United States Air Force
Scientific Advisory Board

Report on

Technology Options
to
Leverage Aerospace Power
in
Operations Other Than Conventional War

Volume 1: Summary
SAB-TR-99-01
February 2000

Cleared for Open Publication

This report is a product of the United States Air Force Scientific Advisory Board Committee on *Technology Options to Leverage Aerospace Power in Operations Other Than Conventional War*. Statements, opinions, recommendations, and conclusions contained in this report are those of the committee and do not necessarily represent the official position of the U.S. Air Force or the Department of Defense.

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Foreword

This volume summarizes the deliberations and conclusions of the 1999 Air Force Scientific Advisory Board (SAB) Summer Study, "Technology Options to Leverage Aerospace Power in Operations Other Than Conventional War." In this study, we considered the potential environments of such operations and developed recommendations for improving Air Force involvement and response. It was an iterative process involving government and industry experts.

The SAB wishes to thank the many individuals who contributed to the deliberations and the report. In addition to SAB members, many ad hoc members devoted their precious time. Industry assisted, and the Air Force major commands were extremely helpful. Many other DoD and non-DoD agencies also provided significant input and assistance.

The Air Force Academy technical writers and panel executive officers provided invaluable assistance to the study, both in coordinating our efforts and in providing substantive input and advice on the conduct of the study and the final report.

The study committee would also like to give special recognition to the SAB Secretariat and support staff, in particular to Major Doug Amon, whose limitless energy and dedication were an inspiration to all of us, and to the ANSER support team led by Dr. Robert Finn and technical editor Ms. Kristin Lynch.

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

Tom McMahan

Mr. Tom McMahan
Study Chair

Dr. Peter R. Worch
Deputy Study Chair

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Executive Summary

The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in operations other than conventional war (OOTCW). (NOTE: The term OOTCW if for the purpose of this study only.) The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations. The terms of reference for the study can be found in Appendix A. Study guidance asked the group to undertake the following major tasks:

- Review operations conducted in the past decade
  - Identify successes and limitations
  - Identify ideas to enable aerospace forces to improve outcomes
- Posit future situations that represent "less-traditional" operations
  - Assess the capabilities of programmed forces
  - Identify deficiencies
- Survey the technology options available and suggest the technologies that should be pursued
  - Near term—examine current operational art
  - Farther term—identify technology options
  - Consider the effects of lethal and non-lethal weapons
- Identify tests or demonstrations necessary for evaluating the study recommendations; recommend appropriate Air Force involvement

The desired outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas, and technologies that would allow U.S. forces to prevail while minimizing the number of aircrew and ground troops that would have to be put at risk in OOTCW. The Air Force sponsors offered operations such as Mogadishu, Somalia (OPERATION RESTORE HOPE), and the continuing no-fly zone operations in Southwest Asia as historical examples for us to study and by which to measure the potential of our recommendations.

The study considered the past and potential future OOTCW environments, including humanitarian relief operations (HUMROs), noncombatant evacuation operations (NEOs), peacekeeping, no-fly zone maintenance, and regional conflict operations. The study's upper range—regional conflict—was understood to be just short of the very significant level of conflict encountered in Kosovo. While the study did not emphasize the lower-intensity operations (HUMRO and NEO), it did become clear early on that such "peacetime" operations have significant operational tempo (OPTEMPO) impacts. The study attempted to define these impacts and to offer mitigation ideas.

The OOTCW environment as defined by the study has the following attributes:

- Diversity of operating environments
- Inability to predict location, geography, and conditions for the next operation
- High likelihood of urban operations
- Extremely high sensitivity to collateral damage
- Need to sense, target, and identify individuals and small groups
- Multinational coalitions
- Potential for a very long duration of "hostilities" with large excursions of intensity

Historical data show that the relative probability of occurrence of operations is highest at the lowest-intensity end of the scale and decreases toward the major theater war (MTW) end of the spectrum. While this is a comforting statistic, the study shows that the frequency of relatively low-intensity, low-risk operations could have the effect of wearing heavily on aerospace forces because of OPTEMPO issues. This could result in an increased risk to the successful execution of aerospace operations in escalated OOTCW and MTW scenarios. As a result, the study team focused its energy on finding ways to reduce these risks.

Two ways of thinking about the application of aerospace power were very helpful to the conduct of the study—Global Engagement Operations (GEO) and effects-based targeting. (NOTE: During Corona 1999, the term GEO was altered to refer to Global Expeditionary Operations vice Global Engagement Operations.) GEO is being used by the Air Force to prepare for the next Quadrennial Defense Review. The study group felt that presenting recommendations in the context of GEO would allow the Air Force leadership to visualize quickly the potential feasibility and impact of those recommendations. A brief description of GEO can be found in Chapter 3 of Volume 1. A complete description is available on CD-ROM and may be requested from the Air Force Scientific Advisory Board Secretariat. Chapter 11 of Volume 1 displays a summary of recommendations showing how each relates to the phases and elements of GEO.

Effects-based targeting involves thinking about the application of aerospace power in terms other than the number of sorties, bombs, and routes desired. It encourages the Joint Forces Commander to think of aerospace power in terms of the effects desired, leaving it to the Joint Force Air Component Commander staff to translate those desired effects into the specifics of air tasking orders. The study group was encouraged from the outset to think in these terms, as lethal and non-lethal weapons were considered regarding OOTCW applications. This directed the group's thinking considering the precision of targeting information and weapons delivery and the yield, or effect, of the weapons.

The study team of 68 members spent more than 12,000 person-hours conducting the Summer Study, visiting more than 71 organizations during 33 major trips. Visits to all levels of Air Force activities took place—from the commanders of major air commands to staff officers and personnel on the flight line. The other Services were included as well, and each provided advisory members to serve on the study. Briefings were received from the senior levels of the U.S. Special Operations Command, Department of State, National Security Agency, Central Intelligence Agency, Federal Emergency Management Agency, and other agencies. The result was a wealth of background data and understanding of Government-wide issues and capabilities involving OOTCW.

