United States Air Force
Scientific Advisory Board

Report on

United States Air Force Expeditionary Forces

Volume 1: Summary

SAB-TR-97-01

November 1997

Authorized for Public Release

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ABSTRACT (Maximum 200 Words)

This study was produced by the Air Force Scientific Advisory Board (SAB). It was requested and approved by both the Secretary and Chief of Staff of the Air Force. It summarizes the deliberations and conclusions of the study committee on providing an overall picture of the SAB concept for Aerospace Expeditionary Forces.

Aerospace Expeditionary Forces (AEFs) are defined to be “tailorable and rapidly employable air and space assets that provide the National Command Authority and the theater commanders-in-chief with desired outcomes for a spectrum of missions ranging from humanitarian relief to joint or combined combat operations.” This volume discusses what the AEF vision is, how its enabled, and what the Air Force should do to meet the AEF needs. The report also recommends exercises and experiments the Air Force can conduct to test the feasibility of the concepts advanced by the study committee. Finally, the report provides key recommendations to the Air Force that the study committee asserts are essential for the effective realization of the vision.

14. SUBJECT TERMS
Aerospace Expeditionary Force, Air Expeditionary Force, AEF, Global Grid, MetaNet, JFACC, Lean Logistics, Force Protection, Command and Control, Regional Contingency Centers, Global Connectivity, Battlespace Awareness, Geospatial Position, Navigation, and Timing, Information Management, Small Bomb System, Light Weight Munitions.

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Foreword

This volume summarizes the deliberations and conclusions of the 1997 Air Force Scientific Advisory Board (SAB) summer study on *United States Air Force Expeditionary Forces*. In this study the Committee develops an enhanced Air Force capability to conduct expeditionary operations, the Aerospace Expeditionary Force (AEF). A combination of operational concepts, new systems, and technologies training and organizational changes are identified in the three volumes of this report. Volume 1 presents an overall picture of the AEF concept. Volumes 2 and 3 provide added detail and reference information for those working particular aspects of the AEF.

The study results represent an outstanding collaboration between the scientific and operational communities and between government and industry. The Study Committee wishes to thank the many individuals who contributed to the deliberations and the report, as listed in Appendix B. In addition to Scientific Advisory Board members, many ad hoc members devoted their time. Industry also assisted and Air Force Major Command liaison officers were extremely helpful. The Air Force Academy provided critical technical writing assistance and several executive officers from the Air Staff and Major Commands provided outstanding administrative and logistical support. We gratefully acknowledge the assistance of the UK Strike Command and DARPA. Senior leadership including General (Retired) Mike Carns, Lieutenant General George Muellner, Lieutenant General John Jumper, Mr. Ron Orr, Mr. Larry Lynn, and Mrs. Natalie Crawford improved the study greatly through contribution of both their people and their own personal time.

The Study Committee would also like to give special recognition to the SAB Secretariat and support staff, in particular Lieutenant Colonel Jim Berke, and the ANSER team, in particular Ms Kristin Lynch, who provided invaluable administrative and logistical assistance in pulling together the myriad of inputs into this final report. Their efforts are greatly appreciated.

We believe the AEF will become the most frequently used Air Force capability and we are proud to have been part of the establishment of this capability. The men and women of the Air Force want to make the AEF happen and, with a little help, they can and will.

Finally, this report reflects the collective judgment of the SAB and hence is not to be viewed as the official position of the United States Air Force.

Dr. Ronald P. Fuchs
Study Director

November 1997

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Executive Summary

When the Chief of Staff and the Secretary of the Air Force tasked the Air Force Scientific Advisory Board to

> *". . . conduct an intense examination of Air Expeditionary Force operations and to recommend to the Air Force opportunities and options for enabling the Air Force to fulfill the training, deployment, sustainment and employment performance it requires to conduct air expeditionary operations . . ."*

they foresaw the possibility of the Air Force offering increased and valuable military options to the United States. Current Air Force core competencies and near-term technological advances provide the foundation for significant enhancements in both operational capability and responsiveness. This report provides a roadmap to fielding new options for Air Force expeditionary operations.

The Scientific Advisory Board Committee defined *Aerospace Expeditionary Forces* (AEFs) as follows:

> ***Aerospace Expeditionary Forces are tailorable and rapidly employable air and space assets that provide the National Command Authority and the theater commanders-in-chief with desired outcomes for a spectrum of missions ranging from humanitarian relief to joint or combined combat operations.***

In the course of this study, the Committee visited personnel ranging from crew chiefs to commanders, from Mountain Home Air Force Base, Idaho to Tazar, Hungary, and gathered information that leads to the belief, relative to today, that an AEF can

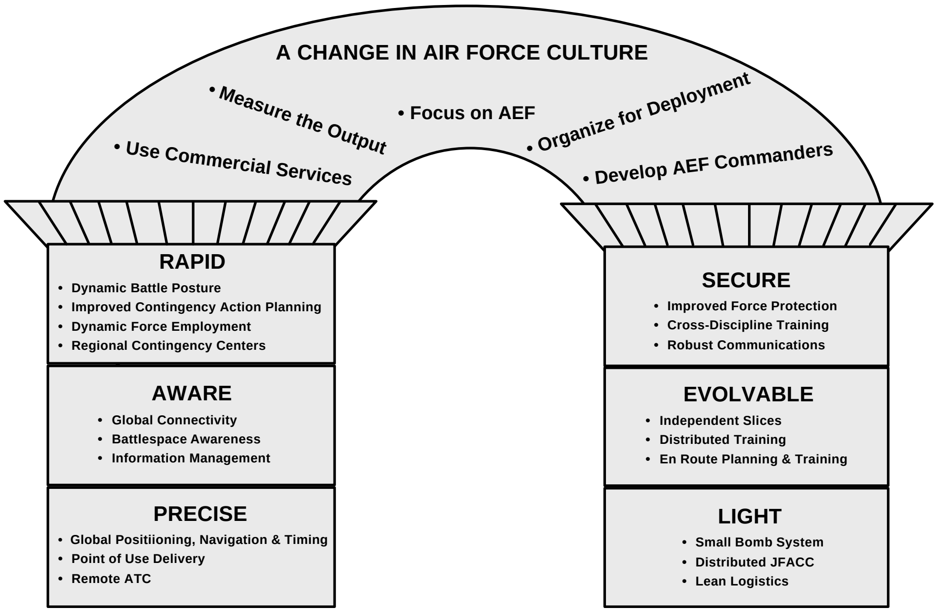
- Respond in less than half the time currently needed, with less than half the airlift, with less than one-third the people forward, to unprepared locations throughout the world
- Operate about an order-of-magnitude more effectively, consistent with other commander-in-chief (CINC) requirements, and with relatively small marginal cost to the current Air Force program and in the near future

Fielding the envisioned AEF will require that the Air Force adopt new operational concepts, new organizational structures, new approaches to training, and new equipment. But most importantly, the AEF is a different culture and the Air Force will have to make the appropriate cultural changes to be successful in this venture.

Taken together, the new approaches will allow the AEF to control the operating tempo of the battlespace by consistently operating with shorter time cycles than the adversary, proactively preparing the battlespace for operations, creating windows of opportunity for AEF exploitation, and inflicting surprise and shock on the adversary. The anticipated result will be a quicker, more efficient achievement of the AEF's objectives with smaller size forces, less support forward, and fewer casualties.

The tremendous leverage created by rapid response to virtually any situation expands the capability of decision makers to influence situations worldwide. Deterrence will be accomplished, in many cases, simply because an AEF exists and the world knows the U.S. has the capability to deliver substantial firepower anywhere in the world within 24 hours. The ability of the AEF to reduce employment timelines to a little more than the flight time from the U.S. to the area of operations provides flexibility to decision makers that has never existed in the past.

The AEF is a giant step forward from today's expeditionary operations, yet it stems from the same core competencies of the Air Force: air and space superiority, global attack, rapid global mobility, precision engagement, information superiority, and agile combat support. The AEF has the potential to provide both a new military capability to the U.S. and a revalidation of the historical basic strengths of the Air Force. The AEF will succeed primarily through fundamental cultural changes in the way the Air Force is organized, trained and equipped.



Keys to the AEF Vision

The essential cultural changes necessary to make an AEF successful include focusing decisions within the Air Force on AEF capabilities, developing commanders who can effectively lead the diverse components of an AEF, organizing the Air Force for rapid deployment, relying upon commercial services (particularly communications), and establishing a continuous self-measurement system based upon desired outcomes.

This new Air Force culture will be technologically enabled by advances in speed of response; understanding of the environment via better use of sensors and connectivity; clear understanding of friendly, enemy and neutral locations and the ability to deliver to precise locations; minimal forward equipment; improved security of forces; and the capability to rapidly assemble and evolve into the right force at the right time. Because the AEF will be used in a variety of scenarios, the Committee identified a spanning set of possible scenarios and subjectively tested the concept against this set. The scenarios used are

- Combat operations mission similar to AEF IV
- Separate combatants mission similar to Bosnia
- Show-of-force mission similar to F-15 fly-overs in Korea
- Counterproliferation mission similar to the Israeli raid on the Iraqi nuclear facility
- Humanitarian relief mission similar to Rwanda
- Battlespace awareness mission

In every scenario and by every relevant measure, the Committee believes the new AEF provides greater (or occasionally equal) capability compared to today's force. One feature of the AEF is that it is easy to test.

After a plan is developed to implement the AEF, the Air Force Chief of Staff and the CINCs can and should regularly use no-notice exercises to validate and test the effectiveness of the concept.

To enable this operational vision of Aerospace Expeditionary Forces, the Committee believes AEF implementation needs to be joint and must be integrated appropriately across the other U.S. Military Services, defense-related agencies, and with allies of the U.S. Full implementation of the specific recommendations below will result in a tailorable and rapidly employable Air Force that provides the National Command Authority and the theater commanders-in-chief with desired outcomes for a spectrum of missions ranging from humanitarian relief to joint or coalition combat operations.

Recommendation Relating to the Joint Approach to AEF Implementation

- The Air Force should ensure that requirements are incorporated for an improved AEF capability into national readiness source documents such as DoD Strategic Guidance, Defense Planning Guidance, Joint Chiefs of Staff Strategic Planning and Operational Requirements documents (e.g., Vision 2010), and CINC Integrated Priority documents and joint operational plans**.**

Recommendations Relating to Operational Characteristics

- The Air Force should organize, train, and equip for deployment and employment of slices (small independent packages) of fighter, bomber, unmanned air vehicle (UAV), tanker, intelligence, surveillance and reconnaissance (ISR), airlift forces, and compatible support slices with an Initial Operating Capability in two years.
- The Air Force should fund the development of munitions with more effectiveness per round and requiring less airlift, such as the Small Bomb System and Low Cost Autonomous Attack System (LOCASS); integrate them on current and planned bombers, fighters, and UAVs; and procure sufficient numbers of the munitions.
- The Air Force should develop the means to do rapid planning, execute employ/deploy mission profiles,[1] and support operational forces from distributed locations, with minimal forward forces, using en route planning, a distributed command center for the Joint Force Air Component Commander, and demand-pull logistics. This concept must be consistent with a minimum forward footprint (people and materiel).
- The Air Force should establish Regional Contingency Centers, implement lean logistics, implement the AEF "Minimum Flight Essential Maintenance" concept, and complete the development and deployment of common operational logistics planning software such as Logisticians' Contingency Assessment Tools (LOGCAT).
- The Air Combat Command (ACC) should be the Air Force lead to work with all relevant DoD and Civil agencies and the Force Protection Battlelab to develop and field effective, highly deployable detection, protection (including nonlethal systems), and decontamination systems for biological, chemical, and laser threats.

Recommendations Involving Information as a Key Enabler

- The Air Force must develop and integrate affordable command and control (C^2) and information systems necessary to find, fix, track, target, and engage any target of interest in the world. This entails establishment of the following:

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[1] "Employ/deploy mission profiles" means that the deploying aircraft (and/or UAVs) conduct a mission at the end of their deployment before landing at their recovery base(s).

- Global Grid system
- Information management, control, and distribution system
- Dynamic battle planning tools and systems
- Geospatial and temporal reference battlespace integration into all AEF platforms, sensors, and weapon systems
- Maximum integration of commercial systems into AEF-relevant information systems

Recommendations Relating to Instilling a New Air Force Culture

- The Air Education and Training Command (AETC) should provide education and training from the classroom to the field that inculcates the AEF philosophy in all members of the Air Force.

- The Air Force should develop, adopt, and continuously track metrics on AEF performance. Furthermore, Air Force inspections must be revised to reflect the AEF concept and scoring must be consistent with these AEF metrics.

Recommendations Relating to Research and Development, Experiments, and Demonstrations

- The Air Force should perform experiments, both field and Advanced Concept Technology Demonstrations (ACTDs), in command, control, and information, lean sustainment, and force protection as discussed in Chapter 4 of this report.

- The Air Force Materiel Command (AFMC) should ensure that, as part of the SAB annual Science and Technology (S&T) quality review of the Air Force Research Laboratory (AFRL), investments are made that underwrite the AEF concepts described herein.

- The Air Force should place high priority on Research and Development (R&D), particularly in the following areas:

  Near to Mid Term

  - Anti-jam and differential Global Positioning System (GPS) (on-orbit and in user equipment)
  - Information management, access, and distribution
  - Network access management (communications)
  - Remote air traffic control (GPS related)
  - Engine reliability and maintainability (e.g., high cycle fatigue)
  - Embedded diagnostics for engines and avionics with inflight reporting
  - Improved chem/bio masks and detection systems
  - Reachback expertise for medical and maintenance diagnoses (telemedicine, telemaintenance, etc.)
  - Communication systems to ensure all forms of “in-transit visibility”
  - Affordable integration of military and commercial satellite systems
  - Distributed and embedded training

  Mid to Far Term

  - Lasers and high power microwave weapons and defensive systems
  - Hypersonics (engines, endothermic fuels, materials, etc.)
  - Space structures (e.g., lightweight structures, deformable optics)
  - Reusable launch vehicles

Realizing the New AEF

The Committee envisions Aerospace Expeditionary Forces to be tailorable and rapidly employable air and space forces that provide the NCA and the CINC with the option to produce the desired outcomes for a range of possible missions the country may be called upon to undertake. The full realization of this AEF depends upon the synergistic combination of the many changes to people, systems, and concepts described throughout this report. However, many advances (particularly organizational, planning, and training) can be made relatively rapidly and inexpensively in the near term. The Air Force should undertake these improvements immediately. The Air Force should assure that funding priorities appropriately consider program/system contributions to making the force more expeditionary.

In its travels and meetings, the Committee developed a renewed appreciation for the creativity, initiative, and enthusiasm of the operational Air Force — a group many of the Committee had previously had little opportunity to investigate and understand. While several key recommendations of this report revolve around cultural changes — and cultural changes are often the most difficult ones to effect — the AEF concept is one the people of the Air Force want to make happen. *They* can succeed in providing this new and valuable military capability to the U.S.

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List of Acronyms and Abbreviations

2BW	2nd Bomb Wing
ABDAR	Aircraft Battle Damage Assessment and Repair
ABL	Airborne Laser
ACADA	Automated Chemical Agent Detector and Alarm
ACE	Aircrew Chemical Ensemble
ACN	Airborne Communications Node
ACTD	Advanced Concept Technology Demonstrations
AEF	Aerospace Expeditionary Force
AERP	Aircrew Eye/Respiratory Protection
AETC	Air Education and Training Command
AFAL	Air Force Armstrong Laboratory
AFB	Air Force Base
AFMC	Air Force Materiel Command
AFRL	Air Force Research Laboratory
AFSST	Air Force Space Support Team
AGAS	Affordable Guided Airdrop System
AGE	Aerospace Ground Equipment
ALC	Air Logistics Center
AMC	Air Mobility Command
AOC	Air Operations Center
AOG	Air Operations Group
AOI	Area of Interest
AOR	Area of Responsibility
ATC	Air Traffic Control
ATIRCM	Advanced Threat Infrared Countermeasure
ATM	Air Traffic Management
ATO	Air Tasking Order
ATR	Automated Target Recognition
AWACS	Airborne Warning and Control System
BADD	Battlefield Awareness Data Dissemination
BC^2A	Bosnia Command and Control Augmentation
BCAT	Base Contingency Action Tool
BDA	Battle Damage Assessment
BIDS	Biological Integration and Detection System
BM	Battle Management
BW	Biological Weapons
C^2	Command and Control
C^2I	Command, Control, and Information
C^4	Command, Control, Communication, and Computers
C^4I	Command, Control, Communication, Computers, and Intelligence
CALCM	Conventional Air Launch Cruise Missile
CAP	Crisis Action Plan
CAT	Common Air Transport
CCD	Charge Coupled Device
CDC	Center for Disease Control
CENTCOM	Central Command

CEP	Circular Error Probable
CINC	Commander-in-Chief
CNS	Communications, Navigation, and Surveillance
COE	Common Operational Environment
COMPES	Contingency Operations Mobility Planning and Execution System
CONOPS	Concept of Operations
CONUS	Continental United States
COP	Common Operational Picture
COTS	Commercial Off-the-Shelf
C-REP	Contractor Repair Enhancement Program
CW	Chemical Weapons
DAOC	Distributed Air Operations Center
DARPA	Defense Advanced Research Projects Agency
dB	Decibel
DBS	Direct Broadcast Service
DCAPES	Deliberate Contingency Action Planning and Execution System
DED	Directed Energy Directorate
DGPS	Differential Global Positioning System
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DMT	Distributed Mission Training
DOC	Designed Operational Capability
DoD	Department of Defense
DOE	Department of Energy
DOS	Department of State
DOT	Department of Transportation
DPRS	Deployable Pavement Repair System
DR	Departure Reliability
D-REP	Depot Repair Enhancement Program
DSP	Defense Support Program
EDCS	Evolutionary Design of Complex Software
EFX	Expeditionary Force Experiment
EHF	Extremely High Frequency
EMD	Engineering and Manufacturing Development
EO	Electro-Optical
ESA	Electronically Steered Antenna
EW	Electronic Warfare
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FMC	Fully Mission Capable
FOD	Foreign Object Damage
FOL	Forward Operating Location
FOV	Field of View
Gbps	Gigabits per Second
GBS	Global Broadcast Service
GCCS	Global Command and Control System
GPS	Global Positioning System
HAE	High Altitude Endurance
HCF	High Cycle Fatigue

HPM	High Power Microwave
HUD	Head Up Display
ICAI	Intelligent Computer-Aided Instruction
IDM	Information Dissemination Management
IFTW	Information for the Warrior
IHPTET	Integrated High Performance Turbine Engine Technology
IM	Information Management
IMA	Integrated Modular Avionics
I/O	Input/Output
IPL	Image Product Library
IPT	Integrated Process Team
IPT	Integrated Product Team
IR	Infrared
IR&D	Independent Research and Development
ISR	Intelligence, Surveillance, and Reconnaissance
ITAP	Improved Toxicological Agent Protective Ensemble
ITAS	In-Theater Airlift Scheduler
IW	Information Warfare
JBPDS	Joint Biological Point Detector System
JBS	Joint Broadcast System
JCAD	Joint Chemical Agent Detector
JDAM	Joint Direct Attack Munition
JDISS	Joint Distributed Information Support System
JEIM	Jet Engine Intermediate Maintenance
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JOPES	Joint Operational Planning and Execution System
JSAM	Joint Service Aircrew Mask
JSF	Joint Strike Fighter
JSLIST	Joint Services Lightweight Integrated Suit Technology
JTF	Joint Tactical Forces
JWARN	Joint Warning and Reporting Network
JWID	Joint Warfighter Interoperability Demonstration
kbps	Kilobits per Second
km	Kilometer
kW	Kilowatt
LADAR	LAser Distancing And Ranging
LCF	Low Cycle Fatigue
LCN	Load Classification Number
LEP	Laser Eye Protection
LNBCRS	Lightweight Nuclear, Biological, and Chemical Reconnaissance System
LL	Lean Logistics
LO	Low Observable
LOCAAS	Low Cost Autonomous Attack System
LODIS	Low Cost Dispenser
LOGCAT	Logisticians' Contingency Assessment Tools
LSCAD	Lightweight Standoff Chemical Agent Detector
MAAS	Mobile Aircraft Arresting System

MASS	Modular Aircraft Support System
Mbps	Megabits per Second
MDS	Mission Design Series
MEMS	Micro-Electro Mechanical System
MHE	Material Handling Equipment
MOB	Main Operating Base
MOG	Maximum On Ground
MOPP	Mission Oriented Protection Posture
MOU	Memorandum of Understanding
MRE	Meals Ready to Eat
MRC	Major Regional Conflict
MSCS	Multiple Source Correlation System
MSK	Mission Support Kit
MSTS	Multi-Source Tactical System
MTI	Moving Target Indicator
MTW	Major Theater War
MW	Megawatt
NASA	National Aeronautics and Space Administration
NBC	Nuclear, Biological, and Chemical
NCA	National Command Authority
NIMA	National Imagery and Mapping Agency
NMC	Non-Mission Capable
NMCM	Non-Mission Capable Maintenance
NMCS	Non-Mission Capable Supply
nmi	Nautical Mile
NSA	National Security Agency
NVG	Night Vision Goggles
NVL	Night Vision Laboratory
O&M	Operations and Maintenance
OA	Obligation Authority
OBIGGS	On Board Inert Gas Generation System
OBOGS	On Board Oxygen Generation System
OPLAN	Operations Plan
OPSL	Optically Pumped Semiconductor Laser
OPTEMPO	Operational Tempo
OSD	Office of the Secretary of Defense
PGM	Precision Guided Munitions
PNT	Position, Navigation, and Timing
POM	Program Objective Memorandum
R&D	Research and Development
R&M	Reliability and Maintainability
RAF	Royal Air Force
RCC	Regional Contingency Center
RD&A	Research, Development, and Acquisition
RF	Radio Frequency
RSP	Readiness Spares Package
S&T	Science and Technology
SAB	Scientific Advisory Board
SAR	Synthetic Aperture Radar

SBS	Small Bomb System
SEAD	Suppression of Enemy Air Defenses
SHF	Super High Frequency
SIDS	Secondary Imagery Dissemination System
SSB	Small Smart Bomb
SSC	Small Scale Contingency
STEP	Survey Tool for Employment Planning
SWA	Southwest Asia
TBM	Theater Ballistic Missiles
TCTO	Time Compliance Technical Orders
TIBS	Tactical Information Broadcast System
TRAP	Tactical (Receive Equipment) Related Applications
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
USTRANSCOM	U.S. Transportation Command
UTC	Unit Type Code
VSAT	Very Small Aperture Terminals
W	Watt
WFI	Warfighter Internet

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Chapter 1

The Aerospace Expeditionary Force (AEF)

1.1 The AEF

The rapidly responding AEF with unprecedented effectiveness per unit deployed described in this report provides the U.S. National Command Authority (NCA) and the warfighting Commanders-in-Chief (CINCs) with truly new military capabilities. The AEF allows new deterrence options, new options for supporting allies through information access, and new capability to increase the political decision making timelines while maintaining an effective military option. The AEF is an opportunity for the Air Force to become even more valuable as an instrument of the U.S. defense establishment. The SAB Study Committee developed and used the following definition for an AEF for this study:

> ***AEFs are tailorable and rapidly employable air and space assets that provide the NCA and the theater CINCs with desired outcomes for a spectrum of missions ranging from humanitarian relief to joint or combined combat operations.***

The AEF represents a change to the Air Force culture emphasizing the following key characteristics:

- Rapid
- Aware
- Precise
- Secure
- Light
- Evolvable

This AEF can operate in joint and combined forces and will provide the NCA and CINCs a military capability that is fast, flexible, precise, sustainable, lethal in combat, and effective in humanitarian and other missions. Several CINCs' Integrated Priority Lists state these characteristics as requirements. The Air Force needs the AEF to meet the wide range of contingencies that may be tasked. These contingencies include deterrence or defeat of threatened use of weapons of mass destruction or ballistic and cruise missiles; deterrence or halt of invading armies before they achieve objectives that will be costly or otherwise difficult for U.S. forces to recover; and providing relief in acute natural and technological disasters, ranging from earthquakes to droughts to epidemics to incidents such as Chernobyl and Bhopal, which require urgent action to minimize casualties and far ranging long-term damage. In addition, further reductions to budgets and forward-deployed forces suggests much more often than in the past, the NCA will be faced with the choice of deploying military forces to a crisis area from the continental United States (CONUS). These considerations dictate the need for wide-ranging airpower capabilities that can be employed on short warning from the U.S. or other locations to often austere bases. Operations that originate and terminate in a home base or start in CONUS and recover at a forward deployment base after engagement are likely to become more prevalent. The AEF satisfies these new needs while meeting contingency commitments.

In the future, the Air Force will operate with its sister Services during most missions. The AEF concept described in this report has as its underlying assumption that the AEF vision and its details will enhance the Air Force's contribution to joint or coalition operations. In fact, the Committee's first recommendations reinforce the need for the Air Force to approach the concept jointly.

1.2 The AEF Vision

The AEF recommended by the SAB is a giant step forward from today's expeditionary operations, yet it stems from the same core competencies of the Air Force: air and space superiority, global attack, rapid global mobility, precision engagement, information superiority, and agile combat support. The keys to building these core competencies into an AEF are shown in Figure 1 and are described in the subsequent sections of this chapter.

The AEF has the potential to provide both a new military capability to the U.S. and a revalidation of the basic strengths of the Air Force. But the AEF will only succeed with fundamental cultural changes in the way the Air Force is organized, trained, and equipped.

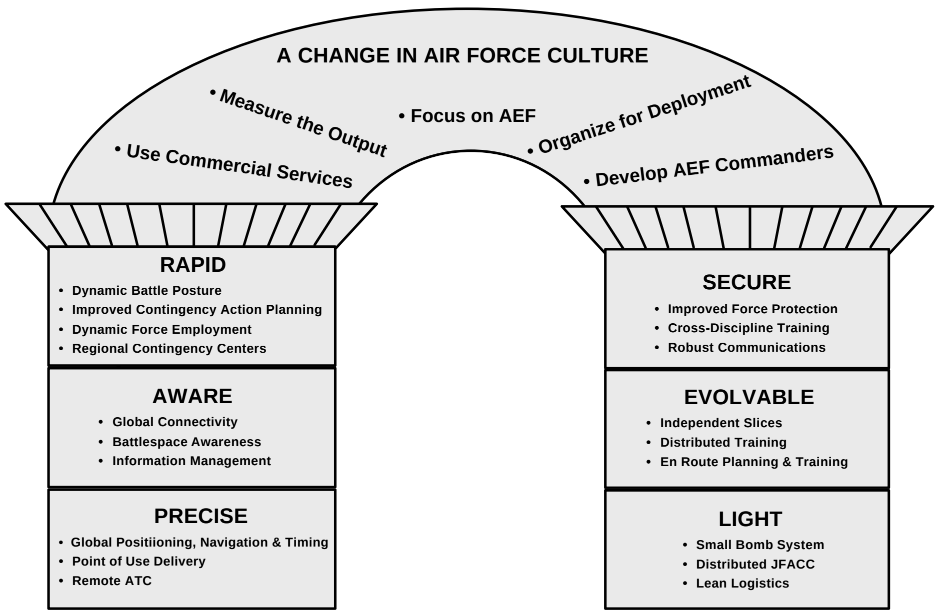

Figure 1. *Keys to the AEF Vision*

The cultural changes necessary to make an AEF successful include focusing decisions within the Air Force on AEF capabilities, developing commanders who can effectively lead the diverse components of an AEF, organizing the Air Force for rapid deployment, relying upon commercial services (particularly communications), and establishing a continuous self-measurement system based upon desired outcomes.

This new Air Force culture will be technologically enabled by advances in speed of response; understanding of the environment via better use of sensors and connectivity; clear understanding of friendly, enemy, and neutral locations and the ability to deliver to those locations; minimal forward deployed equipment; improved security of forces; and the capability to rapidly assemble and evolve into the right force at the right time. Because the AEF will be used in a variety of scenarios, the Committee identified a broad set of possible scenarios and subjectively tested the concept against this set. The scenarios used are

- Combat operations mission similar to AEF IV
- Separate combatants mission similar to Bosnia
- Show-of-force mission similar to F-15 fly-overs in Korea
- Counterproliferation mission similar to the Israeli raid on the Iraqi nuclear facility

- Humanitarian relief mission similar to Rwanda
- Battlespace awareness mission

In addition, the Committee considered the AEF to be the lead deploying force in preplanned or unplanned contingencies that lead to a Major Theater War (MTW) or Small Scale Contingency (SSC).

Note that, as a baseline for comparison of current and projected expeditionary air power, the Committee uses the 90-day deployment of 30 fighters to Southwest Asia in early 1997, which is commonly referred to as AEF IV. The AEF would probably be the normal leading edge force for most major combat operations.

The Committee believes the new AEF provides greater (or occasionally equal) capability compared to today's force in every scenario and by every relevant measure.

1.3 The New Culture

The Air Force contributed greatly to winning the Cold War, but that war is over and the world is a different, and in many ways, more dangerous place. Nevertheless, because Cold War-type missions, such as response to an MTW, still exist, the Air Force still maintains many of the same organizational constructs of the past. The increasing need to respond quickly to many locations with relatively small forces has not been a priority in the organization, training, or equipping of the Air Force. The Committee believes this can and should change and that such change will have a positive impact on the Air Force ability to respond to conventional MTW missions. The structure of the Air Force described in this report will require an AEF mentality to pervade decisions ranging from system acquisition to deployment package sizing. AEF combat capabilities of speed, stealth, and lethality will be enhanced by future platforms (e.g., F-22 and Joint Strike Fighter [JSF]), precision strike, all-weather close air support, dynamic air interdiction, and accurate bomb damage assessment. Designs of these weapon systems must emphasize durability with minimal support while deployed. All Air Force people will have to think light, fast, and lethal.

In the past, developing commanders tended toward specialization, e.g., wing commanders who spent their whole operational career in one or two types of fighters. The character of an AEF will often require a thorough understanding of fighters, bombers, command and control (C^2), information, surveillance, reconnaissance (ISR), transport, force protection, maintenance, and other capabilities. Commanders must make specific efforts to develop understanding and appreciation of diverse systems if they are to mold these elements into a cohesive unit.

The basic building blocks of the Air Force, wings and squadrons, may be too large for AEF purposes. Smaller deployable force increments (herein called "slices") with support sized to these packages are required to maintain normal operations and to respond flexibly and rapidly to a crisis anywhere on the Earth. The AEF will identify both force and provisioning slices within organizational units for independent or distributed operations. These slices will be standardized and trained in equipment and procedures so the composite force can work together effectively from the receipt of an execution order.

In some areas of technology, the commercial marketplace provides capabilities the military cannot afford to own. Just as the Air Force made decisions in the past to rely on commercial transportation systems to meet some needs, the AEF must harness commercial communications technology to provide about a thousand times the capacity of the systems the military will be able to field.

For change to be effective, the Air Force must measure AEF ability to deliver desired outcomes. Adopting and regularly using a set of AEF metrics such as shown in Table 1 will allow a clear understanding of the progress toward achieving the new AEF culture.

Table 1. *AEF Metrics*

Metric	Comment
Response time from execution order to first employment	Because the principal attributes the Committee envisions for the recommended AEF are its enhanced responsiveness to NCA tasking and its decreased footprint in operations, this metric relates to the time it takes after an execution order for AEFs to begin employment to achieve the desired effect.
Time to achieve desired effect	This metric measures how long it takes the proposed AEF to achieve its desired outcome.
Lift required per mission aircraft Personnel deployed forward per mission aircraft Percentage of AEF personnel above unit level deployed forward	These metrics relate to the AEF footprint in the forward area of operations. Reduced footprint of forward forces is a critical enabler of the timelines, survivability, and agility attributes of the SAB's AEF concept. Objective performance for these metrics is likely to vary according to the mission. For example, the lift required should be minimized for combat missions, yet might be maximized for certain humanitarian missions.
Time from information request to receipt by forward unit Location accuracy in the area of interest	These metrics measure various aspects of the communications and geo-location systems that support the AEF. The time metric assumes that all information eventually reaches the requester, and addresses the promptness of the information transfer. Location accuracy measures the quality of the geo-location systems supporting the AEF and their incorporation on all AEF-related platforms, sensors, and weapons.
Error from desired mean point of impact Targets destroyed per sortie	These metrics measure the effectiveness of the weapons systems employed. Average error tracks the weapon impact error, and measures both the accuracy of the weapon and the geospatial reference system employed. Targets destroyed is an outcome measure of the efficiency of AEF combat forces and is influenced both by the size and number of the weapon systems employed and by their accuracy. It therefore relates to the total number of forces and the quantity of expendable ordnance required, which, in turn, relates to footprint.
Casualties per day	This metric is a force effectiveness measure that may be applicable in either combat operations, peacekeeping, or humanitarian relief. Reducing friendly casualties and collateral damage is expected to remain an operational imperative in combat operations expected in the future. Number of hostile casualties is also a key measure of force effectiveness, although the specific mission will determine whether to maximize or minimize the metric.
Percentage of wing personnel trained in AEF doctrine	This metric relates to the degree to which the change in Air Force culture required for full adoption of the proposed AEF concept has permeated the Air Force down to the operational level. Implicit in this metric is development of the necessary doctrine to employ AEFs and the training syllabi to transmit these new perspectives and operating modes to the operating forces.
Percentage of supply and maintenance items delivered as requested	This metric provides information on how effectively the just-in-time logistics system is operating.

1.4 The AEF is Rapid

Warfighters have long recognized the value of rapid response. To paraphrase Clausewitz[2],

> *Never waste time. Unless important advantages are to be gained from hesitation, it is necessary to set to work at once. By speed a hundred enemy measures are nipped in the bud, and public opinion is won most rapidly. It is the most important element of victory. Napoleon, Frederick II, Gustavus Adolphus, Caesar, Hannibal, and Alexander owe the brightest rays of their fame to their swiftness.*

[2] From Clausewitz' 1812 essay "Principles of War," Chapter III.

The AEF will have the capability to initiate action anywhere on the globe within 24 hours after receipt of the execution order as a stand-alone, joint, or coalition expeditionary force. This capability will maximize the time for political and military decision makers to work out peaceful resolutions of crises prior to initiating operations. If the situation permits substantial preplanning prior to the execution order, the AEF will need time only for transit, and response time can take substantially fewer than 24 hours. Thus, once the decision is made, the AEF will offer a uniquely swift response to the mission requirements.

