plans, and the consequences of not improving capabilities. Then the theater joint command can prioritize needs and advise the joint staff and others of theater capabilities and issues. Ongoing capability assessments generated by the Combat Support Center and operations support centers will be incorporated into a theater's operational planning processes executed by CS liaisons in the air operations center.

Although these responsibilities can be performed by different organizations in different theaters, the grouping of the tasks, information required to complete them, and products resulting from each task should not change from one theater to the next. Predefining the organizations to perform each task will ensure ownership of tasks; clear lines of communication; and thus, a smoother transition as the level of operations expands and contracts.

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Combat Support C2 Nodes: Major Responsibilites

CSC2 organizations should operate within the time-tested rules of centralized planning and decentralized execution.

In the Air Force implementation plan, the Air Force has begun to expand guiding principles describing the C2 of combat support and is placing these principles in its doctrine. The Air Force has initiated a review of current processes and started revisions to integrate CS planning with operations planning, consequently, enhancing contingency planning. These revisions and enhancements to doctrine and processes will facilitate the allocation of resources according to required capabilities and ensure closed-loop planning and execution functions are created, which will enable better informed plans.

Centralized Planning with Decentralized Execution within Approved Thresholds

It should be emphasized that these CSC2 organizations should operate within the time-tested rules of centralized planning and decentralized execution that long has been associated with planning and executing air and space operations. Table 2 provides an example, using ammunition, of how CSC2 triggers would elevate decisions to the appropriate decision authority once *planned resource levels* have been breached. The table shows the CSC2 decision level, decision authority for that level, decision elevation trigger or tripwire that would cause a decision to be elevated, and decision authority that would be notified if a breach of decision authority should occur. As shown in the top row of the table, the ammunition control point within a theater, a component (virtual most likely) of the COMAFFOR A-4 staff in the operations support center, has the authority to distribute munitions to COMAFFORs within its area of responsibility up to the level that has been established in the AOR support plan and been approved in the program objective memorandum process. When demands from one COMAFFOR exceeds the plan for that COMAFFOR but is within the allocation amount for the area of responsibility, the ammunition initial control point in the area of responsibility needs to elevate the request to the operations support center. The operations support center can reallocate resources within the area of responsibility to satisfy the COMAFFOR that needed the resource. The operations support center would notify the Combat Support Center that this was about to take place. If the area of responsibility needed more

Decision Level	Decision Authority	Decision Elevation Trigger	Elevation Level
Ammo commodity control point	Allocate munitions to an AFFOR in accordance with established priorities to meet planned requirements	Threshold breach driven by demand from multiple AFFORs within single theater	Operations support center
Operations support center	Munitions allocations within single theater	Threshold breach driven by demand from multiple AFFORs from different theaters	Combat Support Center in consultation and coordination with Operations
Combat Support Center	Munitions allocations to AFFORs in different theaters	Resource competition resulting in capability degradation of one theater versus another theater	Joint Chiefs of Staff and Secretary of Defense

Table 2. CSC2 Nodal Authority and Decision Elevation Triggers

resources than it had, the operations support center, as directed by the designated commander, would elevate the request to the Combat Support Center for decision. This may mean that the Combat Support Center, if directed by Air Force Deputy Chief of Staff, Installations and Logistics, as the designated representative of the Chief of Staff of the Air Force for CS resources, may request additional funding to support the requirement. On the other hand, the Deputy Chief of Staff, Installations and Logistics may direct reallocation of resources from other areas of responsibility to meet the needs of this area of responsibility. These decisions would be supported by financial and weapon system support assessments.

By using this set of decision elevation triggers, daily execution activities can be carried out by the lowest organizational level closest to the operation without undue centralized interference. The rules also provide clear lines of responsibilities and signal when higher authority needs to be involved.

Advantages of the New Standing CSC2 Organizations and Rule Sets

This organizational structure offers three important strengths. First, it enables prioritization and allocation based on operational capability assessments. Capabilities are, therefore, estimated in the context of theater and global priorities, and resources are allocated accordingly. This enables a more informed distribution of CS capabilities, allows the movement of resources before requests are made, and reduces the distress of filling emergency requests. The second strength is that this structure considers the complete spectrum of CS resources. Each resource influences operational capability in some way and, hence, must be prioritized and allocated in conjunction with the others. By centralizing CS capability assessments, capability becomes a commodity, which can be managed like any other, with a single set of decisionmakers. While this management is ultimately broken down into the movement of individual resources, these resources are not managed individually but rather in an integrated manner. The third strength is that by establishing nodes to perform designated tasks this structure is a consistent framework for decisionmaking throughout all phases of operations. Because the standing nodes are devoted to the monitoring, prioritization, and reconfiguration of all CS resources, they are equally capable of addressing long-term weapon-system development considerations, peacetime training, or crisis action planning and execution.

Transitioning from the AS-IS to the TO-BE CSC2 system requires changes to current doctrine and policy. Both doctrine and policy should emphasize the importance of the CSC2 role; describe the basic objectives, functions, and activities of a CSC2 system; and define organizations to perform these functions and activities.

Although these responsibilities can be performed by different organizations in different theaters, the grouping of the tasks, information required to complete them, and products resulting from each task should not change from one theater to the next.

Predefining organizations to perform each task will enable a much smoother transition to war. It will provide a better defined communication network and better define the roles that each augmenter needs to train for. This will result in improved training programs and better trained personnel in wartime positions.

The AEF concept presents significant challenges to the current CS structure. To meet AEF stated objectives, the ACS community has undertaken the challenge of completely reexamining its current support system. Correcting deficiencies in the CSC2 architecture highlighted in this article and further developed in the full report is integral to the success of this effort.

Summary

Transitioning from the *AS-IS* to the *TO-BE* CSC2 system requires changes to current doctrine and policy. Both doctrine and policy should emphasize the importance of the CSC2 role; describe the basic objectives, functions, and activities of a CSC2 system; and define organizations to perform these functions and activities.

Once doctrine and policy describing the role of CSC2 is in place, current processes can be revised to integrate combat support and operations planning as well as combatant commander and joint planning, allocate resources according to required capabilities, and create a closed loop between planning and execution functions, which will enable better informed plans as a campaign continues.

Standing CSC2 organizations, with clear chains of communication between them and well-defined responsibilities, could better facilitate CS planning and execution processes. All changes to the *AS-IS* CSC2 system should be reinforced with training and exercises. Developing a CSC2 course curriculum and expanding the role of combat support in wargames and exercises will train the Air Force in the importance of combat support during a contingency. The changes described above also require different information flows and development of decision support tools, implemented on a robust information systems infrastructure. These tools should focus on execution planning and tradeoff analysis and perform functions such as the translation between operational and support metrics, global and theater capability assessments, and the efficiency with which CS processes are performed.

The AEF concept presents significant challenges to the current CS structure. To meet AEF stated objectives, the ACS community has undertaken the challenge of completely reexamining its current support system. Correcting deficiencies in the CSC2 architecture highlighted in this article and further developed in the full report is integral to the success of this effort.

Notes

1. James A. Leftwich, et al, *Supporting Expeditionary Aerospace Forces: An Operational Architecture for Combat Support Execution Planning and Control*, RAND, MR-1536-AF, Santa Monica, California, 2002.
2. The Air Force is implementing several of these actions. See Maj Gen Sullivan's article in this publication for more information on the specific implementation plan.
3. AFDD 2-8, Command and Control, 16 Feb 01, 31.

Group Captain David J. Foster, RAF, *Logistics on the Move*

- **The operations/logistics partnership is a target for our enemy—protect it.** We must try always to think of an enemy's looking for the decisive points in the partnership. What we want to make strong, they will try to weaken. Where we want agility, they will want to paralyse us. What we can do to our enemy, we can do to ourselves by lack of attention. So all concerned with operations and logistics must protect and care for the partnership and the things it needs for success. This includes stuff and information and people. Also, we must not forget the corollary is just as important: the operations/logistics partnership of the enemy is a target for us; we must attack it.
- **Think about the physics.** Stuff is heavy, and it fills space. Anything we want to do needs to take account of the weight that will have to be moved, over what distance, with what effort. Usually this all comes down to time, a delay between the idea and the act. If we think about the physics we can know the earliest time, we can finish any task and we can separate the possible from the impossible. It is crucial to determine the scope of the physical logistics task early in any planning process. Planners must know how long things take and why they take that long.
- **Think about what needs to be done and when—and tell everybody.** Once we have given instructions and the stuff is in the pipeline, it will fill that space until it emerges at the other end. The goal is to make sure that the stuff coming out of the pipe is exactly what is needed at that point in the operation. If it is not, then we have lost an opportunity—useless stuff is doubly useless, useless in itself and wasting space and effort and time. Moving useless stuff delays operations. Also, priority of order of arrival will change with conditions and with the nature of the force deploying. For example, the political need to show a presence quickly may lead a commander to take the risk of using the first air transport sorties to get aircraft turn-round crews and weapons into theatre before deploying all the force protection elements.
- **Think about defining useful packages of stuff.** Stuff is only useful when all the pieces to complete the jigsaw are assembled. Until the last piece arrives, there is nothing but something complicated with a hole in it. It is vital to know exactly what is needed to make a useful contribution to the operational goals and to manage effort to complete unfinished jigsaws, not simply to start more. Useful stuff often has a *sell-by* date. If it arrives too late, it has no value, and the effort expended has been wasted. The sell-by date must be clear to everyone who is helping build the jigsaw. And it is important to work on the right jigsaw first. In any operation, there is a need to relate stuff in the pipelines to joint operational goals, not to single-service or single-unit priorities. It is no good having all the tanks serviceable if the force cannot get enough aircraft armed and ready to provide air cover or ensuring that the bomber wing gets priority at the expense of its supporting aircraft.
- **Think about what has already been started.** The length of a pipeline is measured in time not distance. There will always be a lag in the system, and it is important to remember what has already been set up to happen later. Constantly changing instructions can waste a lot of energy just moving stuff around to no real purpose. Poorly conceived interventions driven by narrow understanding of local and transitory pain can generate instability and failure in the system.

Amanda Geller, RAND
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John G. Drew, RAND

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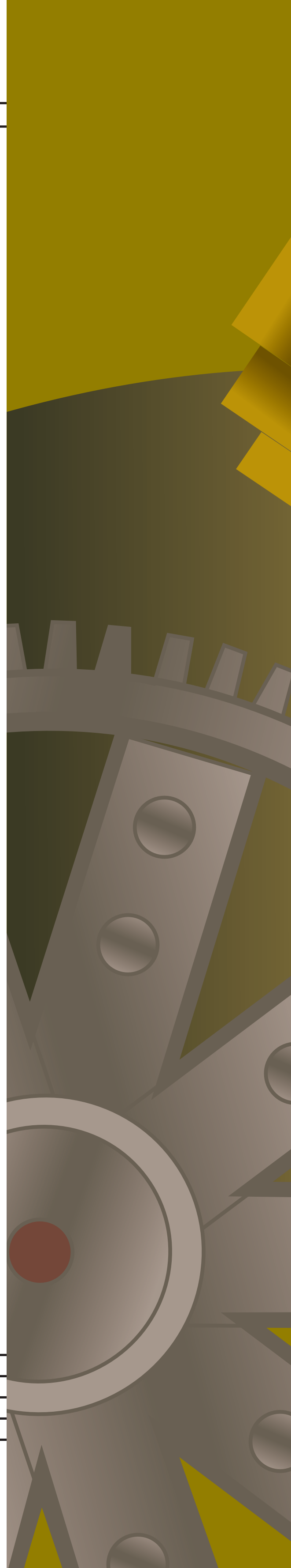
C2 in the CIRF Test: A Proof of Concept

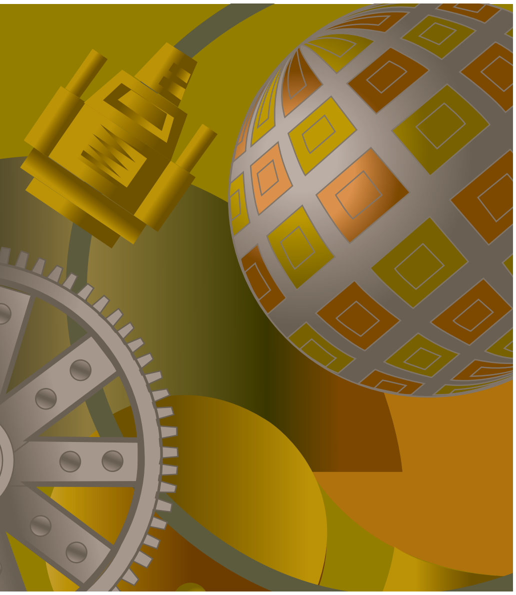
C2 To-Be Operational Architecture

Introduction

We have, in our reports,[1] described the elements of a global Agile Combat Support (ACS) network capable of enabling air and space expeditionary forces. The components of this global ACS network include:

- Forward operating locations (FOL) that can have differing levels of combat support (CS) resources to support a variety of employment time lines





The CSC2 system is a pivotal element of the expeditionary concept, as it is responsible for coordinating the other components of the CS network.