The study resulted in 60 separate recommendations. Each of these is considered to be specifically defined and executable. Twelve are considered "major" recommendations with clearly identified actions and are described in Chapter 10 of this volume. In addition, the study found seven recommendations involving overall Air Force policy or broad areas of technology or capability. These are also detailed in Volume 1. The remaining recommendations are covered in the separate panel sections of Volume 2. The major recommendations are grouped in the following categories:

- Enable persistent intelligence, surveillance, and reconnaissance (ISR)
  - Recommendations that allow the flexible, scalable, long-dwell ISR that OOTCW operations demand, while reducing the OPTEMPO impacts on the forces

- Develop and integrate ISR and dynamic planning
  - Recommendations that will improve or develop the integrated tools needed to apply ISR and battle management and planning in the effects-based operations environment

- Develop a spectrum of tailored weapons effects
  - Recommendations that will improve the lethal and non-lethal applications of aerospace power
- Maintain readiness and presence within OPTEMPO constraints
  - Recommendations that will reduce the impact on airlift, logistics, and training systems

While there is a relatively large number of recommendations, it should not be concluded that the Air Force must undertake a major overhaul to conduct OOTCW. To the contrary, the Summer Study concludes that the majority of the recommendations are applicable across the spectrum of operations. The recommendations are intended to build on current force structure and policy in ways that enhance the ability to conduct OOTCW while avoiding unique solutions applicable only to OOTCW.

Also, several of the recommendations are essentially in common with the results of the SAB's other major 1999 study effort on the Joint Battlespace InfoSphere (JBI). The Summer Study recommendations in this category offer specific, potential uses for the JBI and are identified as JBI-related for cross-reference to that study.

The following is a brief summary of the major recommendations.

Enable Persistent ISR

Recommendation 1: Expand ISR capabilities for unmanned aerial vehicles (UAVs) to augment long-duration data collection. Start with air surveillance on Global Hawk. This will provide a robust capability to supplement ISR functions currently performed by the "low-density/high-demand" platforms and will significantly reduce stress on current platforms and personnel while performing the same missions. This is particularly useful for Shape phase indication and warning and Reshape phase no-fly zone enforcement.

Recommendation 2: Develop sensors and air-launched vehicles for ISR, targeting, and battle damage assessment (BDA) of ground targets. It is essential that the Air Force provide long-duration, low-cost ISR, targeting, and BDA; monitoring and defeat of new threats; and shaping of the battlefield through knowledge and psychological operations. Develop a program to integrate newly developed low-cost sensors and air-launched and airdropped deployment vehicle technologies such as UAVs; ultra-precision (< 1m), robust navigation; high-g, low-power electronics; ultra-miniature guidance systems; micro sensors; and robotics.

Develop and Integrate ISR and Dynamic Planning

Recommendation 3: Implement a force management capability for the Expeditionary Aerospace Force (EAF) and for OOTCW that supports the EAF in the application of aerospace power to OOTCW and enables dynamic effects-based planning, execution, and assessment, including strike, airlift, and training. Feedback consists of dynamic battle control, action or BDA, and effects assessment. Continue selective deployment of the Theater Battle Management Core System (TBMCS), but immediately begin preparation of an operational architecture to ensure that TBMCS meets the needs of the EAF in OOTCW. Include logistics, training, and lift aspects. Assess the proper course of action for TBMCS according to this architecture.

Recommendation 4: Lead the development and deployment of an integrated ISR–Command and Control Information Management System to meet the stringent timelines for tailorable and continuously updated information on demand for warfighters worldwide. Provide dynamic ISR

response to rapidly and significantly changing situations. Develop the operational architecture, functional requirements, and an implementation roadmap; pursue Air Force–owned elements of the roadmap; and lead a joint DoD-intelligence community initiative for development and deployment.

Recommendation 5: Implement robust aerospace expeditionary force (AEF) communications for rapidly emerging crises, thus enabling immediate combat power for OOTCW crisis response anywhere. Provide Global Grid access; communications to support JBI, and direct links to operational platforms. The multilevel secure communications architecture and requirements for OOTCW are the same as for MTW with the added features of rapid reconfigurability, scalability, and deployability. The AEF hardware, software, and bandwidth environment should be the same as the home station so that we "fight the way we train."

Develop a Spectrum of Tailored Weapons Effects

Recommendation 6: Provide a capability for delivery of directed-energy effects to give the Air Force an OOTCW capability to disable or destroy electronic equipment (for example, computers and ignition systems) and other materiel as well as an antipersonnel capability, without producing blast effects, death, or collateral physical damage. Develop a family of air-deliverable directed-energy effects, including continuous wave and pulsed high-power microwave (HPM) devices and high-energy lasers. Accelerate development of compact high-efficiency aircraft electric prime power sources to enable directed-energy applications.

Recommendation 7: Develop anti-materiel agent technologies, weapons, and delivery methods. This would provide the OOTCW forces with a non-lethal capability to disable or deny to the enemy operation of mechanized vehicles, artillery, and communications equipment, and to disrupt airfield operations and roadways using aggressive biodegradable agents such as supercaustic and conductive foams, embrittlement and depolymerization agents, superlubricants, and petroleum, oil, and lubricant contaminants.

Recommendation 8: Develop methods for destroying or neutralizing chemical and biological agents in bunker storage. The Air Force needs a capability for neutralizing chemical and biological agents in bunker storage situations, with no collateral effect. Critical to this capability is an intelligence capability to provide precise storage location in three dimensions ("in the right room") and the capability to deliver a weapon into the storage location. Conduct a research and development program on an intense heat source.

Recommendation 9: Exploit the potential of UAVs for delivery of lethal and non-lethal effects. Flexible modular UAVs and unmanned combat air vehicles (UCAVs) provide low-cost, long-endurance delivery platforms for a broad spectrum of weapon effects. They provide a low-risk means to fill the gaps in the continuum of required force capability. Develop a family of UAVs and UCAVs with standard payload modules for air delivery of lethal and non-lethal effects, including a family of UCAV weapons for the deep precision attack of mobile targets and HPM, laser, gun, dispenser, and jamming modules. Develop associated external systems for command, control, communications, computers, intelligence, and logistics support.

Recommendation 10: Accelerate development of air-deliverable lethal miniature munitions. The OOTCW missions require tailored lethal effects on fixed and mobile targets with low collateral effects. Accelerate demonstration and engineering and manufacturing development of the Low Cost Autonomous Attack System and miniature munitions.

Maintain Readiness and Presence Within OPTEMPO Constraints

Recommendation 11: Create a Distributed Mission Readiness System (DMRS) from the Distributed Mission Training (DMT) Concept. This would provide a robust and flexible Air Force–wide capability that integrates all force elements to help train and rehearse AEF personnel for full-spectrum global engagement (MTW and OOTCW). Establish overall Air Force leadership for the DMRS; implement the Capstone Requirements Document for DMT and develop it into an Air Force DMRS.