In the case of many hostile situations, the AEF's ability to engage rapidly should provide a powerful deterrent to U.S. adversaries. If deterrence fails, however, this capability should control casualties and collateral damage on both sides. Depending on the desired state of readiness (e.g., 24 hour, 48 hour, or 72 hour), operational units will need to adopt an appropriate alert posture. A 24-hour response will require approximately a 4-hour alert posture for deploying forces. Today's normal readiness level is adequate for a 72-hour response (see Table 2).

Table 2. *Summary of Combat Operations Timeline Analysis*

AEF Option	Characteristics	Time to First Delivery
Fighters		
Baseline	AEF IV	70 hours
Enhanced Baseline	Minimum feasible time is required to position tankers and transports. No delays are caused in deploying force. Beddown site has adequate pavements, fuel, water, etc. High quality Contingency Action Planning tools are in use.	50 hours
Prepositioned Lift	Tankers are on 4-hour standby at en route bases. Transports are designated to arrive at departure base in 4 hours. Forward-positioned aerial port is in operation after 12 hours. Minimum mobility planning time is required.	40 hours
Alert Strike Force	Both deployment and first strike crews are on 4-hour recall to take off in 6 hours. Mission planning and crew rest during flight to operational theater. Support cargo and personnel leave in 4 hours.	26 hours
Employ/Deploy Mission Profile	Strike force takes off in 6 hours direct to target area.	20 hours
Bombers		
Without Alert	Current practice	32-48 hours
With 4-hour Alert	Crews and support personnel are on 4-hour recall.	20 hours
Intelligence, Surveillance, and Reconnaissance Aircraft		
Without Alert	Current practice	32-48 hours
With 4-hour Alert	Crews and support personnel are on 4-hour recall.	20 hours

An AEF does not need and cannot afford to rely heavily on prepositioned materiel. However, the AEF can move more rapidly and with less disturbance to normal tasking if Regional Contingency Centers (RCCs) are established (see Figure 2). These RCCs are bases within 1,500 to 2,000-nautical miles (nmi) (C-130 to C-17) range of potential trouble spots. The bases provide prenegotiated diplomatic clearance agreements, support facilities, and stocks of relatively low cost, heavy items such as fuel, water, and bomb bodies. A limited number of RCCs (e.g., eight) would provide worldwide coverage. Two "super" RCCs would be more completely stocked with supplies and equipment for rapid build-up of an RCC into a regional main operating base (MOB).

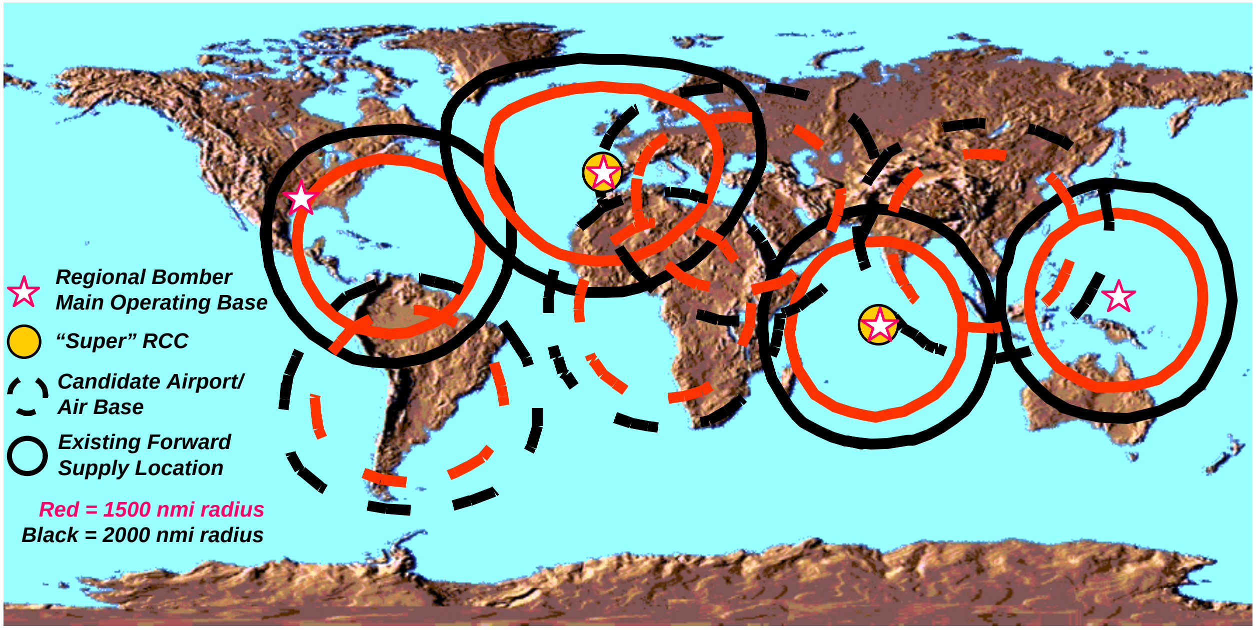

Figure 2. *A Limited Set of Regional Contingency Centers (RCCs) and Bomber Main Operating Bases Enhances AEF Global Coverage, as Illustrated by this Notional Configuration*

In many cases, bombers or bombers escorted by air superiority fighters will provide the most rapid response option. The Air Force can double sortie rates for bombers, relative to CONUS basing, by improving bomber servicing capability (such as the 8th Air Force did for B-52s at Anderson AFB, Guam) at a base in Europe and at Diego Garcia.

The value of time also leads to the need to be able to target and task aircraft en route. The same system that provides this capability can restructure the current Air Tasking Order (ATO) system into one based on mission orders and dynamic retargeting, a recommendation in several past SAB studies.

Finally, rapidity requires crisis action planning (CAP) tools that integrate combat unit and mobility operations, logistics, force protection, and other functions in a collaborative process supported by effective tools and shared databases. The Air Force can and must reduce current CAP timelines of several days to as little as 4 hours to support the AEF's 24-hour response timeline.

1.5 The AEF is Aware

Situation awareness is especially important for a small force. Integration of sensor outputs in a coherent battlefield picture will yield an exquisite understanding of how to best employ forces. Global connectivity will provide the ability to get the right information to the right user at the right time. Many of the necessary sensors are available or are being developed currently; however, the ability to task them and assemble the information into a common operational picture will rely on a management structure, a communications system, precision location systems, and a willingness for all data sources to accept tasking from an information controller.

The AEF battlespace awareness system can support the full range of AEF missions or act as a stand-alone mission. The battlespace awareness AEF requires improvements in deployability, sensor management concepts and full integration of the information provided by each sensor platform.

1.6 The AEF is Precise

The Global Positioning System (GPS) has already spawned a revolution in warfare, but that revolution has barely begun. Advances in GPS, inertial systems, and computers will combine to yield affordable means to develop and maintain a global geospatial position navigation and timing database in near-real time. Accurate geospatial-temporal tagging removes ambiguity, making fusion of data from diverse sensors relatively easy. Target locations can then be determined to a level of accuracy that matches GPS weapon delivery.

Some cases, such as humanitarian relief or crowded airfields, will necessitate parachute delivery of supplies. Simple modifications to conventional round parachutes will make low-cost point-of-use delivery feasible and provide additional AEF capability.

The degree of accuracy available with GPS will allow precision approach and landing. Coupled with assured communications, this will permit the AEF to do air traffic control (ATC) remotely from CONUS or a theater, thus further reducing forward-deployed personnel and equipment.

1.7 The AEF is Secure

Increased threat of cruise missiles and tactical ballistic missiles (particularly carrying biological or chemical warheads) and blinding lasers make new force protection capabilities essential. Improved personal and collective protection will enable AEFs to operate in chemical or biological threat environments. Detection systems are needed to provide adequate warning. When other local basing is available, the small footprint of the AEF will also make moving to another location a more viable response option.

With a flexible, portable perimeter of sensors, the AEF can evaluate the security of each landing, loading, and takeoff. En route security will be enhanced by global connectivity that will provide battlespace awareness, enabling the AEF to avoid or deny the enemy use of weapons. New individual and collective protection systems as well as hardening of weapons systems and threat detectors will enable the AEF to protect itself up to Level 2 threats.

With the small forward force, AEF personnel will be called upon to perform multiple functions. Broad training for such force protection as maintaining detection systems and using small arms will enhance AEF security.

Heavy reliance on commercial communications and GPS will make the security of these systems a special concern of the AEF. A smart communications controller will allow power management and frequency diversity through switching providers. Tightly coupled GPS and inertial systems will provide adequate antijam margins so any effective GPS jammer will be a lucrative target.

1.8 The AEF is Light

The AEF will adopt as a basic principle “don’t take it unless you’re sure you’ll need it forward.” To minimize the exposure of valuable assets, human and physical, to hostilities, the AEF will operate in the theater only with those assets absolutely essential at the points of action. To minimize footprint, the AEF will forward deploy only essential operational, command, support, and force protection assets. Advances in information superiority will enable the AEF to operate with minimum assets, which will optimize operational effectiveness through enhanced precision strike and battle damage assessment (BDA). Technological innovations will minimize base operating and ground support equipment and increase hardware reliability in theater.

The AEF absolute minimum requirement for a "bare base" is a runway, taxiways, and a ramp suitable for airlift and mission operations. If water that can be made potable and fuel supplies are not locally available, the AEF must bring them in; thus, the associated transportation requirement will increase. Communication assurance will allow a distributed Joint Force Air Component Commander (JFACC) and just-in-time logistics. A Small Smart Bomb (SSB) (250 pounds) provides about a factor-of-eight improvement in kills per sortie against about 70 percent of targets and reduces the munitions airlift requirement by about 60 percent.

Table 3 compares current deployment practice as demonstrated in AEF IV to two alternatives. The Minimum Bare-Base Package is the Committee's estimate of the reduction possible with today's equipment and planning tools, given the emphasis on improved procedures and paring resources to the true necessary minimum. The Optimized Package is our estimate of the further reductions that can be achieved by implementing the recommendations of the study, including RCCs, improved support equipment, advanced munitions, and better planning tools. Our analysis indicates that this optimized AEF requires half the airlift (27 vice 56 C-141 loads) and one-third the forward-deployed people (460 vice 1,350) of AEF IV.

Table 3. *Comparison of Optimized AEF Packages to AEF IV for a "Show of Force" Mission*

	Recent (AEF IV)			Achievable Now		SAB AEF	
	Deployed Personnel	Deployed Cargo (C-141s)	Pre-positioned Cargo (C-141s)	Deployed Personnel	Deployed Cargo (C-141s)	Deployed Personnel	Deployed Cargo (C-141s)
Initial Combat Capability	541	16.0	15.8	264	20.9	158	13.0
Force Protection	113	2.7	0.0	118	1.5	118	1.5
Base Operations & Support	576	0.4	14.5	184	9.1	116	7.4
Aerial Port	120	7.0	0.0	69	5.1	69	5.1
Subtotals	1,350	26.1	30.3	632	36.6	460	27.0
Total Cargo (C-141s)	56.4			36.6		27.0	
Total Deployed Personnel	1,350			632		460	

1.9 The AEF is Evolvable

The AEF is designed to change in character continuously over its life from original constitution until steady sustainment or return to home base. For example, a combat AEF may consist of initial sorties using bombers delivering weapons in 20 hours. Simultaneously, fighters might deploy to a forward base and begin deployed operations with minimal maintenance at about 24 hours. Additional assets such as robust maintenance and Harvest kits could arrive in a few days, and, by about the end of a week, a sustainable force similar to the current deployed forces could be operating if desired. The AEF could be supplemented during this entire period with additional capability slices as needed to handle the evolving situation. The AEF may also be the initial deployed force of a larger preplanned or unplanned MTW or SSC.

The AEF will be tailorable from Air Force, joint, and/or combined assets as called for by the particular mission to be served and availability of forces. Keeping the AEF applicable to the spectrum of missions currently envisioned and those that will emerge as the future world state changes will require agility. This mode of operation will become the norm rather than the exception. Assets will be brought together in an efficient way to mesh and meld as required.

To be effective, this force will involve a training system that affordably allows regular exercise of large portions of the Air Force that might participate in an AEF. Slice-sized distributed system simulators and associated C^2 simulators will also provide the ability to assemble an effective integrated force when an AEF is called on.

1.10 Realizing the SAB AEF

The power of the AEF comes from the synergistic effects of all of the recommendations. An example is a system like the Small Smart Bomb. Its effectiveness permits increased numbers on each combat aircraft enabling the target list to be completed significantly sooner with a dramatically reduced sortie levels. The GPS inertial system permits precise delivery day or night and in all weather conditions. The wooden round concept reduces the number of load crews and support equipment and the logistic concept can preclude the need to maintain a bomb dump. The airlift required for bombs, equipment, and people are significantly reduced. That in turn reduces the force protection and other support personnel. Similar examples will be explained throughout the report.

The full realization of the SAB AEF depends on the synergistic combination of the many changes to people, systems, and concepts described throughout this report. However, the Air Force can make many improvements (particularly organizational, planning, and training) relatively rapidly and inexpensively in the near term. Inevitably, some of our recommendations require investment, but we have consistently sought approaches that are affordable and produce the greatest leverage on AEF capability for the funds expended. In its travels and meetings, the Committee developed a renewed appreciation for the creativity, initiative, and enthusiasm of the operational Air Force. Although several key recommendations of this report revolve around cultural changes — and cultural changes are the most difficult ones to effect — the people of the Air Force want to make the AEF concept happen. They can succeed in providing this new and valuable military capability to the U.S.

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Chapter 2

Enabling the AEF Vision

2.1 Introduction

The Committee bases its vision of a responsive, effective, and affordable AEF on increased lethality, effective reachback, small forward footprint, joint/combined operations, enhanced battlespace awareness, and dynamic battle planning and execution. The force must be trained, organized, and equipped for rapid execution of a broad spectrum of missions and must possess the means to ensure survival to operate, integrated CAP, tailored logistics, and ability to operate at austere forward bases.

In this chapter, the Committee addresses a number of specific concepts and issues associated with achieving the vision. First, to establish a baseline, the current capabilities of the Air Force are described. This is followed by a discussion of concepts and issues associated with C^2 and then by logistics considerations. Finally, factors affecting force protection are presented to close out this chapter. Chapter 3 then focuses on the actions needed to effect the desired transformation.

2.2 Current Capability

The following section describes in a general fashion the present experience and capabilities of the Air Force with regard to AEF-type missions.

2.2.1 Timelines

Fast, global response to diverse and unpredictable CINC needs is the essence of the AEF concept. However, today's Air Force units have inherited a Cold War culture and generally think about deployed operations in terms of significantly longer timelines and far more developed and provisioned bases than those contemplated in this study. Currently, the Air Force shortens timelines by selective contingency techniques *on top of* the usual process. This simply expedites, rather than reforms, the old approach and actually adds to the required effort. In this study, the Committee examined the feasibility of offering to the NCA a dependable option to employ air power in about 24 hours from an execute order.

To assess current capability, we can look at the response times of recent operations in areas relevant to our scenarios. Here are some examples:

- In Operation Desert Strike, the 2nd Bomb Wing (2BW) reconfigured nine B-52Hs to carry conventional air launch cruise missiles (CALCMs) in approximately 22 hours. Four aircraft deployed to Anderson Air Force Base (AFB) in 16 hours, left after crew rest for an 18-hour flight to the area of responsibility (AOR), and delivered the strike approximately 65 hours after the "go" order. This could have taken closer to 40 hours had the force been able to take the shorter eastbound route and flown straight to the launch point. Two years of prior work in developing the wing's "Light/Lethal" concept and in bringing Anderson AFB back up to readiness to support B-52 operations made the strike possible at all.
- In the recent Southwest Asia (SWA) deployment, generally labeled AEF IV, the fighter force deployed from East Coast bases and delivered the first sortie in approximately 70 hours from the warning order. Several months of planning and preparation and 10 days of transport missions and base preparations preceded the warning order to receive the arriving fighters. AEF IV is the fastest recent fighter deployment the Committee is aware of.

- In Operation Provide Relief, the humanitarian operation in Somalia, the first C-130 relief delivery sortie occurred 7 days after the President's order, and the full force of 13 C-130s was deployed and flying missions approximately one month later. More recent humanitarian/medical operations by the 3rd Air Force in sub-Saharan Africa have shown the ability to deploy and set up to deliver medical treatment in approximately 24 to 36 hours and to operate with a minimal forward base footprint by relying on extensive reachback.

Especially for missions with combat forces, the demonstrated responsiveness falls short of the 48-hour timeline of the draft Air Force Instruction on Rapid Response AEFs, to say nothing of this study's nominal goal of even faster response. The Committee's evaluation of the deployment process indicates that some or all of the following factors dominate the response time in various scenarios:

- **Mobility Positioning**. Erecting the tanker air bridge and, in some cases, retasking transports to pick up deploying forces greatly limits operations. Deploying and erecting an aerial port from the U.S. has roughly a 24-hour lead time.
- **Aircraft Movement**. Flight time from the U.S. to typical target areas is 12 to 18 hours.
- **Fuel and Munitions**. At non-prepositioned bases, establishing a fuel supply and building up ready munitions stocks can take anything from hours to days.
- **Generating the Force**. Generating aircraft, preparing personnel, and packing and marshaling cargo consumes 12 to 24 hours under normal readiness conditions.
- **Forward Operating Location(s)**. Forces need airfields with adequate runways, parking areas, and water supplies; availability of quarters, utilities, and other support factors reduces the required lift and shortens the timeline.
- **Diplomatic Clearances**. Although largely beyond Air Force control, this problem has consistently and banefully limited virtually every operation of the past few decades.

Under current law and regulations, the launching of an AEF can be governed by as many as four successive operations orders. A Planning Order establishes a requirement, usually long term, to begin planning for a given contingency or geopolitical situation. A Warning Order notifies specific units that they have been identified for an operation and should start preparing. An Alert Order starts the deployment process and authorizes the dispatch of strategic lift forces. The response time of interest is from Alert Order to delivery of first military effect. Figure 3 illustrates the challenge of moving from the current 70-hour or greater response time of U.S.-based tactical wings toward the goal of 24-hour global application of air power. Note that the 24-hour Execute Order to first effect in AEF IV or the Rapid Response AEF goal assumes crew rest quarters are available. The Committee's AEF vision assumes en route employment and/or crew rest en route to a bare base. Later sections of this report examine a range of actions that can move the Air Force to a much more responsive posture without demanding excessive use of resources.

2.2.2 Organizational Constructs

A typical fighter wing has three squadrons of 24 aircraft each plus administrative and support functions and spare aircraft. This fundamental fighting unit uses economies of scale to reduce support personnel, equipment, and spares. Deployment support centers on moving 12 to 18 aircraft from a squadron to a forward base and flying sorties for a month with minimum additional supply and support. This strategy usually uses a fully developed and extensively prepositioned operating base as the forward operating location. It assumes that the wing will need to respond to tasking for an MTW and deploy at least as squadrons and possibly as a complete wing.

Support equipment, technical orders, and staffing concentrate on minimizing cost, but sacrifice flexibility. Consequently, deploying a small number of aircraft (six, for example) requires tailored support packages which takes time, and the deploying package generally takes unique but essential items, leaving the other aircraft insupportable. Furthermore, U.S. Transportation Command (USTRANSCOM)/Air Mobility Command (AMC) have usually known of planned movements and prepared for them for several months.

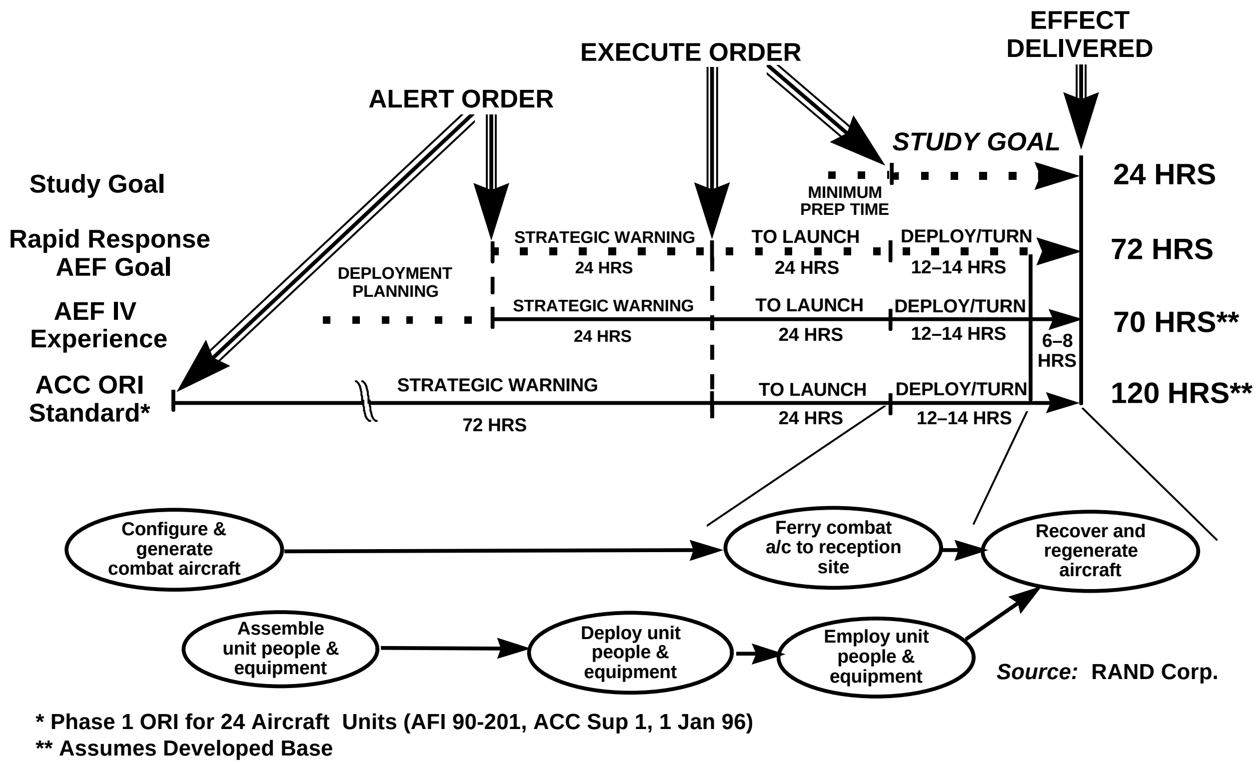


Figure 3. *Relative Timelines for Current Capability and More Responsive Goals*

2.2.3 Footprint

Churchill once remarked ironically that, except in the air, the Royal Air Force (RAF) was the least mobile of the British forces. Air Force wings today still plan on a heavy deployed footprint of prepositioned materiel, maintenance facilities, and other support at a forward operating location or beddown site. The AEF paradigm requires that this be reduced considerably. Nevertheless, current weapon systems demand a good deal of support to allow sustained operations. A fighter flight line requires a fuel supply, including storage and trucks or a hydrant system; aerospace ground equipment (AGE), including generators, light stands, liquid oxygen and nitrogen generators, and other gear; tugs and other vehicles; and a munitions build-up and loading capability. Crash/fire/rescue trucks and a Mobile Aircraft Arresting System (MAAS) can be dispensed with in truly emergency situations, but only at the cost of increased risk of loss of pilots and aircraft. The Committee examined the current minimum needs of a deployed base operation and summarized these needs in Table 3 in Chapter 1.

2.2.4 Lift

Mobility resources for an AEF include airlift missions and tankers positioned to support the air bridge and, as needed, deployed flight operations. Requirements vary widely with the composition of the deploying force, conditions at beddown sites, deployment distance (including available overflight rights), and availability of en route airfields.

A typical F-15 wing deployment list to a bare base calls for 480 short tons of cargo and 583 passengers, representing roughly 30 C-141 equivalents of airlift. Adding flight-line vehicles, fire/crash/rescue trucks, an arresting barrier, and other operational equipment contained in HARVEST kits adds considerably to this total, even if no provision is made to bring in a full kit for personnel support. AEF IV required a total of 54 transport missions to a developed base, including 10 associated with prepositioning, 13 to transport the initial strike force, and 31 for sustainment over a 90-day period. The airlift stream was equivalent to roughly 500,000 ton-miles/day. This kind of lift requirement represents the Committee's point of departure in considering options for a lighter, more responsive AEF.

2.2.5 Information Support

The only current command, control, and information (C^2I) system available for inflight use by the AEF is the Multi-Source Tactical System (MSTS) strap-on package. The Air Force used MSTS in the Qatar deployment to provide en route awareness updates. When the aircraft landed, the MSTS unit was transferred to a ground station until the Joint Distributed Information Support System (JDISS) arrived to replace it.

The MSTS package provided GPS navigation, national intelligence, Tactical (Receive Equipment) Related Applications (TRAP) broadcast, Tactical Information Broadcast System (TIBS), Secondary Imagery Distribution System (SIDS), and a datalink (TADIL-A) for Airborne Warning and Control Systems (AWACS) data overlays. The secure satellite communications connectivity was provided through a KG-84 feeding an LST-5 boosted with a high-power amplifier. The Ultra High Frequency (UHF) SATCOM airborne operation performs poorly at higher latitudes and when co-channel interference, such as in Bosnia, often blocks UHF SATCOM outside the U.S.

Along with the low data rates, the airborne UHF SATCOM forms the weak link in the system's connectivity. A more robust Air Force Space Support Team (AFSST) system has replaced the UHF SATCOM link with an INMARSAT terminal that furnishes 64 kbps, allowing reachback for deployed intelligence work stations. Neither of the systems provide the bandwidth needed to support the much larger needs of the AEF. New airborne higher data rate systems are needed.

2.3 Future AEF Capability

The sections that follow identify the enablers in Command and Control and Information, Logistics and Force Protection that enhance AEF operations in the near term and mid term. They form the basis for meeting the AF SAB Committee's vision for the AEF of the future.

2.4 Command, Control, and Information (C^2I)

2.4.1 Critical Enablers to Robust C^2I in Future AEFs

Any military operation with the attributes of an AEF will place significant reliance on C^2I. Rapid response, dynamic en route planning, and accurate battlespace awareness all depend on the presence of timely information, properly disseminated and used. To obtain and use such information, the Air Force, along with its joint and coalition partners, must upgrade both its equipment and procedures. Here, the Committee will address the necessary enablers, specifically those system-level concepts necessary for an information-intensive operation to succeed.

The Air Force can achieve the following required innovations in the next 5 to 10 years: first is the innovation in information technology, dominated by the commercial sector but also from continuing military research and development (R&D). To benefit, the Air Force must aim at assimilation, certainly more so than its prospective enemies do. Second is the likely air superiority the Air Force will have over its adversaries. This advantage will provide freedom in the use of unmanned aerial vehicles (UAVs) to supplement more conventional means of surveillance or communications, both from the military and commercial sector. Third is the comparative strength of U.S. information and intelligence gathering resources, and fourth is the comparative advantage of the U.S. technology base, such as the capability to field new and precise GPS-enabled weapons.

The Air Force must use its own developmental resources to gain military capabilities and practices beyond what the commercial marketplace can provide to everyone else. The two capabilities that form the foundation of AEF operations are the precision and completeness of our battlespace awareness and the ability to move information where and when needed. These are enabled by the following:

- **Global Connectivity.** Any effort that relies on information must clearly have a means to convey it. Every platform that can potentially participate in an AEF must have some means of assured connectivity. This applies to not only Air Force platforms but those of Joint and Coalition forces as well.
- **Information Management.** Extensive information has no value if not properly managed. Systems must not only ease the interaction of staff with machines but also assist and guide the user community in the gathering, processing, and dissemination of information. This need becomes paramount under the time and spatially distributed pressures of an AEF.
- **Battlespace Awareness.** Awareness in this context means a global capability to precisely, comprehensively, and continuously define the battlespace. This includes the location status of both friendly and enemy forces. This database should be interpretable at several levels of abstraction.
- **Geospatial Position, Navigation, and Timing (PNT).** The accuracy already delivered by GPS has whetted the imagination of both users and developers. For example, the present system needs the ability to conduct remote operations with precision while creating high platform and weapon efficiency. This capability will also enable near-term unambiguous fusing of various sources of information.
- **System Assurance.** An operation that relies on the use of information must therefore secure that capability. More specifically, the connectivity grid and precise location, must have extremely high availability because the operation depends on them. Additionally, systems must be designed to degrade gracefully. The loss of such detail, however, should not disable all operations. All AEF command support systems must default to a minimal but adequate C^2I functionality.

2.4.2 Global Connectivity

Achieving the concepts of the AEF requires high-bandwidth connectivity to the various elements of the AEF, including forward deployed, en route, and reachback support elements. Today, such requirements range from voice connectivity and relatively low-bandwidth electronic mail to maps and other graphics data. Future capacity requirements will grow significantly, driven by concepts such as real-time imagery, video, and telemedicine. For example, digital high-definition video, which will become common over the next 5 years, requires a bandwidth of at least 18 Mbps.

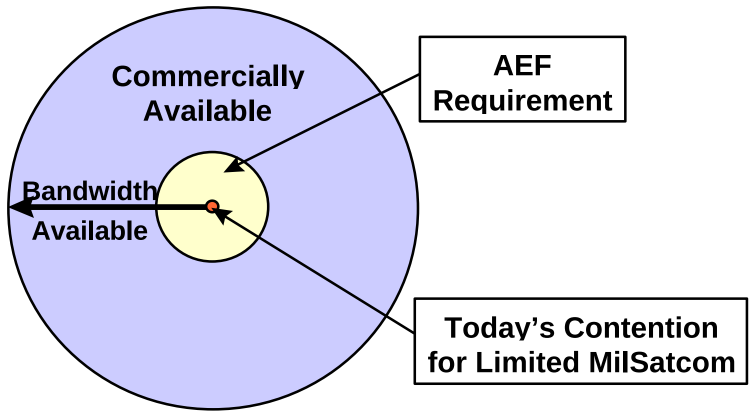


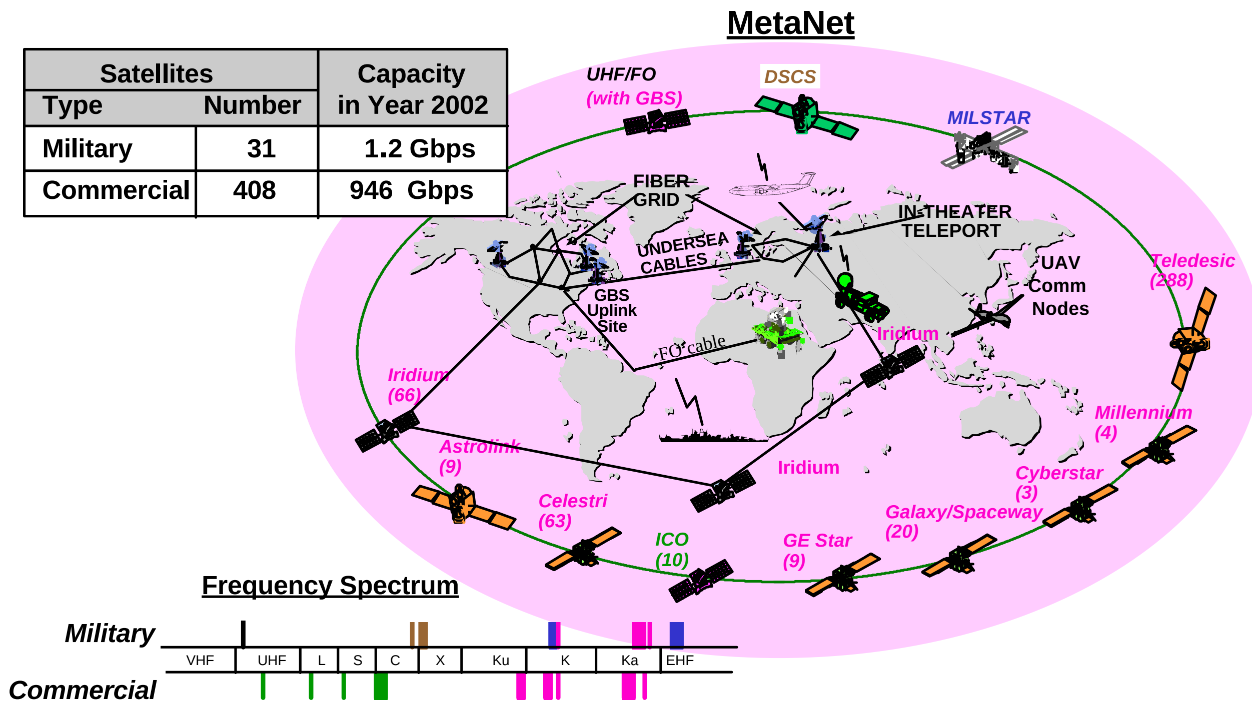
Figure 4. *Military Satellite Communications Assets Require Augmentation to Meet the Needs of the AEF*

By contrast, current communications to en route aircraft elements typically operate at 4.8 kbps, provided by UHF SATCOM. This capacity does not come close to meeting the operational requirements of even near-term AEF missions. Significant contention for communication resources results, with the highest priority users not being served adequately and lowest priority users not being served at all.

Commercial systems planned for future deployment will provide bandwidth to the end user of 155 Mbps or more, with a total capacity of satellite systems of about 950 Gbps by 2002 (see Figure 4). Several commercial systems are designed for a local service area. Exploiting all possible communications assets, both military and commercial, can both alleviate the contention for communication resources and provide the diversity required for robust, highly assured global connectivity. Unique military requirements, such as antijam, will continue to drive the development and use of military systems. The Air Force needs a system approach to permit the integrated use of all available communication assets to satisfy the current and future AEF requirements for global, robust, high-bandwidth connectivity. This will permit the Air Force to take advantage of the vast number of satellites (over 8 systems with over 400 satellites) and their diversity of frequency bands being planned for deployment in the commercial sector. The Committee refers to this integrated system as the MetaNet (see Figure 5).

Such an integrated system will provide more than just increased bandwidth and connectivity. It will also provide a significant increase in connectivity strength through the resulting redundancy and diversity. Taking advantage of the multiplicity of commercial systems in a flexible manner allows communication through any of the possible communication paths. Furthermore, the increased number of frequency bands of the commercial systems provides increased frequency diversity, thereby mitigating the effects of jamming.