- Forward support locations (FSL) and continental United States (CONUS) support locations (CSL); that is, sites for storing heavy CS resources such as munitions or sites with back-shop maintenance capabilities such as jet engine intermediate maintenance (JEIM)
- A robust transportation system to connect the FOLs, FSLs, and CSLs
- A combat support command and control (CSC2) system that facilitates estimating support requirements, configuring the specific nodes of the system selected to support a given contingency, executing support activities, and measuring actual CS performance against planned performance, developing recourse plans when the system is not within control limits, and reacting swiftly to rapidly changing circumstances

A notional illustration of these components of the ACS network of the future is shown in Figure 1.

This article focuses on three components of the ACS network: the CSC2 system, maintenance FSLs, and the distribution system that connects the FSLs to the FOLs. Specifically, we discuss how a CSC2 system was implemented in a test of maintenance FSLs, more commonly known as centralized intermediate repair facilities (CIRF). The CSC2 system implemented during the CIRF test demonstrates the viability of the CSC2 process concepts outlined in the CSC2 TO-BE operational architecture.[2]

CSC2 Objectives

The CSC2 system is a pivotal element of the expeditionary concept, as it is responsible for coordinating the other components of the CS network. Joint and Air Force doctrine defines command and control (C2) as "the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission."[3] It includes the battlespace management process of planning, directing, coordinating, and controlling forces and operations. Command and control involves the integration of the systems, procedures, organizational structures, personnel, equipment, facilities, information and communications that enable a commander to exercise command and control across the range of military operations.[4]

Earlier RAND analysis further delineated required C2 capabilities, based on the support needs of expeditionary operations.[5]

- Generate support requirements based on desired operational effects.
- Provide support assessments quickly and continually and effectively communicate CS capabilities in terms of operational effects.
- Monitor resources in all theaters and allocate resources in accordance with global priorities.

- Be self-monitoring during execution and able to adjust to changes in either CS performance or operational objectives.

Testing CSC2 Concepts in Maintenance FSL Operations

From September 2001 to March 2002, the Air Force developed and tested several CSC2 capabilities associated with the operation of maintenance FSLs, referred to by the Air Force as CIRFs. CIRFs are centralized repair locations that provide intermediate repair capabilities for selected components; for example, engines, electronic warfare (EW) pods, and avionics components. Before describing the CIRF test parameters, we will present a brief background of the events that led to the test in fall 2001.

CIRF History

The concept of centralized intermediate maintenance is not a new one and has been implemented in various forms throughout the Air Force since the Korean conflict. Much of this history is documented in this publication, as well as in RAND report MR-1778-AF, RAND, 2003.[6]

RAND's involvement with CIRF began with the onset of the ACS concept in the late 1990s. There are numerous options for positioning resources and processes at FOLs, FSLs, and CSLs, and each option has differing effects on operational effectiveness and support efficiency. Several analyses have modeled the FOL, FSL, and CSL interactions for individual commodities—including F-15 avionics,[7] low-altitude navigation and targeting infrared for night (LANTIRN) pods,[8] and JEIM[9]—and defined circumstances under which the concepts would be most successful. In each of these studies, a mix of FSLs and CSLs proved to have advantages over the current decentralized maintenance concepts, where each unit would deploy its own intermediate maintenance shops with the aviation units to the deployed site. The centralized maintenance and support concepts were briefed to senior Air Force leadership as early as 1997, and the United States Air Forces in Europe (USAFE) Director of Logistics expressed an interest in testing these ideas in 1998. However, the Air War Over Serbia began in 1999, before a formal test could begin.

CIRF Operations and Noble Anvil[10]

In 1999, USAFE adopted CIRFs (maintenance FSLs) for use in Joint Task Force Noble Anvil (JTFNA), the Air Force component of the Air War Over Serbia. While the Air Force maintained base repair in the CONUS, three overseas facilities already operating informally as maintenance FSLs were officially designated as CIRFs during Noble Anvil. This reduced intermediate-level maintenance deployment by approximately two-thirds,

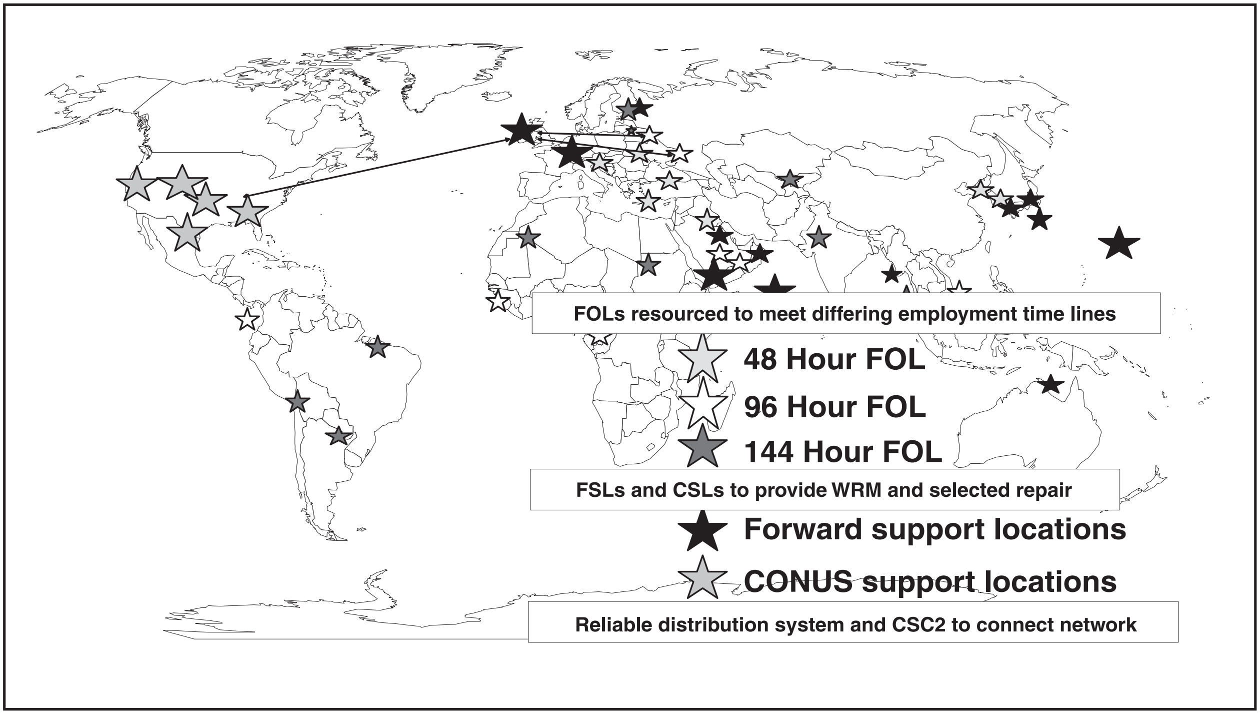


Figure 1: Elements of the ACS Concept

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enabled rapid spinup of repair operations, and demonstrated that CIRFs were capable of supporting contingency operations. However, ad hoc augmentation of CIRF assets significantly delayed the arrival of needed resources. These delays raised several questions regarding CIRF implementation processes and procedures, including CSC2 issues of how organizations should communicate and assets should be managed to meet operational goals.

CIRF Test Background

Based on experiences in JTFNA, the Air Force Deputy Chief of Staff, Installations and Logistics directed further development and testing of several ACS concepts, including that of CIRFs. The test was developed to determine how well CIRFs, with a well-planned support system, could support steady-state operations.

The test involved five wing-level USAFE work centers functioning as CIRFs for engines, LANTIRN pods, EW pods, and F-15 avionics for units supporting Operations Northern Watch and Southern Watch. The USAFE Regional Supply Squadron (RSS) acted as the C2 decision authority and controlled the allocation of spare items throughout the theater. CIRF operations in the test took much from the RAND concept of maintenance FSLs but had several deviations as well.[11] In the test, when selected units deployed to Northern Watch and Southern Watch, they augmented CIRF staffing, equipment, and spares based on pre-established trigger points. The operational environment of the CIRF test is mapped in Figure 2.

The CIRF Test and CSC2 Operational Architecture

This article discusses CSC2 capabilities addressed throughout the CIRF test. The CIRF C2 structure was designed to provide a common operating picture and bring total asset visibility to decisionmakers at all levels, thereby improving support to the warfighter in both planning and execution activities. The common operating picture was to be leveraged in assessing the condition of deployed units to monitor the effectiveness of CIRF operations (based on customer wait time [CWT] and quality of repair), see if support operations should be modified, and monitor the inventory position of all units to see how the repair and spares capability should be allocated. These assessments were to be used to guide prioritization decisions and, in conjunction with Air Force operational goals, prioritize goals for weapon system availability and allocate resources accordingly.

These responsibilities link very closely with the planning and execution process outlined in the CSC2 TO-BE operational architecture and shown in Figure 3. This process begins, as shown on the left side of the figure, with the development of an integrated operational and CS plan. The jointly

C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

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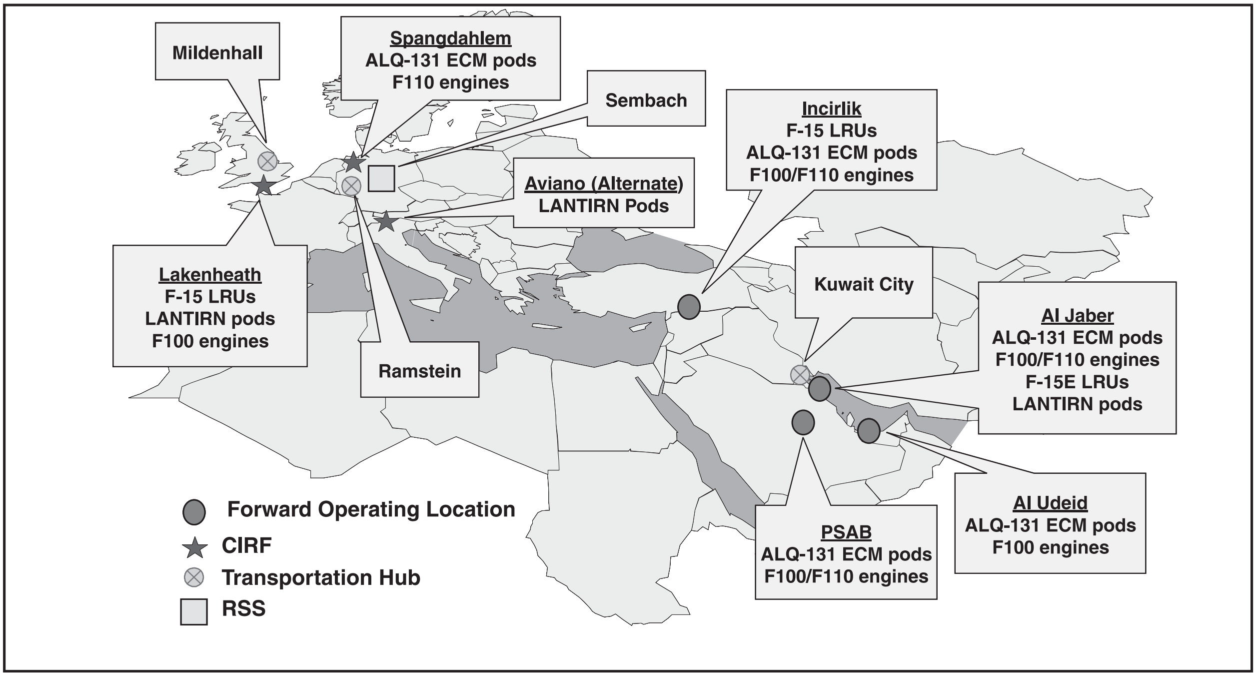

Figure 2: CIRF Test Operational Environment

C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

developed plan is then assessed to determine its feasibility, based on CS resource availabilities. Once the plan is determined to be feasible, it is executed. In the execution control portion of the process, shown in the lower right of the figure, actual CS process performance is compared to the control parameters identified as necessary to achieve the operational measures of effectiveness in the planning process. When a parameter measuring actual CS performance is not within the limits set in the planning phase, the process notifies CS planners that the process is *out of control,* and *get well* analyses and replanning are necessary.