Recommendation 12: Improve airlift responsiveness to OOTCW situations while reducing OPTEMPO impacts. On-time delivery of people and cargo is essential to meeting the mobility requirements of OOTCW without the benefit of mobilization or Civil Reserve Air Fleet activation. Size the airlift force structure on the larger of OOTCW or MTW requirements; reevaluate the active/air reserve component force mix; and increase the active crew ratio. Procure the right mix of C-130J, C-130, and C-17 aircraft and continue or initiate upgrade programs for the C-5 (reliability) and C-130 (avionics). Examine alternative depot maintenance concepts for the KC-135 fleet.

Overarching Recommendations

The study found seven "overarching" recommendations involving overall Air Force policy or broad areas of technology or capability:

- The Global Positioning System is critical to OOTCW. As recommended by the SAB since 1993, the Air Force should improve the accuracy and survivability.
- To successfully transition to an EAF, the Air Force should broaden its focus to encompass training, communications, deployment, weapons, and forward support, in addition to the recommendations of the 1997 SAB AEF Study and this study.
- The Air Force should develop a comprehensive vision and strategy that takes into full account all potential roles of non-lethal weapons, including "variable effect" and delivery from the air and/or space. Integration into the overall response continuum is essential.
- The Air Force should ensure that the Rapid Response Process remains viable to define, develop, and deploy time-sensitive systems identified by the commander in chief as critical to combat operations, including OOTCW.
- The Air Force should ensure that the development of strategies, concepts, techniques for offensive and defensive information warfare are closely coupled for maximum effectiveness.
- The critical requirement for information superiority suggests increased emphasis on defensive information warfare, including assessment of detected threats and development of responses.
- The Air Force should ensure that discretionary funds are available to laboratory managers to focus on promising technologies and revolutionary capabilities. Industry-independent research and development managers should be encouraged to do the same.

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Chapter 1
Introduction

The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in operations other than conventional war (OOTCW). (NOTE: The term OOTCW if for the purpose of this study only.) The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations. The terms of reference for the study can be found in Appendix A. Study guidance asked the group to undertake the following major tasks:

- Review operations conducted in the past decade
  - Identify successes and limitations
  - Identify ideas to enable aerospace forces to improve outcomes
- Posit future situations that represent "less-traditional" operations
  - Assess the capabilities of programmed forces
  - Identify deficiencies
- Survey the technology options available and suggest the technologies that should be pursued
  - Near term—examine current operational art
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  - Consider the effects of lethal and non-lethal weapons
- Identify tests or demonstrations necessary for evaluating the study recommendations; recommend appropriate Air Force involvement

The desired outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas, and technologies that would allow U.S. forces to prevail while minimizing the number of aircrew and ground troops that would have to be put at risk in OOTCW. The Air Force sponsors offered operations such as Mogadishu, Somalia (OPERATION RESTORE HOPE), and the continuing no-fly zone operations in Southwest Asia as historical examples for us to study and by which to measure the potential of our recommendations.

The study team was made up of six panels; the panel membership and charter descriptions are in Appendix B of this volume. The study team of 68 members spent more than 12,000 person-hours conducting the Summer Study, visiting more than 71 organizations during 33 major trips. Visits to all levels of Air Force activities took place—from the commanders of major air commands to staff officers and personnel on the flight line. The other Services were included as well, and each provided advisory members to serve on the study. Briefings were received from the senior levels of the U.S. Special Operations Command, Department of State, National Security Agency, Central Intelligence Agency, Federal Emergency Management Agency, and other agencies. The result was a wealth of background data and understanding of Government-wide issues and capabilities involving OOTCW.

The study resulted in 60 separate recommendations. Each of these is considered to be specifically defined and executable. Twelve are considered "major" recommendations with clearly identified actions and are described in Chapter 10 of this volume. The findings upon which these recommendations are based are discussed, panel-by-panel, in Chapters 4 through 9 of this volume. In addition, the study found

seven recommendations involving overall Air Force policy or broad areas of technology or capability. These are also found in Chapter 10. The remaining recommendations are covered in the separate panel sections of Volume 2.

There is one caveat regarding security that should be noted at this point. The entire Summer Study was conducted without reference or access to Special Access Required (SAR) information. No finding or recommendation of the Study should be inferred as being related to any possible SAR program. Our recommendations are based on opinions that certain actions need to be taken. If a reader knows that those actions are already under way in a SAR environment, the recommendation should be taken as an unwitting endorsement of that effort.

The panels did conduct briefings and reviews at the DoD Secret level; however, the entirety of this report is presented at the Unclassified level. There is a small amount of classified information associated with some of our findings and recommendations. Appropriately cleared personnel may request details through the SAB Secretariat. The reader should be aware that some of the recommendations put forward by the Study may be overcome by existing programs that were beyond the security caveats.

Chapter 2

The Environment for Operations Other Than Conventional War

2.0 Introduction

Of the many changes in the national security landscape brought about by the end of the Cold War, perhaps the most dramatic and consequential is the increasing likelihood that U.S. forces will be called to engage in a greater range of operations, military and nonmilitary, in countries previously beyond our interest. These operations, be they nonmilitary operations such as peacekeeping or humanitarian relief (HUMRO), or military operations such as counterproliferation and counterterrorism, create new challenges to the United States in the application of force in situations not ideally suited to the force structure and combat systems that we developed to fight a peer competitor during the Cold War era. Collectively, these varied requirements are called "operations other than conventional war." It is important to understand that these operations include varying levels of hostility. Nation-building operations, for example, are not hostile by nature, but isolated hostile activity can occur. Enforcing no-fly zones, on the other hand, does involve a reasonable potential for hostile activity as an expected side effect of the operation. Figure 1 represents the range of military operations along the hostility spectrum, including examples of those that fall under OOTCW.