The SAB's October 1996 report on *Vision of Aerospace Command and Control for the 21st Century* recommended moving toward a Global Grid vision using a wide variety of underlying communications technologies. It described a set of actions to move toward this vision, most notably exploiting three planned (but to this date, not carried out) Advanced Concept Technology Demonstrations (ACTDs): SPEAKeasy, Global Hawk Communications Relay (now referred to as the Airborne Communications Node), and Information Grid. The Committee reaffirms these recommendations, particularly in the context of an AEF, where MetaNet is critical to the success of the AEF missions.



Satellites		Capacity
Type	Number	in Year 2002
Military	31	1.2 Gbps
Commercial	408	946 Gbps

Figure 5. *Commercial Communications Systems Provide Global Robustness and Tremendous Capacity*

Achieving the MetaNet will require a long-term vision coupled with a sound architecture and strategy for moving from current capabilities toward that vision. Three specific areas of development are recommended (see Figure 6):

- **Network access management concepts** consistent with Global Grid and the Global Command and Control System (GCCS) that permit exploitation of all available communications assets
- A robust and agile **communications controller** deployable on ground and in aircraft that permits access to all available communications links
- **Aircraft connectivity to diverse communications**, including DoD and commercial services, requiring minimal equipment through the use of programmable radios and reconfigurable antenna suites

2.4.2.1 Network Access Management Concepts

The AEF concept of operations demands an easily and rapidly deployable communications capability providing high-bandwidth connectivity anywhere, anytime, and anyplace. Accomplishing this in a cost-effective way requires a set of network management concepts that permits access to all available commercial, military, and Federal communication assets.

The MetaNet concept uses available communications as links in an overall network. Network access management technology will provide functions such as adaptability to available communications, self-healing networks, quality-of-service management, priority, preemption, and security.

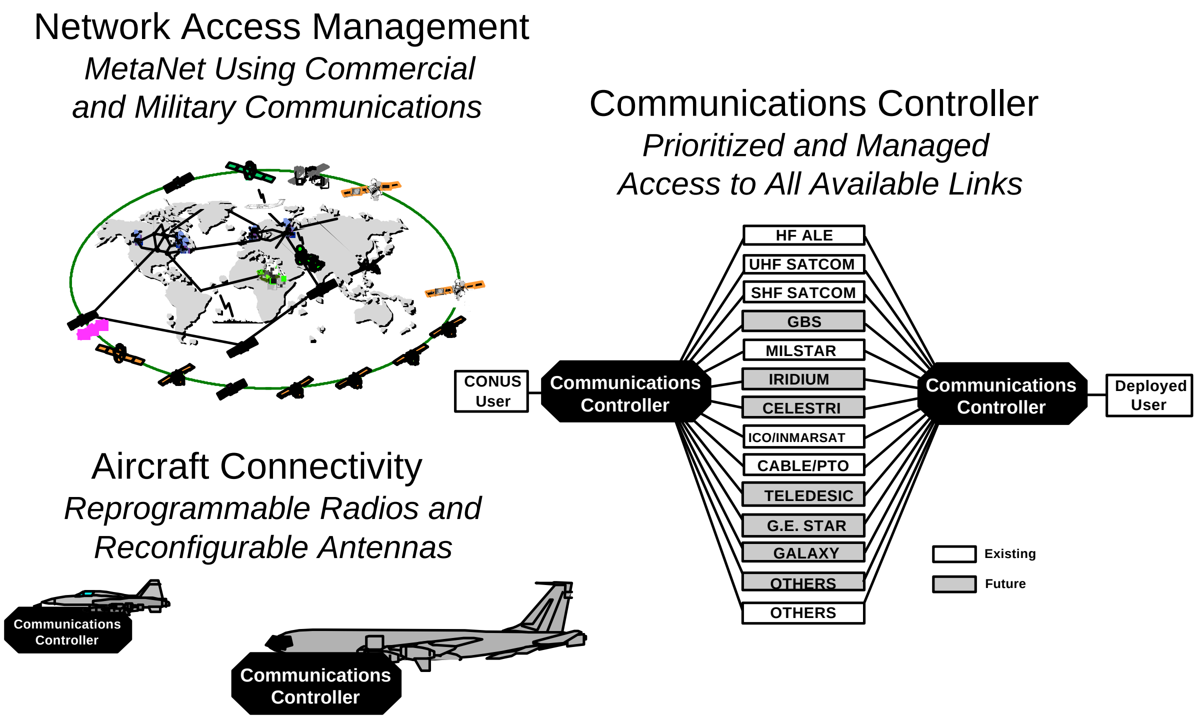


Figure 6. *Accessing Robust AEF Global Connectivity*

The technical architecture must support integration and use of available commercial products and services. Furthermore, the Air Force must adopt a procurement strategy so that commercial and standard military systems are used to the maximum extent possible and AEF-specific systems only as required. For example, commercial off-the-shelf (COTS) communications in satellite networks can facilitate deployment into bare-base environments. The Air Force cannot afford to preposition adequate dedicated communication assets at all possible locations. It must exploit the commercial infosphere to provide needed connectivity, both on initial deployment and in sustainment.

However, the military must guard against becoming just another "dial-up" customer on commercial systems. In urgent situations, the AEF must have leased or at least reserved capability. The communications controller function mentioned earlier must provide the network access management to use such reserved capacity along with the backup military communications to provide assured connectivity. The AEF cannot accept a concept in which an F-16 might encounter a busy signal!

In addition, the Air Force can work with commercial vendors to help them understand the requirements of a large and reliable customer. Thus, commercial vendors will respond to these requirements in a way that directly supports the AEF need and will allow the Air Force to adapt the commercial system to the need.

2.4.2.2 Communications Controller

Achieving the MetaNet concept requires development of a communications controller that interfaces to and integrates the variety of communication assets. A communications controller will provide the functions needed to fully use all available communications resources, including the following:

- Interface to the communication asset
- Selection of the best communication asset and routing over the selected system

- Multiplexing of data on and off the communication assets
- Management of priorities for routing of information
- Security against access denial

A communications controller allows use of all available assets (e.g., Iridium, GlobalStar, UHF SATCOM, Link 16, Global Broadcast Service [GBS], fiber optics, and cellular communications) to provide the robust connectivity needed for AEF operations, whether for aircraft en route or forward-deployed units.

2.4.2.3 Aircraft Connectivity

Critical to the AEF concept is high-bandwidth, two-way assured communications to the warfighter location, including en route aircraft. The communications controller described above will manage, prioritize, and use available communication assets. In addition, the aircraft must have onboard a rich set of communication assets, including satellite, ground, and air links, and the ability to use commercial as well as military communications.

To provide the required flexibility of communications, a "plug and play" architecture will simplify installation of communication assets consistent with the MetaNet. This architecture has three elements:

- A reconfigurable set of antenna assets will allow the required flexibility in installing radios in various frequency bands.
- Reprogrammable radios, such as SPEAKeasy, will provide flexibility in the use of radio equipment in accessing the various communications links. These reprogrammable radios can increase flexibility in ground communications as well. The Air Force should continue to invest in SPEAKeasy-type systems such as the Joint Tactical Radio and extensions to provide this capability.
- The AEF requires increased range of connectivity because of its need for flexibility in deployed locations. UAVs can provide a critical range extension function for connectivity to both ground and air. The Defense Advanced Research Projects Agency (DARPA) is exploring the concept of a UAV communications node, marrying SPEAKeasy-type programmable radios with advanced UAV platforms. The Air Force should continue to partner with DARPA in exploring this concept and adapting it specifically to the AEF requirement for global connectivity.

Finally, the Air Force must develop the communications access controller described above to provide for the integration of all connected communications assets.

2.4.2.4 Assurance of Connectivity

The MetaNet approach of using all available communication assets provides alternate routing across the diverse communication links and paths. Thus, failure of a single communication system does not cause failure of connectivity. The communications access controller would simply select an alternate link transparent to the user. The high bandwidth of commercial connectivity provides a second option for antijam capability by coding at the interface to the communication link. This coding can be done adaptively in response to the changing environment and threat. Last but not least, military highly robust antijam links can be used as an integrated part of the MetaNet and would be automatically selected by the communications access controller based on threat environment and priority of requirement.

Moving in these directions will provide the robust, high-bandwidth, global connectivity required for future AEF operations. By using the high capacity, redundancy, and diversity provided by the commercial sector in an integrated manner, the Air Force can satisfy the AEF needs in a cost-effective manner.

2.4.3 Information Management

Information and its effective use are fundamental to the success of the AEF described in this report. In the past there have been very deep and artificial distinctions between various forms of needed information; for example, most intelligence and its collection have never been directly controlled by operational forces. The pace of an AEF cannot afford such distinctions. To conduct its missions an AEF must be totally integrated in how it gathers information, how it uses it effectively in decision making, and how it disseminates it to the forces for execution. Success of such time-critical operations demands that the Committee think of just one integrated C^2 information support system.

Battlespace awareness, i.e., all relevant information pertaining to the battlespace, including both enemy and friendly forces, is the input to the C^2 process. The C^2 process, in turn, is what the commander uses to arrive at future courses of action. The C^2 process is supplemented by computer-based decision aids which in the AEF may be broadly distributed. Finally, the dissemination of orders, with its attendant explanations and conditions, goes to the executors. The result of those executions forms part of the modified battlespace and the whole process proceeds recursively.

2.4.3.1 The Need for Information Integration and Management

An important aspect of the overall improvement in information management (IM) required by the new AEF paradigm involves the automation and integration of the various components of planning and executing contingency operations (see Figure 7 which builds upon the efforts and technology of the DARPA Battlefield Awareness Data Dissemination ACTD). The Air Force has made progress in replacing manual tools and procedures with work stations running on a local area network. However, the Air Force needs to better integrate the tools and processes used by operational planners, logistics planners, force protection planners, and other functional areas. Clearly, operations must lead the process by defining the mission, target list or other outcomes, weapon systems, and other basic parameters. Traditionally, however, independent groups make operational plans and then pass them to other groups to complete the next phase and implement the plans. This must give way to a more collaborative environment that ensures that plans are feasible and represent optimum use of available resources. In effect, IM requires an automated integrated product team (IPT), led by operations planners with participation by other functional areas and supported by effective tools. An IPT will shrink planning cycle times, generate a better plan, and eliminate the inefficiencies inherent in today's practices.

The key to success of the Committee's AEF concepts, based on austere deployment and employment of force, is the availability of information. The Air Force's present information push distribution systems will overwhelm users in almost any AEF operation without well organized combat information concepts, integrated with training and exercises. IM means significantly more than just scheduling bandwidth. The Air Force must conduct information planning simultaneously with mission planning. The operational plan should have an explicit IM annex that matches mission needs to chartered or designated collections and production. Following planning, the Air Force must focus on execution. Collection, production, and order processing all require specific attention to detail. The life cycle process needs tracking from initiation through in-transit visibility to customer receipt and satisfaction. Workflow and document management tools can aid authentication, delivery, storage, and disposal.

A federated system of infrastructure services will enable simple, timely, efficient, and secure awareness, access, and delivery of information products from producers to consumers in a dynamic, multifaceted environment.

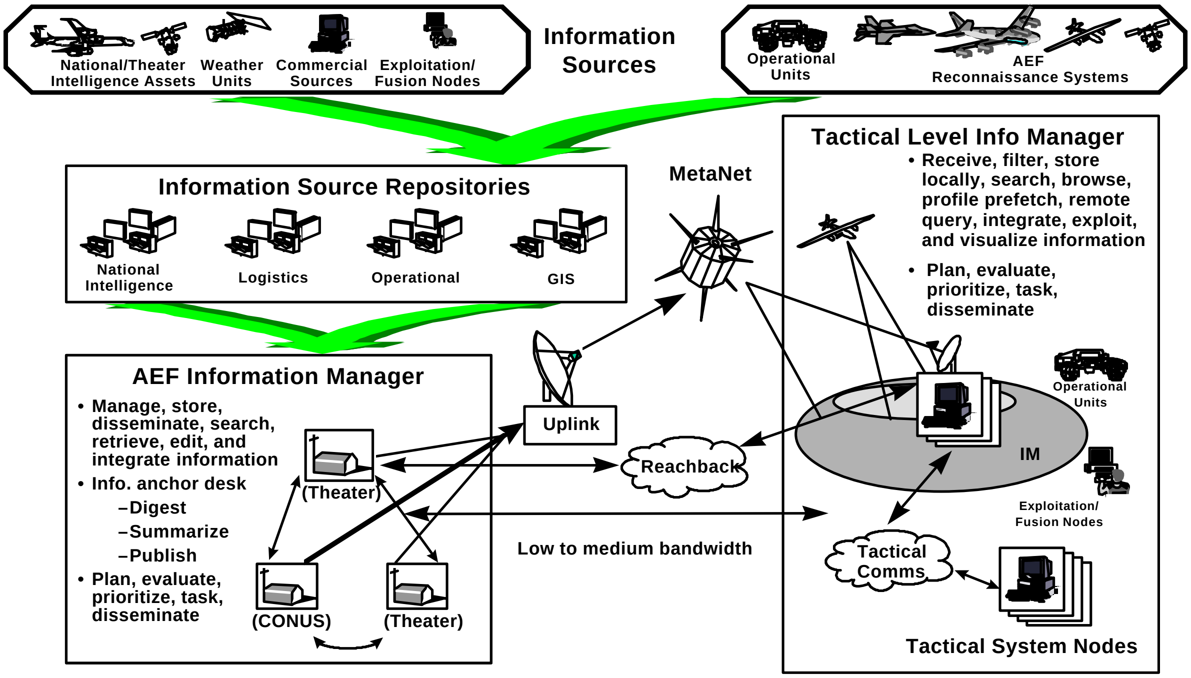


Figure 7. *Information Management Provides the Right Knowledge to the Right User at the Right Time*

2.4.3.2 The Information Manager

The Air Force needs to exploit efforts currently being pursued in both DARPA and the Defense Information Systems Agency (DISA) to obtain the capabilities essential for our AEF concepts. To meet the required timeline and distributed nature of the AEF missions, the Air Force must develop dynamic management tools and systems to store, disseminate, search, retrieve, edit, visualize, exploit, and integrate information in real time. These systems must exploit and extend the capabilities of the Defense Information Infrastructure (DII) Common Operational Environment (COE) and aggressively incorporate commercial developments to ensure that the right information in the right form is at the right place at the right time.

The ability to employ comprehensive, real-time information in a time-critical AEF operation requires a system not only to gather and process information but to manage it as well. Such management is naturally software-based and an integral part of the system that supports the command decision cycle. Because the range of command support activities is large and individual components complex, an information manager, comprising a number of somewhat autonomous modules, works well. These modules will be specific to the function they represent, provide the input/output (I/O) needs of that underlying software, and act in concert to accomplish the needs of the user(s).

Figure 8 shows a useful breakout of the functions of the command cycle. Everything but the mission and its associated information enters from a suite of sensors and other information feeds where it is consolidated into an integrated, real-time picture of the battlespace. The planning and decision-aid segments have connecting arrows because of their strong interdependence. The actual decisions, their attendant stipulations, and how and to whom they are directed form the final steps in a very recursive process.

The information manager assists the commander and staff by offering a consistent natural-language interface and abilities to parse requests among the various functions available, to retrieve information, and to display what it finds in a user-preferred way. It can invoke privilege or priority that an underlying communication system can deliver and, because it is rule-based, can permit easy changes in how it interprets such value statements. Collaboration-based subnets can be established or disestablished at will. Attributes of such a command support system have been mentioned in the 1996 SAB study on *Vision of Aerospace Command and Control for the 21st Century*.

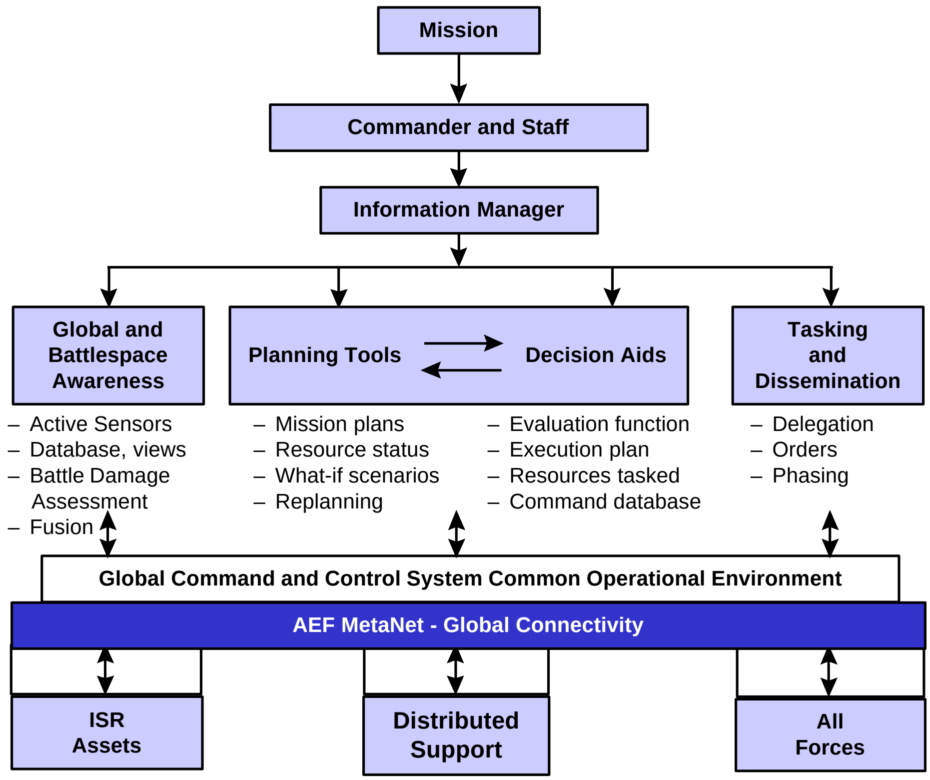


Figure 8. *An AEF C^2 Information System*

As an applications process in the current definition of the COE, the information manager can call on any service therein. For example, it sets many of the parameters that guide the MetaNet's communications controller in selecting carrier resources.

The information manager facilitates information storage and transmission by driving bandwidth reallocation, affecting database management, driving network access management and coordination, and prioritizing the information flow. It allows new information concepts such as push-pull, control mechanisms, robustness, and fusion to really work. The information manager also enables automated information presentation and assimilation for production, display, integration, and distribution. Most importantly, it permits the integration of global capability for warfighting, information, and communications architectures, empowering the AEF to fashion its own C^2I system. The C^2I appendix in Volume 2 further discusses the information manager.

2.4.4 AEF Battlespace Awareness

AEF missions demand complete and timely information. Battlespace awareness capabilities must provide real-time understanding of the friendly, enemy, and geospatial situation. The short planning cycles, the need for en route planning and rehearsal, and the need for continuous battlespace surveillance with reachback to distributed resources drive AEF information requirements well beyond today's capabilities.

Thus, AEF missions are especially challenging because of their need for near real-time information with minimal advance notice. This need in turn drives the need for real-time acquisition, fusion, and dissemination of the best available Government and commercial data so that the necessary information can be assembled in time; the need to create clear, consistent images of the battlespace and battlespace situation so that distributed resources can operate without confusion; and the need to provide rapid access and clear cognitive assimilation of information at all levels so that decisions can be made quickly and accurately (see Figure 9).

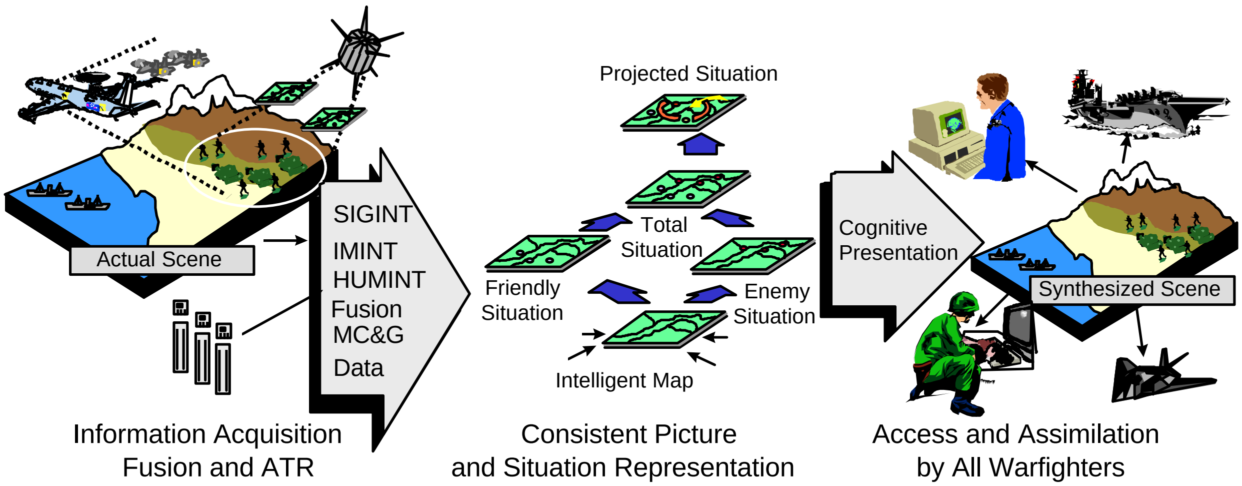


Figure 9. *AEF Battlespace Awareness*

2.4.4.1 AEF Battlespace Awareness Challenge

Creating a common, real-time, image-based AEF battlespace awareness system presents a grand-challenge problem of integration, processing, and information management. Current technology, systems, and organizations cannot provide the needed level of performance.

Creating the solution will require a serious, sustained effort. Battlespace awareness is one part of the overall AEF IM system, described in the previous section. The solution must solve the problems of real-time integration of ISR with command, control, communications, and computers (C^4) management; real-time fusion of all relevant Government, publicly available, and commercial resources; and tailorable presentation of information on different computer platforms, from immersive virtual reality systems to PCs and future Web TVs.

AEF battlespace awareness requires that national, theater, organic, and commercial surveillance and reconnaissance collections are performed as a single, integrated process. This will require real-time tasking of the appropriate collection resources and real-time automated processing for cueing, attention, and tracking with both automated target recognition (ATR) and assisted ATR. Today only a small fraction of the data collected is exploited. This problem will dramatically worsen over the next decade without powerful, real-time ATR tools. However, ATR is a difficult technical problem. Initial success will come from ATR (i.e., human-in-the-loop) systems.

In addition, the design of battlespace awareness systems must support numerous applications such as rapid, accurate targeting and BDA; dynamic, distributed, continuous collaborative planning; en route mission rehearsal and embedded training; and information warfare (IW) and spectrum dominance monitoring, planning, and execution. The wide range of AEF missions will require a suite of many other application-specific capabilities. The commercial world can provide many capabilities as long as the government adheres to the best commercial practices and standards.

2.4.4.2 Leveraging the Commercial and Consumer Zeitgeist

As stated, the Air Force faces a considerable challenge in creating a comprehensive battlespace awareness system. Fortunately, interest and business potential is growing for most of the core technologies and systems required for such an endeavor. The Air Force must aggressively leverage and ensure compatibility with these developments to both maximize performance and minimize cost.

Trends show that the commercial satellite imagery service market will soon be a multibillion-dollar-a-year business. Many companies around the world are attempting to create businesses in specific market niches. Within three years, more than 30 surveillance satellites will operate internationally. These will create content and many of the tools and capabilities needed for battlespace awareness. The Air Force should work with government and industry around the world to help influence standards that maximize interoperability.

In addition, the general area of sensing will explode over the next several decades. Data types will proliferate. Multispectral, hyperspectral small biodetector, and novel ground sensors will claim importance. Digital video on UAVs and other platforms will become a widely accepted data type and will be used in distributed collaboration, logistics, and telemedicine. Starting in 1998, high-end PCs will include a video camera. Web-based sensing of sites around the world will proliferate. Every platform, including humans, will become a potential source of sensing data. Digital high-definition television will transform the entire consumer communications infrastructure over the next decade by providing over 18 Mbps of packetized data per channel. Massive data storage systems and fully interactive information-on-demand systems will be part of the consumer landscape. Digital satellite television, already the fastest growing consumer product ever, will continue to expand and become a huge worldwide market. Information navigation and search tools will become major market areas. Functionality will soar and costs will plummet. As always, content will rule.

In addition to the above, the AEF battlespace awareness system and the previously discussed information system should exploit other powerful technologies, such as the Web. The Web is creating entirely new paradigms for collaboration and data search, as well as new models for broadcasting, such as data-push.

Air Force systems should emulate these conceptual models and integrate the best technologies into the AEF battlespace awareness system. For example, data-push can combine with mission-specific computer-screen icons (e.g., for logistics, collection tasking and coverage, UAV video, and battle orders) that when clicked open up screens with the latest, updated information — that is, a pointcast-like service for AEF missions.

AEF battlespace awareness systems will also have the ability to borrow concepts and technologies from other commercial intelligence organizations. For example, Bloomberg Financial Services provides real-time financial information. Bloomberg aggressively uses state-of-the-art collection, communications, computing, and presentation technologies to provide customers with the best, most timely information. Battlespace awareness efforts can provide similar value for AEF missions.

2.4.4.3 Battlespace Awareness Information Service Provider

The AEF battlespace awareness system is defined by the need to respond quickly and provide real-time information in a clear, compelling fashion. The new Air and Space C^2 Agency should create an organization and system concept with a focus on providing this new service.

The Information Service Provider (see Figure 10) will be part of the creative integration of a "system of systems" that will include collection resources, GPS and other geospatial location systems, storage and distribution systems, and a family of distributed processing tools and applications, such as content creation. Global and battlespace awareness will provide access to a family of layered databases of the best information as rapidly as possible from whatever location. This requires a fundamentally different Service view within the Air Force with, like Bloomberg, a dedication to providing real-time information to support the AEF or to field a battlespace awareness AEF.

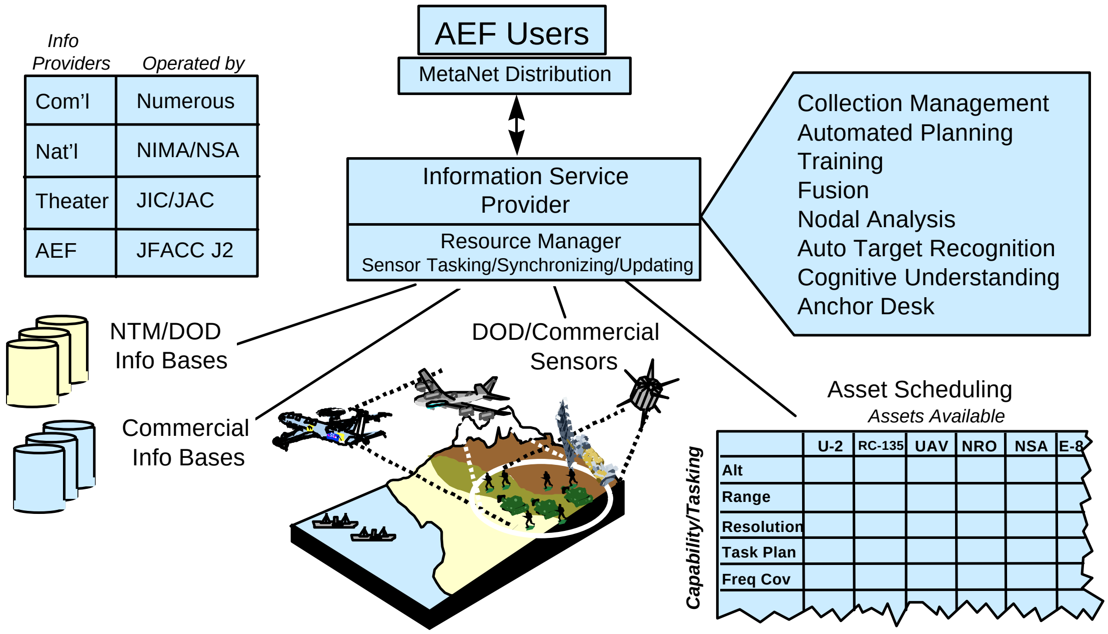


Figure 10. *Battlespace Awareness Information Service Provides Real-Time Information Support*

Business arrangements must be set up with the best information sources around the world. The Information Service Provider would dynamically task U.S. collection resources, integrate these Government and commercial resources, and produce products useful for different AEF missions. It would cut across all U.S. intelligence and DoD organizations to produce the needed integrated, real-time results. As a consequence, the Information Service Provider would help all intelligence organizations to streamline their operations and accelerate their technological advancement.

2.4.4.4 Battlespace Awareness As an AEF Mission Itself

The AEF battlespace awareness system can support AEF missions or act as a stand-alone mission (see Figure 11). The ability to rapidly deploy AEF battlespace awareness resources could provide real-time ISR, IW, public exposure, or deception. It could provide a worldwide Government "CNN" capability. The Air Force could find such abilities increasingly advantageous to prove to adversaries our understanding of their capabilities or to manage world perceptions. Accurate, believable information disseminated worldwide about a crisis or conflict situation may aid in the decision making process and gain public support and international cooperation, in addition to supporting deploying forces.

Although reconnaissance and surveillance satellites will continue as major sources of battlespace awareness for an AEF, often for political reasons the U.S. will need to provide a more obvious indication that activities in a region of the world are being observed. Existing deployments in such cases include a single type of aircraft or several operating independently. In the future, battlespace awareness AEFs need to operate collectively and require a deployable C^2 element when deployed independent of combat forces.

Battlespace awareness is an essential element of the Information Superiority core competency. The consolidation of all ISR assets into a single organization, whose commander is assigned the responsibility to integrate their capabilities into a single battlespace awareness system, would assist in building this AEF capability and the eventual integration of sensors operations and information.

JointSTARS ground surveillance should become the foundation of future battlespace awareness AEFs in which aircraft are deployed and integrate UAV capability into a coherent view of activity. Airborne battlespace awareness AEFs will require rapid deployability to lead, or simultaneously deploy with combat forces.

- AEF requires global capability for Battlefield Awareness
- Rapidly accessible real-time information from ISR assets may be only AEF mission required
- JFACC must be able to dynamically direct and integrate C^2I

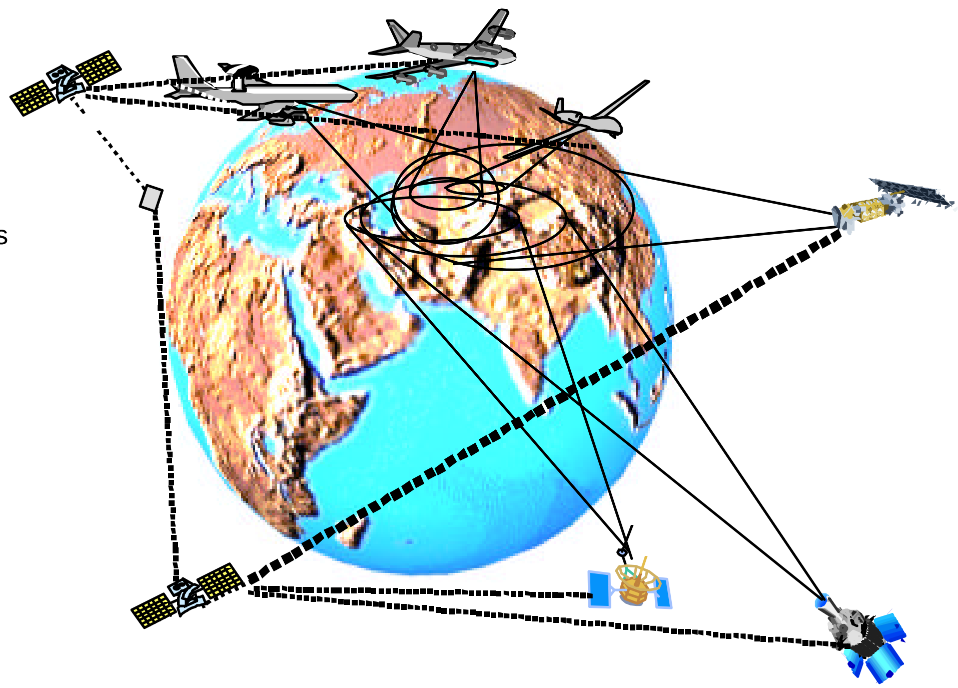


Figure 11. *Battlespace Awareness As an AEF Mission Itself*

2.4.5 Geospatial Position, Navigation, and Timing (PNT)

A common, geospatial and temporal reference system will lay the foundation for all future military operations. Moreover, AEF commanders will prefer weapons using GPS and INS. GPS navigation and landing systems will permit remote Air Traffic Control.

To achieve the needed operational efficiencies and battlefield awareness, the AEF requires a common geospatial and temporal reference system. Therefore, the Air Force must field position, navigation, and timing systems beyond the current GPS with improved geospatial accuracy, antijam, and survivability to enable precision weapons delivery, remote ATC operations, and geospatially based information fusion.

2.4.5.1 A Geospatial and Temporal Framework

Meeting AEF operations timelines demands a common framework for creating and integrating battlespace awareness products. Battlespace awareness requires a large family of databases that contain layered, separable information about the status of the world. A framework currently being developed to be fielded by National Imagery and Mapping Agency (NIMA) includes maps, terrain, imagery, video, weather forecasts, and other information. These data have varying resolution, completeness, timeliness, and accuracy. This step toward a global geospatial and temporal database will allow integration, fusion, and correlation of other formatted data in real time. Global capability will provide initial AEF baselines in times of crisis when regions will need to have their fidelity dramatically improved. Commercial data will play an important role in providing baselines and time histories. AEF missions will require real-time fusion of national and theater sensors, UAVs, hand-held video, and other information sources. Other AEF distributed content creation and distribution requirements include multilevel security, emphasis on data integrity, security, authentication, and personal identification (including continuous biometrics).

A precision position, navigation, and time-referenced battlespace will enable precise target location. In turn, these location data will permit dynamic retargeting, dramatic improvement of kill probability, and a significantly reduced logistics tail. Simultaneously, this location data will maximize the effect of weapons capabilities. For the first time, the Air Force will have pinpoint control of resources, and comprehensive, cooperative engagement. Furthermore, this common geospatial and temporal reference will allow dispersed C^2 of forces, new levels of fusion, a common grid for all sensors, and realistic trend analysis.

The Air Force needs to craft a long-term PNT service rather than just a system. Given that the U.S., and indeed the world, is not now receiving or expecting to receive all of its PNT capabilities from the GPS, it should explore the possible evolution of a global PNT service prior to locking into a future plan for the GPS system. This means defining what PNT services the users (military and civil) require and how best to provide those services rather than merely focusing on what any given system, or any evolution of a system, can provide as user services.