This process centers on integrated operations and CS planning but also incorporates activities for continually monitoring and adjusting performance. A key element of planning and execution in the process template is the feedback loop that determines how well the system is expected to perform (during planning) or is performing (during execution) and warns of potential system failure. It is this feedback loop that tells the RSS support planners to act when the CS plan should be reconfigured to meet dynamic operational requirements, during both planning and execution. The feedback loop can drive changes in the CS plan and might call for a shift in the operational plan as well. Feedback might include notification of missions that cannot be performed because of CS limitations.[12] For the CS system to provide timely feedback to the operators, it must be tightly coupled with their planning and execution processes and systems and provide options that will result in the same operational effects, yet cost less in CS terms.

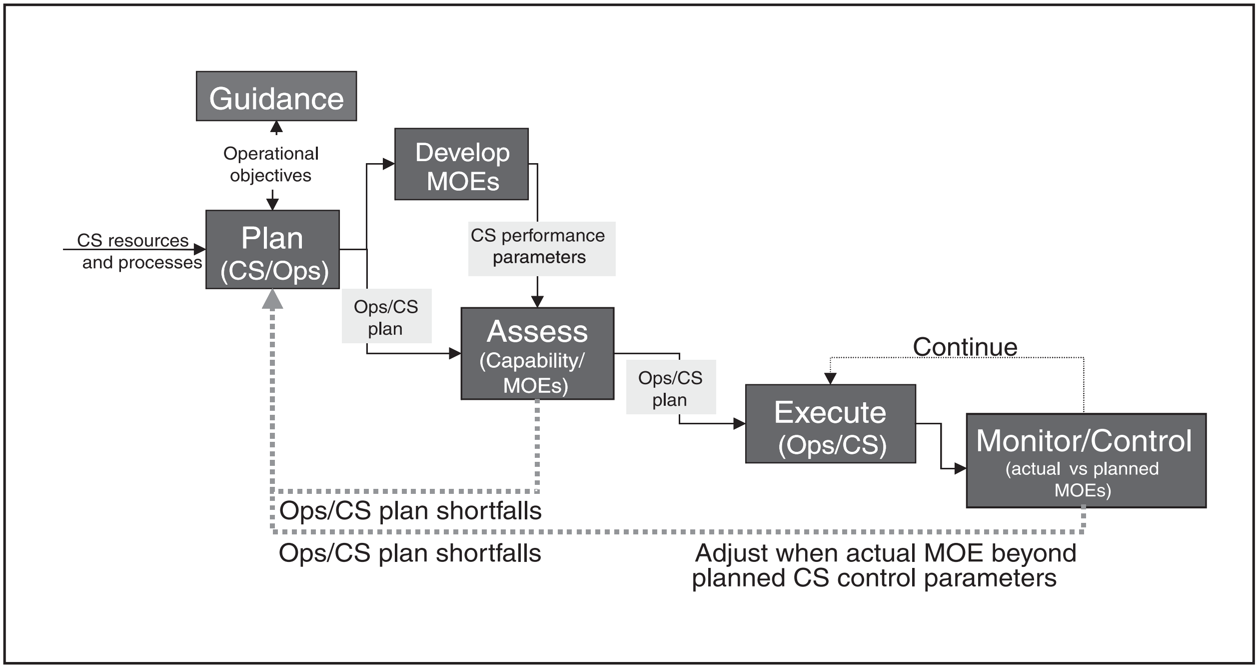

Figure 3. CSC2 TO-BE Closed-Loop Process Used to Control Fighter CIRF Operations During the CIRF Test

The C2 responsibilities defined in the CIRF test tie very closely to this process, as the resource allocation and prioritization of weapon system availability are both parts of the integrated planning process. Likewise, the common operating picture and comprehensive assessments of deployed units are necessary for the feedback loop that links the planning and execution phases.

CIRF Test Results

By most counts, the CIRF test showed centralized maintenance operations to be an effective step toward a global ACS framework. The CIRF supported all deployed sorties at a reduced deployment footprint. The regional supply squadron provided responsive decisionmaking capability; logistics costs and requirements were reduced; and the pre-established trigger points, with few exceptions, successfully supported operations. Procedures and performance standards were established in advance, based on operational needs, and used to measure performance and guide operations throughout the test. For example, while support operations and spares inventories occasionally fell short of the standards set at the beginning of the test and necessitated loaners from other units, the ability of units to recognize when operations were falling short and provide the necessary resources demonstrates the effectiveness of the pre-established performance standards and feedback loops. However, as CIRF implementation progressed, opportunities to improve operations were uncovered. There were several instances of processes, chains of command, and information systems not being defined for situations that arose. In this section, we detail the achievements of the CIRF test, with respect to the four C2 objectives discussed earlier.

C2 Objective 1. Generate Support Requirements Based on Desired Operational Effects

In the CIRF test, a primary goal of the concept was to meet the sortie requirements of Northern Watch and Southern Watch. The RSS personnel—composed of maintenance, transportation, and supply planners—used these sortie requirements and projected flying hours to determine FOL spare levels and performance standards for transportation times, maintenance times, and all other components of customer wait time.

As illustrated in Figure 4, CIRF planners used operational sortie generation and weapon system availability objectives to establish control parameters for CS performance—including expected unit component removal rates, transportation times to and from the CIRFs to the operational locations, CIRF repair times, inventory buffer levels; for example, contingency high-priority mission support kit levels and other parameters—and tracked actual *logistics pipeline* performance against these control parameters.[13]

The bottom of Figure 5 shows some of the CS process control parameters monitored during the CIRF test. The top half of the figure shows how two parameters associated with customer wait times, one from

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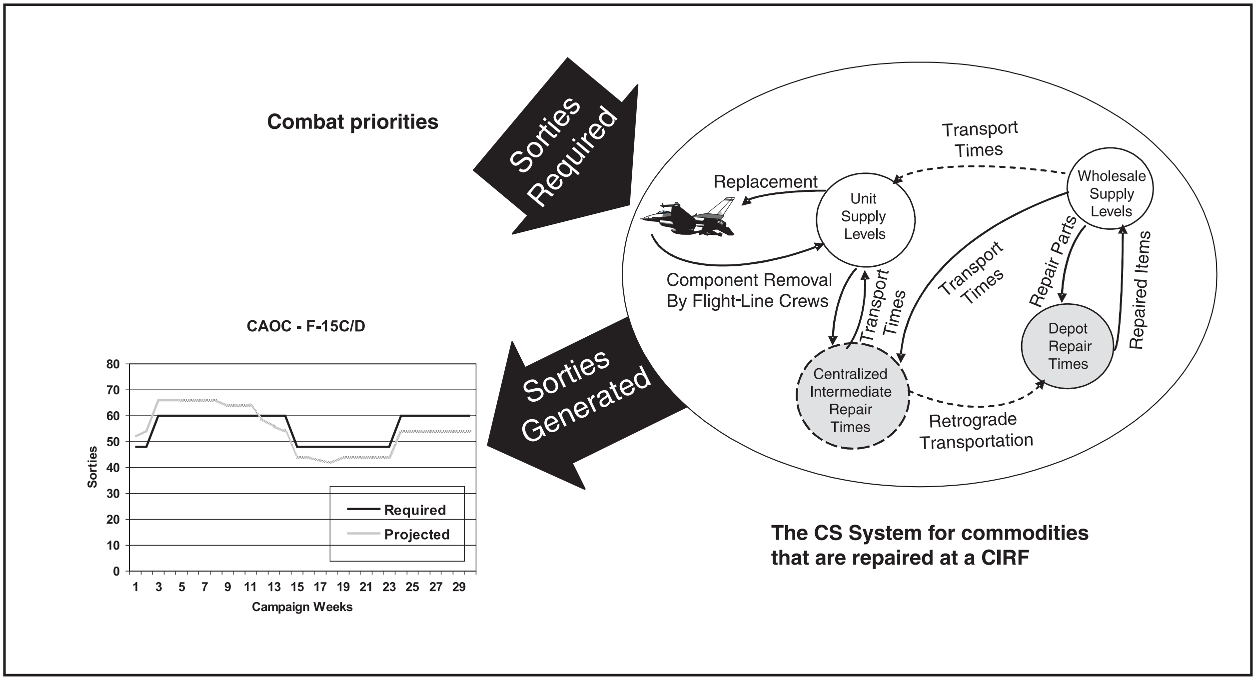

Figure 4. CS Performance Parameters Were Related to Operational Measures of Effectiveness

the CIRF to deployed units and the other from depots to the CIRFs, were monitored against *trigger points* or control limits. The CWT control graphs show the percentiles of total customer wait time for a number of FOLs for a 3-month period in Enduring Freedom.

The performance threshold lines on the figure illustrate how the C2 system might indicate if a control limit were breached and the theater distribution system (TDS) performance or strategic resupply system were out of control and had the potential to affect weapon system availability objectives. This comparison of support performance to the control parameters established from operational goals took place during the Enduring Freedom CIRF test. Personnel at the USAFE Regional Supply Squadron monitored transportation, maintenance, and supply parameters and compared them to those needed to achieve operational weapon system availability objectives, as shown on this figure.[14]

When the performance of the theater distribution system was out of tolerance with these, RSS personnel indicated how this performance, if left uncorrected, would impact future operations and were able to do this before the negative impacts actually occurred.

Another example of the CIRF test's link between operational and support performance was seen when determining spare levels at each FOL and process performance parameters for the CIRF. Support thresholds set in the CIRF test plan were later verified using a simulation model, which simulated a unit's flying schedule and associated base and CIRF processes to track daily spare engine and pod inventories at each base and in CIRF processes associated with intermediate repair operations over the duration of the Northern Watch and Southern Watch scenario.[15]

To verify the target set in the CIRF test, we used the simulation model and held all operational requirements constant. We then varied support performance incrementally. For example, for a given sortie profile, we examined how variations in transportation performance or removal rates might affect spares levels at the FOLs. In this manner, we could establish threshold values for process performance parameters and verify that targets set at the beginning of the CIRF test were adequate to achieve operational goals. The Air Force has recommended similar CWT goal development for other mission-design series and commodities.

Using these techniques, we also were able to observe interactions among performance parameters—for example, removal rates and customer wait time—and how they would impact operational performance (that is, sortie generation capability). For example, at low engine-removal rates, 1- or 2- day variations in the customer wait time for engines sent to the CIRF do not have a significant impact on operational readiness. With fewer removals, the time each engine spends in repair is not as noteworthy, since, unless CWT increases by an order of magnitude, additional engines are still unlikely to break in the time that the original engine is gone.

C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

Another example of the CIRF test's link between operational and support performance was seen when determining spare levels at each FOL and process performance parameters for the CIRF.