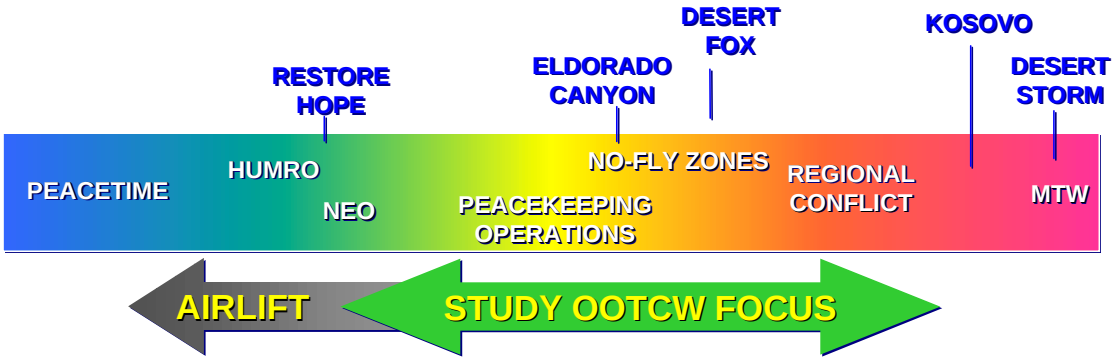

Figure 1. *The spectrum of OOTCW showing the primary focus of the study as spanned by the green arrow.*

As Figure 1 depicts, the spectrum of operations in which the U.S. military will likely find itself involved runs the gamut through increasingly hostile situations. It is important to understand that OOTCW can include two generic sets—those standalone operations that are, by their nature, not conventional, and nonconventional operations within a larger, conventional operation. The Air Force must not focus exclusively on the uniquely nonconventional operations, such as noncombatant evacuation (NEO) and HUMRO, to the extent that it finds itself unprepared to execute nonconventional missions within a conventional operation.

This study focused on those operations where some use of force could reasonably be expected. At the low end of the operations spectrum would be opposed NEO. Major theater war (MTW) crowns the spectrum at the hostile end. While the sponsors of the study encouraged the focus as shown by the green arrow in Figure 1, the study team realized that the lower end of the intensity scale would have significant impact on the security, communications, airlift, and logistics force elements. As a result, the Deployment

and Sustainment Panel spent considerable effort defining the issues and offering options to lower the operational tempo (OPTEMPO) impacts.

This chapter will discuss the broad trends in the international environment that suggest OOTCW will grow in the coming years, the types of operations included in OOTCW, and the unique challenges posed by OOTCW.

2.1 Broad Trends in the International Environment

From the standpoint of OOTCW, a number of broad trends in the international environment are relevant to the application of aerospace power, including the following:

- *Small-Scale Conflicts.* Since the end of the Cold War—and in part the result of the breakup of the Soviet Union and Yugoslavia—a number of small-scale conflicts have arisen, both in areas of significant interest to the United States (for example, Europe) and in areas of lesser importance (for example, Africa). Figure 2 presents data on the annual number of major armed conflicts worldwide. It shows that the number of such conflicts has declined since they peaked in 1993.[1] The commitment of U.S. military forces to conflict resolution and underwriting peace abroad has been substantial (for example, Southwest Asia, Haiti, Bosnia, and Kosovo) and may in part account for the fact that the number of conflicts has declined since 1993. However, these commitments also have resulted in many open-ended commitments of aerospace, ground, and naval forces to foster the conditions for long-term political reconciliation and peace. There is no reason to believe that these long-term demands on Air Force capabilities will end in the near future, and certain operations such as no-fly zones may pose particular challenges because of their required OPTEMPO and personnel tempo (PERSTEMPO).

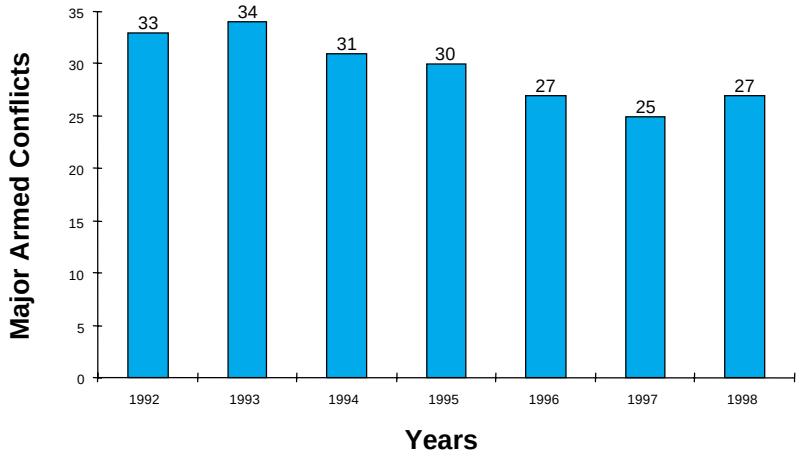

Figure 2. *The frequency of small-scale conflicts declined from 1992 to 1998.*

[1] Data are from Margareta Sollenberg, Peter Wallensteen, and Andrés Jato, "Major Armed Conflicts," in *Stockholm International Peace Research Institute Yearbook 1999: Armaments, Disarmament, and International Security*, Oxford: Oxford University Press, 1999, and Peter Wallensteen and Margareta Sollenberg, "Armed Conflicts and Regional Conflict Complexes, 1989–97," *Journal of Peace Research*, Vol. 35, No. 5, 1998, pp. 621–634. All but two of the 27 major armed conflicts in 1998 were internal conflicts; the other two—between Eritrea and Ethiopia, and between India and Pakistan—were interstate conflicts. The increase from 25 conflicts in 1997 to 27 in 1998 is accounted for by two new conflicts that erupted in Africa in 1998.

- *Terrorism.* Although the annual number of international terrorist incidents is declining, there is evidence that terrorist organizations are increasingly interested in weapons of mass destruction (WMD). Although this interest has principally been manifested in the use of high explosives (for example, Oklahoma City, the World Trade Center, al Khobar barracks, and U.S. embassies in Africa) because of the relative ease with which they can be acquired or constructed, some organizations (for example, Aum Shinrikyo and Osama bin Laden's organization) are also exhibiting increased interest in biological and chemical weapons. Furthermore, there is evidence that U.S. facilities are increasingly being targeted.
- *Concern About the Proliferation, Threat, or Use of WMD.* In addition to the interest in WMD expressed by terrorist groups and other transnational actors, a number of state actors—notably Iraq, North Korea, Iran, and Libya—are known both to sponsor terrorism and have active WMD development programs. The proliferation of nuclear, radiological, chemical, or biological weapons is an area of increasing concern to U.S. policymakers, and this concern is likely to continue.
- *Concern About the Proliferation, Threat, or Use of Ballistic and Cruise Missiles.* As with WMD, there is also concern about the proliferation of ballistic and cruise missiles, which can be used to disrupt U.S. deployments, place in-theater forces at risk, or threaten U.S. allies or friends. Also, like WMD, there seems little reason to believe that the risks of missile proliferation will recede in the near future.

2.2 Types of Operations Included in OOTCW

Although OOTCW are not limited to the following, the more important types of OOTCW are listed in Table 1.