2.4.5.2 GPS/Inertial Weapons As the Weapons of Choice

Advances in GPS technology and demonstrated enhancements to the GPS infrastructure have proved the ability to supply the GPS signal-in-space to an accuracy of better than 1 meter. This capability enables the concept of precision weapon delivery to a total circular error probable (CEP) of fewer than 3 meters using an augmented GPS guidance system. Such weapons are inherently low cost and all-weather — both significant advantages over other precision weapon concepts.

To maximize the effectiveness of GPS-guided weapons, two issues take priority: (1) assuring the precision of the munitions delivery and (2) assuring the availability of the GPS signal (even in the presence of enemy countermeasures). Ongoing GPS development activities address both of these issues.

Differential GPS (DGPS) methods have already been employed to demonstrate the improved positioning performance possible with GPS. Sub-meter accuracies are possible when the GPS system errors are corrected. However, because a communication link to the munitions is needed to receive the DGPS corrections, this approach has not met with full user acceptance. In the far term, the Air Force must adopt an autonomous approach to achieve full operational effectiveness for wide-scale precision weapons delivery. However, in the mid term the Air Force should investigate the use of a UAV for the relay of DGPS correction signals.

The DARPA Micro-Electro Mechanical System (MEMS) program has achieved significant advances in inertial instrumentation resulting in a miniaturized, low-cost INS. For air-to-ground munitions with a short time of flight, high-precision accuracy can be achieved with a relatively low-quality INS. For short times of flight, the dominant error source for an inertial navigation system becomes the level to which it can be initialized from the aircraft (e.g., position, velocity, or heading). Even without continuous GPS corrections, with correct initialization onboard the weapon's delivery platform, the weapon's INS can sustain an accuracy of 10 to 20 meters for short times of flight (less than 60 seconds). However, with the improved MEMS upgrades, accuracies of 2 to 3 meters have been achieved.

The integration of GPS and INS technology provides a robust, high-accuracy guidance capability for munitions delivery. The performance of existing GPS/INS weapon systems, such as JDAM, have already proved the effectiveness of precision weapons as a force multiplier. With the GPS performance and antijam enhancements in development, further accuracy and robustness in "smart" weapons can enable fewer than 3-meter CEP weapons delivery.

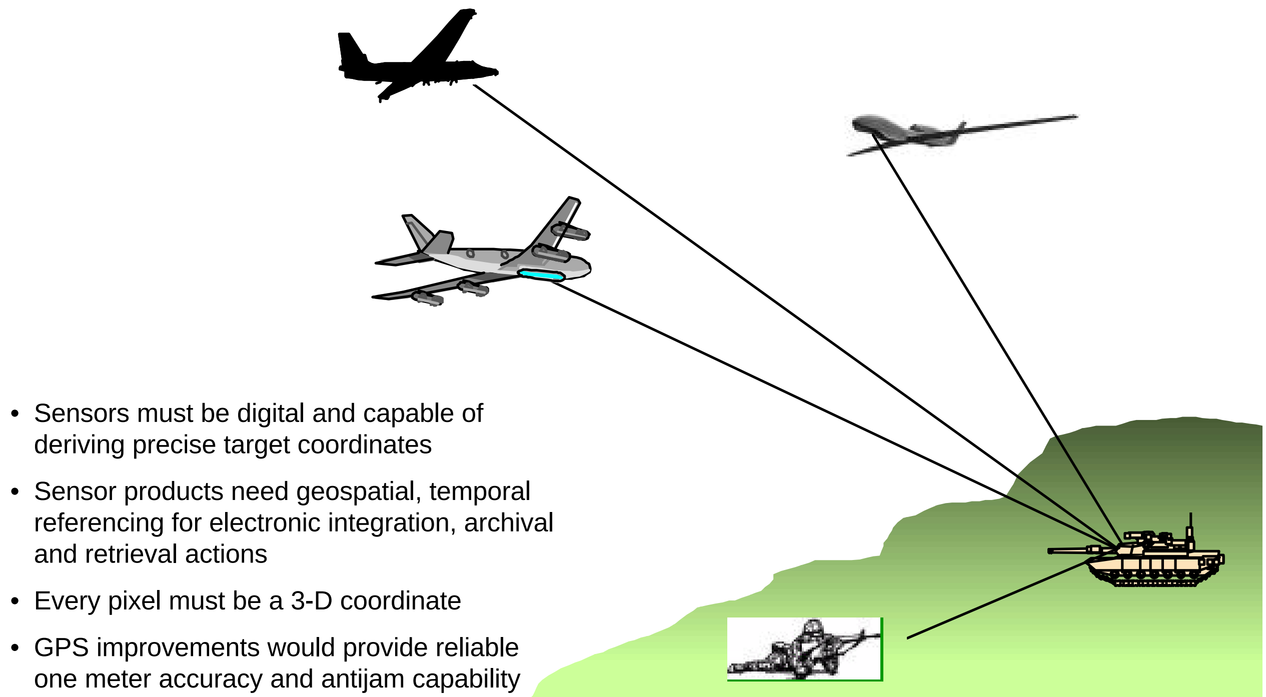


Figure 12. *Precision Delivery Requires Precise Target Location*

To capitalize on the ability to find, fix, track, and target any object on the globe, the AEF must geospatially derive precise range, elevation, and azimuth to the desired point (see Figure 12). Once this information is determined and transmitted to the appropriate weapon system, GPS/INS-enabled weapons will achieve the desired results.

2.4.6 C^2I System Assurance

Commanders worry about catastrophic failure of combat systems on which they must depend. The Global Grid concept inherently provides increased reliability through diversity and redundancy. A wide variety of dynamically controlled military and commercial links significantly assures the communications connectivity. Information and communications controller features of the MetaNet must provide for controlled degradation of performance as bandwidth is reduced or communications links are eliminated.

2.4.6.1 Information Warfare

The increased dependence on modern information technology offers the opposition an opportunity to an Achilles' heel if the Air Force is not careful to block the many access paths. At the same time, aggressive use of these techniques will minimize the loss of life on both sides. The myriad uses of specialized software and hardware complicates the opposition's ability to access the Air Force system, but the Air Force move to a more compliant architecture will make the attack easier and increase the risk for greater damage. Therefore, the Air Force must design all future systems to be tamper-free.

End-to-end encryption as promised by the use of Fortessa-like encryption cards in all laptops and terminals will greatly reduce the access to our circuits. Gateway monitoring for illicit attempts provides necessary detection and isolation of the attempted activity. An enhanced quick reaction IW response team can provide the means to recover from an attack.

Physical security to protect all hardware and disks, even unclassified, will reduce the likelihood of access that will allow the aggressor to monitor, control, or deny our use of systems. Access verification is the first line of defense of an information system. The retina pattern and fingerprint comparisons provide an easy approach to assuring the user proper identification. Passwords still have a place in layered defense. Multilevel security access limits also add protection. The total security package must have an in-depth architecture that can be continuously monitored and upgraded.

2.4.6.2 Connectivity Assurance

The $40 billion commercial SATCOM revolution will be in operation in 4 years. The Air Force must start preparation now to take advantage of the plethora of commercial satellite systems with exceptional bandwidths of up to 2.048 gigabits. This new technology will allow an architecture that provides an assured reachback capability through multiple robust circuits, augmenting the military system. This diverse capability dramatically reduces the current concerns of jamming, interference, IW, and terrorism. Instead of having communications anchored to the military frequency band, commercial SATCOM will allow communications to be distributed throughout the mass of commercial and civil traffic.

The concept of a distributed staff depends on continuous communications that must have the redundancy to assure connectivity under stressed conditions. If care is not taken, communications could be the Achilles' heel of an AEF deployment. The detection of the AEF's radio-frequency (RF) signature will provide the opposition information on its build-up and expected arrival time. The steadily increasing dependence on communications, computers, and GPS provides opportunities, even for Third World countries, to disrupt the AEF deployment.

The basic system architecture proposed for an AEF was conceived to meet the stressing situation of wideband communications en route. The selected architecture has an overabundance of available communication paths and bandwidth that enables the user to automatically select the optimum channel available. This results in a redundancy that assures the desired connectivity during equipment malfunctions, co-channel interference, and jamming. A narrow-band survival link provides the service channel for switching circuits and reconfiguring the hardware and antennas to the next-best communications link. If this backbone line is lost a priority link sequence will engage. To ascertain the availability of diverse circuits, continuous loop probes aid the selection of a valid current access. Bit rate monitoring on each circuit will dynamically allow the redistribution of data if the circuit fails for any reason. The use of numerous independent communications systems that are spread out physically and spectrally provide the confidence that communications will be possible. Today's end-to-end encryption systems can ensure information integrity.

The Air Force can adapt the very wide-band commercial system to provide either antijam or reduced antenna size for inflight use. When the 1.2-Gbps data rate available is reduced to a 1.2-Mbps rate, a 2-inch dish can replace the usual 5-foot dish. On the ground, a full-sized dish can be used. The reduced bandwidth mode will then provide a 30-dB margin where the jamming threat is greatest.

The current antennas needed to provide diversified SATCOM access do not match the AEF's need for inflight operation and simple, lightweight ground deployment. A single antenna does not allow broad-spectrum coverage (UHF to millimeter). An azimuth and elevation tracking electronically steered antenna will provide access to nonsynchronous SATCOM and enable inflight operations.

2.4.6.3 Jamming

Jamming has a renewed importance for AEF operations as it becomes more dependent on C^2 systems. If the AEF is to use the needed reachback architecture, it must ensure dependence on these systems.

To prevent jamming, an AEF system must avoid identification as a hostile communication circuit or emission. The use of commercial systems for AEF applications will spread its data through diverse routine traffic, making the access very complex for the attacker. Antijam protection on existing systems can be provided by adapting the data throughput, allowing normal power to dwell longer on each bit of information where necessary. This would improve the signal-to-jamming ratio, effectively reducing the jammers' range.

2.4.6.4 GPS Jamming

The AEF will lose the tremendous gains of using GPS to control smart weapons if the opposition is allowed to jam the system. Only dramatic upgrades will avoid this threat. The enemy can easily use off-the-shelf troposcatter hardware to jam GPS operations. By shifting digital troposcatter systems like the U.S. AMTD4 down 8 percent in frequency to the GPS range, a user can produce 10 kW with data rates up to 8.5 Mbps. A small 200-watt drum-sized package could be assembled from modified ham gear at a cost of $3,000, will allow a large distributed field deployment.

The Air Force can combine a variety of demonstrated techniques for a robust battlefield capability, including adaptive nulling antenna arrays, integration and fielding of the numerous receiver upgrades available to provide matched dynamic tracking and increased dynamic range, and airborne UAV-carrying pseudo-satellites (pseudolites which provide high-power and close-in GPS navigational data), which will overpower jammers. Developing and using out-of-band pseudolites with GPS down converters for weapons, developing cheap radiation homing weapons for GPS and military communications frequencies, and developing a joint jamming evaluation group will also counter the effects of jamming. The appropriate combination of these to obtain 30 dB of processing gain will decrease the effectiveness of a 60-mile jammer to 1¼ miles and allow an inertial system to provide the desired weapons accuracy.

Figure 13 depicts in graphical form the relationship between the jammer size and the GPS receiver antijam capability that determines the target protected area. The current military receivers have a jammer tolerance of 54 dB above the received signal levels from the satellites. Using advanced receiver improvements and nulling antennas in the future, the AEF can raise the tolerance level to a combined level of 98 dB. This 44-dB increase in protection will reduce the protected target area against a 1-kW jammer from a 190-km diameter circle to a 1.2-km diameter circle. The AEF can even raise the jamming margin up to 120 dB, reducing the protected circle to a 184-meter diameter. At the 120-dB level, the enemy must use psuedolites and homing weapons to offset this capability. A HARM missile tuned to the antijammer frequency can negate this jamming effort. (see the area colored red [shaded area above 120 dB] in Figure 13.)

Figure 13 highlights current and future capabilities. As the Air Force improves its system, the opposition can increase its effective radiated power up to approximately 100 megawatts before it becomes too costly for the jammer to continue. Thus, antijam weapons provide an effective capability.

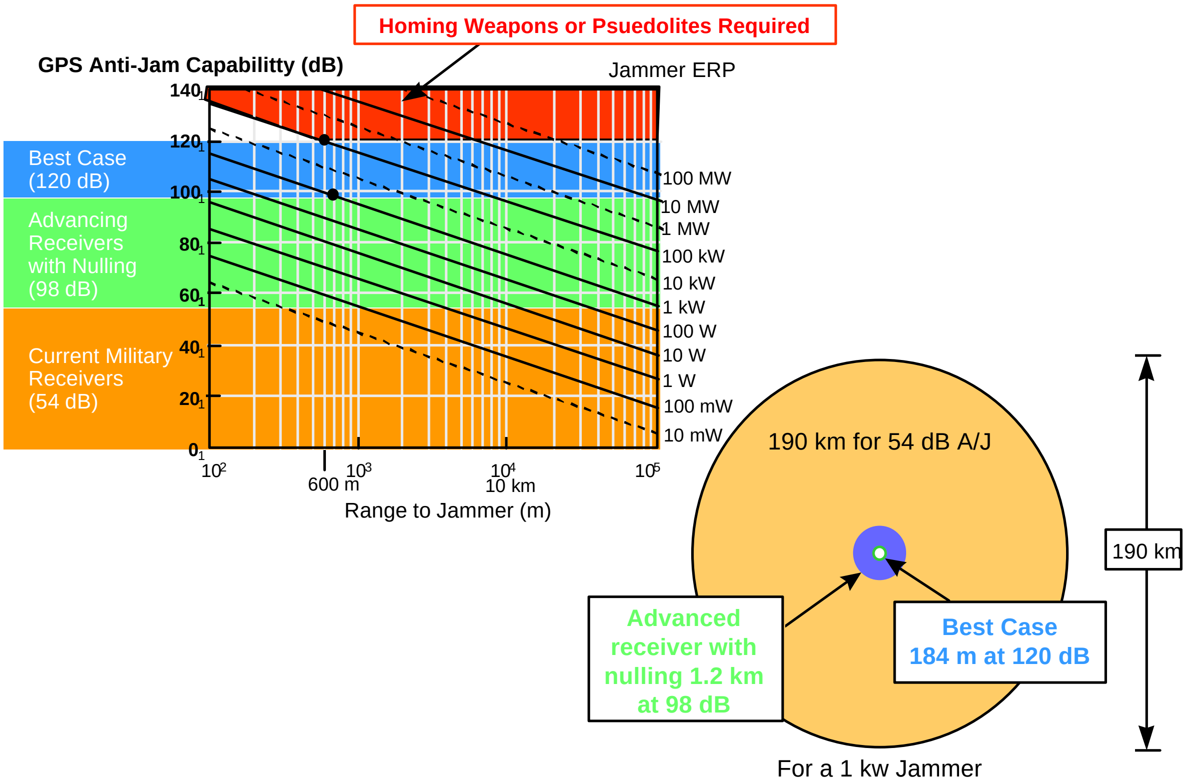


Figure 13. *Potential Exists to Alleviate GPS Jamming*

2.4.7 New Operational Concepts Enabled by New C² Capability

The above C² enablers naturally lead to new operational concepts and even new AEF missions. The following sections give some examples of these new concepts, which are aggregated into two groups: those dealing with the ability to distribute resources according to the situation unconstrained by line-of-sight connectivity and those enabled by an ability to have real-time knowledge and to dynamically plan and execute accordingly.

Distributed operations with continuous and complete connectivity may now give the Air Force a capability it could never afford. As a consequence, the Air Force has the flexibly to locate available resources where and when the situation dictates. The information technology world simply sees this concept as distributed digital systems that have the virtue of fidelity, independent of intervening distance.

2.4.7.1 Distributed JFACC

Figure 14 illustrates a distributed but fully connected JFACC. To be general, Figure 14 shows JFACC components deployed, airborne, and CONUS- or theater-based. Normally, only the JFACC with the direct staff would be forward deployed, and the main support group, with all of its resources and connectivity, would remain back in CONUS or theater. It is, of course, the complete connectivity that permits this virtual assemblage of people and continuous, fail-safe operation.

In the short term, the Air Force should configure the existing Air Operations Groups (AOGs), such as the 32nd AOG at Ramstein AB, Germany, to exercise the distributed JFACC operation to aid in the definition and development of the proper information tools to support the distributed JFACC vision.

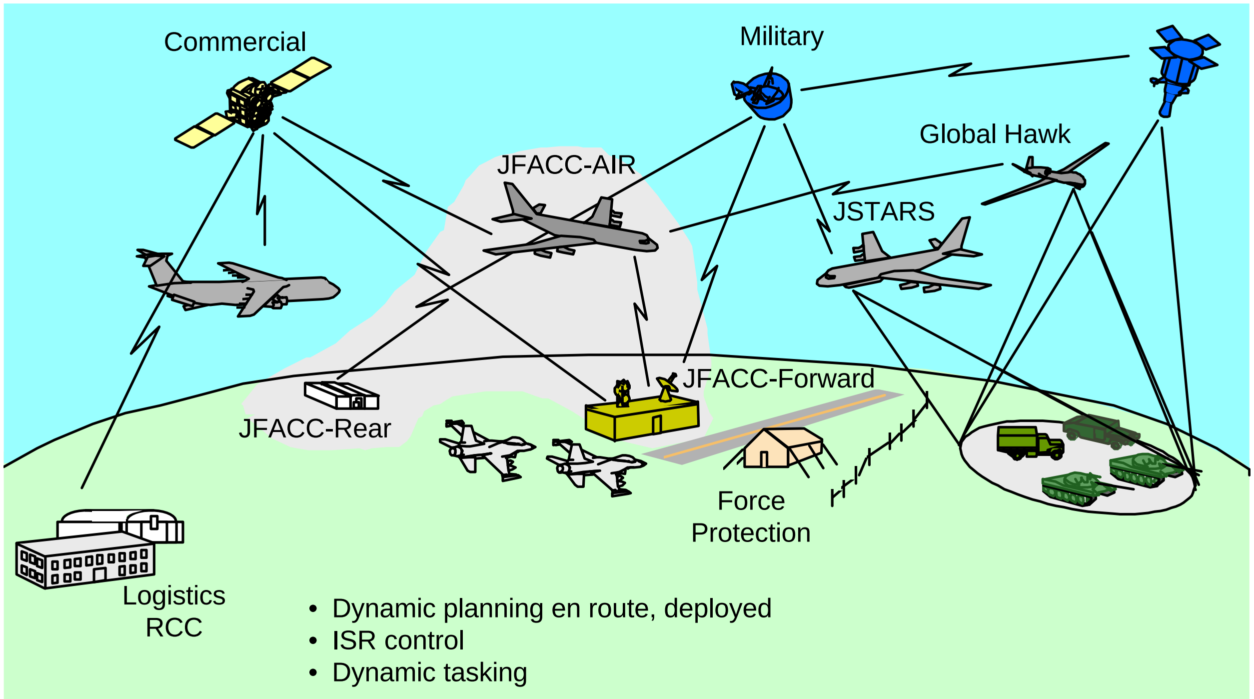


Figure 14. *A Distributed JFACC Reduces the Planning Staff Forward by More Than an Order of Magnitude*

2.4.7.2 Dynamic Force Employment

The pace of an AEF demands that aircraft be launched before all planning and target selection is done. That fact and the need to respond dynamically as the AEF mission unfolds require an inflight planning system. This capability may come from onboard equipment or reachback or, for sake of assurance, both.

Although real-time dynamics are involved in the concept of en route planning mentioned above, the new operational concepts for all-weather close air support and dynamic air interdiction are also enabled.

2.4.7.3 All-Weather Close Air Support

Night and weather currently limit the operational capability of the Air Force in the close air support mission. For example, the winter months in Bosnia permit close air support only 13 percent of the time. Precise target location in a three-dimensional GPS reference system, GPS inertial guided weapons, and aircraft equipped for weapons delivery of GPS weapons provide the key to creating an all-weather CAS capability.

Precise GPS target coordinates can be derived by airborne sensor systems if they are properly modified. Actions are underway to modify U-2, JSTARS, and Predator platforms to provide geospatial and temporal referencing that will determine GPS target coordinates. In addition, a handheld device incorporating a GPS receiver linked to a MEMS inertial chip, an encrypted precision code capability (P/Y code), and a laser range finder will generate a three-dimensional, geospatially correlated location of a selected target. By moving this device rapidly before aiming it at the target, it provides a differential GPS accuracy of 2 to 3 milliradians.

Precision target location allows targeting with GPS-guided weapons. The Joint Stand-Off Weapon (JSOW) and JDAM will enter the inventory soon. A MEMS inertial chip integrated with the GPS will permit delivery accuracy of less than three meters. Small Smart Bomb or similar programs will improve accuracy and increase weapons effectiveness.

This operational capability enables all-weather day and night close air support and has other operational implications. Target destruction can be accomplished from higher altitudes in level flight rather from low level attacks. All types of aircraft with GPS capability can be used for close air support, expanding the force that can be applied to that mission.

2.4.7.4 Dynamic Air Interdiction

JSTARS and other ground surveillance systems enable a new operational concept called Dynamic Air Interdiction. Presently, interdiction campaigns are planned and executed through the Air Tasking Order process. Target lists generally include bridges, key intersections, and roads traversing limiting terrain. The ability to see enemy vehicle movements with Moving Target Indicator (MTI) permits analysis of the enemy's attack plan and in some cases, enemy intention. It will also show enemy positions relative to friendly forces. The ground and air commanders or their representatives, using the same information, decide on the pattern of interdiction to halt or shape the flow of enemy forces dynamically. Strike aircraft are assigned targets in real time and interdict them using day or night all-weather GPS delivery described in the paragraph above. Interdicting targets, only when a specific objective requires increased pace of combat, provides further advantage to the force that can dynamically respond. It also reduces collateral damage.

2.4.7.5 Modern Battlespace Management

A precise knowledge of the battlespace is an ideal that is increasingly more achievable. When the AEF commander employs this knowledge with real-time planning and execution systems, enormous advantages accrue. An AEF can continuously surprise the enemy by predominantly operating inside the enemy's decision or reaction time. Also, a single platform or sortie can carry many more precise weapons. The carrying of a large number of individually targetable weapons also means that inflight targeting will become common practice. Above all, the AEF has the ability to orchestrate a confluence of precise power in time and space that will appear decisive to the enemy (see Figure 15).

Beyond the advantage of "out-knowing" the enemy in combat, however, the AEF commander can use that information to preempt the need to engage the enemy with force at all. While the nation occasionally has employed selective release of special, sensor-derived knowledge, such as during the Cuban blockade, the Committee believes that more beneficial opportunities to do so exist. Selective public release of specific imagery or other intelligence may act both as a deterrent and as a way to limit the U.S. involvement in hostile action. For example, in cases in which specific adversary activity may prove inimical even to those around him, letting local authorities witness the activity through a form of public release, such as CNN, may help the U.S. hand off some of its peacekeeping role to those most affected. In other cases, the U.S. may benefit by deploying the same kinds of intelligence gathering assets that support its forces to a locality where they can provide information to an ally.

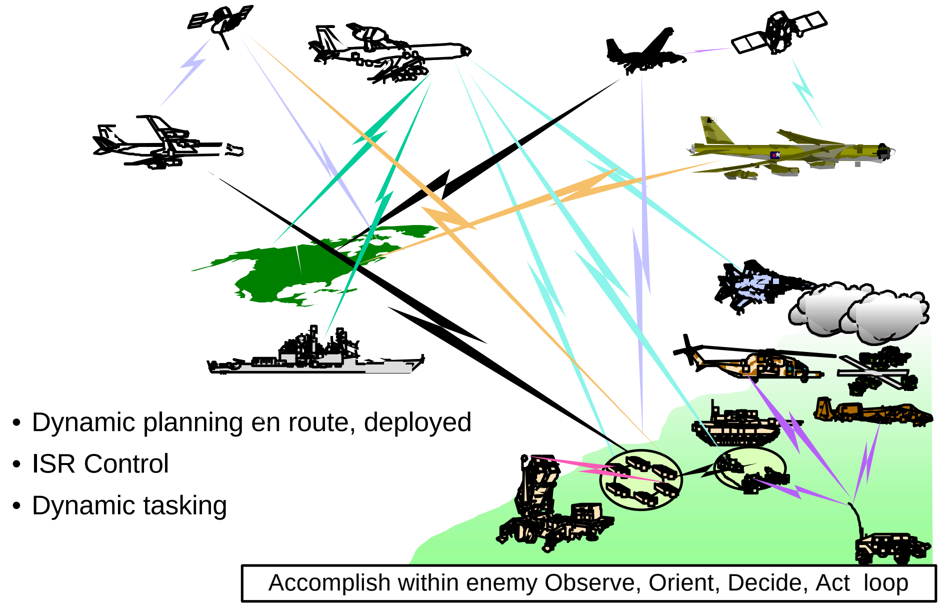


Figure 15. *New Operational Concepts Are Enabled by the Dynamic Nature of the AEF*

2.4.7.6 Remote, Distributed Air Traffic Control Operations

GPS and communication reachback capability remotely provide ATC services to any AEF location. Aircraft modified to receive these data and equipped with a ground proximity warning device can land at any AEF location without the need for ATC equipment at that location. This concept greatly reduces AEF footprint while increasing the timeliness of achieving desired outcomes (see Figure 16).

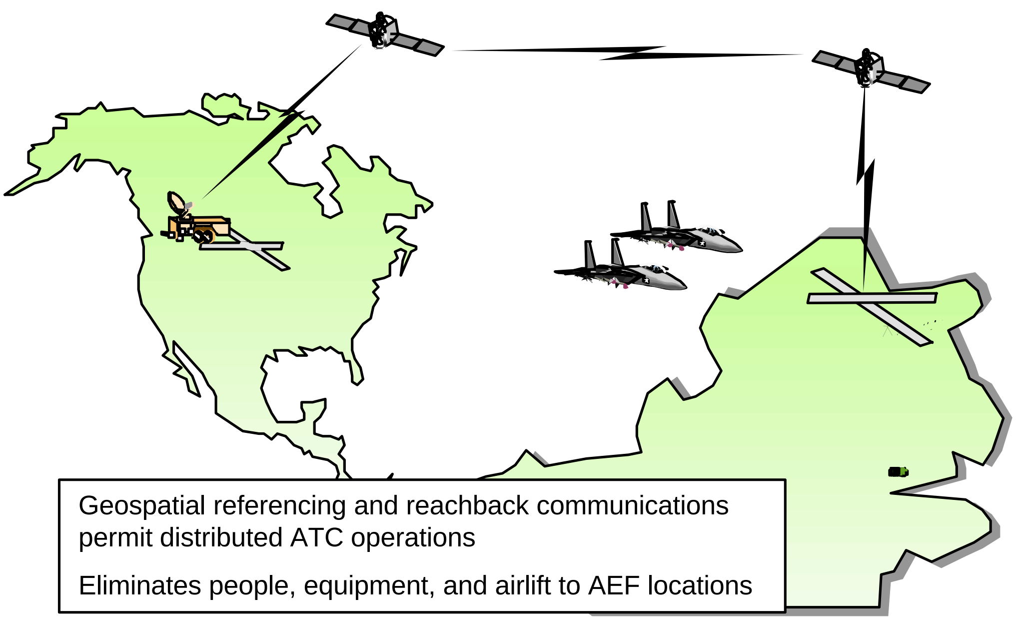


Figure 16. *Distributed Air Traffic Control Operations Are Now Feasible Using GPS and Assured Connectivity*

The International Civil Aviation Organization has endorsed a new communications, navigation, and surveillance/air traffic management (CNS/ATM) concept that will capitalize on military and commercial technological advancements to improve air traffic management. As the Air Force upgrades its equipment to comply with the intent of the National Airspace Management program and as it capitalizes on worldwide communications and global positioning connectivity, it can conduct approach control and landing activities for the forward-based AEF units from CONUS locations. In this distributed mode of ATM, pilot-to-controller voice and data connectivity will supply the precision information needed to separate and sequence aircraft, without requiring the controller or equipment to be physically deployed to the AEF airfield.

The adoption of this distributed ATC management concept will obviate the need to generate airlift to move heavy TPN-19 precision and surveillance approach radar systems (requires a C-5), older and logistically demanding MPN-14K mobile radar systems, TRN-26 TACAN systems, and associated support equipment (requiring 1 to 2 C-141s and 30 personnel). Operational timelines will improve as no one will need to calibrate and certify these ATC systems. Using the CNS/ATM concept for ATM operations could greatly enhance controller certification and exercise scenarios.

2.4.8 C^2I Transition Plan

The end state described for the Committee's key enablers of global connectivity, battlespace awareness, information management, geospatial PNT, and system assurance should be seen as change—a constantly evolving set of capabilities on our road map to attain C^2I capabilities vital to the AEF concepts proposal. Section 3.3.2 provides an expanded view of important research, development, and acquisition (RD&A) activities vital to this transition plan. In addition, Section 4.2 provides valuable ACTDs and experiments that will facilitate more rapid implementation of the C^2I roadmap.

Implementation of the full C^2I concept described here throughout the Air Force will require time. This implementation will have to occur eventually, regardless of AEF operations, in order to maintain the capability of the Air Force in the modern world. Initially AEF implementation might be limited to certain types of aircraft (i.e. one bomber type, one fighter type, one cargo aircraft type, etc.) and certain quantities of aircraft (e.g., one squadron of F-16 HARM Targeting System). New aircraft such as the JSF and F-22 should have the needed capability incorporated initially.

Given the tremendous advances the commercial world already has made in information systems, and the major impending growth of commercial worldwide space-based communications systems and commercial and foreign space-based imaging systems, the keys to successful migration are

- Enhancements and exploitation of the DII to satisfy Air Force and AEF needs
- Establishment of an AEF C^2I system architecture that fully incorporates commercial capabilities and AEF requirements
- Development of new military value-added capabilities that integrate naturally with those obtained from the commercially based architecture

Materiel Command (AFMC) acquisition centers to exploit commercial capabilities for all program baselines and to focus on unique military value-added functionality to a commercial base.

^{2}I migration will lead to global connectivity. This near-

(JBS), Challenge Athena, direct broadcast service (DBS), and existing military satellite communications tied together through an Internet router connecting AEF ground elements, large airborne platforms, and joint and coalition elements to provide a rapidly available grid and communications controller consistent with the long-term MetaNet architecture. An immediate major expansion in use of commercial DBS will dramatically enhance the viability of proposed AEF concepts in the near term. In the near and long term, as Iridium, Celestri, Teledesic, GlobalStar, GBS, and other assets are fielded, they will be tied into the grid, and a joint DARPA/Air Force-fielded communication and network controller based on commercial capabilities will evolve from the Internet router. Similarly, incorporating existing Web tools into a battlespace awareness anchor desk will enable near-term fusion of military, intelligence, and commercial information.

Current 24-hour responsiveness for deployable communications brings a mixture of 1970s vintage hardware and software to meet rapidly growing bandwidth needs. Initial packages include UHF, super high frequency (SHF), satellite terminals, air-to-ground radios, telephone switches, message terminals, hand-held radios, tactical secure data communications, and copper wire, requiring almost two C-141 aircraft. The future AEFs should continue with increased requirements for bandwidth to transmit imagery, allow collaborative planning, and accomplish real-time access to distributed data through the reachback concept of operations. This migration will lead to fewer people and fewer than one C-141, as shown in Figure 17.

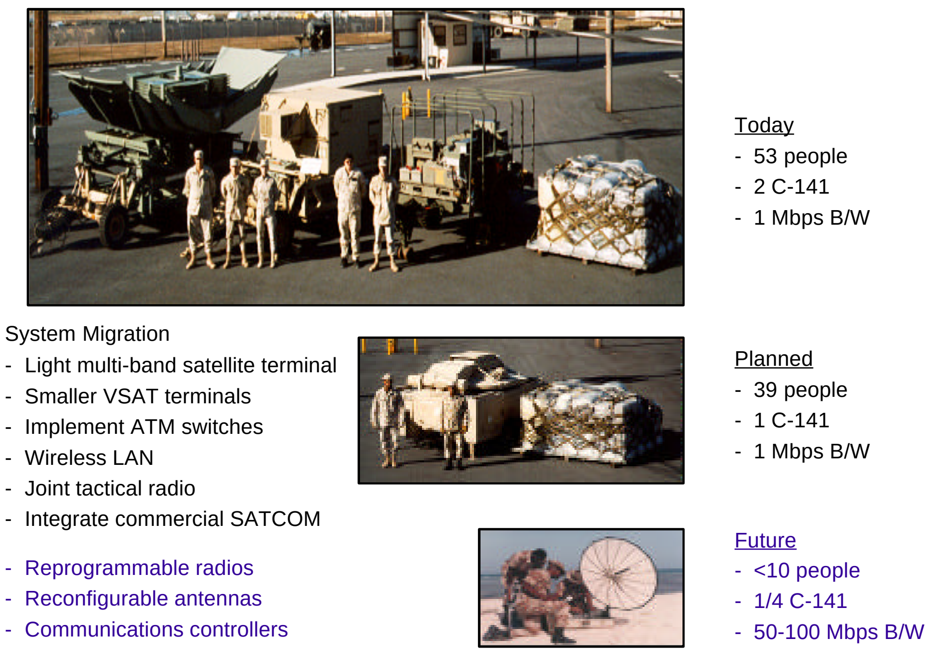


Figure 17. *AEF Deployable Communications Will Require Less Airlift and Provide More Capacity*

The application of commercial tools based on the Bloomberg and information manager models previously discussed will enable fielded battlespace awareness and information management systems in the mid term. The first AEF mission could be battlespace awareness with the goal to task and deploy collection resources and use reachback capability to bring the information back to the JFACC, integrating these resources in a common, cognitive, friendly form. Today's commercial tools can fundamentally accomplish this.

DARPA programs such as JFACC After Next, Battlefield Awareness Data Dissemination (BADD), and Bosnia Command and Control Augmentation (BC^{2}A), together with commercial systems, provide a road to successful C^{2}I for AEFs.

Logistics

Several of the logistics processes associated with deploying and sustaining an AEF the force lighter, more responsive, and more globally usable. Better tools and procedures, improved organization and provisioning, and more effective posturing of the mobility force are among these. Appendix H in provides more details.