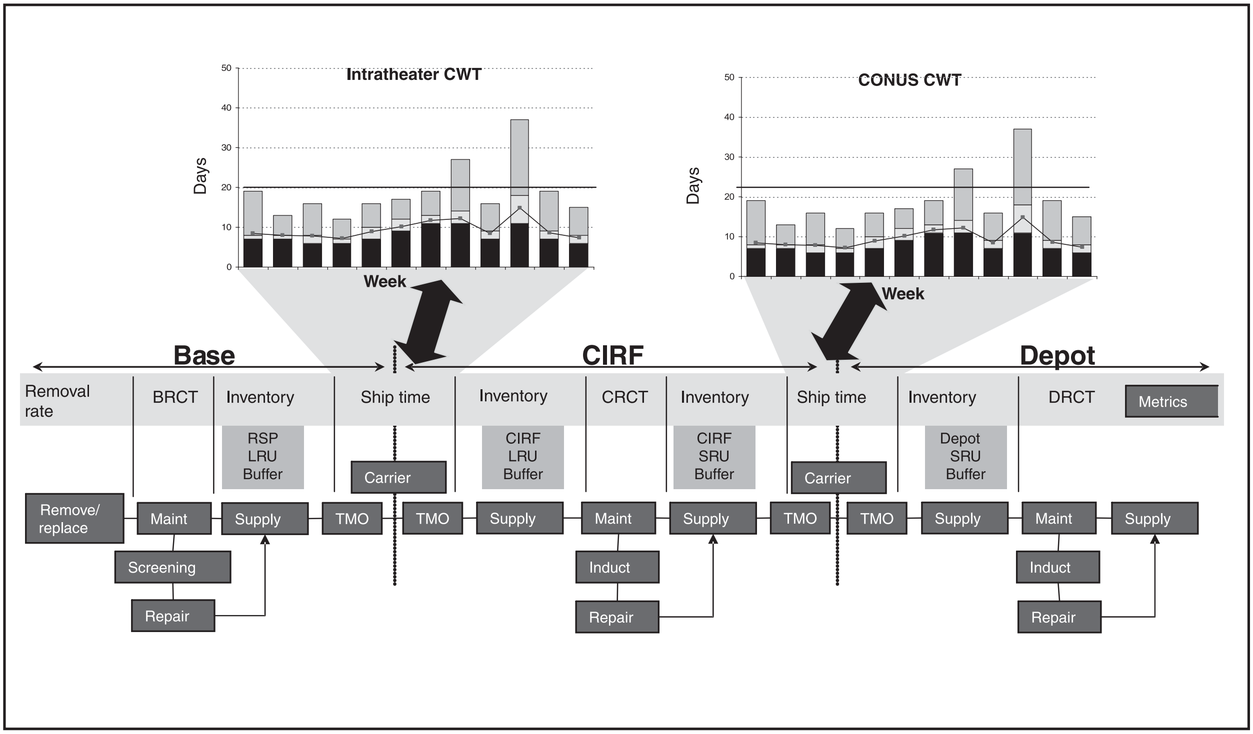

Figure 5. Actual Process Performance and Resource Levels Were Compared with Planned Values

C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

One of the key enablers of access to status reports and quick and effective support assessments is the CIRF staff's ability to provide a common operating picture. During the CIRF test, this common operating picture was provided through the Air Force portal. At the time of the CIRF test, the portal had four modules: Fleet Engine Status, Fleet Engine Trending Report, Fleet CIRF Engine Status, and Fleet Pod Status.

However, at higher removal rates, with more engines sent to the CIRF, the time each engine spends not mission capable has a much greater impact on spare parts inventories and the ability for units to meet their sortie requirements.

C2 Objective 2. Provide Support Assessments Quickly, Continually, and Effectively and Update and Communicate Status Reports

One of the key enablers of access to status reports and quick and effective support assessments is the CIRF staff's ability to provide a common operating picture. During the CIRF test, this common operating picture was provided through the Air Force portal. At the time of the CIRF test, the portal had four modules: Fleet Engine Status, Fleet Engine Trending Report, Fleet CIRF Engine Status, and Fleet Pod Status. Further information on the capabilities of each module is provided in "CIRF Toolkit: Developing a Logistics Common Operating Picture."[16] This information system provided the status of each engine and pod at each unit and the availability status of transportation resources, allowing units to anticipate when they would get repaired parts back.

The CIRF portal also enabled immediate transfer of information and automatic aggregation of information from a central database. This ensured that once a part was repaired, shipped, or delivered its status would be updated and allocation and prioritization decisions would be made from the most current information possible.

After the CIRF toolkit was completed in January 2002, it was first implemented by USAFE, Air Combat Command, and the Pacific Air Forces and received positive feedback from maintenance personnel. Air Mobility Command (AMC), Air Force Special Operations Command, Air Education and Training Command, Air National Guard, and Air Force Reserve Command users were to be added next, with the anticipation of reducing the reporting workload throughout the CIRF community by 25 percent.

However, throughout the CIRF test, several opportunities for improvement were also noted. While the toolkit facilitated the sharing of data across organizations, there was also valuable information not incorporated. For example, the portal did not contain complete information about engines and pods while they were in repair. Furthermore, this information was not only not included in the portal but also not centralized at positions within the CIRF. During the test, there was no point of contact established for unit status. As a result, deployed units called several people in the propulsion flight for information. This led to problems on multiple fronts. Fielding questions not only distracted CIRF personnel from their primary responsibilities but also resulted in conflicting reports when the same question was posed to more than one person.

Similarly, while the CIRF toolkit contained the status of each engine and pod, during the test, it did not provide this information as a unit status report. As a result, it was difficult to provide feedback on a unit's capability or on what its needs might be. This made it more difficult for the regional supply squadron to allocate effectively. The portal also provided very little information on changes to units' taskings. The CIRF staff was, therefore, caught shorthanded at points throughout the test, when taskings were changed and units deployed with a greater workload or fewer augmentees than expected. To correct these deficiencies, the Air Force Maintenance Management Division has recommended continuing the development of the CIRF toolkit and using the toolkit to formalize the tracking of engines and pods.

C2 Objective 3. Monitor Resources in all Theaters and Allocate in Accordance with Global Priorities

As the decisionmaking authority of the CIRF test, the USAFE Regional Supply Squadron monitored resources in the European Command (EUCOM) and Central Command (CENTCOM) theaters. The regional supply squadron combines the supply C2 responsibilities of mission capability management, stock control, stock fund management, information system management, operational assessment and analysis, and reachback support procedures with the transportation C2 responsibilities of shipment tracing and tracking, source selection, traffic management research, movement arrangements, shipment expediting, customs issues, and channel requirements. The organization is designed to interface with the maintainers at the CIRF to provide "combatant commanders…with operational materiel distribution C2 and regional weapon system support" and provide a comprehensive picture of the CIRF's needs.

The integrated nature of the regional supply squadron allowed the CIRF to provide responsive support to the deployed units. However, some holes in C2 presented challenges. The USAFE Regional Supply Squadron had the authority to distribute parts to both EUCOM and CENTCOM forces, despite their being different theaters. As a result, the USAFE Regional Supply Squadron was unfamiliar with the full spectrum of CENTCOM theater issues. Furthermore, the regional supply squadron faced some difficulties in resource allocation. Lack of clearly defined decision processes and command relationships forced the regional supply squadron to coordinate among deployed units, CIRFs, and MAJCOMs about personnel, equipment, status, funding, and transportation. Many of these issues were out of the RSS area of responsibility, and the regional supply squadron did not have the authority to set policies or determine resource allocation.

CIRF operations also raised issues of prioritizing support to USAFE *home* units that hosted CIRF and deployed units. When deployed units faced shortages, home wings often were forced to provide their resources as loaners. In these circumstances, their home support could potentially be degraded. Although the needs of the deployed units were generally given higher priority than those of the home units, care needs to be given to ensure that home-station support does not impact the training capability and, thus, place the Air Force at risk of being unable to respond to additional conflicts.

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C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

One key to the success of the CIRF test was the clear definition of support goals and the ability of CIRF staff to monitor their own performance and make corrections when the goals were not being met.

The lack of definition in command relationships was just one manifestation of the difficulties the CIRF faced in resource allocation. Although the regional supply squadron performed well as the CIRF decision authority, decision rules for cross-theater support were not yet fully developed at the time of the test. Maintenance and part requirements often were renegotiated throughout the course of operations. Because the CIRF was often not prepared for these added requirements, additional capability needed to be deployed. Augmentation presented many challenges as well, since augmentee unit type codes had not been defined at the start of the test and staff needed to be pulled in by unit line number instead. Furthermore, to moderate the delays caused by the augmentation process, many man-hours were spent trying to provide an added capability from the CIRF home wings. CIRF wings often were forced to provide their own resources as loaners, leading to further complications, as touched on above. Home-station support was compromised, support was degraded, assets became tied up in AWP status, and tracking of funds was complicated. Finally, although CIRF-wing line-replaceable units were authorized with the same Joint Chiefs of Staff project code as those of deployed units, this authorization was not universally understood.

C2 Objective 4. Be Self-Monitoring and Adjust to Changes in Operational Needs and Support Performance

One key to the success of the CIRF test was the clear definition of support goals and the ability of CIRF staff to monitor their own performance and make corrections when the goals were not being met. For example, as part of the Strategic Distribution Management Initiative (SDMI), transportation planners monitored the customer wait time of each item sent to the CIRF, through each stage of the repair process. They could, therefore, determine when customer wait time exceeded the target times and examine their transportation processes to see how resources could be put to better use. Throughout the CIRF test, the tanker airlift control center (TACC) at AMC provided qualitative feedback to USAFE, the US Transportation Command (USTRANSCOM), and other organizations on issues underlying the SDMI CWT statistics. This feedback allowed transporters to take corrective actions when needed, as was the case in the use of C-130s in CIRF transportation. Originally, USAFE was using a combination of trucks and C-130s to move cargo to the CIRF. C-130s were often available, and planners were concerned that they would otherwise fly empty, wasting valuable airlift capacity. However, channel routes for C-130s were unpredictable, and the cargo waiting for airlift could at times have been shipped faster by truck. TACC reports highlighted this issue and relayed concerns to USAFE, who ultimately shifted to a truck-only policy.

Another example of the C2 responsiveness in the CIRF test dealt with TDS performance to Al Jabar Air Base in Kuwait. Transportation times were consistently above the CWT performance criteria of 4 to 6 days to allow support of EW pods and LANTIRN to this location. The RSS personnel worked with AMC and USTRANSCOM personnel to improve TDS performance to this location, but the customer wait time could not be improved with resources that USTRANSCOM was willing to allocate to the theater distribution system. As a result, the regional supply squadron and deployed unit personnel made the decision to deploy EW and LANTIRN repair capability to Al Jabar during the Enduring Freedom CIRF test.

Use of this CSC2 process during the CIRF test represented a significant improvement in CSC2. These concepts and associated doctrine and educational programs that fully describe the process are being established to implement these concepts across a wide variety of CS processes Air Force-wide.

Despite these capabilities, the CIRF test revealed opportunities for further improvement to feedback capabilities. Limitations in information systems presented challenges in forecasting and information transfer. For example, the CIRF toolkit did not have a simple way to provide feedback on the status of units. Information was tracked by engine and pod serial number, which made it difficult to aggregate records to the unit level. In addition, the two information systems used in requirements forecasting, GATES and Brio, are under study to improve forecasting capabilities. The ability of the CIRF staff to predict cargo arrival and plan accordingly is dependent on the accuracy of these systems.

Even if feedback was given, CIRF planners still had difficulties using this information to adjust their operational and support plans. For example, if assets sent to the CIRF were missing components or had problems not described in their accompanying documentation, CIRF staff did not always have channels through which to follow up. In the event these discrepancies needed to be investigated before repair could proceed, the lack of accountability led to an increase in customer wait time. This lack of documentation also made it difficult to investigate foreign object damage or equipment abuse possibilities and did not provide a way to incorporate these issues into policies and plans.

Going Forward: Implementing C2 Changes

Changes to Air Force operational and CS processes and the C2 elements supporting them (that is, doctrine and policy, organizational relationships, training, and information systems) will allow the Air Force to better meet each of its C2 objectives.