Table 1. *Smaller-Scale Contingencies*

Category	***Type***	***Description***	***Examples***
Intervention Operations	Opposed Interventions	Deploy forces into a country to rapidly restore legitimate governments, defeat an opposition force, and restore stability as soon as possible.	Just Cause (Panama) 1989 Urgent Fury (Grenada) 1983
	Humanitarian Intervention	Provide security for delivery of humanitarian assistance in the midst of an ongoing conflict.	Restore Hope (Somalia) 1992 Provide Comfort (Iraq) 1991
Peacekeeping Operations (large)	Peace Accord Implementation	Assist in implementing military aspects of an agreement to end a conflict by overseeing the terms of the agreement.	Bosnia IFOR 1995 Restore Democracy (Haiti) 1994
	Follow-on Peace Operations	Long-term operations to enhance and maintain stability in a region long enough for local authorities to establish independent, effective control.	Bosnia SFOR 1996
Peacekeeping Operations (small)	Interpositional Peacekeeping	Observe and patrol buffer zones between formerly warring parties to ensure that terms of a cease-fire are observed. May serve as a preventive tool to stop a conflict from spilling over into new areas.	Sinai since 1982 Macedonia since 1993
Humanitarian Operations	Foreign Humanitarian Assistance	Relieve or reduce the results of natural or manmade disasters or other endemic conditions that might seriously threaten life or result in great damage.	Support Hope (Rwanda) 1994 Safe Haven (Cuban refugees in Panama) 1994 Sea Angel (Bangladesh) 1991
	Domestic Disaster Relief	Temporary support, when permitted by law, normally undertaken when an emergency overtaxes the capabilities of the civil authorities.	Hurricane Andrew 1992 TF Wildfire (western states) 1994
Other Operations (long)	No-Fly Zones	Patrol airspace to enforce restrictions placed on a government or entity.	Southern Watch (Iraq) since 1991 Deny Flight (Bosnia) since 1993
	Maritime Intercept Operations	Patrol seas to enforce restrictions placed on a government or entity. Often used to pick up migrants, or to enforce economic sanctions.	Sharp Guard (Adriatic) 1992 Arabian Gulf 1991–1998
	Support to Domestic Authorities	Long-term support for domestic authorities where the military is not the lead governmental agency.	Counterdrug Support
Other Operations (short)	Noncombatant Evacuation Operations	Extract American and/or other citizens from unstable areas where commercial transportation is either unsafe or unavailable.	Assured Response (Liberia) 1996 Distant Runner (Rwanda) 1994 Silver Wake (Albania) 1997
	Shows of Force	Deploy forces to a crisis area to deter some action or signal commitment and resolve, while enhancing military response capability and options.	Iraq 1998 China/Taiwan 1996 Vigilant Warrior (Iraq) 1994 Earnest Will (Arabian Gulf 1990)
	Strike	Short-duration attacks (air, land, or sea) against high-value targets or in response to an adversary's action.	Eldorado Canyon (Libya) 1986 Desert Strike (Iraq) 1996 Achille Lauro

2.3 Characteristics of OOTCW

2.3.1 Key Characteristics

A number of key characteristics differentiate OOTCW from MTW operations. Among these characteristics are the following:

- *Coalitions.* The United States frequently conducts OOTCW in a coalition setting, either in the context of a United Nations (UN) operation, or in a non-UN setting (for example, the North Atlantic Treaty Organization [NATO]). In such cases, the objectives and strategy pursued, the military means employed, and the very nature of the tactical operations that will be conducted all can be subject to the coalition's least-common-denominator consensus, or the UN Security Council resolution establishing the mandate.
- *The Media*. The ubiquitous presence of the media changes the nature of warfare, particularly OOTCW. By emphasizing in its coverage the moral and humane dimensions of conflicts, the sources of domestic opposition to military operations, and any execution errors that may occur in the course of operations, Air Force OOTCW—particularly lethal operations—will in the future be under unprecedented public scrutiny. Furthermore, media news cycles will press for nearly instantaneous information on the conduct and results of the operation—information that political leaders also will want to supply to gain advantages in the battle for public opinion.
- *Minimal or No Collateral Damage.* In OOTCW, the importance of minimizing collateral damage increases, for two reasons. In both cases, the pressure for damage-limiting tends to come from domestic and international audiences, including coalition partners. First, in war, international law requires combatants to avoid unnecessary death and injury to noncombatants and to avoid collateral damage, particularly to artistic, cultural, or religious sites. While OOTCW rarely involves a U.S. declaration of war, OOTCW almost always involves a UN/coalition mandate that is geared to the preservation of life. Second, OOTCW frequently occur in cases where the stakes are relatively small or where, as in the case of Kosovo, action is taken primarily for moral rather than strategic reasons. In such cases, the demand that the costs to noncombatants be commensurate with the stakes leads to an even greater requirement for minimizing collateral damage than in cases where the stakes are greater.
- *Minimal or No Friendly Casualties.* The same logic that has led to an increasing desire to minimize collateral damage applies to minimizing friendly casualties. Congressional and public support is more sensitive to casualties in military operations where primary U.S. interests are difficult to articulate (for example, Bosnia and Kosovo) than in cases where vital interests and moral equities are perceived (for example, the Gulf War). Differences among coalition members in their level of commitment (that is, their willingness to accept costs) also lead to an increased importance for minimizing casualties, since casualties may lead to fissures in the coalition.
- *Nongovernmental Organizations (NGOs).* The presence in many OOTCW of NGOs, including charities and other private voluntary organizations, can create complexities. From the standpoint of lethal effects, perhaps most important is how the presence of these organizations can complicate targeting, since civilians from such organizations may be located in proximity to important targets or may even be held as human shields.

2.3.2 OOTCW Probability, Lethality, and Consequences of Failure

OOTCW may often involve the employment of lethal means, but OOTCW follow a characteristic "spectrum of threat" probability-versus-lethality curve in which probability and lethality are inversely related, and where noncombat OOTCW are far more likely than those that involve lethal operations.

Figure 3 illustrates this point, and characterizes the relative frequency (or probability) of different types of Air Force operations during 1990–1996. The operations are ordered in terms of their lethality.[2] As suggested by Figure 3, the probability and lethality of OOTCW are inversely related. The least lethal OOTCW (for example, humanitarian aid and disaster relief in an unopposed environment) are the most common, at least in part because they impose the smallest costs and therefore tend to pose small political risks. On the other hand, the most lethal operations (for example, strikes, raids, and MTWs) are the least common.[3] As noted earlier, this probability distribution is somewhat comforting if it portends few high-intensity conflicts. However, many lower-intensity operations run the risk that the force structure will be stressed by those operations to the point that rapid response to escalated levels of intensity will be difficult to deal with.