.1

Improved CAP for logistics functions depends on two basic principles:

> Transition from a situation in which functional stovepipes exchange vital information late in the cycle, if at all, to a collaborative environment supported by tools that facilitate communication and decision making

> Transition to an employment-driven planning model in which the traditional emphasis on supply-based push of people and materiel from the rear to the engaged forces, based on peacetime estimates, gives way to a transportation-based operational pull according to the current needs of the deployed force

This change requires procedures, decision aids, databases, and other tools that automate the process and facilitate integration of operations, transportation, logistics, force protection, and other functional areas. Figure 18 summarizes the desired environment portraying the principal ideas of collaborative planning involving all functional areas in an integrated process team (IPT), use of tools designed for CAP, and reduction of the familiar six-step planning cycle of several days to a reengineered process executed in hours. Volume 2, Appendix H, describes specific tools and procedures. This acceleration is vital to meeting AEF goal timelines, to extracting the maximum military effectiveness from constrained force structure, and to ensuring the ability to deploy an AEF anywhere in the world with the right resources to accomplish its mission and survive (see Figure 18).

The available planning tools of the Joint Operational Planning and Execution System (JOPES), a theater-level, deliberate planning environment do not promote CAP. A number of current initiatives, notably the Logisticians' Contingency Assessment Tools (LOGCAT) program and DARPA's Joint Logistics ACTD (JLACTD) and JFACC After Next programs, will, if completed and fielded, substantially meet the need. A prominent example is the combination of the Survey Tool for Employment Planning (STEP) and the Beddown Capability Assessment Tool (BCAT). STEP creates a powerful, portable tool set for gathering data (including pictures) at a potential beddown site. BCAT imports these data and automates the preparation of a Base Support Plan. Together, they will greatly enhance the ability of the Air Force to develop and maintain the global beddown database that is essential to efficient planning and minimum airlift and support demands for an AEF. Comparable improvements through other tools now in development, coupled with a more collaborative process for contingency planning and execution, will shorten the planning cycle and maximize the chances that the right materiel and personnel will be delivered to the right places at the right times. The Air Force has begun development of the Deliberate Contingency Action Planning and Execution System (DCAPES) which will replace the current Contingency Operations Mobility Planning and Execution System (COMPES). DCAPES will incorporate many of the functions being developed in the DARPA programs and will be a major step toward the required CAP capability. An on-line dialog function under BCAT supports the coordination of deployment planning between lead and supporting units to ensure that collectively they take everything that is needed, but not more.

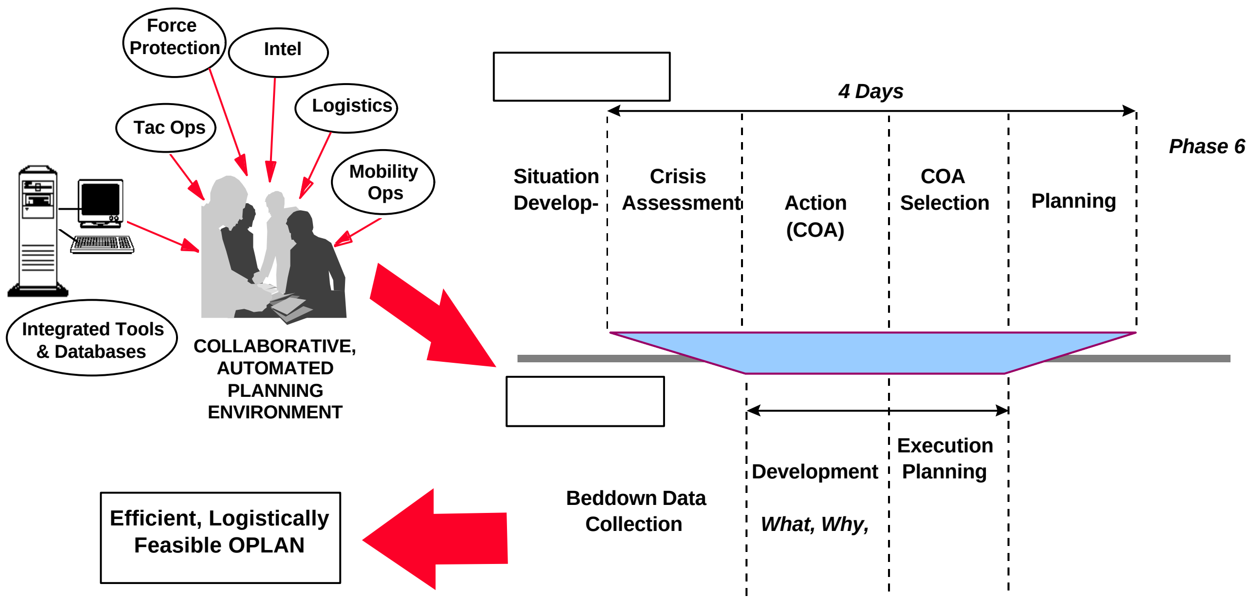
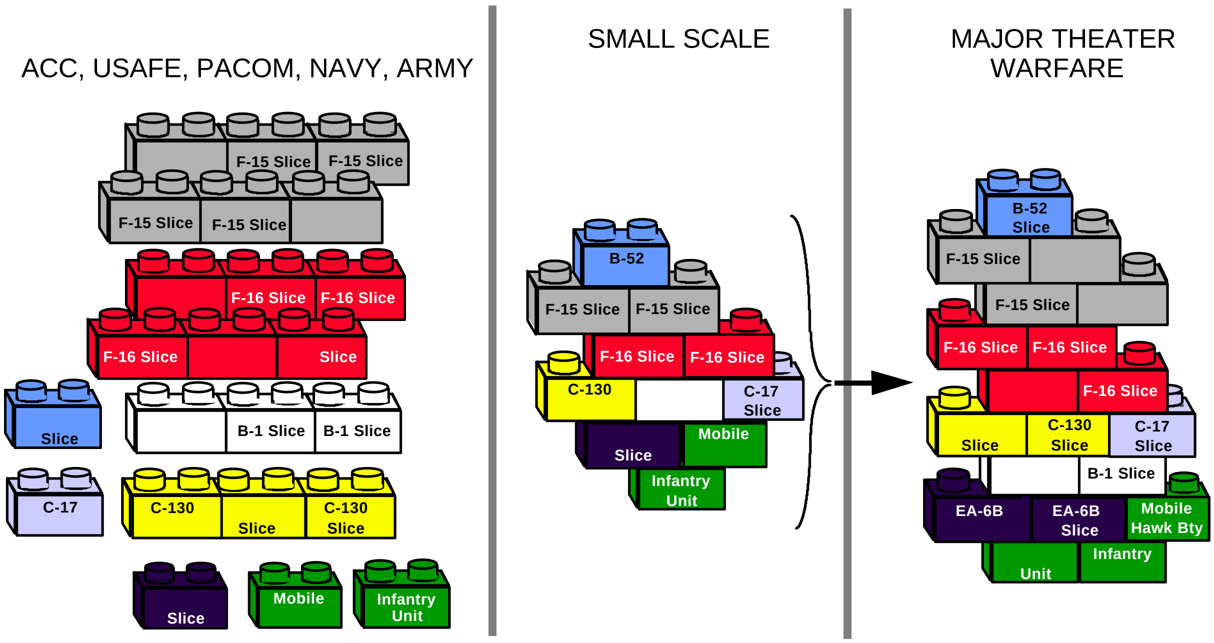


Figure 18. *An Integrated Planning/Execution Environment for AEF Reduces Planning Time by More Than 95 Percent While Assuring Logistics and Operational Compatibility*

2.5.2 Independent Slices for Enhanced Deployability

Air Force units organize, train, and equip to execute the taskings in their Designed Operational Capability (DOC) statements. Current Air Force organization for deployment, a Cold War holdover, assumes that combat units will deploy as squadrons or wings. The resulting unit type codes (UTCs), which define the force packages to be deployed, tend to be large (e.g., 12 fighters from an 18-aircraft squadron). Furthermore, the Air Force assumes that these force packages will be aggregated into large formations to fight big wars. As a consequence, and to save money, the Air Force codes many units as "dependent," meaning they are not authorized some items of equipment needed to operate because they presumably will link up with independent units that have those items. In reality, a squadron commonly must support geographically distributed operations and borrow or do without equipment at some locations. Also, deployable spare parts kits (called Readiness Spares Packages or RSPs) are generally provide for 30 days of operations, much longer than the "short and sharp" AEFs considered in this study.

Many AEF missions, nonlethal as well as lethal, will be joint/combined operations, either from the start or as the situation evolves. In addition to the interoperability considerations discussed in the C^2 parts of this report, jointness has implications for logistics. Today, the Services can share some commodities, such as rations and small arms ammunition; however, there are too few efforts to achieve common equipment that effectively meets the needs of all. For example, the Army procures chemical and biological protective gear that is notoriously incompatible with flight-line activities. As for deployable fuel systems, the Air Force and Marines use different bladders, fuel trailers, and other gear, and the Air Force fuels its planes with JP-8, whereas the Navy and Marines use JP-5 to reduce fire hazard aboard ship.



. Small Slices, Including Army nd Navy Units, Can Be Combined To Tailor Forces Across The Mission Spectrum

believes the flexibility of the force for AEF missions and, coincidentally, improve its its normal stated, current UTCs should give way to smaller slices more of which designated as independent and provisioned accordingly. Typical slices are six three-to- - ship bomber packages, a -ship C-130 element, and, perhaps, single AWACS, JointSTARS, and RIVET JOINT aircraft. Slices should employ common equipment and procedures, especially training, so they can

Figure 19 uses the analogy of a set of building blocks that can be combined in ways to meet specific needs, including joint and combined forces. The figure stresses the ease with which such a force can evolve Section further discusses this issue. Appendix H in

2.5.3 Affordable Infrastructure Options for AEFs

The Committee the Air Force's personnel and assets. The does not fit the current situation As feasible compromise, the Air Force can establish eight, of Located within a C-130 or C-17 mission radius (1 500 nmi ,000 , respectively) facilities suitable for rapidly developing a MOB and for heavy materiel such as bomb bodies to reduce the required ton-miles of transportation from CONUS. Likely locations be air bases of allied nations or major airports with their good runways and extensive cargo and maintenance facilities stablishing will entail little cost because most of what would be Volume 2 contains a description.

The ir F continues ase assets and taskings the requirement to execute MTW contingencies. This leads to a significant logistics infrastructure that would be available and important to an AEF. A prominent which ensures the supply of engines to an MTW force. heaters can also maintain all or part of the assets in the Mission Support Kit (MSK) of the primary deploying units. This will allow these units to marry up with a standard kit upon arrival in the theater, reducing the required lift from CONUS and increasing the chances that a fully stocked kit will be available at the start of a deployed operation. The Committee strongly believes that both MTW and SSC taskings must be considered in designing the global logistics infrastructure, and that they are complementary in providing the foundation for global engagement.

The Air Force must establish regional MOBs for the bomber force. Both B-52s and B-1s require substantial support environments, including very large RSPs and support equipment, to sustain operations. Analysis in the bomber community consistently indicates that three overseas MOBs, in addition to CONUS bases, will support global bomber operations: Anderson AFB on Guam, Diego Garcia, and Moron or another base in Europe. Volume 2 gives more information on the requirements to build up the latter two bases to the required levels.

2.5.4 Mobility Forces

The AEF concept demands responsive, reliable airlift. As C-17s enter the force in numbers, they will often be the preferred lifters for AEFs because they are specifically designed to deal with constraints on the number of aircraft that can be parked and unloaded at any one time (referred to as maximum on ground or MOG) at small forward bases. Transport of the 30-fighter package described in Chapter 2 requires roughly 14 to 20 C-17 sorties. Some circumstances favor C-5s simply because they require fewer sorties to deliver a given list of cargo and passengers. However, current C-5 departure reliability is less than desired and presents a serious problem.

Rapid deployments at forward bases depend on adequate runways and ramp space. The F-16 requires a runway length of at least 7,000 feet and a surface strength of at least Load Classification Number (LCN) 60. These pavements will support airlifters. Other airfield characteristics such as runway width, taxiway width, and parking area (e.g., access, size and shape, and obstacles), as well as weather, host nation customs, and competition with other airfield users, can affect transport operations. Both the C-17 and the C-130 have a ground backup capability that allows them to maneuver on limited airfield areas, and both have the ability to offload pallets onto the ground without external material handling equipment (MHE) if required.

Activation of the C-17 center wing tank would have major advantages in AEF situations, both from increased range and from improved ability to fly in fuel to forward bases. The current C-17 fuel volume restricts its long-range AEF capability and increases its reliance on tankers. At low cost, the Air Force can activate the C-17’s center wing tank to extend the range. At ranges greater than 3,000 nmi, use of this tank will decrease the tanker sorties required or increase the payload available up to 80,000 pounds. Figure 20 shows the power of increased range in terms of geographical coverage with unrefueled operations. The estimated daily requirement for 30 fighters is 670,000 pounds of fuel and 132,000 pounds of munitions. The C-17 could deliver these quantities at a 1,500-nmi radius mission with 5 sorties per day. At a 2,000-nmi radius, it would require 7 sorties. The high volume C-17 delivery with the center wing tank provides a new capability without adding tanks, bladders, or pumps in the cargo compartment thus retaining the flexibility to trade off cargo and fuel or to back haul cargo, troops, or aeroevac patients.

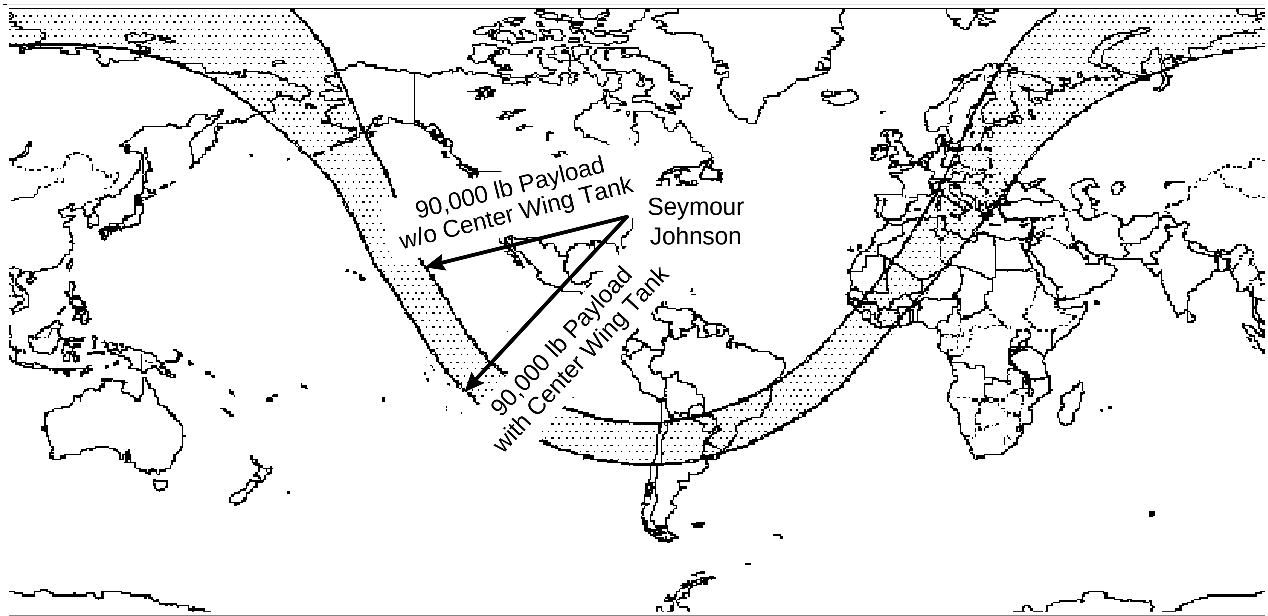


Figure 20 *Activating the C-17 Center W Tank Greatly mproves Its U and Reduces T Requirements*

.5 Light Weight Munitions

In a shooting war, with current munitions, as much as 80 of the sustainment lift can be consumed by bomb bodies, and a large force of personnel, vehicles, and equipment is required to feed built-up munitions to ,000 of ordnance per sortie, in a two-a-day operation, require 96 short tons of bomb bodies per day; that translates to 10 C-130, 5 C-141, or 2 C-17

Advanced munitions like the Small Smart Bomb (SSB) offer both lower tare weight per weapon and more kills per sortie. Replacing 2000- warheads with 250-pound the lift nt by a factor of eight for the same number of , and larger aircraft loadouts mean fewer sorties to prosecute a target list, further reducing the logistics burden. Smaller munitions are inherently easier

priority in the sustainment area. There is
logistics dimension of the AEF concept. SSB has been treated primarily as an F-22 air-to-ground weapon; in

2.5.6 Improved Supportability of Deployed Forces

One key to enhanced AEF effectiveness is reduced dependence on external support resources. This can be

reforming legacy support practices that
goal must be to transition from the current assumption of large personnel contingents and fixed bases with substantial maintenance and repair facilities to a concept of sortie generation at austere bases with minimal
2.5.2,
section 2.5.7), and

The Committee advocates a concept of "Minimum Flight-Essential Maintenance" at beddown sites. The elements of the concept are

- **No Major Scheduled Maintenance.** Aircraft designated for deployment should not have phase inspections, time-compliance technical orders (TCTOs), or other mandatory scheduled maintenance due. Any such scheduled maintenance that becomes necessary should be accomplished by rotating the aircraft from the forward base to a regional main operating base (MOB). In particular, no engine inspections should be done except in response to reported problems. Only routing crew chief inspections and servicing as part of aircraft generation are in order.

- **Only Basic Organization-Level Maintenance.** Crew chiefs, supported by a skeleton crew of specialists, can do remove-and-replace repairs by drawing on minimum maintenance stocks. Normal servicing (fuel, munitions, liquid oxygen, etc.) must, of course, be performed. Any aircraft break that exceeds these capabilities should be dealt with either by rotating the aircraft to the rear or by converting it to a cannibalization bird at the forward base.

A significant reduction in deployed support can be realized through improved R&M in Air Force weapons systems and support equipment. Correction of specific R&M problems can have useful leverage on both mission capable rates and required support. An example is the secondary power system of the F-15, which has been the primary source of ground aborts since the aircraft entered the inventory. To achieve the highest gain at the lowest cost, R&M improvements must be done at the front end of the weapons system or subsystem upgrades development to avoid costly retrofits. Further, the effort should be focused on what are typically the "long poles in the tent" (complex, and hence, high cost elements) to get the greatest payback for the investment. The emphasis on R&M which is evident in the F-22 and Joint Strike Fighter programs will pay major dividends for future AEFs.

The Lean Sustainment Panel looked at a variety of recent maintenance data, especially trends in key indicators. The picture is not pretty. The mission capability (MC) rates picture has deteriorated over the past few years. During Desert Shield/Desert Storm, the following statistics were typical for the F-16 fleet:

- MC rates in the high 80s, as high as 92 percent in some cases
- NMCM rates around 4 percent
- NMCS rates around 5 to 6 percent

Today, the MC rate averages around 80 percent and goes as low as the 70 percent figure cited earlier, while NMCS rates area around 8 to 10 percent and NMCM rates average around 10 to 12 percent and go up to a high of 14 percent.

For the F-15 fleet, including home base operations and recent AEF deployments, MC rates run around 80 percent, down from 85 percent in Desert Shield/Desert Storm. Trends in NMCS and NMCM rates are similar to those for the F-16. MC rates are deteriorating rapidly, as a result of (at least) the following factors:

- NMCM rates have worsened as a result of continuing high operations tempo, due largely to deployments. This increases demand for scarce parts, accelerates age-related system problems, degrades training of support personnel, and puts the logistics system in an endless catch-up mode. For example, landing gear problems and wing root fuel leaks have surfaced as problems with the F-16, presumably due to more landings at heavier gross weights, reflecting both overall heavy usage and the trend to hang more equipment like LANTIRN and HARM Targeting System on the aircraft.

- NMCS continues to worsen because the logistics system is not delivering to the flight line the spares to meet even the rather low MC goals on which the budget is based. This is due in large part to the fact that depot obligation authority (OA) is constrained and is not optimally applied to fix the units really needed in the field.

With a smaller force structure, high operational tempo, and globally diverse commitments, R&M is a central AEF issue, because it is vital that the maximum possible military effectiveness be extracted from these limited assets. Specific R&M issues include the following:

- **Aircraft.** Emphasis on keeping future weapon systems, such as F-22, JSF, and CV-22, compatible with operations at austere sites is essential to maintaining AEF capability. A particular concern is for low observable (LO) features that are durable and maintainable under field conditions. Specific opportunities include replacement of hydraulics with electric actuators and On Board Oxygen/Inert Gas Generation Systems (OBOGS/OBIGGS). Tires with more lifetime on inferior pavements would reduce a major current flight line maintenance burden. F-16s today get 5 to 8 landings per tire set; a reasonable goal to shoot for would be 50 landings. Computerized technical data and maintenance aids for fast troubleshooting by non-specialists would also have great value.

- **Support Equipment.** A flight line today contains an assortment of gear, much of it single-function and some of it aircraft-unique, which adds to deployment cargo lists and creates its own support burden. Acquisition and modification programs that increase reliability, create multifunction equipment, reduce corrosion susceptibility, and standardize support equipment across multiple aircraft would significantly alleviate these problems. An example is the Air Force Research Laboratory Modular Aircraft Support System (MASS) program to reduce numbers and types of flight line carts. Figure 21 suggests the improvement that is possible with improved flight line gear.

- **Air Base Operations.** An air base is, in effect, a system, but is thought of as a collection of independent pieces for shelter, transportation, sanitation, and so forth. A coherent management focus and program to optimize the materiel that deploys to support an AEF would yield reductions in weight, personnel, erection time, and cost.

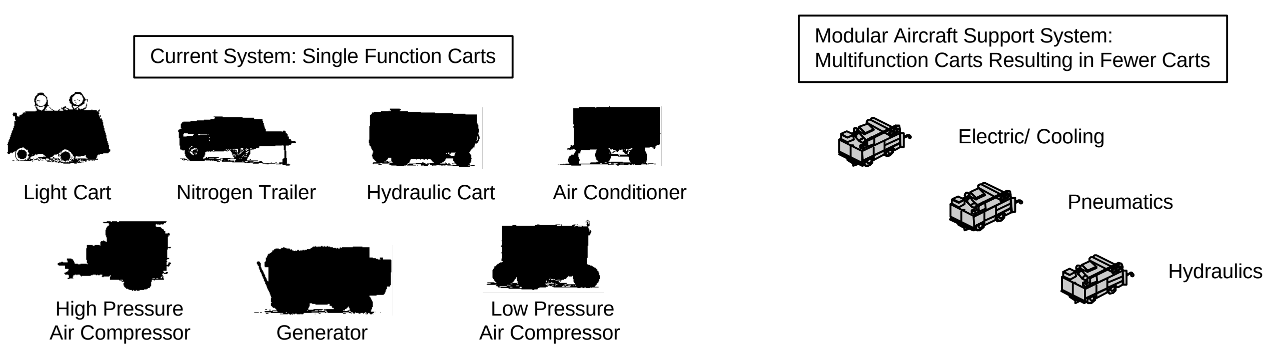


Figure 21. *Lightweight, Multifunction Support Equipment Can Significantly Reduce the Deployed Footprint*

2.5.7 Lean Logistics

Lean Logistics (LL) is the centerpiece of the Air Force strategy to improve the responsiveness and decrease the cost of materiel support to systems. It is based on optimizing the support pipeline through expedited repair of failed items and time-definite transportation to and from a repair facility to cope with unpredictable demand for spares and lower the overall inventory levels needed to maintain a given mission capable rate. The uncertainty in peacetime demand for spares, from base to base and over time, has been observed and documented extensively. During wartime, the uncertainty in demand is dramatically increased, especially with regard to changes in the means of distribution. This uncertainty was substantiated by the Operation Desert Shield and Operation Desert Storm experience. Reasons for these changes in demand pattern can be surmised after the fact but are difficult to predict because they are so situation dependent. In that conflict, supply shortages were overcome by using the resources of non-deployed units to support the deployed force; this worked for weapon systems which had substantial numbers remaining in CONUS, but not for aircraft such as the F-4G, F-117, and F-15E without substantial numbers in CONUS. Furthermore, lack of retrograde movement of failed items meant that the depots played an inadequate role in generating the needed spares flow. This approach would not work today with an overall smaller force confronted with a high operational tempo (OPTEMPO) and highly uncertain tasking.

The LL concept was developed by the RAND Corporation and named by the Air Force to deal with this fundamental problem of demand uncertainty. Key elements of the LL concept are as follows:

- Significant acceleration of both organic repairs, addressed by the Depot Repair Enhancement Program (D-REP), and contractor repairs, addressed by a matching Contractor REP (C-REP)
- Reliable and rapid (time-definite) transportation between engaged forces and sources of supply
- Information systems that provide the necessary connectivity to the logistics support system, including transmission of field failure data to accompany returned items
- Ways to rapidly fabricate items not in stock, especially older items whose original source is no longer available
- Continuous improvement based on results of exercises and field experience

The Air Force has started implementing the first three of these elements. Furthermore, in anticipation of the expected improvements, the Air Force has reduced pipeline requirements in order to decrease operations and maintenance (O&M) budgets and generate resource offsets for force modernization. However, LL has not been fully implemented. Failure to achieve the goals of rapid turnaround in repairable items and fast transport to and from the field will necessarily result in a shortage of spares with attendant impacts on mission capable rates of the force. The Air Force has made good progress on organic repair through D-REP, but little to date in the C-REP area, despite efforts by Air Force Materiel Command (AFMC). Unfortunately, many items with critical shortages depend on contractor repair. Existing contracts typically allow 90- to 180-day turnaround times, which are totally incompatible with LL. This situation must improve for logistics reachback to work and for the overall high availability of the force structure demanded by global engagement to become a reality.

Another critical piece is better provisions for returning field failure data to the depot. An example that came to the attention of the Committee is life support equipment, but this is a long-standing problem with avionics and other high value items. It is common for an item to arrive at the depot without pilot debriefing data, local test results, and other indications that would assist the depot in diagnosis. Fixing this would reduce “cannot duplicate” rates and increase the overall effectiveness of the repair pipeline.

2.6 Force Protection

Force protection is the detection, warning, defeat, and/or delay of threats and mitigation of the effects of threats on mission performance. Threats include enemy (terrorist, special purpose and guerrilla force, and small tactical group) operations (kidnapping, standoff, and penetration attack), weapons (biological, chemical, conventional, laser, nuclear, and radio frequency), naturally occurring phenomena (dangerous flora and fauna, fatigue, high elevation, hunger, infectious disease, night, low-level radiation, thirst, and weather), and occupational hazards (fire, hazardous waste, injury, and toxic agents).

2.6.1 Enemy Operations

Enemy operations are categorized into three levels: (1) small-scale operations conducted by agents, sympathizers, partisans, and terrorist groups; (2) special purpose attack, long-range reconnaissance, intelligence gathering, and sabotage operations conducted by special purpose, guerrilla, or unconventional forces, or small tactical units; and (3) major attacks by airborne, heliborne, or amphibious forces via aircraft and theater missiles with conventional and/or biological, chemical, or nuclear weapons. AEF force protection personnel must defeat Level 1 threats, defeat or delay Level 2 threats, but only delay Level 3 threats. Defeat of Level 3 threats requires more aircraft and/or support from Army, Navy, Marine, or Allied units. In the context of this report, force protection does not include offensive operations required to defeat Level 3 threats.

A review of ground attacks on airfields from 1940 through 1992 indicates that attacks have occurred in Vietnam (493 attacks), Panama (4), Afghanistan (3), Korea (3), El Salvador (2), Grenada (2), the Falklands (1), and the Philippines (1). During World War II, 130 airfield attacks occurred across Northern Africa, in the Pacific Islands, and throughout Europe. Three attacks took place during Operation Desert Storm. The objectives of these attacks are listed in Figure 22, the attack techniques in Figure 23, and the tactics in Figure 24.

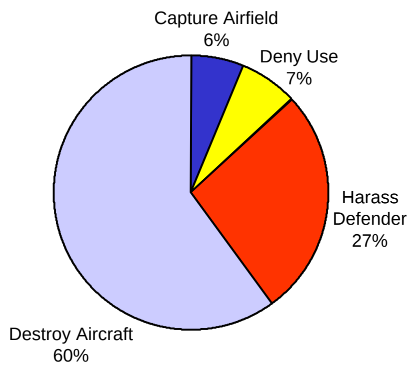


Figure 22. *Historical Airfield Attack Objectives*

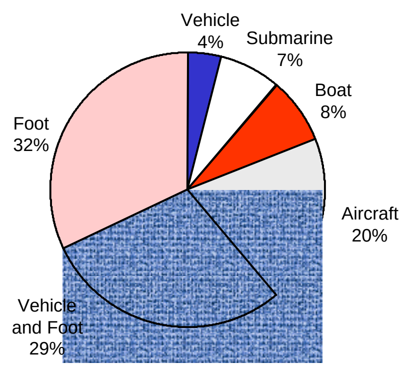


Figure 23. *Insertion Techniques Used in Airfield Attacks (Except Vietnam)*

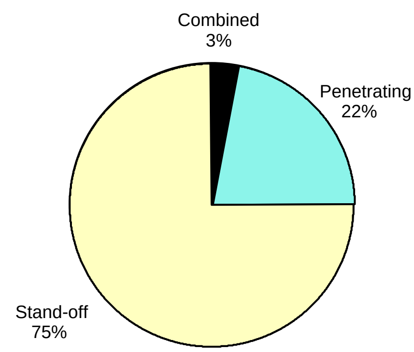


Figure 24. *Tactics Used in Airfield Attacks*

The majority of attacks were stand-off attacks. The stand-off threat includes mortars, surface-to-air missiles, and rifles. Figure 25 presents the distances which an enemy, using the particular weapons, could threaten an AEF airbase.

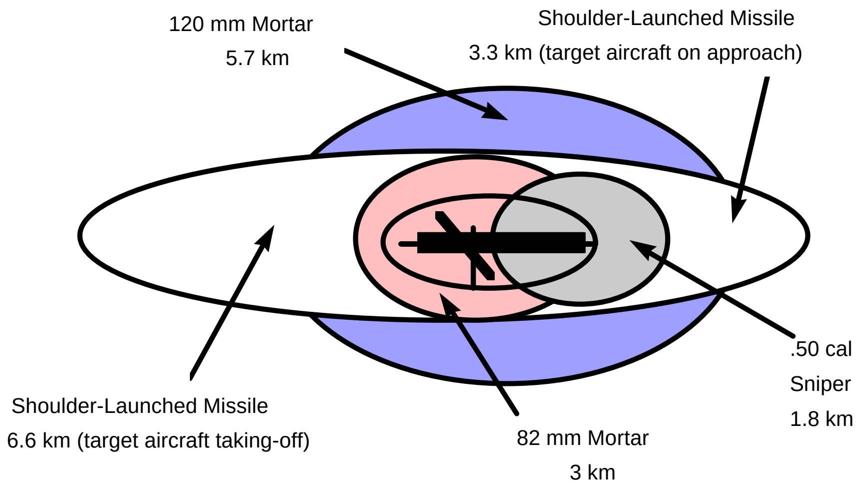


Figure 25. *Size of the Stand-Off Threat Footprint*

Although the number of terrorist incidents worldwide is decreasing (see Figure 26), some evidence suggests that lethality is increasing. Incidents involving the U.S. Military occurred throughout the world (see Figure 27). The incidents were bombings (58 incidents), attacks (31), assassinations (19), kidnappings (13), and threats of violence (8).

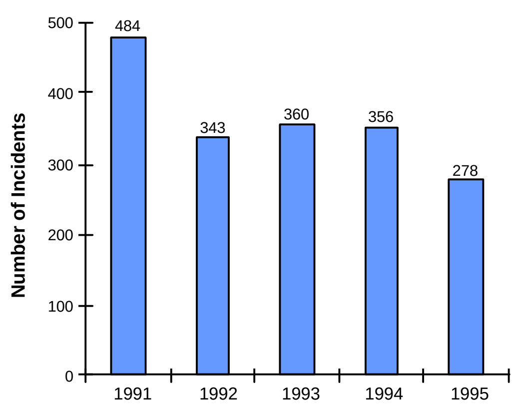


Figure 26. *Terrorists Incidents Worldwide (from Preliminary Analysis of RAND-St. Andrews Andrews Chronology of Terrorism), 1991 - 1995*

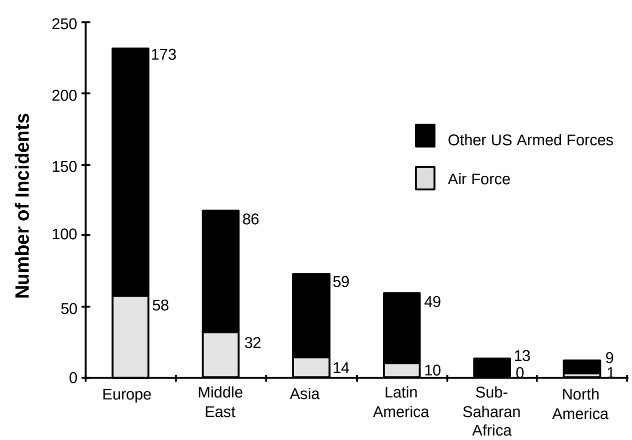


Figure 27. *Terrorist Attacks on U.S. Military (from Preliminary Analysis of RAND-St. Chronology of Terrorism), 1991 - 1995*

The data presented in Figure 27 indicate that terrorists have attacked U.S. Military personnel throughout the world. This threat will likely persist in the future, with greater lethality and sophistication. Analysis of terrorist data suggests three trends: (1) terrorists will continue to rely on guns and bombs but these will be more lethal; (2) the sophistication of terrorist weapons will continue to lay in their simplicity; and (3) combinations of new types of terrorist entities with different motivations and great access to weapons of mass destruction may, surface to produce new and deadlier adversaries.

The AEF commander has three defensive options during enemy operations: (1) detect the enemy and move prior to attack, (2) defend against the enemy and move after the attack, and (3) defend against and counter the enemy while remaining in place. The AEF force protection package must ensure that any of these three options is viable.

2.6.2 Unconventional Weapon Threats

The historical data presented above describe attacks against airfields using conventional weapons. Future attacks may include unconventional weapons, such as biological and chemical agents and lasers. Note that this study excludes nuclear weapons from consideration for an AEF deployment. To date, U.S. forces have never been attacked with biological weapons. However, some terrorist groups have possessed cultures of clostridium botulinum (German Baader-Meinhof), anthrax (Aum Shirikyo), tularenesis, plague, and dysentery. United Nations inspections of Iraqi facilities discovered evidence of botulinum toxin, anthrax bacteria, and clostridium perfingens. Biological weapons are inexpensive, are easy to package, provide wide-area coverage, are difficult to detect during production, and are lethal (20 percent or more fatalities from anthrax) or debilitating (up to 80 percent from anthrax).