Changes to Air Force operational and CS processes and the C2 elements supporting them (that is, doctrine and policy, organizational relationships, training, and information systems) will allow the Air Force to better meet each of its C2 objectives. Some steps that may be taken to improve the C2 network are described below.

Organizational Changes

As discussed above, many of the CSC2 tasks are currently performed by the USAFE Regional Supply Squadron to manage the CIRF. These C2 features of the regional supply squadron can be accessed *virtually* by the COMAFFOR A4. These functions can be done from the COMAFFOR A4 Rear in a reachback fashion by a *permanent and standing* operations

C2 in the CIRF Test: A Proof of Concept—C2 To-Be Operational Architecture

The CIRF test provided an opportunity to not only study the implementation of CIRFs but also test the many C2 concepts that enable this implementation. Over the 6 months of CIRF test operations, the centralized repair and decisionmaking organizations performed effectively and were able to meet each of the four objectives established in the C2 architecture.

support center that would receive *virtual* inputs from the regional supply squadron with respect to CIRF operations. This will leave the regional supply squadron to focus on the daily supply operations of the CIRF and the rest of its theater and allow the operations support center to have visibility of spares involved in this operation, as well as spares supported by other processes and resources needed to initiate and sustain operations. Operations support centers should have visibility of theater resources and the ability to work with the Air Force and joint communities to ensure these allocations are in accordance with theater and global operational priorities. The operations support centers should report to the theater AFFOR/A-4 and communicate with inventory or commodity control points and the Air Staff Combat Support Center. The Combat Support Center should have responsibility for providing integrated weapon system assessments across commodities. It will have the capability to support allocation decisions when multiple theaters are competing for the same resources.

Each of the operations support centers and the Combat Support Center should have clear channels of communication with the deployed units, with the CIRF, and among each other.[17]

Information Sharing

Another important aspect of command and control is the successful sharing of information. The CIRF toolkit could be expanded to include the status of engines and pods in repair and aggregate status reports to provide information by unit. In addition, all operations, support, and C2 nodes (that is, the regional supply squadron, CIRF, and deployed units) could establish points of contact to provide all parties involved with a common operating picture.

Similarly, procedures should be instituted to inform these nodes of changes to deployments. The AEF Center and MAJCOMs should inform the nodes when the deployment packages change, either through the CIRF toolkit or other established channels. The operations support center can then task additional CIRF augmentees and enable the CIRF to allocate spares accordingly. The CIRF staff also should have a feedback channel for cases where deployed assets and equipment are broken, incomplete, or not properly documented. This will allow units to correct their deployments and explore root causes of these discrepancies.

Doctrine, Policy, and Training

Based on the success of the CIRF test, the Air Force is proceeding with further implementation of the CIRF concept. To assist in this implementation, CIRF scenarios could be incorporated into Air Force and joint policy. The Air Force Maintenance Management Division; Materiel Management and Policy Division; Deployment and Distribution Management Division; and Planning, Doctrine, and Wargames Division have been tasked with incorporating CIRF procedures into Air Force Doctrine Document (AFDD) 2-4, *Combat Support*; Air Force Instruction (AFI) 21-101, *Aerospace Equipment Maintenance Management*; Air

Force Manual 23-110, *USAF Supply*; and AFI 24-201, *Cargo Movement.* This will involve revising spare item allocation standards and defining manpower and support unit type codes that can be used in a centralized maintenance scenario. In addition, further study of CIRF scenarios—to identify deployment requirements, performance standards, and other resource needs—could enhance operations. More specifically, the Air Force has tasked the USAFE Maintenance, Supply, and Transportation Directorates with evaluating the CWT goals and reassessing them every 6 months. This will keep transportation performance standards current with changing operational objectives.

Summary

The CIRF test provided an opportunity to not only study the implementation of CIRFs but also test the many C2 concepts that enable this implementation. Over the 6 months of CIRF test operations, the centralized repair and decisionmaking organizations performed effectively and were able to meet each of the four objectives established in the C2 architecture. However, there were also several areas in which shortfalls were noted. Standardizing organizational roles and responsibilities, process and information requirements, and channels of communication will further improve command and control and enable smoother implementation of future CIRF operations.

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Notes

1. For a full definition of the five basic components of the ACS infrastructure, see "Further Reading" in this publication.
2. James A. Leftwich, et al, *Supporting Expeditionary Aerospace Forces: An Operational Architecture for Combat Support Execution Planning and Control*, RAND, MR-1536-AF, Santa Monica, California, 2002.
3. Joint Pub 1-02, *DoD Dictionary of Military and Associated Terms*, 12 Apr 01.
4. AFDD-1, *Basic Air Force Doctrine*, 1 Sep 97.
5. Summarized from Leftwich, et al, *An Operational Architecture for Combat Support Execution Planning and Control*, MR-1536-AF, RAND, Santa Monica, California, 2002.
6. Amanda Geller, et al, *Supporting Air and Space Expeditionary Forces: Analysis of Maintenance Forward Support Location Operations*, MR-1778-AF, RAND, Santa Monica, California, 2003.
7. Eric Peltz, et al, *Supporting Expeditionary Aerospace Forces: An Analysis of F-15 Avionics Options*, RAND, MR-1174-AF, Santa Monica, California, 2000.
8. Amatzi Feinberg, et al, *Supporting Expeditionary Aerospace Forces: Expanded Analysis of LANTIRN Options*, RAND, MR-1225-AF, Santa Monica, California, 2001.
9. Mahyar A. Amouzegar, et al, *Supporting Expeditionary Aerospace Forces: Alternatives for Jet Engine Intermediate Maintenance*, RAND, MR-1431-AF, Santa Monica, California, 2001.
10. A complete RAND analysis of JTFNA is provided in Amatzia Feinberg, et al, *Supporting Expeditionary Aerospace Forces: Lessons from the Air War Over Serbia*, RAND, MR-1263-AF, Santa Monica, California, 2002.
11. The Air Force did not centralize maintenance in CONUS, the potential for which was discussed in MR-1174, MR-1225, and MR-1431. Instead, the CIRF test was based on CIRFs implemented to support overseas deployments and contingencies. The units maintained base maintenance in CONUS.

12. Leftwich, et al, 2002.
13. Methods on how to derive logistics performance parameters from operational metrics for reparable components have been known for some time. See such articles as Robert S. Tripp, “Measuring and Managing Readiness: The Concept and Design of a Wartime Spares Push System,” *Logistics Spectrum*, Vol 17, No 2, Summer 1983; Robert S. Tripp and Raymond Pyles, “Measuring and Managing Readiness: An Old Problem—A New Approach,” *Air Force Journal of Logistics*, Spring, 1983; and other publications on Dyna-METRIC and the Weapon System Availability Model.
14. The RSS personnel were performing a COMAFFOR A4 function as outlined by the CSC2 operational architecture. These personnel could be considered to be a virtual extension of the UTASC, an operations support center, as described in the CSC2 operational architecture.
15. Further information on the RAND model and analysis is contained in Geller, et al.
16. Article in *The Exceptional Release,* Logistics Officer Association Magazine, Spring 2002.
17. More discussion about organizational roles needed to support the CSC2 operational architecture can be found in “Combat Support C2 Nodes: Major Responsibilities,” in this publication.

Section 4: Concepts, Training, and Doctrine

combat support

Section 4 contains three short articles. The first expands on the concept of Agile Combat Support. It is followed by articles that highlight the importance of leader development and doctrine.

ACS is recognized as the product of processes that will effectively ready and prepare our forces for quick response and efficiently sustain an operational activity with the right resource at the right place, at the right time, and for the right length of time.

The Concept

Agile Combat Support

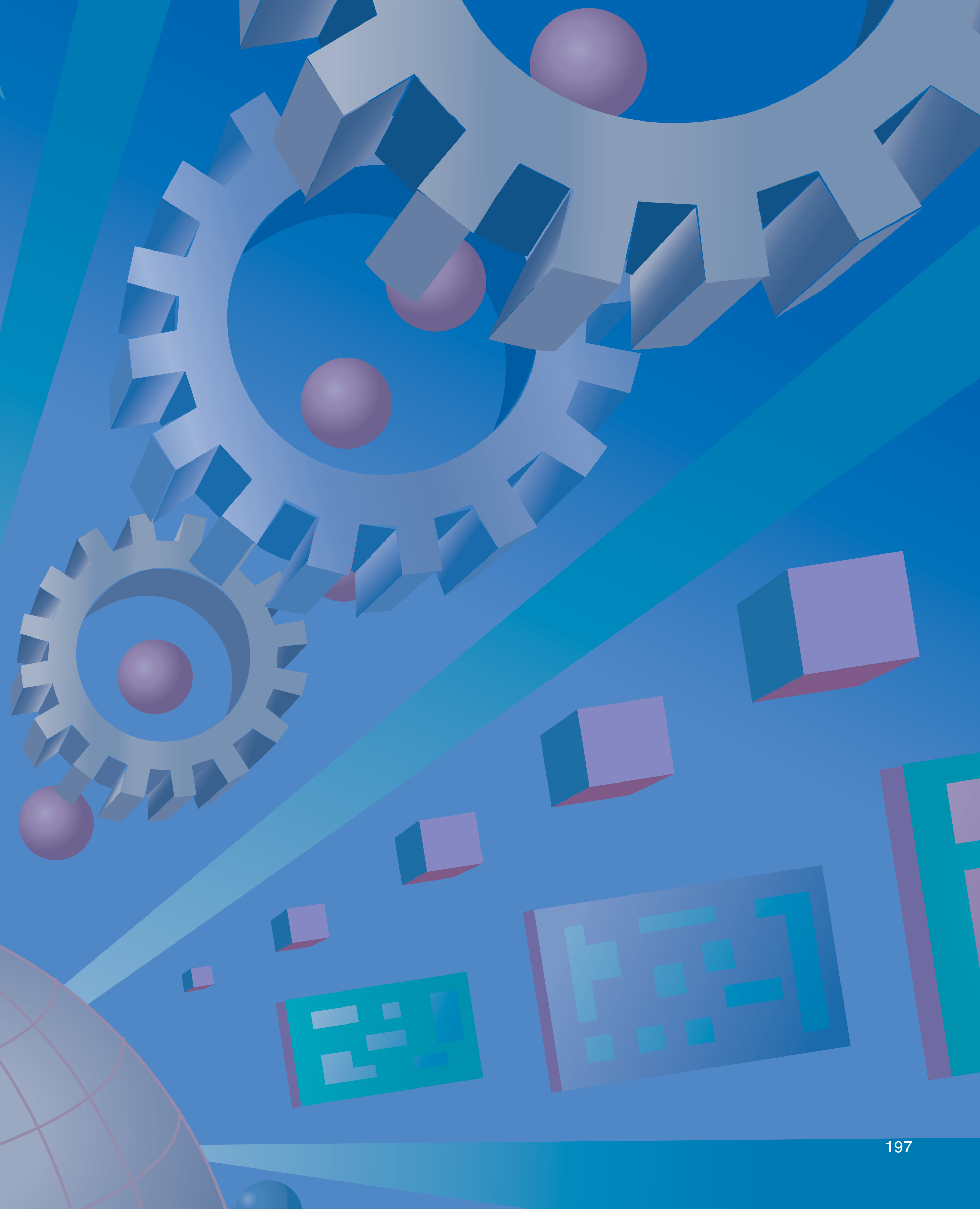
Colonel Connie Morrow, Air Staff
Pat Battles, Synergy

Introduction

The Air Force defines airpower transformation as a fundamental change involving the integration of three elements:

> Advanced technologies providing a new capability, new concepts of operation (CONOPS) producing order-of-magnitude increases in our ability to achieve desired effects, and organizational change to codify changed CONOPS.[1]

The Air Force has a long history of transformational thought; some may say we have been transforming since before our creation as a separate force. Indeed, the Air Force was born of one of the most transformational operational concepts in the history of warfare: independent airpower. As Secretary of the Air Force James G. Roche has said:



The Concept: Agile Combat Support

Today, ACS is recognized as the product of processes that effectively ready and prepare our forces for quick response and efficiently sustain an operational activity with the right resource at the right place, at the right time, and for the right length of time.