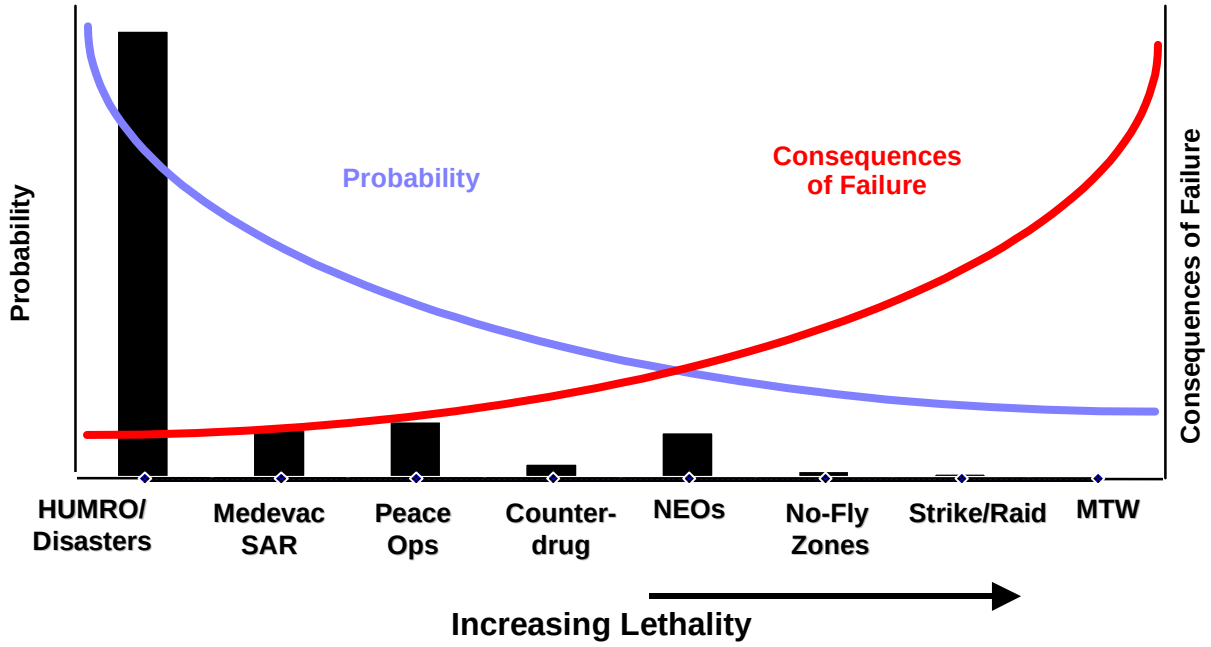

Figure 3. *The probability of lower-intensity conflict is substantially higher than that of major theater war.*

[2] Data are from Table A.1 in Alan Vick, David T. Orletsky, Abram N. Shulsky, and John Stillion, *Preparing the U.S. Air Force for Military Operations Other Than War*, Santa Monica, CA: RAND, MR-842-AF, 1997.

[3] Figure 3 shows that there have been only three instances of enforcing no-fly zones since 1990 (SOUTHERN WATCH and PROVIDE COMFORT/NORTHERN WATCH in Southwest Asia and DENY FLIGHT in Bosnia) and that there has been only one MTW (DESERT STORM) during this period. In fact, MTWs have historically been once-a-generation affairs (for example, Korea, Vietnam, and the Gulf War).

2.4 Unique Aspects of OOTCW

Not all aspects of the conduct of OOTCW are unique to this environment. Regardless of the size or nature of the conflict, U.S. forces can be expected to operate within the context of the *Joint Vision 2010* pillars—Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimensional Protection. Thus, while some aspects of the execution of these pillars may differ when applied to OOTCW, many are the same. Preparation to engage in OOTCW is not incompatible with preparation to engage in MTW. There are some unique aspects to OOTCW, however, and they arise from the following fundamental characteristics:

- Inability to predict location, geography, or conditions for the next operation
- High likelihood of urban operations
- Extremely high sensitivity to collateral damage
- Need to sense, target, and identify individuals and small groups
- Involvement of multinational coalitions
- Potential for a long duration of "hostilities"

Each of these characteristics is discussed in more detail in the following sections of this chapter.

2.4.1 Force Structure Considerations

OOTCW consume the majority of the day-to-day, month-to-month, and year-to-year Air Force tasking. However, forces are sized according to two nearly simultaneous MTWs, and the assumption is that these forces will then be adequate to conduct all smaller operations. In an MTW, mobilized forces are available. During OOTCW, the active-duty force bears the brunt of the tasking. For cost and political reasons, the ratio of the active forces to the air reserve component (ARC) has decreased from 1.4:1 to 0.6:1 (or from more than 5:1 to about 2:1, counting only strategic airlift) during the past decade. We expect that the OOTCW requirements may demand increased active-duty aircraft and crews.

2.4.2 Intelligence Considerations

The Assured Support to Operational Commanders (ASOC) document describes the military operational intelligence (OPINTEL) requirements during conventional war and OOTCW. While the Air Force's Global Engagement Operations (GEO) strategy[4] was developed after the ASOC was published, the strategy would likely not drastically change the essential elements of information (EEIs) codified in the document. (NOTE: During Corona 1999, the term GEO was altered to refer to Global Expeditionary Operations vice Global Engagement Operations.) Based on the ASOC, the differences in the primary intelligence, surveillance, and reconnaissance (ISR) needs appear to be:

- *Timeliness*. The amount of time from a triggering event to the point when dominant battlespace awareness is achieved is very small. Historically, months of force buildup and ISR preparation of the battlespace precede conventional war operations. OOTCW (as defined for this study) are often required within days or weeks after such an event, driving ISR timelines to as little as minutes or hours.
- *Area of Coverage*. An OOTCW could be required anywhere in the world, and several of them may occur simultaneously. The area of specific interest in a given operation is smaller—on the order of thousands of square nautical miles instead of hundreds of thousands.

[4] A brief description of GEO can be found in Chapter 3 of this volume.

- *Level of Detail*. Monitoring the actions and understanding the intentions of very small units (or even individual people) can be critical to mission success.
- *Political or Legal Preparation*. Sudden and surprising events could occur with little warning, placing forces in danger without time for congressional preparation.

2.4.3 Communications Considerations

Reduced force structure and fewer forward locations further typify the environment. With fewer forces based in garrison within the United States, and rotated into theaters of operations in Aerospace Expeditionary Forces (AEFs), the force management system must deploy with the forces and not rely on having a strong infrastructure. Austere operating bases will be the norm. Thus, a lightweight, easily configurable, and adaptive system is required. The system will have to interface and communicate with allies, other government services and agencies, and NGOs.