Terrorist groups also have chemical weapons (CW). For example, the Aum Shirikyo training center contained tons of chemicals for sarin production. CW were used in World War I and more recently in the Iran-Iraq War. Iraq was the first nation to use nerve agent on the battlefield, attacking unprepared Iranian troops in 1984. By 1990, Iraq had the largest CW agent production capability in the Third World, annually producing thousands of tons of blister and nerve agents. Chemical weapons are inexpensive, provide wide-area coverage, and, since they resemble agricultural products, are difficult to detect during manufacture.

Lasers also threaten the AEF. Data from the NASA Aviation Safety Reporting System database for the last two years provide examples of commercial flights in which the pilots suffered eye damage from lasers. These include aircraft landings at Honolulu, Las Vegas, Miami, New York, Los Angeles, and Phoenix. In Phoenix, one crew member was flashblinded, with resulting after-images and loss of night vision for about 1½ hours. Takeoffs have also been affected: in a 737 outbound from Los Angeles, two pilots were struck by a blinding flash that lasted 5 to 10 seconds. The first officer had burns on the outer eye and broken blood vessels. In a flight from Cleveland, one crew member received a bright blue light in his right eye and experienced vision impairment for the next 1½ hours.

Data from the National Air Intelligence Center indicate that, in the U.S. alone, commercial lasers have caused over 50 blinding incidents. Lasers have also injured a number of Air Force personnel. For example, the Palace Casino’s laser show laser-illuminated a C-130 landing at Keesler AFB. The flight engineer, who was looking straight ahead, was blinded for 3 to 5 seconds and then experienced blurred vision. The next day, he experienced eye pain requiring eye drops. In April of this year, two Royal Canadian Air Force helicopter pilots were laser-illuminated from a Russian trawler during a routine mission.

Laser weapons are inexpensive, sold openly by the Third World, have line-of-sight aiming, and are capable of producing catastrophic results if used against aircrews and sensors in flight (especially during takeoffs and landings). Commercially available laser weapons include the ZM-87, developed by the Chinese and first displayed at the International Defense Exhibition in 1995. In addition, the Russians sell a truck-mounted high-energy laser. Ground personnel also face risk. For example, the University of Tasmania in Hobart sells a CO_2 laser system for controlling forest undergrowth. The system is used to ignite logging debris from distances of 100 to 1,500 meters. The laser, costing $86,500, is mounted on a gun turret carried in a 2-ton truck and is simple to operate. Similar systems are available commercially throughout the world.

2.6.3 Naturally Occurring Phenomena and Occupational Hazards

Data provided by Epidemiology Services (AFAL/AOES) for the Joint Task Force Southwest Asia (AEF IV) are provided in Table 4. The data show the number of visits to the on-site clinic from December 1996 to

June 1997. The largest number of visits related to infectious disease. The diseases included viral disease and chlamydiae (primarily warts, 195 cases), intestinal infections (147), viral skin lesions (primarily herpes, 34), strep throat (27), parasitic diseases (14), and sexually transmitted diseases (3). The work-related injuries consisted of complications from medical care (primarily accidental puncture, 92), sprains and strains (67), superficial injuries (35), bruises and hematomas (32), burns (17), fractures (14), open wounds (8), foreign bodies (6), crushing injuries (3), dislocations (2), and head trauma (2). The two radiation cases occurred from exposure prior to deployment to AEF IV. Toxic-agent visits were predominately smoke inhalation (7 cases) but there was one medical overdose. The weather-related visits included both heat-related illness (primarily dehydration, 39 cases) and cold-related illness (4 cases). Data for Bosnia (maintained by the U.S. Army CHPPM at Aberdeen Proving Grounds) are similar. A review of Air Force Safety Office data on maintainer mishaps (1992 to 1997) indicates that the predominant workplace injuries were musculoskeletal (e.g., strains and twists) with fractures and eye injuries among those next in frequency.

Table 4. *Number of Clinic Visits in AEF IV*

Diagnosis	Number of Visits
Dangerous Flora	0
Dangerous Fauna	47
Fatigue	70
Infectious Disease	1,020
Work-Related Injury	357
Radiation	2
Toxic Agents	7
Weather	43

2.6.4 AEF Force Protection Readiness

Table 5 summarizes the status of the AEF in protecting itself against the threats described above. In the table, “red” status means that personnel will be injured if the limiting factor is not corrected. “Yellow” indicates a potential for injury. Organizing, training, and equipping AEF-deployable personnel takes investment (see Chapter 4). The greatest deficiencies are in the biological, chemical, and laser weapon areas. Of less concern are fatigue, fire, hazardous waste, high elevation, hunger, infectious disease, injury, low-level radiation exposure, thirst, and adverse weather.

Table 5. *Status of AEF Force Protection*

Threat	Operational Requirement	Limiting Factors	Status
Biological Weapons (BW)	Organization	No effective advocacy at Air Combat Command (ACC)	Red
	Predeployment preparation	No BW-specific doctrine No Air Force combat center working BW issues Insufficient training and knowledge Inadequate weather and simulation modeling of biological agent dispersion	Red
	Stand-off detection	Air Force has no stand-off detection	Red
	Detection	Air Force has no point detectors	Red
	Personal protection	Poor mask fit Mask only option for BW not specified under AFMAN 32-4005 Personnel Protection and Attack Actions (Mission Oriented Protective Postures and Variations)	Yellow
	Collective protection	Air Force has few collective protection systems	Red
	Casualty management	No concept of operations for BW casualty management	Yellow
Chemical Weapons (CW)	Organization	No effective advocacy at ACC	Red
	Predeployment preparation	No CW-specific doctrine No Air Force combat center working CW issues Training and knowledge is insufficient Inadequate weather and simulation modeling of chemical agent dispersion	Red
	Stand-off detection	Air Force has no stand-off detection	Red
	Detection	No concept of operations for point detectors	Yellow
	Personal protection	Poor mask fit Mission Oriented Protective Posture (MOPP) 4 limits vision and imposes heat stress	Yellow
	Collective protection	Air Force has few collective protection systems Transport aircraft are at risk	Red
	Decontamination	Insufficient number of M17 units and no training	Red
	Sustainability	Equipment is inadequate	Red
	Casualty management	No CONOPS for CW casualty management in AEF deployments	Yellow
Conventional Weapons	Organization	The security police equipment management agency was disbanded leaving a void in COTS acquisition	Red
	Detection	Prepositioned material storage areas will be prime terrorist targets It is extremely time consuming and difficult to detect a bomb in a truck	Red
	Protection	AEF force protection in a Level 3 threat requires more aircraft and/or support from Army, Navy, Marines, or allied units	Red
Infectious Disease	Predeployment preparation	There is limited infectious disease intelligence information on possible sites Standard immunization records are not computerized or linked to operations planning Harvest Falcon has been incorrectly fielded with resulting illness	Yellow

Table 5. *Status of AEF Force Protection (continued)*

Threat	Operational Requirement	Limiting Factors	Status
Laser Weapons	Personal protection	Force protection personnel do not have laser eye protection (LEP) No aircrew LEP has been approved for night or Night Vision Goggles (NVGs) Current LEP is unsafe for flying since it reduces visibility of Head Up Display (HUD) symbology	Red
Night	Personnel protection	NVGs are not compatible with current crew stations NVGs have narrow field of view	Red
Radio Frequency (RF) Weapons	Personnel protection	China and Russia are developing RF weapons	Red
Terrorists	Predeployment preparation	Many bases have been judged vulnerable to terrorists	Red
	Aircraft self-protection	Most aircraft have no self-protection against small arms fire and shoulder-launched weapons Currently used flares and decoys may cause collateral damage	Red
Toxic Agents	Organization	Tech Orders are not current on toxic threats	Red
Weather	Sustainability	Accurate weather forecasting requires 7-day local forecaster experience	Yellow

2.6.5 AEF Force Protection Enablers

There are eight key enablers to providing effective AEF force protection:

- **Self-protection of information, airlift, materials, and the force.** Information self-protection includes hardening detectors against conventional weapon effects, such as heat and overpressure, laser blinding, and toxic agents (including agents used in decontamination). Information self-protection requires maintaining secure information transmission with efficient use of bandwidth and redundant channels. Aircraft self-protection is based on the use of a portable perimeter with remote sensors and an onboard situation display to keep the aircrew informed of threats. Secure stops and storage are critical to airlift. Also, each item to be removed from or placed in the cargo holds must be scanned automatically for biological, chemical, and radiation hazards and for self-protection of materials. In addition, materials require hardened storage, long shelf life, stable storage conditions, and tamper-evident locks. Self-protection of personnel spans the gamut of protective clothing, masks, occupational gear, food, and water, as well as training, physical conditioning, and appropriate immunization/chemotherapy prophylaxis. Self-protection of weapons includes the use of armor to protect against small arms fire, sealants to minimize contamination, and timely maintenance.
- **Reachback.** This includes detection with remote sensors, wide-area surveillance over the base, and the ability to destroy or deny threats to the base. The AEF must reach into the site to take material samples as needed and reach into on-site expert systems to support such practices as site selection, medical diagnoses, and maintenance procedures. Reach also includes reaching back to analysis centers with samples, centers of excellence, and medical support (e.g., telemedicine) when the expert systems are not complete.
- **Multiple roles for personnel and equipment.** One example is tents that provide camouflage or concealment as well as chemical and weather protection. Personnel must also cross-train in more than one specialty required for AEF deployments. For example, physicians or

physician's assistants might cross-train in public health, pilots in unconventional threat detection and protection, and meteorologists in communications specialties.

- **Division of labor.** A division of labor among Air Force Operations (to perform warfighting missions such as leading edge of a major combat operation, peace operations, and show of force), Air Force Special Operations (to perform covert missions, such as support to global awareness), and the Air National Guard and Air Force Reserves (to perform humanitarian missions) reflects each group's strengths in training, equipment, and experience in accomplishing the AEF missions.
- **Integration.** Integration in the design of weapon systems for self-protection, decontaminability, and safe materials can reduce costs and ensure compatability. Integration is critical among detectors for the same threat, different threats, warnings, and information passed to the C^2 system. Integration also affects the lifestyles of Air Force personnel by blending fitness activities with self-defense training, Meals Ready to Eat (MREs) with circadian rhythm (e.g., ingesting carbohydrates for sleep, proteins for waking), and training for multirole tasks. Databases on immunization, health, skills, and experiences must also be integrated to be usable and accessible to support the selection of personnel to be deployed.
- **Simplicity.** Warnings should be prescriptive, with the direction provided dependent on the threat detected: "put on mask" for a toxic threat, "take cover" for a conventional weapon attack, "do not eat or drink" for a biological threat, "stay away" for hostile fauna, and "get help" when the fitness-for-duty monitor detects fatigue.
- **Speed.** Enemy intelligence sources may detect AEF deployment plans quickly or before they are implemented. Setting up and tearing down the base imposes risks prior to a functional operation. Processing, analyzing, and transmitting information is crucial in responding to threats. The Air Force may respond by moving the base.
- **Flexible perimeter.** The perimeter highly depends on location, potential use of unconventional weapons, the strength of the enemy, fatigue, terrain, visibility, and weather.

The Air Force must overcome the limitations listed in Table 5, yet much of the current effort is unfocused and relies too heavily on Army efforts, which are focused on satisfying a different need. The Committee recommends that the Air Combat Command (ACC) be assigned the Air Force lead to work with other agencies to develop and field highly deployable detection, protection, and decontamination systems for biological, chemical, and laser threats.

For this effort to be successful, ACC must make maximum use of the resources and expertise of all responsible agencies, both military and civilian. These potential partners in the effort include the U.S. Department of State (DOS), other Department of Defense (DoD) agencies and Military Services, Department of Transportation (DOT), Public Health Service, the Food and Drug Administration (FDA), the Department of Energy (DOE), Center for Disease Control (CDC), and the host nation. With these partners, the Air Force can effectively and efficiently develop the proper technology, tactics, techniques, and training to overcome these threats.

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Chapter 3

What the Air Force Should Do to Meet the AEF Needs

The role of the U.S. Air Force is to organize, train, and equip the forces to be employed by the CINCs of the Unified and Specified commands. Hence, the purpose of this chapter is to translate the concepts, enablers, and technology needs identified in the preceding chapters into specific and actionable recommendations for the Air Force in this role as it applies to the AEF.

3.1 Organizing

The discussion in previous sections suggests a further subdivision of Air Force units into smaller force increments, referred to as "slices," that can be tailored and combined to most effectively match a CINC's requirements in a wide and unpredictable range of contingencies. This general principle applies most strongly to combat wings, but it also bears consideration in nonlethal missions such as humanitarian relief and global battlefield awareness. The key attributes of the proposed slices are as follows:

- *A number of aircraft based on the smallest grouping that can efficiently train, deploy, and operate as an independent unit or as an element of a larger composite force.* This attribute should be explored in experiments and exercises. Our experience suggests that a fighter or bomber slice would be six aircraft, expected to fly four in any given mission, three C-130s or C-17s assigned as theater airlift, and single tail numbers of strategic airlift or ISR platforms. A number of wings, including two bomber wings and several fighter wings, have begun developing tailored force and support packages smaller than their traditional UTCs, which are equivalent to these slices. Their experience will be valuable.
- *Provisioning of some or all slices for independent operations.* Support equipment, Readiness Spares Package (RSP) kits, and other assets should be based on levels that allow these slices to deploy with all required means to generate sorties or to serve as lead units in combination with other supporting slices that deploy in a dependent posture. For example, a fighter or bomber squadron with 24 aircraft might be equipped to generate two independent slices and one dependent slice. This would allow operation at two deployed sites or one deployed site and the home base without pulling in resources from other units. To make this affordable, the current rules for computing and controlling kit contents must change. Lean logistics and daily priority resupply can reduce required RSP levels, and unit kits can be supplemented by assets provided by other units or the supported theater (see Volume 2). In addition, attention will be required to the command structure, personnel, and administrative and other support resources to ensure that a slice is truly capable of operating autonomously. For example, the slice would require O-level maintenance personnel and equipment, supplemented by such maintenance specialists, munitions personnel, and other support as required by the Mission Design Series (MDS) and the mission. Provisioning RSP kits for 7 to 10 days of operations, vice the current kit levels based on 30 days, will help with the problem of finding enough assets to make multiple slices independent. However, kit contents are not completely proportional to assumed length of use, and it would be an oversimplification to simply cut them by two thirds. Kits should also be available for use by other slices, for example, those from another unit that was not tagged as independent.
- *Normalization of the equipment, tactics, procedures, and training of slices of a given MDS to facilitate the rapid integration of slices from multiple sourcing squadrons into a composite force.* The goal is for slices of like aircraft to be effective in a larger force upon arrival in the

AOR. This will also facilitate coordination among lead and supporting units to ensure the overall force deploys with no more and no fewer assets than needed to do the job.

- *Provisions for the supported theater or the lead deploying unit to provide or coordinate base operations and support in such areas as command and control, fuel and munitions, force protection, personnel support, and local contracting.* For the slice concept to work, the organizational structure must ensure that a deployed site possess all the capabilities necessary to generate sorties, integrate into theater command and control structures, and ensure the health and safety of deployed personnel.

This organizational concept has important implications for both predeployment and deployment operations. When designated as vulnerable for deployment, a wing or squadron will be tasked to have a number of slices ready to move within a specified time, which may vary with the level of alert in effect. These aircraft will be FMC and not due for phase inspections or other scheduled maintenance. To get minimum time reaction in a situation requiring a combat force, a bomber slice will frequently be dispatched first. Based on the Light/Lethal work done by 2BW, the Committee believes that these aircraft will move with a small number of C-5s and C-17s plus appropriate tanker support. They will deliver the first sortie, recover to a theater MOB or back to the CONUS, and continue as required. Their movement will also help establish the tanker bridge for ensuing deployments.

At the same time, tactical aircraft slices will be generated and launched to beddown sites in the AOR. As shown earlier in Table 3, the Committee has estimated that a considerable reduction is possible in the amount of airlift and number of people associated with deploying a 30-fighter force compared to current practice.

The organizational principles described here will help to ensure that such a force, regardless of how it is sourced, can function upon arrival as a coherent unit because all slices will be equipped and trained around a common understanding of deployed operations.

In the event that the AEF operation continues past the initial phase or grows to a larger contingency, the proposed reorganization will deliver further benefits. A larger fraction of the force structure could be generated and sent to the AOR on an accelerated schedule because overall deficiencies in equipment, spares, and personnel will be reduced. Aggregation of slices into larger formations is inherently easier than segregating wings or squadrons to source an AEF, especially given the current situation in which many squadrons are designated as dependent and thus lack the means to operate autonomously. In a long-term operation, the slice represents a logical increment of forces to rotate out of the AOR in order to distribute the deployment burden and manage operational tempo issues.

As part of this overall AEF organizational reform, a new, austere approach to maintenance at beddown sites is important and will have significant impact on the organization and provisioning of deployable units. An overall logistics infrastructure predicated on affordable support to global operations is part and parcel of this Committee’s AEF vision. Scheduled maintenance at forward sites, including engine inspections, should be eliminated. The RCC concept described earlier enables a maintenance approach in which aircraft failures beyond O-level repair capability can be dealt with by rotating the aircraft to the rear or, in many real-world situations, designating it as a cannibalization aircraft. It is feasible in extended operations to rotate individual aircraft or entire slices in and out of forward sites on a regular basis, perhaps weekly. I-level shops such as the Jet Engine Intermediate Maintenance (JEIM) facility, will be established at the RCC or other theater base. The result would be to minimize the required lift and the number of personnel exposed to hazard at forward bases.

A number of actions, some with funding implications, are required to implement this more flexible AEF concept. The most obvious is to progressively purchase the equipment and spares to bring slices up to independent status. In addition, theater or regional mission support kits that are not assigned to a specific unit can be established. Deploying slices would then mate up with these assets upon arrival in theater. This would reduce the total requirement for equipment and spares to enable independent slices. This investment could easily be time phased to bring whatever portion of the total force is to be used in the AEF role up to readiness within annually available resources.

The other significant investment involves establishment of the RCC network and any other infrastructure, such as regional engine repair facilities and MSK assets, for use by deploying units. Related to the RCC need is the need for resources to develop the bomber MOBs described in Section 2.5.3. Anderson Air Force Base, Diego Garcia, and Moron Air Base are largely ready for B-52 operations today with deployment of the same support equipment. Details are in the Lean Sustainment Appendix H in Volume 2.

In addition, wings must make the needed organizational changes. Slice commanders must to be prepared and supported to exercise command while deployed either alone or in a larger composite force. The I-level maintenance shops and other support functions must be prepared to provide personnel and equipment, and they should exercise with slices in practice deployments. The wing must be ready to deploy C^2, force protection, personnel support, and other capabilities to set up a functioning deployed base when designated as lead unit. The net effect may be a modest increase in staffing levels in some parts of the wing. These steps are straightforward.

Finally, the Air Force should consolidate all ISR assets into a single organization whose commander is assigned the responsibility to integrate their capabilities into a single battlespace awareness system.

3.2 Training

3.2.1 Overview

The Committee examined training issues for each AEF study area to identify critical issues and promising approaches and technologies. Training includes instruction, practice, and rehearsal. Instruction focuses on new knowledge. Practice is the process of translating knowledge to skills. Rehearsal focuses on practicing the operational scenarios soon to be executed.

AEF missions dictate unique operations training requirements. Geographical separation of organizations prior to deployment implies a need for distributed training to allow crews to learn in advance how to coordinate with their supporting forces and functions. Some training functions may have to deploy with the AEF, for example, mission planning, intelligence, targeting, and electronic warfare/suppression of enemy air defenses (EW/SEAD) planning and employment. AEF missions are likely to need to provide their own capabilities in these areas.

The lack of existing operations plans may create the need for C^2 training focused on real-time integration of plan modules. The distributed nature of organizations will also create unique C^2 training needs. En route mission planning dictates capabilities for in-the-cockpit rehearsals to complement predeployment instructions and practice. This will require crews to utilize normal cockpit displays — for both flight and systems — as planning and rehearsal tools.

The lack of prior plans will result in logistics planning being performed by the deploying organization and tailored using plan modules. Operations with minimal maintenance (for example, flights servicing, no scheduled maintenance, and minimum flight essential repair) imply important changes for training. Training maintainers to support a wide variety of deployed systems may also stress personnel and career policies.

AEF missions present considerable challenges for force protection because forces inherently on the perimeter are likely to lack force protection infrastructure. Training is needed before and during deployment to ensure that deployed forces can meet their own protection needs. Crosstraining may be needed to ensure acceptable levels of necessary skills, for example, all AEF forces are trained in personnel protection, but one pilot is trained in current threat tactics, techniques, and technologies.

3.2.2 AEF Training Needs

Training recommendations are summarized in Figure 28.

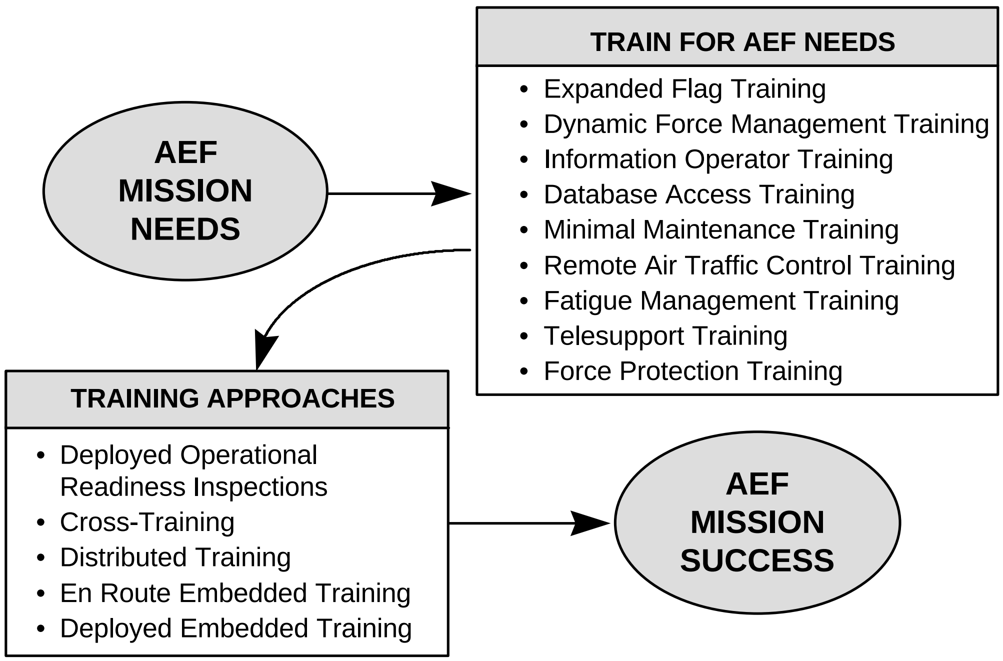

Figure 28. *Air Force Training Needs to Reflect AEF Operations*

AEF missions will impose a variety of new demands. Thus, an overriding issue concerns the substantial risk that current training will leave the Air Force unprepared. For example, AEF missions will routinely use reachback communications during daily operations and must be trained to operate in this manner. As another example, AEF missions will often be conducted as joint or coalition operations. Training should reflect these conditions and be harmonized with appropriate joint or coalition organizations. The Air Force training must be systematically assessed at all levels to assure that people "train as they plan to fight" for AEF missions. Specific recommendations follow.

3.2.2.1 Exercises and Other Training Events

Flag and other training exercises are mostly oriented toward massive force-on-force missions. This leaves people ill prepared for the wide spectrum of AEF missions, such as global awareness. Flag exercises should be expanded and reoriented to reflect all AEF scenarios, with scenarios and instruction changed accordingly to enable practice of AEF missions.

AEF mission characteristics often preclude having off-the-shelf operations plans. Response time requirements of AEF missions will preclude planning before execution. These two factors dictate dynamic battle management. Training for parallel planning and execution, including instruction and practice in use of the relevant information tools and decision processes, should be part of the routine Air Force training syllabus.

Information will be a weapon in future operations. Multiple career fields relate to information, but a big-picture approach to information as a warfighting tool is missing The Air Force should merge communications, intelligence, weapons controller, and air traffic control (ATC) career fields into an "information operator" career field, with training modified accordingly.

AEF missions will require rapid access to a wide range of DoD, other government, and commercial databases. The Committee recommends development of instruction and practice in the use of standard tools for transparent access and utilization of NIMA, NSA, other government, and commercial databases by information operators.

AEF missions will require remote ATC operations. Training should be developed to support this capability.

The smaller AEF footprint depends on reachback communications for such areas as diagnostics, repair, supply, and telemedicine. Instructions should be developed and practice for working with these "tele-support" systems and using communications functions underlying these systems, should be instituted.

AEF missions may be premised on minimal maintenance (flight servicing, no scheduled maintenance, and minimum flight essential repair). Maintenance personnel should be trained to perform in this environment, including training to assess the usability of degraded systems.

AEF missions will require people to work for long periods of time, in part to meet the tight response requirements and in part to compensate for lean staffing. Training in fatigue management, both for countermeasures and for the ability to recognize unacceptable performance degradation, will improve performance under these conditions.

Force protection capabilities will be limited during many AEF missions and personnel will have to compensate for this lack. Predeployment training of air and ground personnel in self-protection, including use of chemical and biological gear, laser protection, and use of small arms with at least one member of each air and ground crew should be trained to be a resource person in these areas.

3.2.2.3 Training Approaches and Technologies

The training needs just outlined can be met using several training approaches and technologies. While some of these approaches and technologies are readily available, the content needed to use them for effective training may require substantial research and development. In particular, all of these training approaches and technologies should include mechanisms for measurement, feedback, and adaptation of training to trainees' performance and individual characteristics.

AEF organizations will be much leaner than traditional Air Force organizations, and many specialties will not be available, for example, personnel with specialization in various aspects of force protection. The Air Force should increase the breadth of training and use of cross-training to ensure that required skill mixes are available, including provision of refresher training and reachback for data unavailable at the point of deployment.

AEF organizations will be assembled from many standing organizations. Consequently, AEF air and ground teams may not have had opportunities to develop team skills. Distributed training technologies that can be employed to provide practice and rehearsal of mission planning and operations both before and during AEF deployments should be developed and fielded.

A large proportion of the time available for planning and preparing for AEF missions will be time en route. While some of this time may be used for sleep, much of it could be used profitably for training. Proficiency tends to degrade during deployment because of the lack of practice components of training. In addition, promotions of enlisted personnel may be at risk because they are not prepared for tests. Embedded training technologies (like simulation and intelligent computer-aided instruction) that can be used to provide ongoing training both before and during deployment for C^2, air, and ground personnel should be developed.

3.3 Equipping

Equipping the Air Force for the AEF mission will require changing priorities for investments, particularly in RD&A and O&M accounts. Several acquisition programs like Small Bomb System (SBS) and technology programs like Aircraft SATCOM Antenna and Distributed Air Operations Center that address AEF needs are already underway, and several more can be moderately refocused to meet AEF needs. The purpose of this section is to provide the Air Force with some specific recommendations for prioritizing each year's Program Objective Memorandum (POM) by identifying existing programs that should be sustained or altered and new programs that should be added to meet AEF goals in the near and mid term. The programs included in this section are viewed as enabling or providing high-leverage benefits for an AEF. Programs that benefit the Air Force in a general sense may also be important to AEF, but they are not included. For the purpose of this discussion, "near term" is defined as capabilities that can begin to be fielded in the next 5 years (i.e., through 2002). "Mid term" is defined as capabilities that can begin to be fielded in 5 to 15 years (i.e., from 2003 through 2012). Technologies for the far term, producing capabilities fieldable more than 15 years in the future, are addressed in Volume 2.

Expanded descriptions for most existing or planned programs can also be found in Volume 2. Unless otherwise indicated in Volume 2, these descriptions characterize the program as presented to the Committee and do not incorporate any of the changes that may be recommended in this section.

3.3.1 Operations and Training

3.3.1.1 Near Term

The Distributed Mission Training (DMT) program objective is to create deployable full mission training tools for effective and efficient mission training to enable unconstrained combat mission training and rehearsal as part of the Joint Synthetic Battlespace. DMT sites should operate as a wide area network of high fidelity weapons system trainers, mission planning systems, debrief tools, and validated training methods and strategies to maintain high-level mission readiness and skill proficiency. The AEF can benefit from the availability of high-fidelity, deployable training systems for mission training and evaluation. DMT should allow the Air Force to practice high-end mission tasks in a mission environment that includes C^4I and joint service components. It should also allow assessment of alternative mission plans under "what-if" conditions and a full mission training system that can go to war with the AEF force. Of particular importance is the measurement of the training output and modification of the system to achieve training goals. If successful, DMT might reduce AEF training costs, reduce training demands on aircraft, and increase force effectiveness.

Intelligent Computer Assisted Instruction (ICAI) supports tailored student learning via the computer. Section 3.2 describes the need for focused, specialized training for AEF personnel. ICAI will facilitate the rapid preparation of training models with minimum lead time. Preparation of lessons using ICAI depends on a suite of authoring tools called RIDES, VIVIDS, and JavaRIDES. These authoring tools permit reduced time to prepare lessons and instructional programs. RIDES is a mature tool; VIVIDS is now being field tested. JavaRIDES will require a 12-month effort to reprogram the RIDES tool into Java so that RIDES may be used for "device-independent" Internet delivery. The benefit to the AEF is that distance learning is an enabler of remote site and distributed training. The Committee recommends the JavaRIDES effort be funded to allow Internet delivery of the ICAI.

3.3.1.2 Mid Term

Effective, efficient operations require a mix of different aircraft for different missions. In the mid term, the AEF requires effective strike aircraft, aircraft to protect the AEF, and aircraft to supply the AEF and provide the air bridge. Strike and force protection aircraft programs are already underway. However, the air transport leg is weak and needs attention. These areas and needs are addressed in this section.

The JSF program addresses AEF-like objectives in its operational requirements, trades, and technology maturation. This will lead to a joint operational requirements document in the year 2000 and the first operational aircraft in 2008. However, to maximize the opportunity for the JSF to fulfill AEF objectives, the Air Force should request the JSF Program Office to address in detail the recommendations of this report.

The Airborne Laser (ABL) is a directed energy system with a high-energy laser and beam control system. Its tasks include destroying theater ballistic missiles (TBM) in their boost phase. These missiles are likely to be launched against opponents such as an AEF. An additional capability of the ABL is high-precision location of mobile launchers once the TBM has been launched. This launch point information can be communicated rapidly from the ABL to the AEF so that the launcher can be targeted and destroyed. The Committee recommends that the ABL compatibility with the AEF mission be examined to see if it can be quickly deployed with the AEF.

The AEF requires reliable, versatile transports for both strategic airlift and in-theater operations. In addition to hauling large levels of tonnage, it is desirable to have aircraft with versatility over a wide range of possible cargo suites. The C-5 and C-130 inventories are both aging. As shown in Figure 29, the newer C-17 aircraft will transport about 170,000 pounds of cargo about 2,400 nmi and the C-5 will carry 260,000 pounds about 1,600 nmi. If fuel is substituted for cargo, the range of each aircraft increases. The addition of a fuel tank to the C-17 makes the C-17 competitive with C-5 payloads of about 100,000 pounds and, therefore, becomes an effective replacement for the aging C-5 AEF operations. The C-17 can also be used as a fuel delivery vehicle to bare bases.

The aging C-130 problem can be solved by developing a new in-theater transport. The Committee envisions a new concept called the Common Air Transport (CAT) which would be an in-theater subsonic airplane to transport prepositioned modules or "pods" containing communications, weapons, and fuel. These pods would be interchangeable and reconfigurable containers that can be connected or expanded to form a functional complex at a bare base. The external carriage of detachable pods has weight and drag penalties that may be acceptable if traded against mission time reduction and enhanced deployability. The CAT would reduce the logistics delivery time, reduce the number of aircraft on the ground during base build-up, provide lean logistics capability, and reduce the tear-down time required for redeployment. The Air Force Research Laboratory (AFRL) should initiate a study to identify the trades associated with podded transport aircraft and their value to the AEF. This study should also include the capability of current inventory aircraft to deliver modules that could be quickly deployed.

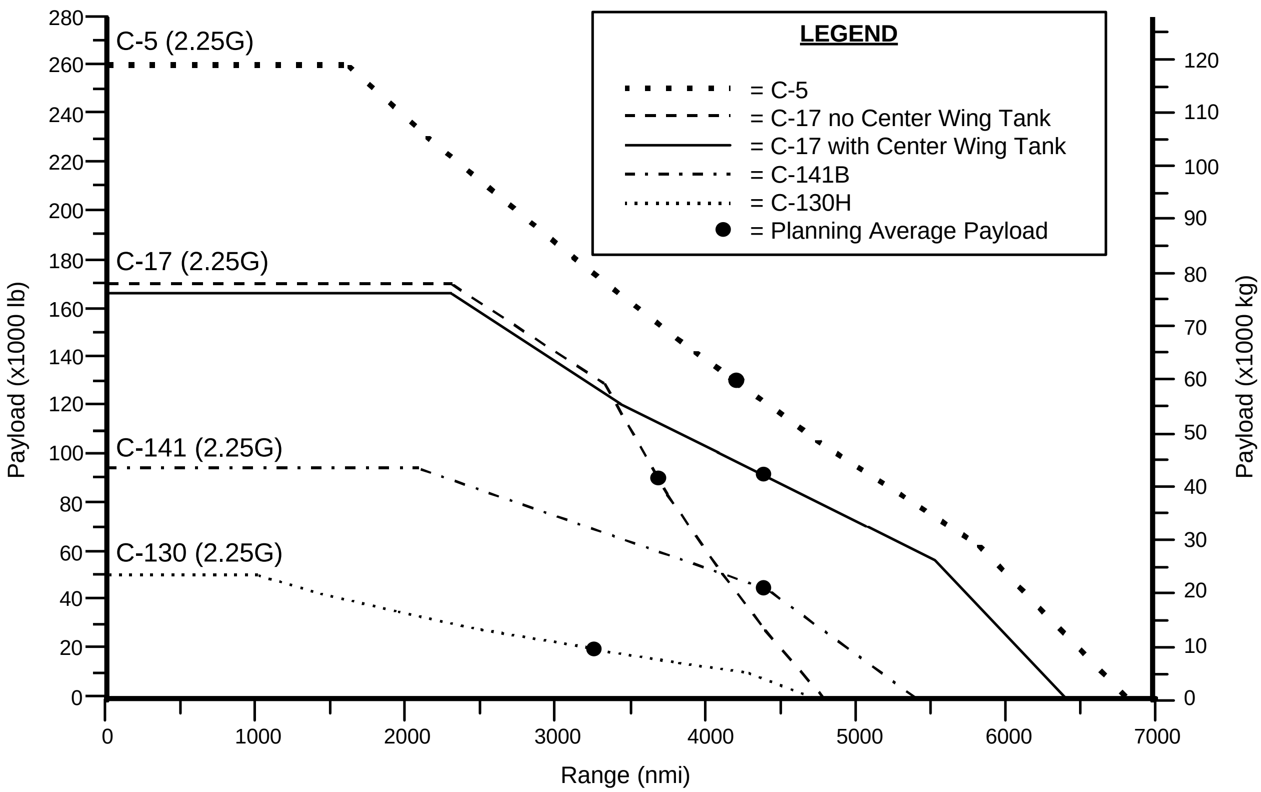

Figure 29. *Payload range comparison of AMC transport aircraft*

3.3.2 Command and Control (C^2)

3.3.2.1 Near Term

The transition toward the AEF C^2 vision is already underway. Capabilities that can begin to be fielded in the next five years are described in the following paragraphs.