> [Transformation] is a philosophy—a predisposition to exploring adaptations of existing and new systems, doctrines, and organizations. It has been part of the total Air Force for decades . . . it is an approach to developing capabilities and exploring new concepts of operation that allow us to be truly relevant in the era in which we find ourselves, and for years to come.[2]

The CONOPS that shapes how the combat support (CS) communities address the challenge of transforming to meet the demands of our era is the Agile Combat Support (ACS) concept of operations.

Discussion

No one would disagree that Air Force CS capabilities have come a long way in 60 years. This transformation began under the umbrella of the Cold War and continues to this day. During the Cold War, our national security strategy called for significant forward presence; there was a degree of confidence about our enemy and the likely courses of action. The proximity of the threat demanded an *in place* response capability. Because parts were cheap, transportation was expensive, and we had years to develop CS infrastructures, we prepositioned both fighting forces and large stocks of dedicated war reserve materiel to meet the responsiveness requirements. Our Korean conflict CS concept was to take everything, not because we planned for any particular support requirements from the commanders but because we had no idea when or how we would be resupplied. As the political environment changed, our military requirements adapted. The Gulf War marked a change in both our operating and support concepts; we moved into a new theater in a relatively short period of time, creating new operating locations. Straddling the old and the new, we moved what has been referred to as an iron mountain of Cold War capability forward to prosecute the Desert War. We needed every bit of the 6 months it took to prepare for the first Gulf War, and we came away with volumes of lessons learned. By the late 1990s, as we entered the Air War Over Serbia, some of those lessons began to pay dividends.

The concept of an ACS capability began to take shape in the Air War Over Serbia, an operation foreshadowing our 21st century air and space expeditionary force (AEF). For the first time, US air forces were first in and constituted the preponderance of force in a theater. Our CS professionals were called on to manage theater distribution and provide combat support from 22 new operating locations. Another major change in the way the Air Force provided forces was the transition from generating sorties from long-established forward operating locations to the projection of a continental United States (CONUS)-based capability into regions with little or no existing infrastructure. During the Air War Over Serbia, we demonstrated one of our more basic needs was the capability to create an operating base—quickly. Today, we know this capability to open and establish an airbase is as much an operational necessity as the basic projection of combat airpower. In Operation Iraqi

Freedom, our forces operated out of 32 austere bases, which were opened and established in a matter of days.

At the close of the 20th century, the Air Force was ready for the AEF concept to debut. To meet the dawning challenges, the Chief of Staff called for a comprehensive logistics review and a corresponding concept for a capabilities-based vision of Agile Combat Support. The vision was to transform CS capabilities to produce a more flexible force. Basic tenets of the original concept were the exploitation of technology, an increase in our ability to protect our forces, a more effective organization to CS command and control (C2) forces, and a reduction of the deployment footprint through reachback and CS regionalization. In 1999, the Chief of Staff called for an ACS CONOPS to produce and sustain mission-capable air and space forces.

Today, ACS is recognized as the product of processes that effectively ready and prepare our forces for quick response and efficiently sustain an operational activity with the right resource at the right place, at the right time, and for the right length of time. In warfighting terms, combat support is the science of planning and carrying out the movement and maintenance of forces. This definition of combat support is distinctly separate from the activities we label as operations or those functions that employ combat capabilities. Combat support and operations, together, create combat capability.

Our doctrine says Agile Combat Support is:

> …the foundation of global engagement and the linchpin that ties together Air Force distinctive capabilities. It includes the actions taken to create, sustain, and protect aerospace personnel, assets, and capabilities throughout the spectrum of peacetime and wartime military operations. Further, it supports the unique contributions of aerospace power: speed, flexibility, and global reach.[3]

While the ACS CONOPS focuses on Agile Combat Support for employed aerospace forces in a deployed environment, this core Air Force competency also affects processes that are CONUS-based and accomplish organize, train, and equip functions. Specifically, to quote Air Force Doctrine Document 1:

> … although support to contingency operations is absolutely critical to our success as a force, ACS is not just a concept for deployed operations. Every facet of our service must be focused on providing what ultimately is combat support, whether it is better educated warriors, better home-based support for members and their families, better methods to manage our personnel system, or more efficient processes to conduct business—those things that keep our people trained, motivated, and ready. Equally important to a technologically dependent service like our own is agility in our acquisition and modernization processes, which will provide greater warfighting flexibility.[4]

The purpose of the ACS CONOPS is to convey how Agile Combat Support— through its effects, master processes, and capabilities—enables and sustains AEF operational CONOPS in a dynamic environment. To

The Concept: Agile Combat Support

Agile Combat Support directly supports Focused Logistics and Full Dimension Protection as set forth in Joint Vision 2020.

expand on that thought, Agile Combat Support is the ability to sustain flexible and efficient combat operations while providing a highly responsive force support through a seamless and ACS system. Its mission is to create, sustain, and protect all air and space forces across the full spectrum of military operations

Agile Combat Support directly supports Focused Logistics and Full Dimension Protection as set forth in *Joint Vision 2020*. The Chief of Staff established his vision in *Air Force Vision 2020: Global Vigilance, Reach, and Power* to develop the Air Force role in achieving Joint Vision 2020. This vision continues to express Agile Combat Support as the building block that enables aerospace power to contribute to joint force commander objectives.

The ACS CONOPS also presents a description of how the Air Force integrates effects-based CS capabilities and further provides a framework for evaluating alternatives to doctrine, organizations, training, and

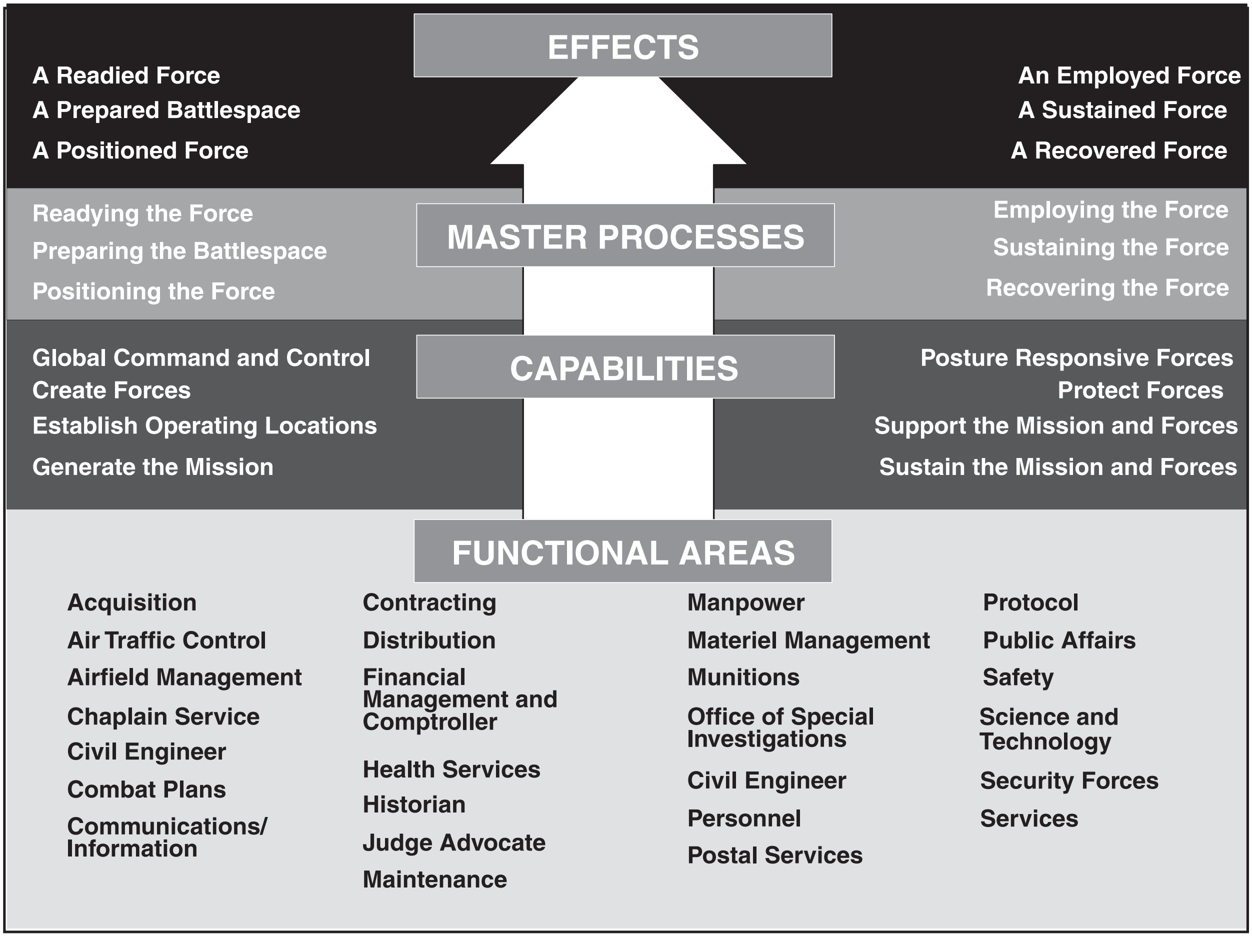


Figure 1. Creating ACS Effects

technologies. The overarching theme of effects-based capabilities allows the ACS CONOPS to better integrate with the operational concepts.

The concept of Agile Combat Support, by design, provides a platform for speculative and provocative discussion about future AEF concepts and capabilities. Figure 1 graphically shows the complicated interrelationship between the functional areas, master processes, and ACS capabilities and effects and how these support the combatant commander. The ACS CONOPS horizontally integrates 26 functional areas key to AEF operations. Each is part of and critical to the master processes that produce ACS capabilities, these capabilities being to create forces, command and control, establish operating locations, protect forces, posture responsive forces, generate the mission, support the mission and forces, and sustain the mission and forces.

The ACS CONOPS is an incubator for transformational capabilities key to delivering ACS to the combatant commander. It is an evolving document and, as such, will continue to respond to unprecedented reform in military roles and missions, the challenges of increased uncertainty in the international security arena, and significant reductions in resources. As a result of these challenges, the Air Force is realigning its organizations, doctrine, and training to decisively establish itself as an expeditionary air force. The entire Air Force has felt the effects of this realignment, and expeditionary CS activities have been heavily impacted. AEFs are operating simultaneously from widely separated locations around the world, placing strong demands on CS activities and resources. This dictates that we devise new ways of doing business with new or enhanced capabilities.

Meeting these challenges requires a fundamental redesign of ACS command and control. The time has arrived to transform ACS command and control so it is effects-based and capability-enabled. We need an ACS C2 enterprise that is highly mobile, technologically superior, robust, responsive, flexible, and fully integrated with operational capabilities. The ACS CONOPS, with its discussion of ACS command and control, embodies this effort. ACS command and control is the keystone capability to establish effective integration of operations and ACS functions and force multipliers to achieve viable support capabilities for multiple operations worldwide in the face of increasing requirements and decreasing resources. The combined effect of ACS capabilities is that which we deliver to the combatant commander: mission capable, combat air and space forces.

The time has arrived to transform ACS command and control so it is effects-based and capability-enabled. We need an ACS C2 enterprise that is highly mobile, technologically superior, robust, responsive, flexible, and fully integrated with operational capabilities. The ACS CONOPS, with its discussion of ACS command and control, embodies this effort.

Notes

1. Maj Gen David A. Deptula, *"Air Force Transformation: Past Present, and Future,"* Aerospace Power Journal, Fall 2001 [Online] Available: http://www.airpower.maxwell.af.mil/airchronicles/apj/apj01/fal01/phifal01.html.
2. Dr James G. Roche, Secretary of the Air Force Remarks for the activation of the 116th Air Control Wing, Robins AFB, Georgia, 30 Sep 02 [Online] Available: http://www.af.mil/news/speech/current/sph2002_15.html.
3. Air Force Doctrine Document 1, *Basic Doctrine*, Air Force Doctrine Center, Maxwell AFB, Alabama, Sep 97.
4. AFDD 2-4, Combat Support, Draft, Air Force Doctrine Center, Maxwell AFB, Alabama, 2003.