2.4.4 Weapons Considerations

2.4.4.1 Lethal Weapons

From the standpoint of lethal effects, the foregoing suggests both the need for a high degree of precision in the use of lethal means for OOTCW and an environment in which survivability in many cases can outweigh military effectiveness in importance. More specifically, the current environment increases the need for five types of precision:

1. *Precise Target Information in Three Dimensions*. Future targets could include individual rooms, either in a multistory apartment building or in a deeply buried bunker. The possibility of such targets leads to a need for precise targeting in three dimensions.
2. *Precise Timing*. The need to hit smaller targets also may lead to a need for more precise timing information so that the weapon is put on target at the precise moment that is required to realize the desired effects. For example, it is easy to imagine that the probability of a successful attack on a terrorist cell would be greatly enhanced if the attack could be cued by real-time intelligence that indicates their presence at a specific location.
3. *Precise Delivery*. More precise means of delivering weapons will enable target planners and warfighters to exploit more precise targeting information, even to the extent that they will be able to consider which of a number of specific aim points on a target should be attacked.
4. *Precise, Tailored Effects*. Precise, tailored weapons effects will allow warfighters to exploit the other forms of precision by enabling real-time tailoring of precise weapons effects to specific targets—both in terms of geometry and fragmentation pattern.
5. *Precise, Rapid Effects Assessment*. Finally, the effectiveness and efficiency of OOTCW operations will be greatly enhanced by precise, real-time assessment of effects, including battle damage assessment (BDA) and other forms of combat assessment.

2.4.4.2 Non-Lethal Weapons

The traditional U.S. method of dealing with adversaries has been with military mass, maneuver, and firepower. That approach has certainly served the nation well through modern history. The respective Service schools have been heavy on Clausewitz and light on Sun Tzu, and the traditional military thinking has been reflective of how to fight in modern times using massed armies and overpowering aerospace and sea power. Although using non-lethal means to deal with one's adversaries is as old as warfare, the post–Cold War national security environment in which the United States finds itself calls for

exploiting all means at its disposal to deal with a so-called asymmetric threat that is often transnational and sometimes obscure. Recent operations where the Air Force has participated in small-scale contingencies—for example, Haiti, Somalia, and Bosnia, have been contingencies where the use of non-lethal means to deal with the adversaries have been used. The Air Force might have played a larger role if non-lethal means had been better understood and if more capability had been available. The same could be said about Kosovo operations in 1999. Those operations provided opportunities to employ non-lethal means using current technology. A specific example of such an opportunity was the Serb increase in their Kosovo presence; the NATO air strikes in Yugoslavia did little to stop Serbian operations against the Kosovars. Aerospace power was not employed to halt the initial Serb occupation, destruction, and pillaging of Kosovo. Had non-lethal means been a ready element of the aerospace force continuum, perhaps U.S. aerospace power would have been employed earlier in the crisis and the carnage greatly reduced. Non-lethal means must be better understood and available to the respective commanders before their employment can routinely be expected. The Air Force can and will be a major component of the nation's capability to prosecute OOTCW in the future. Its strategy, vision, and plans must reflect how aerospace power can contribute using non-lethal weapons and means to become more relevant in the 21st century.

2.5 Panel Discussions

The foregoing provides a general summary of how the Summer Study defined the environment of OOTCW. Chapters 4 through 9 provide a summary of each panel's work. Each will discuss the specific environment factors for that panel, operational challenges for OOTCW, and a brief summary of the findings of the panel. Additional detail on the panels' findings may be found in Volume 2.

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Chapter 3

Global Engagement Operations

(NOTE: During Corona 1999, the term GEO was altered to refer to Global Expeditionary Operations vice Global Engagement Operations.)

3.0 The Relationship of GEO to the Summer Study

During the conduct of the study, we found it very useful to think of GEO as a contextual framework for our thought processes about OOTCW. Our Air Force advisors made it clear that the Air Force would use the GEO context in formulating the future force structure and response to the Quadrennial Defense Review (QDR). Thus, we felt it would be appropriate to present our recommendations in a way that clearly shows their relationship to the phases and elements of GEO. This chapter provides a top-level description of GEO. A CD-ROM with complete details is available upon request through the SAB Secretariat. In Chapter 11 we present a matrix of our major recommendations, showing how each relates to the phases and elements of GEO. In that chapter we also describe recommended new GEO elements. These were derived as the study progressed, and we found that new opportunities may be available to the Air Force based on the technologies and capabilities the Summer Study recommends that the Air Force pursue.

3.1 Introduction to U.S. Air Force Global Engagement Operations

Under the current national security strategy, the United States exercises leadership in the international community through the policy of engagement. The national military strategy (NMS) supports this policy with the selective use of military force to shape the security environment and to respond to crises. While the Air Force changes organizationally to support the NMS, what is conspicuously absent is the aircrew's view on how the Air Force believes aerospace power helps the NMS to achieve national security objectives. This operational vacuum is the "how we operate" story that complements the Expeditionary Aerospace Force (EAF) and offers expeditionary options for the Joint Force Commander (JFC) to employ aerospace power in peacetime and in conflict.

In both the 1997 QDR report and NMS, the Secretary of Defense and the Chairman of the Joint Chiefs of Staff introduced an integrated strategic approach embodied by the terms *Shape*, *Respond*, and *Prepare Now*. Successive national security strategies have embraced this approach as a way to address the needs of the post–Cold War environment.

The Shape–Respond–Prepare Now construct builds on the premise that the United States will remain globally engaged to shape the international environment and create conditions favorable to U.S. interests and global security. These shaping efforts endeavor to reduce the frequency of crises. The U.S. military, however, must retain the capability to respond to the full spectrum of crises to protect our national interests. Simultaneously, while managing the OPTEMPO and PERSTEMPO caused by both shape and respond operations, the U.S. military must prepare now for an uncertain future. This future could have a sustained tempo much like the 1990s or perhaps a new security environment requiring advanced capabilities and force structure.

Another outgrowth of the first (1997) QDR was the development of the Halt concept as part of the two-MTW strategy. During the QDR deliberations, campaign analysis using the tactical warfare model revealed specific assumptions regarding the use of aerospace forces during an MTW (see Figure 4). Essentially the campaign model holds aerospace power in reserve until a decisive ground offensive,

instead of sustaining and capitalizing on the capability to conduct counterland or counterinvasion operations.