A high priority in the near term is to get the AEF airplanes into a global network. The earliest way to accomplish this is to acquire Ku-band airborne antennas that have been developed to provide direct broadcast from commercial satellites to commercial aircraft. Installation of these commercial antennas on all the large military aircraft to be employed in AEF operations (AWACS, Joint STARS, ABCCC, RIVET JOINT, etc.) will enable receipt of wideband video, imagery, and data via leased commercial satellite transponders. Concurrently, all aircraft to be employed in AEF operations (fighters, bombers, and support aircraft) should be equipped with a secure data link and GPS receivers that are integrated with the aircraft's inertial navigation system. This will enable the large aircraft to receive imagery and other broadband targeting information via satellite and then relay GPS target coordinates and attack orders to the fighters and bombers via Link 16. Although the Air Force claims information superiority to be the foundation of its battlefield dominance, information in and out of the aircraft unnecessarily lags aircraft modernization.

The DARPA battlefield awareness programs are generally heading in the right direction to support the AEF C^2 approach described in this report. In particular, the Air Force should leverage the DARPA Warfighter Internet (WFI) investment to provide the high-priority MetaNet communications controller capability described in Chapter 2. Specifically, the Air Force should urge DARPA to extend the WFI to voice as well as data and to place heavier emphasis on incorporating commercial SATCOM capabilities. Although this current DARPA project extends into the mid term, an initial version of the communications controller is possible in the near term by leveraging Internet routing technology. By playing a more active role in these AEF-relevant programs, the Air Force can assist DARPA in increasing the focus on military-specific needs such as priority, preemption, robustness, and survivability, and thereby facilitate transition to fielding.

The Joint STARS enhancements being developed by the AFRL are important for situational awareness and targeting for the AEF. Of particular note is the Off-Board Augmented Theater Surveillance program, which will fuse information from off-board ELINT and radar sensors with the Joint STARS synthetic aperture radar (SAR) and MTI picture.

The Image Product Library (IPL), a server-based archive for imagery products, is an AFRL program that will be fielded during 1997. It will provide the AEF with reachback access to imagery by using a browser interface over SIPRNET to find and request image files, which subsequently can be delivered over the GBS. An important enhancement in a later issue of IPL will be the fusion of the imagery with GPS digital terrain maps to register the images in GPS coordinates. A recommended addition for the future to accommodate the dynamic retargeting requirements of an AEF is the capability to automatically catalog the imagery in the library according to quality and currency.

To minimize the number of weapons needed to destroy the target set, the AEF needs prompt battle damage assessment information. An imaging sensor on an inexpensive, expendable, miniature, GPS-guided glider that is released by the attacking munitions or aircraft prior to munitions impact can transmit target imagery from several aspects within minutes after impact. Industry independent research and development (IR&D) programs have begun development of such a capability using commercially available components, and the AFRL should pursue a technology demonstration from a strike aircraft.

New commercial satellite communications services will be available in the near term that can provide robust augmentation of military communications satellites. Commercial VSAT networks and commercial mobile, broadcast, and bandwidth-on-demand services can provide a plethora of reachback options for the AEF. In addition, the incorporation of commercial DBS technology into the last three Navy UHF Follow-On satellites will make GBS available to deployed AEF forces in the military Ka band. The predecessor to the GBS service, the JBS, is being employed successfully in support of combined operations in Bosnia now. The Air Force must develop an approach for leasing and obtaining landing rights for commercial communications satellite services and develop information management techniques that will optimize the benefits of GBS.

3.3.2.2 Mid Term

Section 2.4 described several enablers that would yield the C^2 capability needed for efficient and effective AEF operations in the future. Existing and needed technology programs that are important to the development and fielding of such a C^2 capability in the mid term are identified in the following paragraphs.

3.3.2.2.1 Connectivity

Inexpensive (installation and unit cost), low-profile, electronically steered antennas (ESA) for EHF and SHF SATCOM to and from aircraft is a high-priority technology requirement to enable Milstar, GBS, and DSCS connectivity. The AFRL needs to emphasize and fully fund the development of airborne ESA technology, which is necessary for achieving AEF objectives for reachback, en route planning, and dynamic targeting. This effort should include photonically controlled, true-time-delay SATCOM antennas, which offer better nulls, decreased beam broadening at high squint angles, and decreased jamming susceptibility.

Programmable radios are the key to providing diverse aircraft communications without requiring installation of multiple radio equipment. The AFRL's SPEAKeasy Programmable Modular Communications System program is a good starting point, but should be extended to bands above 2 GHz. Problems with instability need to be resolved.

Rich communications are critical to the AEF. The DARPA Airborne Communications Node (ACN) program, which combines a programmable radio with the Global Hawk UAV, can provide enriched connectivity with flexible use of a variety of communications links. The Air Force should actively engage in the ACN program to influence its direction to fulfill AEF objectives. For example, the ACN communications suite should include rebroadcast of GPS corrections received from a differential GPS receiver at the forward operating location (FOL) in order to improve SBS accuracy.

To exploit the capabilities of UAVs such as Global Hawk for the benefit of AEF operations, their operations should be integrated into the warfighters' C^2 battlefield environment. AFRL is planning a program, UAV-Integrated C^2 Operations, that can address this need. This program should be consistent with the battlespace awareness concept described in Section 2.4.4 and use the evolving DII standards.

3.3.2.2.2 Dynamic Planning

The DARPA JFACC After Next program will develop a capability to plan and control air operations using a continuous planning, execution, assessment, and replanning model. These tools will allow improved operations of joint air operations and enable an AEF force to respond to situation changes and to support dispersed operations. This program should be supported with special emphasis given to real-time operation and development of a distributed system that can survive the loss of any specific node.

The Distributed Air Operations Center task (DAOC) will develop software to allow distributed operators to collaborate across wide-area networks. This software will allow the JTF Commander and the JFACC to provide full AOC capabilities without deploying the full AOC staff. This concept might be applied to and supported by the AEF. However, it is not clear that the collaboration tools, as described, have sufficient functionality for the AEF.

An AFRL program for Integrated Real-Time Information In and Out of the Combat Aircraft Cockpit will demonstrate the ability of strike aircraft to perform real-time mission changes, including the ability to locate and destroy targets, using off-board information that is relayed to the cockpit. This information will include target imagery and coordinates, weather data, and route information. The companion Expanded Situation Awareness Insertion Program will design, develop, evaluate and demonstrate hardware and software to provide aircrews with enhanced situation awareness. These two programs will benefit the AEF because they can turn the cockpit into an en route planning node to support dispersed operations. The Air Force should support these programs, consistent with their demonstrated progress and value to the AEF.

The In-Theater Airlift Scheduler (ITAS) generates flyable schedules in a format ready for insertion into the daily Air Tasking Order. This capability will enhance theater air transport for the AEF. The ITAS prototype is available and AMC and DARPA are funding the development of an operational strategic airlift and air refueling scheduler.

The Information for the Warrior Program (IFTW) will provide reachback capability to the Tanker Airlift Control Center and in-transit status for aircraft, crew, cargo, and passengers. The IFTW program will demonstrate seamless connectivity to deployed units and aircraft using military and commercial communications networks. The AMC estimates that a 30 percent increased efficiency will result from improved C^2 efficiency. This effort will support the AEF concept and contribute to quick responsive air mobility.

3.3.2.2.3 Precision

The AEF needs to rely heavily on the GPS for the precise location of its forces, threats, and targets. However, high aircraft integration costs and legitimate concerns about GPS jamming have slowed the incorporation of GPS receivers into Air Force aircraft. The AFRL and the GPS Joint Program Office should initiate technology programs to develop an inexpensive miniature integrated GPS/INS which can be installed inexpensively in existing aircraft, and a next-generation GPS III concept for satellites, receivers, and aircraft antennas, which will provide the precision and antijam performance needed for AEF and other military operations.

The AFRL has defined a currently unfunded program called Pathfinder Autonomous Landing Guidance to address Category III landing for the first aircraft into a bare base. As presented in Section 2.4.5, the Committee recommends a GPS-aided Category II landing capability for all aircraft using the AEF FOL. Consequently, the Pathfinder Autonomous Landing Guidance program should be funded and refocused on employing a combination of only GPS, INS, and radar altimeter to achieve a decision to proceed with the landing at 100-ft altitude.

The NASA Dryden Flight Research Center may partially fund a program called the Pilot's Landing System that could augment the aforementioned GPS landing system for added flight safety, system integrity assurance, and pilot confidence. It employs an ultraviolet sensor to detect runway lights in fog at over three times the pilot's vision capability and project them on the HUD. The Air Force should join NASA in the flight testing of this capability together with deployable airport navigation lighting that emits adequately in the ultraviolet.

3.3.2.2.4 Information Collection and Management

The AEF needs "meta-software" technology that can facilitate rapid replanning, rapid adaptation, and rapid reverification of Air Force software-intensive systems across the spectrum from sensor processing through C^2, avionics, satellite control, and logistics. The current Air Force Science and Technology (S&T) program has some initiatives in this direction, through its investments with DARPA in artificial intelligence-aided planning technology and a collaborative effort with the DARPA Evolutionary Design of Complex Software (EDCS) program. The EDCS program includes research and exploratory application of meta-software capabilities to Air Force systems (B-2, Joint STARS, F-16, and satellite ground systems for example) and should continue to be supported by the Air Force.

AFRL plans include a valuable program for "smart push" of imagery based upon user information requirement profiles. This technology is to be incorporated into the IPL architecture referred to in the preceding section on near-term C^2 technology programs. However, it is essential that this program be consistent with the standards for data archiving being set by NIMA and be complementary to the DARPA battlefield awareness and data dissemination program as well as both DISA and DARPA Bosnia Command and Control Augmentation (BC^2A) and information dissemination management (IDM) programs.

A Multiple Source Correlation System (MSCS) is already fielded to provide an automatically correlated real-time air and ground situation display using information from multiple intelligence and C^2 sources. The AFRL continues to invest in a SIGINT correlation and fusion program to develop and demonstrate enhancements to capabilities such as MSCS. This AFRL program should be focused on the global awareness concepts described in Section 2.4.4 and should be expanded to incorporate commercial, allied, and open sources.

The AEF will need timely availability of imagery in order to permit en route planning in support of a no-notice or short-notice AEF deployment. Since UAVs cannot be expected to be in the AOR any sooner than the deploying forces, the AEF will require imagery from satellites to support preparation of the battlefield.

DARPA is presently embarked upon a Surveillance Targeting And Reconnaissance satelLITE (STARLITE) project that is particularly responsive to the needs of the AEF. STARLITE is intended to be the low end of a complementary high/low mix with National systems that will provides timely, precise targeting data directly to the warfighter in response to the warfighter's direct tasking. STARLITE is proposed to consist of 24 to 48 satellites with X-band SAR/MTI radar at a cost of less than $100 million per satellite. The Committee recommends that the Air Force seek a major role in this project in order to align the project with the AEF C^2I objectives advocated in this report.

To complement the STARLITE radar imagery and provide dual phenomenology to avoid possible radar countermeasures, the Air Force should ask NIMA, which is responsible for consolidating overhead imaging requirements, for electro-optical capability that

- Is responsive (the time from the initial task to collect of hours or less)
- Has the ability to monitor rather than sample (has an average image access time of 30 minutes or more)
- Is frequent (can handle five or more image access opportunities per day, with an average revisit interval of two hours or less)
- Has IR (nighttime) capability
- Can monitor an extended area of interest (AOI) of 100 to 200 nmi on a side, with the capability of multiple collects to dozens of targets within the AOI on a daily basis (and a total collection capacity of hundreds of points per day within the AOI)
- Can monitor lines of communication and other limited-area missions
- Has quality commensurate with the tasks (10-to-40-inch ground sample distance)
- Can register and present targets in GPS coordinates

3.3.3 Logistics

3.3.3.1 Near Term

Improved engine durability and reliability is essential for lean sustainment of AEF operations. Over the past 10 years, the long-term reliability average of the large fighter engines in the Air Force inventory, as measured by frequency of Class A incidents, has improved by a factor of 5, from about 5×10^{-5} to less than 1×10^{-5}. Concurrently, improved basic life characteristics such as low cycle fatigue (LCF) have allowed engines to stay on wing longer. This has led to more common high cycle fatigue (HCF) failures. HCF has always been an issue, but it has been overshadowed by the prevalence of LCF.

In recent years, engine supportability has deteriorated, in part because of a shift in maintenance practices driven by the cost and availability of spares. Today "on-condition maintenance" is practiced instead of "reliability centered maintenance," which has reduced the interval between engine removals. The prospect of trading some performance for increased time between inspections and removals is attractive in principle, but it is very difficult to practice because of possible intervention of other unanticipated failure modes associated with the new operating domain. Nevertheless, the Air Force should investigate whether a modest reduction in engine performance could increase the period between inspections.

It would also be beneficial if engine maintenance and alert periods for AEF deployment could be synchronized so that the slices of aircraft vulnerable for AEF deployment were those that just have had reliability centered maintenance. These engines should be highly reliable for the next inspection interval (currently 200 hours). This approach appears to be operationally feasible and should be considered.

In the longer term, having parts of the turbine engine technology (see section 3.3.3.2.4) refocused on methods and materials to increase engine robustness (at the expense of some performance) would substantially benefit future engines used in AEF situations. Better tracking of the total cost/benefit for improvements would encourage investment in durability improvements instead of increased performance. Such improvements might include development, test, and evaluation of incremental improvements in critical components such as turbine blades, main shaft bearings, and fan/compressor airfoils. This will require changes within the Air Force propulsion technology community and some subcommunities of the engine companies. These changes may reflect the new realities of AEF requirements and therefore should be strongly advocated by top management.

Many current systems have well known R&M problems that dominate the non-mission capable (NMC) rates and maintenance manhours. An example is the secondary power system of the F-15, which has been the leading cause of ground aborts since the aircraft entered the inventory. A careful analysis of such problems, followed by specific corrective programs, would have useful leverage on the deployability and austere supportability of the fleet.

Persistently low DR rates for the C-5A and C-5B are seriously detrimental to Air Force airlift capability in general, and they present a serious constraint on their potential use in an AEF. If a C-5 breaks, it could block a ramp or taxiway and shut down aerial port operations. Not to use the C-5 in an AEF means over half of the total (Air Force and Air Reserve Component) strategic airlift capacity must be proscribed, with serious impact on planning and response time. In addition, its large payload and long unrefueled range provide deployment efficiencies that ease other resource constraints. However, the need to restore C-5 DR is not unique to AEF operations, so any improvement program should consider benefit to Air Force operations as a whole. If the AEF is to be realized, then the Air Force will have to decide between committing to C-17s as the AEF airlifter or fixing the C-5.

One critical area of equipping the force deals not with systems and technologies but with spare parts. For years, budget priorities have led to chronic underfunding of accounts for purchase and repair of spares. Budgets are typically computed on the basis of achieving an in-commission rate of 85 percent, but in the real world, this translates to a lower figure. A combination of budget constraints and inadequate tools to forecast demand for spares meant that, by the end of the third quarter of FY 97, all five Air Logistics Centers (ALCs) had consumed their obligation authority (OA) for repairs. This meant that with a full quarter of flying to go, the ALCs could only do urgent (mission capable) repairs and not even all of those. Across the fleet NMC rates, cannibalization rates, and other key indicators show disturbing trends. The Committee believes that it is urgent that Lean Logistics be fully implemented as soon as possible, including improved demand forecasting, and that funding be provided for an overall spares posture that keeps today's smaller force structure adequately ready. This does not involve large purchases of new materiel, but does require major improvement in logistics processes. This is further discussed in Volume 2.

3.3.3.2 Mid Term

3.3.3.2.1 Improved Munitions and Delivery Systems

The concept expressed elsewhere in this report as the Small Smart Bomb (SSB) is to transition to acquisition as the Small Bomb System (SBS). The SBS is a new acquisition program for a GPS-guided 250-pound bomb, including warhead, body, and JDAM-like guidance kit. It also includes a multiple carriage and release system. Current plans call for a threshold program that will permit subsonic and supersonic release from internal carriage on the F-117 and F-22. The objective program would extend internal carriage to the B-1, B-2, and JSF, and provide for general subsonic external carriage and release.

The design requirements do not preclude differential GPS, although it is not specifically called out. The SBS program is currently funded with $10 M in FY 99. A January 1999 Request For Proposal is planned with award of two 24-month Program Definition and Risk Reduction contracts in April 1999. Following a subsequent 24-month Engineering and Manufacturing Development (EMD) contract, production could begin in 2003. The Committee recommends that the objective SBS program be fully funded and specifically include the F-15E and F-16C. Earlier deployment of the SBS on at least one bomber and one fighter would increase AEF capability at little cost or risk. The SBS should be transported as an all up round, thus an insensitive fuse should be part of the program. In order to effectively utilize the SBS with the precision called for in this report, differential GPS must be available in the AEF AOR. To this end, the Committee recommend that a GPS receiver be installed at the FOL that can calculate and transmit the GPS correction signals to a Global Hawk ACN for rebroadcast to the AEF SBS weapons. The GPS ground receiver needs to be viewing the same GPS satellites as the SBS. Hence, if the SBS targets are more than approximately 300 nmi from the FOL, additional ground receivers will be required.

The Low Cost Autonomous Attack System (LOCAAS) is an autonomous, miniature munition for the entire spectrum of mobile ground targets. Like the SBS, the LOCASS is also a small-size munition that allows large loadouts and increased kills per sortie on all aircraft. The LAser Distancing And Ranging/Automated Target Recognition (LADAR/ATR) provides the ability to find and discriminate targets of interest and the multimode warhead allows the optimization of lethality-on-the fly for specific targets while INS/GPS and a miniature turbojet engine provide standoff, flexible mission planning and search patterns. The current program has been halted because Army support of the ACTD has been withdrawn. The program should proceed under Air Force funding.

The Low Cost Dispenser (LODIS) is a low-cost dispensing system compatible with both the SBS and the LOCAAS weapons. LODIS increases the loadout for the F-22, JSF, F-15, F-16, F-117, B-1, and B-2, enables easy loading from the shipping container, and permits individual bomb release or multiple release with multiple targeting. The current program should stay on schedule with award in 1998 and completion of flight tests in 2000. Every effort should be made to synchronize development of SBS, LOCAAS, and LODIS, and a plan should be established to rapidly transition them into fielded systems.

The Affordable Guided Airdrop System (AGAS) makes use of inventory parachutes and airdrop equipment in combination with GPS guidance and a novel type of pneumatic actuator to comprise an affordable system for precisely controlled point of use delivery of cargo. If the winds are known or can be measured in near real time, an accuracy of 100-meter CEP from 25,000-ft altitude has been demonstrated. Accurate airdrop supports the AEF desired attributes of a dispersed operating style, a small footprint, and "consumables provided daily." This capability is particularly useful for humanitarian missions. The Air Force should initiate a program (possibly joint with the Army) to quickly develop and field this capability.

The Airborne High Power Microwave (HPM) program develops and transitions this weapon technology into the operational inventory. HPM represents a major potential advance in electronic combat technology by extending conventional RF power output several orders of magnitude. This enables the damage and disruption of targets critical to the success of the AEF mission. Studies should be conducted to assess the role and integration concepts of an airborne HPM weapon system within the context of the AEF, and the resulting program should be funded to assure transition to the operational commands in a timely manner.

3.3.3.2.2 *AEF Airfield-Related Technologies*

An airfield pavement evaluation will provide lightweight, deployable equipment for rapidly determining the load carrying capability of potential or selected airfields for AEF use. This new technology allows the AEF to evaluate airfield availability and options rapidly, continuously, and accurately. This program should be funded through Phase II, which will be complete in 1998. Further development efforts should be based on the evolving requirements of the AEF and the specific concept within which the pavement assessment tool would be used.

The Deployable Pavement Repair System (DPRS) is essential to an AEF operation to permit rapid repair of damage and minimize foreign object damage (FOD) generation. A prototype one cubic yard capacity system will soon be deployed to Air Force units responsible for airfield repair. FOD amelioration and rapid restoration to service of air fields using indigenous materials are essential for an AEF operation. The Committee recommends that the Air Force initiate an aggressive field evaluation of the DPRS prototype system under realistic AEF combat conditions.

The Lightweight Material/Rapid Base Stabilization will allow fast extension of aircraft parking aprons at AEF airfields. Emphasis is on rapid soil stabilization to minimize the requirement to transport or import materials. Transportable lightweight matting also will be evaluated as a competing approach. Expanded availability of serviceable airfields is needed for effective AEF. The Committee recommends that the Air Force also link a field evaluation of this effort to the DPRS evaluation recommended earlier.

An improved airfield site characterization capability would allow better, faster data from which to select usable AEF airfields. A key enabling technology for this is complete and rapid (digital) photographic characterization of potential sites. Such databases will require large data storage and retrieval capability. The development of three-dimensional optical memories is integral to achieving this end. Funding should be provided for a prototype massively parallel three-dimensional optical memories with at least terabyte capacity.

Aircraft tire technology is a significant factor in logistics support for an AEF. Today the F-16 can make five to eight missions with a set of tires. The F-16 also is known to cause airfield deterioration. Improvement in both of these operational characteristics would ease the logistics of an AEF. A study must be initiated to determine if new tire designs or materials that can extend the tire life. A positive outcome of this study would have major implications for all aircraft, both military and commercial.

A Modular Aircraft Support System (MASS) will address technologies to improve reliability, commonality, and life cycle costs of AGE. Multifunctional units that are common to multiple platforms will reduce the AEF footprint and allow reliability focused efforts to address fewer discrete modules with improved probability of success. Proof of concept efforts should be funded, including economic trade studies, to establish the feasibility and benefit of MASS. If feasible, the characteristics required for compatibility should be identified, codified, and used as requirements for future Air Force systems.

3.3.3.2.3 *Enabling Technology for AEF Logistics Support*

LOGCAT is intended to improve the quality and timeliness of wing logistics planning and replanning for short-notice contingencies. The benefit of LOGCAT is acceleration of deployment of the right force. LOGCAT, as currently described, consists of five “nested” tasks. A scoping study of Task 1 (LOG-AID) must be funded and the feasibility and benefit of completing LOGCAT assessed.

Aircraft Battle Damage Assessment and Repair (ABDAR) will provide quick and easy access to information needed to rapidly assess and repair battle-damaged aircraft. In the AEF scenarios, the need to maintain the aircraft will be significantly reduced, however, the need to assess the system and determine if it is capable of returning to battle will be required. In addition, the cross-training required of the AEF personnel demands tools that aid the determination of the most efficient means of assessing the aircraft for return to battle. The Air Force should ensure that evolving requirements of the AEF are integrated with the ABDAR initiative and attempt to structure the effort such that fielding can begin before 2002.

3.3.3.2.4 AEF Avionics and Power Technologies

Integrated Modular Avionics (IMA) can consolidate up to 20 federated systems into a single integrated system. IMA for AEF allows functional requirements to be added to aircraft and reduces support costs because of increased commonality and fewer individual modules. Lower support costs and higher aircraft availability are needed for AEF. IMA should be incorporated in emerging Air Force electronics programs to create a bottom-up IMA environment. This may require some top-down guidance to overcome resistance to higher first costs; these are offset by reduced life cycle costs.

The Integral Starter/Generator (IS/G) and Integrated Power Unit (IPU) of the Air Force Research Laboratory's More Electric Aircraft program will provide the electrical power needed to eliminate hydraulics from future military aircraft, thereby removing a major contributor to the maintenance and ground equipment required to support AEF operations. The starter/generator is actually internal to the turbine engine, on the main spool, eliminating the need for the power takeoff shaft and its associated accessory drive gearbox, and leaving only electrical wiring coming off the engine. The IPU will provide 200 kW of pre-flight auxiliary power and eliminate the need for both the existing auxiliary power unit (APU) and emergency power unit (EPU). The Committee strongly endorses the planned JSF-sponsored demonstration of these technologies.

Features like built-in diagnostics, onboard oxygen/inert gas generation systems, and electric actuators, which improve reliability and reduce the need for external support equipment, should be emphasized in developmental systems like the F-22, JSF, and CV-22. A specific concern is for low observable (LO) designs that are durable and allow signature maintenance and measurement under field conditions.

The Integrated High Performance Turbine Engine Technology (IHPTET) program is the only mid- to far-term propulsion technology in the DoD. This program is highly biased toward performance improvement. New realities suggest that IHPTET needs to be refocused to provide better balance among performance, cost, reliability, and maintainability. Earlier incorporation of IHPTET-generated technologies into Air Force propulsion systems will be required to support thrust growth and fuel consumption requirements as they emerge. IHPTET should rebalance expenditures to improve readiness of proven technologies for incorporation in Air Force production engines.

3.3.4 Force Protection

Various technologies are under development to respond to potential threats to the security and effectiveness of the AEF. In this section, the technologies are grouped according to the threat to which they are intended to respond. The accompanying table summarizes recommendations. Current and proposed technologies are arranged according to hierarchy of AEF operational functions. The listed functions correlate with the discussion presented in Section 2.6, Force Protection.

3.3.4.1 Chemical and Biological Threats

From the first entry to a forward operating location, the AEF is potentially vulnerable to attack by chemical and biological weapons. Most of the technology development applicable to the chemical and biological threat falls within the Joint Nuclear, Biological and Chemical (NBC) Defense program. Under Public Law 103-160, all NBC RD&A programs require joint services management, with OSD oversight. The Army is the executive agent for the chemical and biological programs. The primary Air Force point of contact with the program is through the Chemical-Biological Defense Systems Division of the Human Systems Center.

The most urgent requirements include stand-off detection of chemical and biological agents, improvements in chemical and biological protective gear, and development of an integrated warning system. Several technologies are under development for improved stand-off detection. Before the first aircraft lands on a proposed forward operating location, the location must be surveyed to be sure that it is free of contamination.

Arrive Alive is a Committee-proposed concept in which small sensors would be dropped on the airfield, detect contaminants in the environment, and transmit their findings to the aircraft that dropped them. This concept could be implemented with currently available equipment, but integration with a communication system is required. Once operations are established, continuous monitoring of the perimeter for chemical and biological agents is required. Stand-off detection of agents at distances up to 20 to 30 km are required. It may be necessary to patrol the perimeter with sensors mounted in helicopters, ground vehicles, or UAVs.

Current chemical and biological protective gear is uncomfortable to wear, especially in hot weather, and severely limits mobility of the wearer. Development activities should focus on lighter-weight suits, which can provide greater mobility in confined spaces, with internal cooling. Eye protection should provide less restricted peripheral vision. This will enhance the ability of maintenance crews to service aircraft in a contaminated environment. The fit of protective respiratory masks for both ground and air crews needs to be improved to provide complete protection from biological and chemical agents.

Collective protection is currently provided by metal frame shelters. Sponsored by the Army's Natick R&D Center, development is under way for lightweight, inflatable structures, based on new textile fabrication technologies. Significant weight reduction is accomplished through use of inflatable "Air Beams" as arches. Wright Research Site collaborates with the Natick R&D center in developing deployable/reusable shelter systems. Continued development is required, especially to enable operations in a chemical and biological environment.

The identification and classification of casualties (triage) will be expedited by the development of the Vital Signs Monitor, which measures heart rate and respiration, even through protective clothing. A prototype device will be available this year, and a man-portable system could be available in two years. The program is sponsored by the Armstrong Research Site.

Table 6. *Summary of Technology Development for Force Protection: Chemical and Biological Threats*

Operational Function	Near Term (0-5 yrs)	Mid Term (5-15 yrs)	Far Term (> 15 yrs)
Stand-Off Detection	Seek Smoke (it detects, but doesn't identify agents)	LSCAD (Chem)	Hyperspectral analysis
Requirement: Stand-off detection of chemical and bio agents at distances up to 20 to 30 km. Chemical agents may be gaseous or aerosol. Bio agents may be transported by various means, including aerosol. Detection must discriminate between chemical and biological agents and passive backgrounds like smoke, pollen, defoliants, etc.			
Point Detection	Bio - BIDS, Chem - ACADA	Bio - JBPDS, Chem - JCAD, Bio - Joint Service Agent Water Monitor	Wearable "Chem-Alert on a Chip"
Requirements: Increased sensitivity, response to a wide variety of agents. Same discrimination requirements as above. Samples may be collected by various means, including ground vehicles (LNBCRS), UAVs, and helicopter			

to obtain some stand-off capability.

Warning	Chem - ACADA	Multi-sensor warning system (JWARN)	Integrated warning system
Requirements: Unambiguous, prescriptive warning integrated with C^2. Multiple independent sensors create a confusing array of signals and impose a logistic burden. Need for clear prescriptive warnings like "Bio Alert - Don Protective Gear."			

Individual Protection	Chem - ACE, ITAP	Chem - JSLIST	Lightweight, internally cooled suit
Aircrew - AERP	Aircrew - JSAM	Improved vision, fit	
Requirements: Wearer ability to perform all mission requirements without hindrance, excessive fatigue, or discomfort. Greatest current need is for improved cooling, preferably internal, in chem protective gear to permit longer periods of operation. Some technologies may be derived from civilian sector (e.g., semiconductor device industry).			

Collective Protection	Current Technology	Advanced Integrated Collective Protection Systems	Self-sealing structures
Requirements: Light weight, portable structures with overpressure and sealable apertures. Current technology is not optimized for light weight or for chemical and biological protection.			

Decontamination	Current Technology, Bio: UV (sunlight) exposure	HPM Biothreat Detection and Destruction (for contaminated material)	Bio Decon by vacuum heating
Requirements: Removal of active agent to below hazardous level. If decon is impossible, segregation of contaminated material is required.			

Sustainability	Current Technology	Joint Service Agent Water Monitor	Vaccine and Antidote
Requirements: Maintenance of conditions necessary to continue operations, including water, food, and environmental conditions. Personnel must be able to continue operations in presence of biological and chemical agents.			

3.3.4.2 Aircraft Self-Protection

AEF operations are likely to be carried out under conditions in which aircraft are vulnerable to ground-based weapons on takeoff and landing. These weapons may be very mobile, even man-portable, so advance detection may be extremely difficult. Thus, self-protection is very important for AEF operations. Current countermeasures against IR-seeking missiles rely on flares or flash lamps to divert the missile from the target. Near-term development is carried out in the joint Advanced Threat IR Countermeasure (ATIRCM) program, sponsored by the Army Night Vision Laboratory (NVL). The Air Force Directed Energy Directorate (DED) is responsible for technology development for ATIRCM. A variety of lasers are under continuing development for this mission.

Semiconductor lasers provide an especially attractive alternative because of their small size, high efficiency, and potential for low-cost production. A joint program was undertaken by the Phillips and Wright Research Sites, along with the UK's Malvern and Farnborough sites, to test and evaluate mid-IR, optically pumped semiconductor laser (OPSL) technology developed at the Phillips Research Site. The semiconductor lasers were effective against several types of seekers, protecting platforms with signatures over 150 watts per steradian (W/sr). A semiconductor source for ATIRCM will be delivered to the Army for evaluation in FY 99, with possible integration in FY 01.

Wideband HPM sources offer a robust defense against a wide variety of missile threats, including both EO- and RF-guided missiles. Their effectiveness does not depend on specific attributes of the target, thus eliminating the need for specific intelligence information. By eliminating expendables, they reduce the logistics burden. HPM development is under way at the Phillips Research Site. Field demonstration of the system is planned for FY 03.

The AFRL needs to integrate the aircraft self-protection programs at the Wright and Phillips Research Sites into a single, coherent investment strategy. Emphasis should be placed in the near term on ATIRCM, and in the mid term on HPM.

In AEF operations air crews are vulnerable to laser dazzling weapons on takeoff and landing. Protection can be provided by laser-protective eyewear. In-band protection is required to shield against visible lasers, such as dazzling weapons. Out-of-band protection protects against our own systems in training and in operational situations. In-band protection represents a longer-term, higher-risk development path. Current equipment provides limited protection and is not effective in all situations or against all credible threats. AFRL should have a program to develop and field adequate laser eye protection in the near term.

3.3.4.3 Perimeter Defense

It will be essential for the AEF to establish and defend a physical perimeter around the forward operating location to protect against physical intrusion. Chemical and biological threats have been discussed in Section 3.3.4.1. Clandestine entry of high explosives on personnel or in vehicles constitutes a probable threat. Current technology, in use by the Federal Aviation Administration (FAA) and other agencies, detects explosives by X-ray transmission or back scattering. Development of improved technologies based on neutron analysis and optical detection of explosive residues or vapors is being carried out at the DOE's Lawrence Livermore, Sandia, and Oak Ridge laboratories and in some industrial laboratories. Longer-term technologies under development at the DOE laboratories include detection of explosive residues for forensic investigations by laser spectroscopy. The AFRL needs to maintain close contact with research on sensor development and analytic methods at the DOE National Laboratories and influence these efforts so a useful product can be developed for the AEF.