The change to the new combat wing organization and the requirement to develop a combat support command and control operational architecture led the Air Force Chief of Staff—through Air Force Installations, the Logistics and the Agile Combat Support Executive Steering Group, and the Colonels Advisory Group—to address the training and leadership processes of doctrine, organization, training, materiel, leadership, personnel, and facilities.

Leader Development

Education and Training

Major Lisa Hess, Air Staff

Introduction

Lieutenant General Michael E. Zettler, Deputy Chief of Staff, Installations and Logistics, described "our Air Force today [as] expeditionary, and our prime operating environment is in a deployed state." The change to the new combat wing organization and the requirement to develop a combat support command and control (CSC2) operational architecture led the Air Force Chief of Staff—through the Air Force Deputy Chief of Staff, Installations and Logistics; Agile Combat Support (ACS) Executive Steering Group; and Colonels Advisory Group—to address the training and leadership processes of doctrine, organization, training and education, materiel, leadership, personnel, and facilities (DOTMLPF).

Dsicussion

There are numerous initiatives to ensure we now *grow* mission support group (MSG) commanders, as well as other combat support (CS) colonels, to command and control (C2) in an expeditionary environment, both at and above wing level.

Leader Development: Education and Training

There are numerous initiatives to ensure we now grow *mission support group (MSG) commanders, as well as other combat support (CS) colonels, to command and control (C2) in an expeditionary environment, both at and above wing level.*

The MSG Commanders Course and the new Expeditionary Combat Support (ECS) Executive Warrior Course will provide training for MSG commanders, potential expeditionary MSG commanders, and A-4s. Eagle Flag will provide the final field training exercise for CS personnel prior to their air and space expeditionary force (AEF) rotation and give them the opportunity to test their ability to open and establish an airbase and provide initial command and control. On the academic side, one of Air Command and Staff College's (ACSC) eight new specialized studies will provide an overview of Agile Combat Support for officers and civilians within and outside the ACS community. The Air Force Institute of Technology is revamping short courses to be in line with the new combat wing organization and logistics processes. Finally, the Advanced Logistics Readiness Officer Course will provide a special logistics expertise to the warfighter.

The following paragraphs describe these initiatives in greater detail.

- **Eagle Flag, Air Mobility Warfare Center (AMWC), Fort Dix, New Jersey.** Eagle Flag's mission is to exercise opening and establishing an airbase to initial operating capability and provide initial command and control. Air Force lessons learned indicate we can open and establish bases, but it is often on the backs of our great CS warriors, who learn as they go. Through a combination of doctrine (the Global Mobility Concept of Operations [CONOPS], ACS CONOPS, and training [Eagle Flag]), we can reduce the footprint for this mission while having a new airfield ready for mission forces in record time. Eagle Flag will consist of 29 functional areas. It is a 1-week, fully integrated field training exercise, with the first scheduled for 13 October 2003. Down the road, Eagle Flag may be expanded to be conducted in the Nevada desert and integrated into Red Flag, Blue Flag, or other operations and C2 exercises. Like its operations counterpart (Red Flag), Eagle Flag is an opportunity to open and establish a base in a learning environment before deploying. "A field-training exercise completes the [AEF preparatory] training by integrating all [combat support] specialties into one military operation striving toward a single mission" says Major General Timothy A. Peppe, special assistant to the Chief of Staff of the Air Force for AEF.
- **MSG Commanders Course, Maxwell AFB, Alabama**. The Logistics Group Commander and Support Group Commander Courses have transitioned to Maintenance Group Commander and MSG Commanders Courses at Air University (AU). These courses traditionally have focused on peacetime and home-station issues. AU added expeditionary flavor to the MSG Commanders Course by providing experienced expeditionary commanders for panels, an ECS training session, and additional expeditionary focus from guest speakers.
- **ECS Executive Warrior Course, AMWC, Fort Dix, New Jersey**. This new course will stand up in January 2004 for potential

expeditionary MSG (EMSG) commanders and A-4s to provide more extensive expeditionary training at the operational level of war. It consists of three parts: a mentor's bureau, a 1-week seminar, and a quick reference handbook. The mentor's bureau provides potential expeditionary group commanders and A-4s access to graduated counterparts for guidance. These *mentors* also may assist or sit on panels during the seminar, which will address hot topics, trends within combat support, and lessons learned. Topics would likely include the en route system, reachback supply, deployment preparation, and opening and establishing a base. The quick reference handbook provides information for the deployed group commander or A-4.

- **Advanced Logistics Readiness Officer Course, AMWC, Fort Dix, New Jersey**. This advanced course came from a Corona decision to create highly skilled operational logistics readiness officers competent in ACS command and control and experts on ACS and ECS processes. The course will provide warfighting commanders with officers who possess special expertise in the application of expeditionary logistics and the ability to leverage effects-based logistics to improve combat capability. The course will focus on the ACS processes of Ready the Force, Prepare the Battlespace, Position the Force, Employ the Force, Sustain the Force, and Recover the Force. The target audience will be fully qualified logistics readiness officer captains with 6-8 years of service. Those completing this course will be targeted for key positions in logistics readiness squadrons, wing combat support centers, A-4/A-5, air operations centers, regional supply squadrons, and other CSC2 nodes. They will be highly skilled logisticians capable of not only providing combat support to air expeditionary forces and warfighting commanders but also instructing unit level logistics officers and advising senior commanders. The first class is scheduled for February 2004.
- **ACSC Agile Combat Support, Maxwell AFB, Alabama**. At Corona Fall 2002, the Air Force adopted a new vision for *deliberate personnel development,* and in November 2002, the Chief of Staff released the force development construct. It is designed to link our education, training, experiences, promotions, and assignment policies and programs to force requirements and institutional needs. Currently, ACSC is approximately 10 months long with two semesters, focusing on international security; military studies; and leadership, command, and communications studies. The new ACSC course contains three modules. The first two are focused on strategy and airpower, leadership, and joint warfighting. The third will provide specialized studies, which will run for 7 weeks. Two weeks will focus on command, and the other five will be devoted to specialized professional development. Courses being developed for the specialized study program are Air and Space Power Employment, Plans and Programs, Acquisition Management, Political-Military Strategist, Space

Operations, Mobility Operations, Information Operations, and Agile Combat Support. The audience of the ACS course is expected to consist of personnel from multiple Air Force specialty codes with follow-on assignments to an Air or Joint Staff within the ACS community or an assignment in a base-level maintenance support group, maintenance group, or wing staff. ACS CONOPS master processes will provide the outline for the course: Ready the Force, Prepare the Battlespace, Position the Force, Employ the Force, Sustain the Force, and Recover the Force. The curriculum will include expeditionary, as well as in-garrison, education. Case studies, classroom instruction, and field trips will round out the education.

As these programs are developed, processes are being put in place to ensure tactics, techniques, and procedures are updated; lessons learned are incorporated into training; and doctrine is continuously improved. The next push in the leadership pillar of DOTMLPF is to incorporate more CSC2 into exercises, wargames, and experimentation.

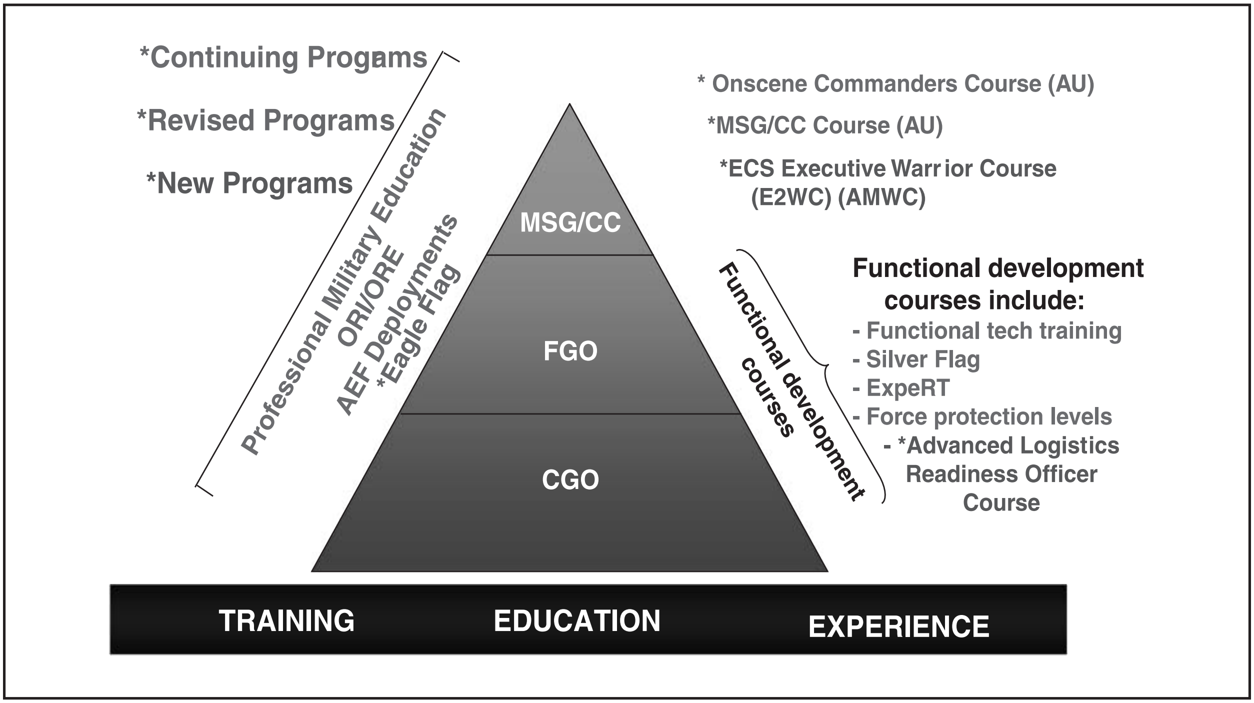


Figure 1. ECS Leader Training and Development

Group Captain David J. Foster, RAF, *Logistics on the Move*

Be nice to your mother but love your logisticians and communicators.

Gen Charles A. Horner, USAF

Logistics comprises the means and arrangements which work out the plans of strategy and tactics. Strategy decides where to act, logistics brings the troops to that point.

Jomini

I don't ever, ever, ever want to hear the term logistics tail again. If our aircraft, missiles, and weapons are the teeth of our military might, then logistics is the muscle, tendons, and sinews that make the teeth bite down and hold on—logistics is the jawbone! Hear that? The JAWBONE!

Lt Gen Leo Marquez, USAF

We must bear the clamor of fools who would pick flaws in a pin while the country hangs in the balance.

Maj Gen Montgomery C. Meigs, USA

Logistics must be simple—everyone thinks they're an expert.

~Anonymous

Gentlemen, the officer who doesn't know his communications and supply, as well as his tactics, is totally useless.

Gen George S. Patton

With the move to reduce the forward footprint and transition to a distribution-based vice inventory-based sustainment system, deployed forces are much more reliant on reachback to support outside the theater than ever before. Clearly defined C2 roles and responsibilities for combat support have become absolutely critical to the combatant commander's effective execution of the mission. Yet, as the CSC2 operational architecture report shows, Air Force doctrine on CSC2 is almost nonexistent.