Visual observation of the perimeter at night depends on night vision equipment. Night vision observation is enhanced when combined with infrared illumination. This is another potent application of semiconductor laser technology. Current night vision goggles offer a limited field of view (40^{o} circular). A Panoramic Night Vision Goggle, under development at the Armstrong Research Site, provides an expanded field of vision (FOV) in a $100^{o} \times 40^{o}$ format. An improved physical design reduces fatigue to the wearer. Related work in industry focuses on improving the sensitivity of night vision equipment through use of electron-beam-driven charge coupled devices (CCDs). Commercial markets include the Border Patrol and other law enforcement agencies. The Air Force should maintain awareness of efforts in these agencies.

Land mines present a widespread threat, particularly in areas in which there has been prolonged civil or guerrilla conflict. Several technologies are in development under Army sponsorship for airborne stand-off land mine detection. These include thermal imaging, ground penetrating radar, and laser spectral reflection. Again, this is not primarily an Air Force program, but one of which the Air Force should be aware.

Increasingly, there is a need for security measures that are nonlethal and have a minimum of residual effects. Current approaches include sonic disrupters, laser dazzlers, foam, and rubber bullets. Alternative, active denial technologies are currently under development at the Air Force Research Laboratory, with sponsorship from the U.S. Marine Corps. A system demonstration is scheduled for FY 00 with testing of an integrated system by FY 03. Extended capabilities are also under long-term development.

Table 7. *Summary of Technology Development for Force Protection: Other Threats*

Operational Function	Near Term (0-5 yrs)	Mid Term (5-15 yrs)	Far Term (> 15 yrs)
Aircraft Self-Protection Current Eye Protection Goggles	ATIRCM (FY 01) Laser Eye Protection	High Power Microwave Improved Laser Eye Protection	Continued improvement
Requirements: Robust defense independent of prior knowledge of threat specifics.			
Perimeter Defense	Current Technology, X-ray transmission or scattering	Neutron analysis, Optical detection	Trace analysis
Current night vision equipment	Panoramic Night Vision Goggle, Infrared illumination	Improved CCD	
Current nonlethal security measures	AFRL program	AFRL program	
Requirements: Detection of clandestine entry of explosives. Nonlethal means of active denial, with minimum of residual effects, and graduated response up to and including temporary disablement. This mission is shared with other military services and civilian agencies. Close coordination with their technology development activities is required.			

3.3.5 High Priority Research and Development Areas that Should Be Pursued

Table 8 summarizes the areas of research and development that represent what the Committee believes the Air Force should pursue with high priority in order to help achieve the AEF vision as described in this report. Funded programs are described in more detail in Volume 2, Appendix G, of this report.

Table 8. *High Priority Research and Development*

Timeframe	Research and Development Area
Near to Mid Term	• Anti-jam and differential Global Positioning System (GPS) (on-orbit and in user equipment) • Information management, access, and distribution • Network access management (communications) • Remote air traffic control (GPS related) • Engine reliability and maintainability (e.g., high cycle fatigue) • Embedded diagnostics for engines and avionics with inflight reporting • Improved chem/bio masks and detection systems • Reachback expertise for medical and maintenance diagnosis (telemedicine, telemaintenance, etc.) • Communication systems to ensure all forms of "in-transit visibility" • Affordable integration of military and commercial satellite systems • Distributed and embedded training
Mid to Far Term	• Lasers and high power microwave weapons and defensive systems • Hypersonics (engines, endothermic fuels, materials, etc.) • Space structures (e.g., lightweight; deformable optics) • Reusable launch vehicles

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Chapter 4

Exercises and Experiments

4.1 Introduction

This chapter addresses experiments that may be employed to test the feasibility of concepts advanced by this Committee. These experiments may be conducted by the appropriate Battle Laboratories, Advanced Concept Technology Demonstrations (ACTDs), exercises of various varieties, or in other ways deemed appropriate by the Air Force. The following sections outline proposed experiments for consideration.

4.2 Candidate Experiments

4.2.1 C^{2}I Experiments

Air Force Requirements for Battlefield Awareness and Dissemination ACTDs. The Air Force must take an aggressive approach and drive AEF requirements into several ongoing ACTDs and deployments, including Advanced Joint Planning, High Altitude Endurance (HAE) UAVs, BADD, JFACC After Next, BC^{2}A, and Bosnia drawdown redeployment.

MetaNet ACTD. The Air Force should sponsor an ACTD to validate the use of an information and communications controller, integrated commercial and military communications, and the associated management concepts necessary to achieve robust connectivity and enable implementation of the reachback concept for support operations.

En Route Planning and Execution. The Air Force should conduct a family of interrelated communications connectivity experiments that demonstrate use of commercial and other available antennas, programmable radio, satellite, and distribution systems along with the information and a communications controller to achieve the required connectivity, reliability, and bandwidth both en route and at the forward deployment location. The experiments should validate the concepts that en route connectivity supports en route planning and execution and verify that software reprogrammable radios are required.

Battlespace Awareness Expeditionary Force Experiment (EFX) 98. As part of EFX 98, the Air Force should prototype and validate a battlespace awareness and control system utilizing representative commercial, international, DoD, intelligence community, and targeted AEF sensors, directing the collection to the maximum extent possible in support of forward operations. The exercise should validate battlespace awareness development and control system concepts, demonstrate AEF's required global capability for battlespace awareness, and evaluate battlespace awareness as an AEF mission.

Distributed JFACC. The Air Force should develop an MOU with DARPA to jointly develop, implement, and experiment with software agents to manage information in support of distributed JFACC concepts. The Air Force should validate distributed JFACC concepts through reachback at EFX 98 and Joint Warfighter Interoperability Demonstration (JWID) 98, demonstrating distributed staffing and the potential for significant reductions in the number of JFACC personnel forward deployed to the area of operations through the reachback concept and en route and forward distributed planning.

Precision Navigation, Position, and Timing. The Air Force should validate the use of precision navigation, position, and timing as the foundation of future battlespace infosphere by conducting an ACTD to integrate representative sensor, weapon systems, and databases using a geospatial-based system based on precise navigation and timing information. The system should be tested in a jamming environment as well as a benign environment. The impact of the geospatial and temporal database on the ability to perform multi-sensor fusion should be evaluated.

Remote ATC. The Air Force should conduct an experiment during EFX 98 to demonstrate the feasibility of substituting GPS-based navigation for precision approach radars to enable a reachback ATC concept.

4.2.2 Lean Sustainment Experiments

Feasibility of Independent Slices. The Air Force should conduct an experiment operating a six-ship unit of fighters and/or bombers for seven days at an austere site. The ability of such a unit to generate mission-capable sorties should be measured under the assumption that only minimum flight-essential maintenance is accomplished. Groups of aircraft, called “slices” in this report, should be combined from separate wings to test the feasibility of generating mutual support if a particular AEF were to be drawn from multiple units.

Crisis Action Planning. The Air Force should test the ability to develop an operations plan (OPLAN) within four hours and should test the quality and utility of new tools and databases.

Regional Contingency Center. The Air Force should experiment with the RCC and “Super RCC” concept by attempting just-in-time resupply from CONUS and an RCC to deployed units and then comparing the results. Analysis should be performed to determine the content of the RCC kit.

Minimum Bare Base Package. The Air Force should conduct trial deployments using the minimum package defined in Volume 2 to validate or refine the true minimal personnel and material to set up a bare base operation.

Minimum Time-to-First-Effect. The Air Force should conduct trial deployments based on the principles stated in this report to establish the true minimum times to delivery of first effect in various scenarios.

4.2.3 Force Protection Experiments

Technology Validation. The Air Force should develop and conduct experiments to validate a concept of operations for new force protection technologies, including a force protection planner, weapon detection, denial, and expedient physical protection.

4.2.4 Technology Experiments

Far-Term Technology Concepts. The Air Force should analyze the applicability of promising far-term AEF technologies described in Volume 2. An example could be the determination of the value of spaceplanes in establishing an AEF presence at the combat area within one hour of the execution order.

Chapter 5

Recommendations

As stated at the beginning of this report, Aerospace Expeditionary Forces are envisioned to be *tailorable* and rapidly *employable* air and space forces that provide the NCA and the theater CINCs with the option to produce the desired outcomes for a range of missions the country may be called upon to undertake. The Committee asserts that the key recommendations of this study are essential for the effective realization of the vision. However, many improvements can be made to today's AEF operations with organizational and training changes coupled with the usual ability of Air Force personnel to find creative solutions to problems. The Air Force should assure that funding priorities appropriately consider program/system contributions to making the force more expeditionary.

The study recommendations are discussed in four general categories:

- 5.1 Joint approach to AEF implementation
- 5.2 Operational characteristics
- 5.3 Information as the key enabler
- 5.4 Air Force culture

5.1 Joint Approach to AEF Implementation

The AEF is an Air Force initiative responsive to the national and allied need for rapid, effective capability. To reach full potential, AEF initiatives must be integrated and coordinated appropriately across the other Services and agencies and with our allies.

5.1.1 The Air Force should ensure that the requirements are incorporated for an improved AEF capability into national readiness source documents such as DoD Strategic Guidance, Defense Planning Guidance, Joint Chiefs of Staff Strategic Planning and Operational Requirements documents (for example, Vision 2010), and CINC Integrated Priority documents and joint operational plans**.**

5.2 Recommendations Relating to Operational Characteristics

The characteristics of the AEF can be realized most effectively by addressing several key issues. Small, modular force packages contribute directly to achieving the goals of rapid response, evolvability, and the ability to operate in austere bases.

5.2.1 To prepare for AEF operations, the Air Force should organize, train, and equip for employment of slices (small independent packages) of fighter, bomber, UAV, tanker, ISR, and airlift forces, and compatible support slices within two years. Concepts should include

- Forces prepared to employ within 24 hours
- Varying unit alert postures
- Force packages of less than squadron strength
- Tailored UTCs with unit and regional mission support kits to allow independent deployed and distributed operations and optimized logistics support
- Prepositioned tankers

5.2.2 To prepare for battlespace awareness AEF missions

- The Air Force should develop an operational concept for the integration of ISR assets, including UAVs, and organize, train, and equip a command and control capability for use when only ISR assets are deployed on an AEF mission

5.2.3 To reduce munitions airlift and handling requirements and increase sortie effectiveness, the Air Force should fund the development, integration on current and planned bombers, fighters, and UAVs, and deployment of a munition like the 250-pound Small Bomb System all-up round as soon as possible.

- In the longer term, the Air Force should pursue additional gains through a focused development program in munitions requiring less total airlift, such as the Low Cost Autonomous Attack System (LOCAAS), and lightweight common munitions handling equipment

5.2.4 Achieving a much reduced AEF forward-deployed footprint is critical to the success of the Committee's AEF concept. Therefore, the Air Force should develop the means to do rapid planning, execute employ/deploy[3] mission profiles, and support operational forces from distributed locations in a manner that supports

- Employment planning while the AEF is en route to the forward operating location
- Distributed JFACC operations with only a small fraction of associated equipment and personnel deployed to the forward operating location
- Demand-pull instead of supply-push logistics concepts
- Minimum essential forward deployment of intelligence, medical, force protection, and other support functions

5.2.5 To reduce forward deployment of personnel and equipment and enable very rapid employment, the Air Force should

- Establish selected RCCs worldwide to enable rapid forward deployment of AEF assets using theater airlift
- Complete implementation of the lean logistics concept for time-definite sustainment lift, item tracking, and highly responsive depot-level repair
- Implement the AEF "Minimum Flight Essential Maintenance" concept and focused supportability improvements with particular emphasis on engine durability
- Complete the development and deployment of common operational logistics planning software such as a global beddown database and LOGCAT in conjunction with databases and procedures for employment-driven planning and execution of tactical operations

5.2.6 To enhance the security of AEF deployed forces Air Combat Command (ACC) should

- Be the Air Force lead to work with DoD, DOE, DOS, CDC, DOT, etc. to develop and field effective, highly deployable detection, protection, and decontamination systems for biological, chemical, and laser threats, including the proper technology, tactics, techniques, and training

[3] "Employ/deploy mission profiles" means that the deploying aircraft (and/or UAVs) conduct a mission at the end of their deployment before landing at their recovery base(s).

- Work in conjunction with the Human Systems Center of Air Force Materiel Command, the 820th Security Forces, and the Force Protection Battlelab
- Promote the development of non-lethal force protection systems

5.3 Recommendations Involving Information As a Key Enabler

A theme implicit in the proposed operational concept is availability of many diverse types of information for everyone and every organization involved in the mission. This information availability is not possible today but, as discussed above, commercial developments coupled with focused DoD developments make this vision possible in the foreseeable future. There are several key elements required to realize the C^2I systems that enable the achievement of the operational requirements of the AEF affordability.

5.3.1 The Air Force, in conjunction with the Defense Information Systems Agency (DISA), should implement the Global Grid concept by integrating a system of military and commercial communications services and systems (called MetaNet in this study) that provides sufficient global connectivity to achieve robust reachback and en route operations. To do this, the Air Force must

- Integrate military and rapidly emerging commercial services and systems, including the development of communications controllers, programmable radios, and reconfigureable airborne antenna and radio suites
- Manage the MetaNet as a system of networks and communication devices. Network management constitutes the critical challenge to achievement of the MetaNet and requires special attention

5.3.2 To meet the timeline required by and the distributed nature of AEF missions, the Air Force should develop dynamic management tools and systems to store, search, retrieve, edit, visualize, integrate, exploit, prioritize, and disseminate information in real time. These systems must

- Exploit and extend the capabilities of the Defense Information Infrastructure (DII) Common Operational Environment (COE)
- Aggressively leverage commercial developments to ensure that the right information in the right form is provided to the right place at the right time

5.3.3 The AEF must have access to precision position, navigation, and timing services beyond the current GPS capability, including improved geospatial accuracy, antijam, and survivability characteristics. Therefore, the Air Force, in conjunction with the National Imagery and Mapping Agency (NIMA), must create a geospatial and temporal referenced battlespace and integrate its use into all AEF platforms, sensors, and weapons systems.

5.3.4 To achieve total situational awareness for an AEF battlespace anywhere on the globe, the Air Force, in conjunction with DISA, should develop and field a capability that

- Captures all Government and commercial sources that relate to the situation
- Correlates and fuses the information to achieve a common operational picture (COP)
- Identifies shortfalls and directs the collection of new and relevant information in real time in response to the Joint Forces Commander’s needs

5.3.5 Implementing these recommendations in a robust AEF information environment will allow the AEF to conduct much more effective combat operations. To fully exploit this opportunity, ACC should develop, implement, and train its commanders in C^2 doctrine and modify the ATO cycle with flexible and dynamic execution control that

- Incorporates distributed, continuous, shorter, mission-dependent collaborative planning and execution cycles
- Capitalizes on distributed battlespace awareness to permit parallel planning and execution
- Allows interactive, en route mission planning in the cockpit
- Allows platforms to assume multiple roles and missions
- Permits precision all-weather day/night operations

5.3.6 To provide the robustness required to implement the AEF concepts recommended in this study, the Air Force, in conjunction with DISA, should not only improve, develop, and implement military-unique systems but also collaborate with commercial system and service providers to ensure adequate protection for its growing dependency on AEF-relevant information systems, including

- Antijam
- End-to-end encryption
- Data authentication
- Continuous user identification
- Use of diversity for robustness

5.4 Recommendations Relating to Instilling a New Air Force Culture

To achieve the AEF characteristics and goals, the Air Force must change, fundamentally, the way in which it operates. These changes will impact the manner in which the Air Force organizes, trains, and equips its forces for all operations. This report has identified several specific initiatives. For emphasis, the following recommendations indicate the fundamental nature of the change.

5.4.1 The effective and efficient execution of AEF taskings requires an Air Force commitment to organizational change. As such,

- AETC should provide education and training from the classroom to the field that inculcates the AEF philosophy in all members of the Air Force.
- The Air Force should provide a plan that incentivizes commanders to implement AEF concepts (e.g., rapid response, reachback, distributed and collaborative operations, broad access to information, and joint/combined operations)

5.4.2 Recognizing the challenge and impact of the changes recommended by this study, the Air Force should validate the AEF concepts recommended herein, and the effectiveness of the associated cultural changes, by

- Conducting all the experiments and field exercises in a manner that stretches the existing capability and incentivizes continuous improvement, not only the meeting of standards
- Learning from problems in exercises to evolve new Air Force operational capabilities
- Generating appropriate metric data to monitor and guide the AEF-driven changes required

5.4.3 The Air Force should modify its inspection processes to include metrics specific to the AEF concept.

5.5 Recommendations Relating to Research and Development, Experiments, and Demonstrations

5.5.1 The Air Force should perform experiments, both field and Advanced Concept Technology Demonstrations (ACTDs), in command, control, and information, lean sustainment, and force protection as discussed in Chapter 4 of this report.

5.5.2 The Air Force Materiel Command (AFMC) should ensure that, as part of the SAB annual Science and Technology (S&T) quality review of the Air Force Research Laboratory (AFRL), investments are made that underwrite the AEF concepts described herein.

5.5.3 Place high priority on Research and Development (R&D), particularly in the following areas:

Near to Mid Term

- Antijam and differential Global Positioning System (GPS) (on-orbit and in user equipment)
- Information management, access, and distribution
- Network access management (communications)
- Remote air traffic control (GPS related)
- Engine reliability and maintainability (e.g., high cycle fatigue)
- Embedded diagnostics for engines and avionics with inflight reporting
- Improved chem/bio masks and detection systems
- Reachback expertise for medical and maintenance diagnoses (telemedicine, telemaintenance, etc.)
- Communication systems to ensure all forms of “in-transit visibility”
- Affordable integration of military and commercial satellite systems
- Distributed and embedded training

Mid to Far Term

- Lasers and high power microwave weapons and defensive systems
- Hypersonics (engines, endothermic fuels, materials, etc.)
- Space structures (e.g., lightweight structures, deformable optics)
- Reusable launch vehicles

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Appendix A

Terms of Reference

USAF Scientific Advisory Board 1997 Study on
United States Air Force Expeditionary Forces

11 February 1997

BACKGROUND: The majority of U.S. Air Force and other DoD operations since the end of the Cold War have been limited-objective, non-Major Regional Conflict (MRC) activities (Operation Desert Storm being the primary exception). There have been many of them and they typically lasted a long time, with infrastructure often at a premium. The number of simultaneous operations precluded any one of them being able to count on all the support services the Air Force has for that single event. The likelihood of having months to organize, plan, and deploy has grown increasingly smaller. The need to conduct operations quickly, in austere environments, with a minimum of support and support infrastructure has become the norm.

For more than forty years the Air Force operated out of a robust peacetime infrastructure at home and, most importantly, abroad. This has changed significantly since the breakup of the Soviet Union. The capability to quickly deploy and fight "lean and mean," while a strength of the Air Force in the past, must be "reengineered" today. At the Fall CORONA in October 1996, General Fogleman and his senior Air Force leaders developed a strategic vision for the Air Force. The strategic vision, *Global Engagement: A Vision for the 21st Century Air Force*, charts a path into the next century as an Air Force team within the joint team. Global Engagement is based on six core competencies: a*ir and space superiority, global attack, rapid global mobility, precision engagement, information superiority,* and *agile combat support.* One aspect of the *global attack* core competency is described as follows:

> "The Air Force has developed and demonstrated the concept of an Air Expeditionary Force (AEF) rapidly deployable from the U.S. This expeditionary force can be tailored to meet the needs of the Joint Force Commander, both for lethal and non-lethal applications, and can launch and be ready to fight in less than three days. The Air Force will develop new ways of doing mobility, force deployment, protection, and sustainability in support of the expeditionary concept.
>
> "Air Force power projection and presence capabilities today are a complementary mix of long-range and theater aircraft, based in the U.S. and forward-based. The Air Force has relied heavily in the past on the elements of that mix that were permanently forward-based overseas. Currently, the Air Force is increasing the role of expeditionary forces to maintain its global engagement capability. In the future, capabilities based in the continental U.S. will likely become the primary means for crisis response and power projection as long-range air and space-based assets increasingly fill the requirements of the Global Attack core competency."

STUDY PRODUCTS: Briefing to AF/CC and SAF/OS in October 1997. Report completion by December 1997.

STUDY CHARTER: The goal of the 1997 SAB Summer Study is to conduct an intense examination of AEF operations and to recommend to the Air Force opportunities and options for enabling the Air Force to fulfill the training, deployment, sustainment, and employment performance it requires to conduct air expeditionary operations. Specifically, this study will examine/suggest

- Likely context/constraints for the warfighting elements (e.g., deploy to a specified set of scenarios, meet an operational tasking within a specified time, sustain the tasking with stream resupply for the necessary time, or operate in a specified environment [such as chemical and biological])
- Interoperability and joint service compatibility requirements
- Minimum warfighting elements that need to be forward deployed and deployed infrastructure requirements
- Minimum support facilities required for what length of time
- Minimum system support required, including Battle Management (BM)/C^3ISR
- Concept of operations for logistics, supplies, and support (such as information systems)
- Core expeditionary forces and scenario-dependent supplemental forces
- Recommended investments to support force capabilities
- Security and security system requirements
- Training and training system requirements

SUGGESTED PANEL STRUCTURE

Operational Context and Training Panel. Identify relevant scenarios, describe operational concepts, determine system requirements for deployment and operations, define shortfalls, establish minimum force structure. Define infrastructure for the AEF battlelab. Define potential organizational structures for AEF.

Technology Thrusts Panel. Identify current technology applications that support expeditionary operations. Establish linkage between shortfalls and technology developments. Identify high-leverage technology investments. Develop investment recommendations and associated costs.

Lean Sustainment Panel. Establish logistics and maintenance concepts (building on AF/ILX concepts) such as reach-back that allow the tasks to be performed at a fraction of the current deployment cube. Define shortfalls and recommend solutions.

Environment (Chemical and Biological and Force Protection) Panel. Identify human factor requirements such as protective gear and operational alternatives for conducting operations in a chemical and biological environment. Define force protection and security concepts. Define potential organizational changes, investment options, and other factors required to accomplish this portion of the AEF mission.

Command, Control, and Information Panel. Tailor top-level BM/command, control, communications, and intelligence (C^3I) architectures (building on the SAB C^2 Vision Study) to support ops concepts. Identify shortfalls in current systems (in deployability, latency, interoperability, targeting, mission planning, currency, capability, opsec, etc.) and recommend solutions to identified shortfalls.

Integration and Cost Assessment Panel. Integrate and coordinate other panel efforts to develop a coherent program. Identify costs of current and alternative AEF concepts. Establish an affordable approach to the AEF mission.

STUDY MEMBERSHIP

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Appendix B

Study Organization

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Appendix C

Panel Report Abstracts

This report consists of three Volumes. Volume 1 is the Summary Volume of the report. Volume 2 contains Appendices E - F and Volume 3 contains Appendix I. The Appendices are titled as follows:

Appendix E: Operational Context and Training

Appendix F: Command, Control, and Information

Appendix G: Technology Thrusts

Appendix H: Lean Sustainment

Appendix I: Environment (Biological, Chemical, and Force Protection)

A short summary of the contents of each appendix follows.

Operations Context and Training: Volume 2, Appendix E

The purpose of the Operational Context and Training panel was to set the stage and provide the background required by the other panels of the study for them to use as a basis for their work. This Annex begins with a brief review of the need for an Aerospace Expeditionary Force (AEF). Such aspects as the motivation for an AEF, a definition of an AEF, a vision for an AEF, the fundamental building blocks of an AEF, and the likely missions for an AEF are reviewed. Next, the current and future operating environment in which an AEF might be employed is covered. Included in this section are constraints on future military resources and operations, the various current and future actors in the operating environment, and the implications for an AEF that result. With the foregoing as a basis, a representative spectrum of missions that an AEF might be expected to perform is presented. These missions range from full-scale conventional war to humanitarian relief operations. With the range of missions established, the needed operational capabilities and qualities of an AEF are put forward and explained in the context of the missions that an AEF might have to perform. The Annex next makes comments on the organization and operation of USAF Battlelabs in support of making the AEF part of the Air Force culture and concludes with a detailed review of the training implications that result.

Table C-1. *Overview of AEF Operational Context and Training*

Section Number	Title
1.0	Introduction
2.0	The Need for an AEF
3.0	Likely Future AEF Missions
4.0	Needed AEF Capabilities
Annex	A Précis of Recent Global Trends

Command, Control, and Information: Volume 2, Appendix F

Appendix F provides a more extensive discussion of the improvements in Command, Control, and Information that are the foundation of the SAB Committee's vision for the AEF. Some of the text is identical to the Volume 1 sections on C^2I. The reader can review this appendix with the knowledge that all of the information in Volume 1 on C^2I is included in this appendix.

Table C-2. *Overview of AEF Command, Control, and Information (C^2I)*

Section Number	Title
1.0	Overview
2.0	Critical Enablers to C^2I in Future AEFs
3.0	New Operational Concepts Enabled by New Command and Control Capability
4.0	C^2I Transition Plan
5.0	Required Experiments and Demonstrations
6.0	Recommendations
7.0	Summary

Technology Thrusts: Volume 2, Appendix G

Volume 1 of this report addresses operations, training, and equipment that, if implemented, would make major improvements in the effectiveness of AEFs in the near- and mid-term time frames (through 2012). In the future, however, it may be possible to provide an even faster response with an even smaller footprint forward. Concepts and emerging technologies exist that if developed and employed could make paradigm-changing improvements to AEF operations mainly in the longer term, that is beyond 2012. These concepts and technologies, and a vision of their potential effect on AEF operations, are described in Appendix G in Volume 2.

Table C-3. *Overview of AEF Technology Thrusts*

Section Number	Title
1.0	Long-Term Vision of AEF
2.0	Advanced Technologies to Enable This AEF Vision
3.0	AEF Concepts and Technologies

Lean Sustainment: Volume 2, Appendix H

A primary theme of the study is reduction in deployment footprint and in the time required to prepare, deploy, and employ an AEF anywhere in the world. The Lean Sustainment Panel examined the full range of logistics functions associated with an AEF, including transportation, supply, munitions, fuel, maintenance, civil engineering, base operations, and personnel support services. Through interaction with experts in each of these areas, supported by modeling and analysis, the Lean Sustainment Panel has estimated the minimum feasible package of personnel and materiel required to set up a combat AEF at an austere forward base and the minimum feasible time from receipt of an execution order to delivery of a military effect. The Panel identified the primary limiting factors and made recommendations to move the Air Force closer to the goal of rapid, global response across the spectrum of operations.

The Panel found that significant improvements in planning and execution monitoring processes are essential to the AEF concept. Logistics planning must be based on required operational outputs and must switch from traditional "supply push" to responsive "demand pull." Crisis action planning must be faster, better integrated across functional areas, and based on modern information systems. The Panel also found that AEF-eligible wings should be trained, organized, and equipped to deploy sub-squadron sized "slices" that can be aggregated as required to tailor a force to a specific mission. Minimum response times depend on posturing mobility forces (tankers and transports) for rapid movement of deploying forces and may require some level of alert status for units designated as primary for AEF tasking.

Important infrastructure improvements include establishment of Regional Contingency Centers as in-theater support sites to reduce required airlift and establishment of bomber main operating bases to allow global bomber operations. Focused investments in reliability and maintainability improvements in airlift and in regional mission support assets would have major benefits, especially with reduced force structure. Full implementation of the Lean Logistics initiative is essential to minimizing AEF logistics footprint. Similarly, we have defined a "Minimum Flight-Esssential Maintenance" concept for forward-deployed forces. A number of technologies, notably advanced munitions like Small, Smart Bomb and enhanced engine durability, offer significant payoffs for deployed operations.

Table C-4. *Overview of AEF Lean Sustainment*

Section Number	Title
1.0	Introduction
2.0	Deployment Processes and Timelines
3.0	Tools for Employment-Driven Crisis Action Planning
4.0	Minimum Bare Base Package
5.0	Infrastructure Considerations
6.0	Airlift
7.0	Deployment Base Operability
8.0	Reliability and Supportability Issues
9.0	Cost Estimates
10.0	Findings
11.0	Recommendations
Annex	Logistics Acronyms

Environment (Biological, Chemical, and Force Protection): Volume 3, Appendix I

Force protection is the detection, warning, defeat and/or delay of threats and minimization of the effects of threats on mission performance. Threats include enemy (terrorist, special purpose force, guerrilla, and small tactical group) operations (kidnapping, stand-off and penetration attack), weapons (biological, chemical, conventional, laser, nuclear, radio frequency), naturally occurring phenomena (dangerous flora and fauna, fatigue, high elevation, hunger, infectious disease, night, low-level radiation, thirst, weather), and occupational hazards (fire, hazardous waste, injury, toxic agents). The current and future countermeasures for these threats as well as the responsible organizations, relevant references, and points of contact are presented in Volume 3, Aerospace Expeditionary Force Environmental Threats and Force Protection. A general introduction, glossary of terms, and acknowledgments are also provided in Volume 3 (see Table C-5).

Table C-5. *Overview of AEF Environmental Threats and Force Protection*

Section Number	Title
1.0	Introduction
2.0	Terrorists
3.0	Biological Weapons
4.0	Chemical Weapons
5.0	Toxic Agents
6.0	Conventional Weapons
7.0	Lasers
8.0	Ionizing Radiation
9.0	Radio Frequency Radiation
10.0	Dangerous Flora and Fauna
11.0	Fatigue
12.0	Infectious Disease and Injury
13.0	Night
14.0	Weather and Climate
15.0	Glossary
16.0	Acknowledgments

Appendix D

Top Level Organizations Visited

Air Force Research Laboratory (AFRL)
Air Logistics Symposium
American Red Cross
ANSER Corporation
Armed Forces Medical Intelligence Center
Defense Advanced Research Projects Agency (DARPA)
Defense Information System Agency (DISA)
Defense Intelligence Agency (DIA)
Defense Logistics Agency (DLA)
Defense Research Agency, United Kingdom
DFI International
Hughes Corporation
McDonnell Douglas Aircraft Company
National Academy of Sciences and Engineering Beckman Center
National Air Intelligence Agency (NAIC)
Permanent Joint Headquarters, United Kingdom
Professional Bodyguards Association, United Kingdom
RAND
Royal Air Force Strike Command, United Kingdom
Synergy, Incorporated
US Army Medical Research Institute of Chemical Defense (USAMRICD)
US Army Medical Research Institute of Infectious Disease (USAMRIID)
US Army Natick Research, Development and Engineering Center (NRDEC)
US Army Research Institute of Environmental Medicine (US ARIEM)
US Army Soldier Systems Command
US Army, Ft. Rucker, AL
USAF Academy (USAFA)
USAF Air Combat Command (ACC)
USAF Materiel Command (AFMC)
USAF Air Mobility Command (AMC)
USAF Air Education and Training Command (AETC)
USAF Headquarters
USAF in Europe (USAFE)
USAF Special Operations Command (AFSOC)
USAF Surgeon General
US Marine Corps Headquarters
US Joint Chiefs of Staff Director for Operations (J-3)
World Health Organization
Worldwide Chemical Nuclear, Biological, and Chemical Operations Symposium

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Initial Distribution

Headquarters Air Force

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AF/CC	Chief of Staff
AF/CV	Vice Chief of Staff
AF/CVA	Assistant Vice Chief of Staff
AF/HO	Historian
AF/ST	Chief Scientist
AF/SC	Communications and Information
AF/SG	Surgeon General
AF/SF	Security Forces
AF/TE	Test and Evaluation

Assistant Secretary for Acquisition

SAF/AQ	Assistant Secretary for Acquisition
SAF/AQ	Military Director, USAF Scientific Advisory Board
SAF/AQI	Information Dominance
SAF/AQL	Special Programs
SAF/AQP	Global Power
SAF/AQQ	Global Reach
SAF/AQR	Science, Technology and Engineering
SAF/AQS	Space and Nuclear Deterrence
SAF/AQX	Management Policy and Program Integration

Deputy Chief of Staff, Air and Space Operations

AF/XO	DCS, Air and Space Operations
AF/XOC	Command and Control
AF/XOI	Intelligence, Surveillance and Reconnaissance
AF/XOJ	Joint Matters
AF/XOO	Operations and Training
AF/XOR	Operational Requirements

Deputy Chief of Staff, Installations and Logistics

AF/IL	DCS, Installations and Logistics
AF/ILX	Plans and Integration

Deputy Chief of Staff, Plans and Programs

AF/XP	DCS, Plans and Programs
AF/XPI	Information and Systems
AF/XPM	Manpower, Organization and Quality
AF/XPP	Programs
AF/XPX	Strategic Planning
AF/XPY	Analysis

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Deputy Chief of Staff, Personnel

AF/DP	DCS, Personnel

Office of the Secretary of Defense

USD (A&T)	Under Secretary for Acquisition and Technology
USD (A&T)/DSB	Defense Science Board
DARPA	Defense Advanced Research Projects Agency
DISA	Defense Information Systems Agency
DIA	Defense Intelligence Agency
BMDO	Ballistic Missile Defense Office

Other Air Force Organizations

AFMC	Air Force Materiel Command
– CC	- Commander, Air Force Materiel Command
– EN	- Directorate of Engineering and Technical Management
– AFRL	- Air Force Research Laboratory
– SMC	- Space and Missile Systems Center
– ESC	- Electronic Systems Center
– ASC	- Aeronautics Systems Center
– HSC	- Human Systems Center
– AFOSR	- Air Force Office of Scientific Research
ACC	Air Combat Command
– CC	- Commander, Air Combat Command
– ASC2A	- Air and Space Command and Control Agency
– 366th Wing	- 366th Wing at Mountain Home Air Force Base
AMC	Air Mobility Command
AFSPC	Air Force Space Command
PACAF	Pacific Air Forces
USAFE	U.S. Air Forces Europe
AETC	Air Education and Training Command
– AU	- Air University
AFOTEC	Air Force Test and Evaluation Center
AFSOC	Air Force Special Operations Command
AIA	Air Intelligence Agency
NAIC	National Air Intelligence Center
USAFA	U.S. Air Force Academy
NGB/CF	National Guard Bureau
AFSAA	Air Force Studies and Analysis Agency

U.S. Army

ASB	Army Science Board

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NRAC	Naval Research Advisory Committee

U.S. Marine Corps

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Joint Staff

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J3	Operations
J4	Logistics
J5	Strategic Plans and Policies
J6	Command, Control, Communications & Computer Systems
J7	Operational Plans and Interoperability
J8	Force Structure, Resources and Assessment

Other

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Aerospace Corporation
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Naval Studies Board
Royal Air Force/Headquarters Strike Command, United Kingdom
Permanent Joint Headquarters, United Kingdom

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