Combat Support C2

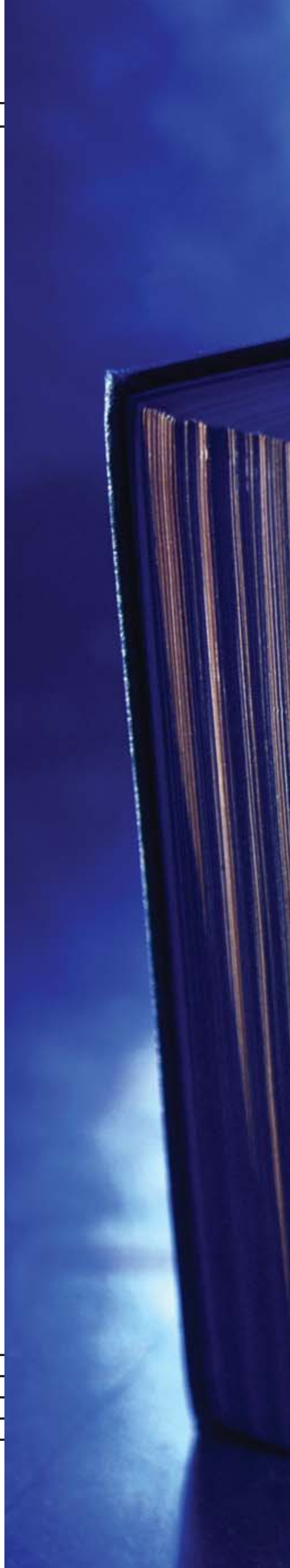
The Importance of Doctrine

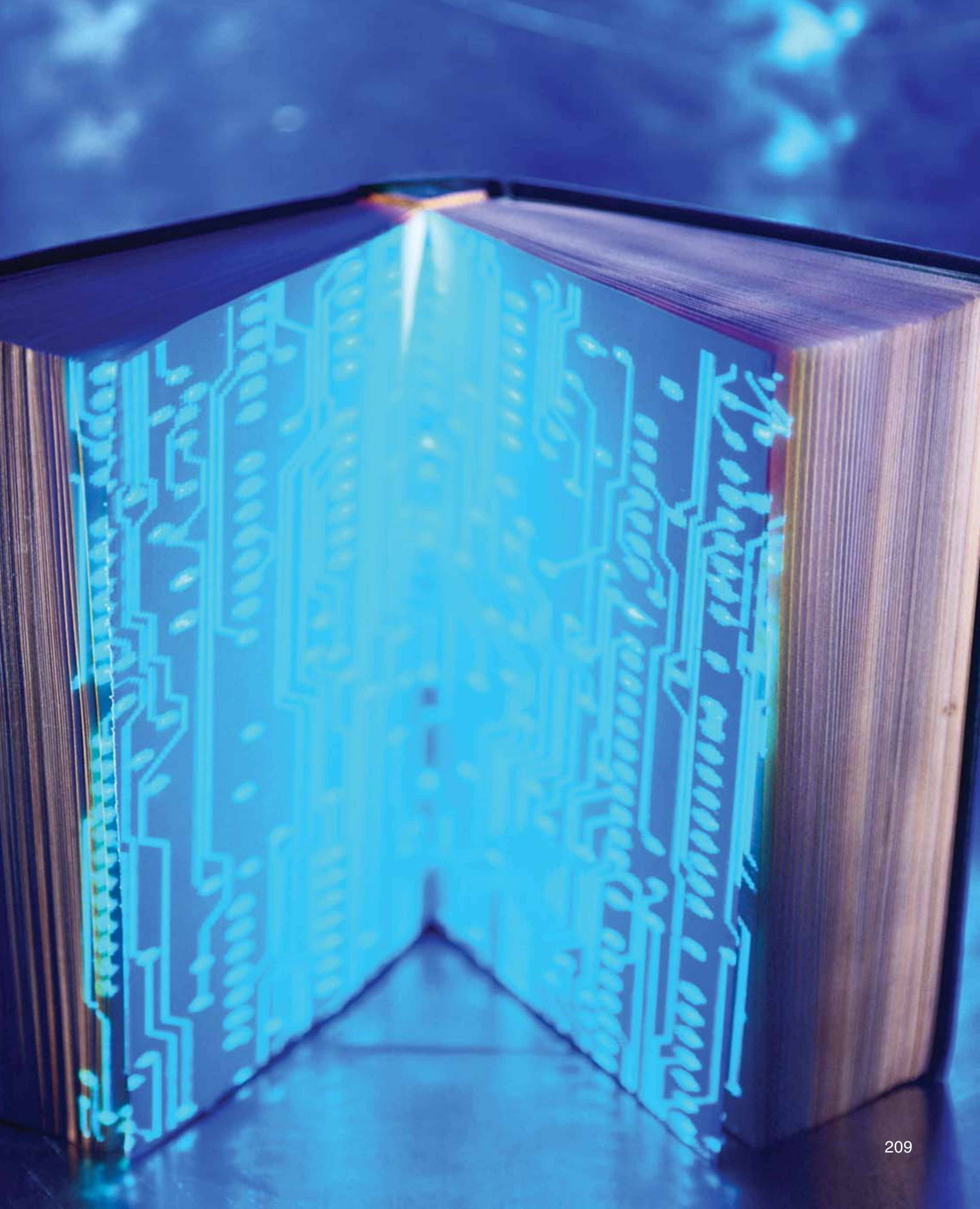
Lieutenant Colonel John Richards, Air Staff

Introduction

The combat support command and control (CSC2) operational architecture report[1] highlights the importance of doctrine in establishing an effective command and control (C2) structure. Sound guidance on command and control is especially important in the area of combat support (CS) because responsibilities typically cross between combatant command and service chains of command and usually extend beyond the borders of the combatant commander's theater. Our existing CS doctrine is extremely thin, especially in the area of command and control, and needs a complete overhaul.

Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, defines doctrine as "fundamental principles by which military forces or elements thereof guide their





Combat Support C2: The Importance of Doctrine

In the CS arena, a review of lessons learned from Operation Desert Storm to Operation Enduring Freedom indicates that, in many areas, we have failed to learn from past experience.

actions in support of national objectives." Doctrine allows us to provide our warfighters with knowledge on how best to employ air and space forces by providing them with distilled insights and wisdom gained from experience in warfare and other military operations.[2] Doctrine is similar to policy in that it provides guidance to the warfighter on how to accomplish the mission, but unlike policy, doctrine does not mandate compliance with a specific process or practice. Doctrine allows the warfighter the flexibility to deviate as circumstances dictate. While policy is often written to ensure compliance with law, international agreement, or convention; specify standardization for efficiency or effectiveness; or ensure safety, doctrine is written to guide our warfighters' actions so they do not have to relearn lessons with each successive operation.

Discussion

In the CS arena, a review of lessons learned from Operation Desert Storm to Operation Enduring Freedom indicates that, in many areas, we have failed to learn from past experience. In part, that is due to a lack of adequate CS doctrine. We have not done an effective job of translating lessons learned into doctrine, which leads us to repeat our mistakes or fail to pass on our successes from one operation to the next. To improve CS doctrine, we must institutionalize a process that allows us to capture lessons learned; test potential solutions to identified problems and successful innovations through wargames, experiments, exercises, or field tests; and then translate concepts that can be implemented into doctrine. This is especially true in the area of CSC2.

CSC2 is one of the least documented, least understood, yet most critical areas of combat support. The requirement for services to provide organized, trained, and equipped forces to the combatant commanders and[3] sustain those forces extends into the theater in both peacetime and war.[4] With the move to reduce the forward footprint and transition to a distribution-based vice inventory-based sustainment system, deployed forces are much more reliant on reachback to support outside the theater than ever before. Clearly defined C2 roles and responsibilities for combat support have become absolutely critical to the combatant commander's effective execution of the mission. Yet, as the CSC2 operational architecture report shows, Air Force doctrine on CSC2 is almost nonexistent.

At the fall 2001 Air Force Installations and Logistics/Major Command (MAJCOM) Directors of Logistics Conference, our senior logistics leaders reviewed Air Force Doctrine Document (AFDD) 2-4, *Combat Support*, and decided that a major overhaul was overdue. With the publication of AFDD 2-4 three years before, Air Force CS processes had undergone significant transformation that needed to be incorporated into doctrine. The original publication included little in the way of useful guidance for engaged forces and contained almost nothing about the tasks, capabilities, and effects of combat support. In coordination with the Air Force Doctrine

Center, Air Force Installations and Logistics and MAJCOMs initiated a major revision of AFDD 2-4 in January 2002. Subsequently, all subordinate doctrine documents[5] to AFDD 2-4 have been opened for revision by the Air Force Doctrine Center, while a new document, AFDD 2-4.5, *Legal Support*, has just been published. However, with the execution of Enduring Freedom and Iraqi Freedom and development of the Chief of Staff's six operational concepts of operation,[6] the knowledge gap has grown even wider.

While we have made a good start on identifying problems with current CS doctrine and have made some inroads into rewriting existing documents in the 2-4 series, much work remains to be done. We need to capture and incorporate the lessons learned from recent operations. We need to capture and incorporate transformational concepts now being implemented. And we need to expand and improve CS information in critical documents outside the AFDD 2-4 series such as AFDD 2, *Organization and Employment of Aerospace Power*, and AFDD 2-8, *Command and Control*.

Notes

1. James A. Leftwich, et al, *Supporting Expeditionary Aerospace Forces: An Operational Architecture for Combat Support Execution Planning and Control*, RAND, MR-1536-AF, Santa Monica, California. 2002
2. Joint Pub 1, *Joint Warfare of the Armed Forces of the United States*, Department of Defense, Washington DC, 14 Nov 00.
3. Joint Pub 0-2, *Unified Action Armed Forces*, Department of Defense, Washington DC, 10 Jul 01.
4. Joint Pub 4-0, *Doctrine for Logistics Support of Joint Operations*, 6 Apr 00.
5. AFDD 2-4.1, *Force Protection*, AFDD 2-4.2, *Health Services*; AFDD 2-4.3, *Education and Training*; AFDD *2-4.4,* Bases Infrastructure and Facilities.
6. Global Strike, Global Response, Homeland Security, Global Mobility, Nuclear Response, Space and C4ISR.

Further Reading

A Concept for Evolving to the Agile Combat Support/Mobility System of the Future, Robert S. Tripp, et al, RAND, MR-1179-AF, Santa Monica, California, 2000

An Integrated Strategic Agile Combat Support Planning Framework, Robert S. Tripp, et al, RAND, MR-1056-AF, Santa Monica, California, 1999

New Agile Combat Support Postures, Lionel Galway, et al, RAND, MR-1075-AF, Santa Monica, California, 1999

An Analysis of F-15 Avionics Options, Eric Peltz, et al, RAND, MR-1174-AF, Santa Monica, California, 2000

Expanded Analysis of LANTIRN Options, Amatzia Feinberg, et al, RAND, MR-1225-AF, Santa Monica, California, 2001

Lessons From the Air War Over Serbia, Amatzia Feinberg, et al, RAND, MR-1263-AF (FOUO), Santa Monica, California, 2002

Alternatives for Jet Engine Intermediate Maintenance, Mahyar A. Amouzegar, et al, RAND, MR-1431-AF, Santa Monica, California, 2002

Engine Maintenance Systems Evaluation (EnMasse): A User's Guide, Mahyar A. Amouzegar, et al, RAND, SMR-1614-AF, Santa Monica, California, 2002

A Combat Support Command and Control Architecture for Supporting the Expeditionary Aerospace Force, James Leftwich, et al, RAND MR-1536-AF, Santa Monica, California, 2003

Forward Support Location Options (U), Tom LaTourrette, et al.. RAND MR-1497-AF, Santa Monica, California, 2002

Reconfiguring Footprint to Speed Expeditionary Aerospace Forces Deployment, Lionel A. Galway, et al.. RAND, MR-1625-AF, Santa Monica, California, 2003

Analysis of Maintenance Forward Support Location Operations, Amanda Geller, et al, RAND, MR-1778-AF, Santa Monica, California, 2003

"Lessons from the Air War Over Afghanistan," Robert S. Tripp, et al, RAND, forthcoming

"Lessons from Operation Iraqi Freedom," Robert S. Tripp, et al, RAND, forthcoming

The dramatic increase in deployments from the CONUS, combined with the reduction of Air Force resource levels that spawned the AEF concept, have also increased the need for effective combat support (CS). Because CS resources are heavy and constitute a large portion of the deployments, they have the potential to enable or constrain operational goals, particularly in today's environment, which is so dependent on rapid deployment. Consequently, the Air Force is reexamining its CS infrastructure, to focus on faster deployment, smaller footprint, greater personnel stability, and increased flexibility.