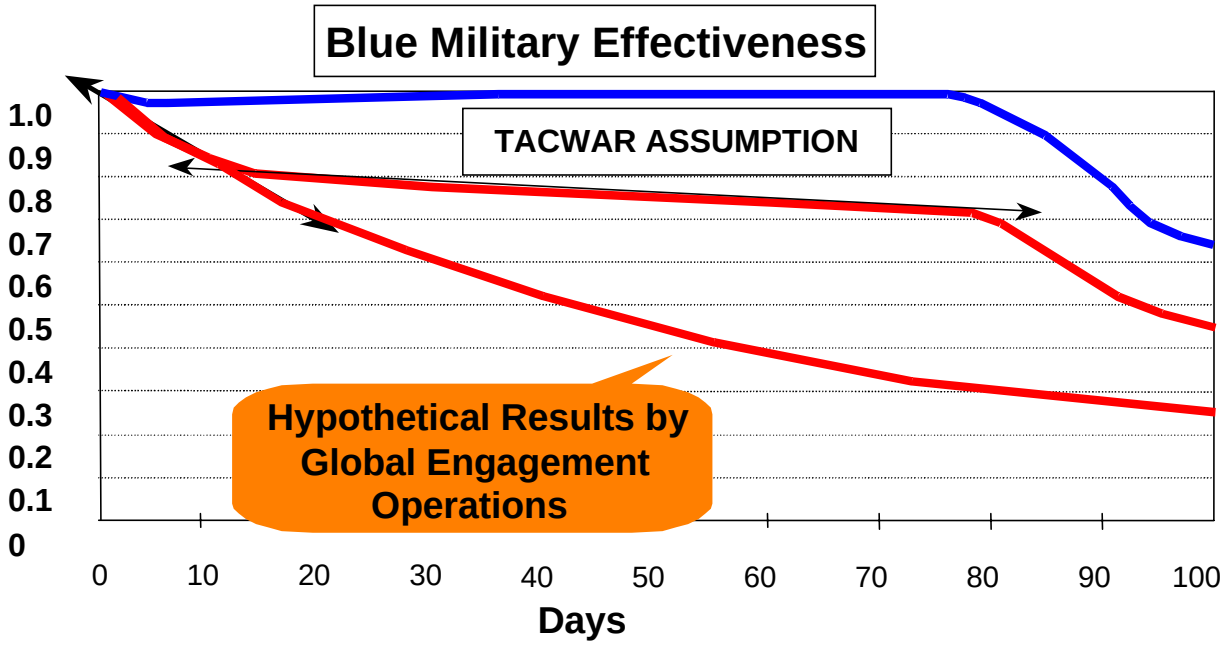

Figure 4. *Old campaign analysis assumptions and new hypothetical results from sustained counterland operations using GEO.*

Although a ground offensive is one possible step within the joint campaign, aircrews also wanted to offer the JFC more options (including the "halt the invading forces" phase), each potentially decisive in its strategic effect.

The 1997 QDR recognized that "to rapidly defeat initial enemy advances" was advantageous to the JFC. "Failure to halt an enemy invasion rapidly" would make the joint campaign "much more difficult, lengthy, and costly."[5] Since the QDR report, however, aircrews have recognized several limitations to the Halt concept as first envisioned.

Therefore, with combined and joint operations in mind, GEO accomplishes three goals in regard to the Halt concept. First, GEO incorporates the Halt concept into an operational strategy rather than making it the sole operational mechanism or dominating phase of a joint operation. The Halt capabilities of joint and combined aerospace forces—namely, speed, range, stealth, and precision—had broader implications for joint operations beyond the counterinvasion approach. Rapid, joint expeditionary forces may be able to achieve strategic preemption or "checkmating" actions even before an adversary can act. After halting an adversary, combined or joint forces also have coercive strategy options that may not always include the need for large-scale invasions.

Second, GEO broadens the Halt definition to include military operations across the full spectrum of operations. The Air Force offers a range of halt-like capabilities, from humanitarian missions to the role of strategic forces, which are not narrowly defined to conventional, counterinvasion effects. Finally, GEO bolsters the indivisibility of the Air Force by addressing the wide range of Air Force operational

[5] "1997 Quadrennial Defense Review," Sec. III, "Defense Strategy," http://www.defenselink.mil/pubs/qdr/sec3.html.

capabilities and effects beyond those specified in the initial Halt concept. Thus, GEO tells a broader "how we operate" story and, in doing so, provides an aerospace-centric operational framework for joint operations.

GEO should also tell the Air Force story to three audiences: an internal Air Force audience that needs to hear a unifying message about aerospace power; a joint audience ready to accept a more aerospace-centric view of future joint operations; and finally the American public, which relies on the military to protect its broad interests in the international environment, needs to hear the story of Air Force capabilities.

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Chapter 4
Intelligence and Vigilance

4.0 Environment

The task of defining technologies to support intelligence and vigilance for OOTCW presented several challenges. The first involved constraining the definitions of the terms "intelligence" and "vigilance." The boundaries of our efforts include technologies and systems that provide situational awareness and operational and observational readiness. More specifically, we focused on

- The collection and development of data from or about targets, the distillation of this data into knowledge, and the dissemination of derived information to those who can use it to decide or act
- Understanding the actions and inferring the intents of potential adversaries
- The ability to project real or perceived U.S. presence, knowledge, and power
- The ability to provide rapid response capability to a wide variety of stimuli over large geographic regions
- The ability to conduct effective demonstrations of knowledge, force, and control for a sustained period

A second challenge arose in differentiating between "conventional" and "other than conventional" warfare in terms of ISR needs, current system capabilities, and shortfalls. In consideration of the Somalia 2010 vignette[6] and the potential situations that might derive from it, several conventional war and OOTCW differentiators became apparent and are displayed in Table 2.

[6] Vignettes prepared by AB Technologies under contract for AF/XO.

Table 2. *Several factors show a clear differentiation between the ISR needs of OOTCW and conventional warfare operations*

Factor	Conventional War	OOTCW
Acceptability of Collateral Damage	Low	Extremely low
Target Nature	Target structure understood; military and political forces	Target structure needs study; individuals, or small groups
Nature of Adversary Equipment	Mostly military, some commercial	More commercial
Urban/Rural Mix	Even	More urban
WMD Threshold for Use	Very high	Medium
National Boundaries	Understood	Perhaps transnational
Clarity of Opponent Intent	Identified and understood	Unclear and not well understood
Own Force Composition/Command and Control (C^2)	U.S. identity/C^2 well defined	Coalition/NATO/UN; multiple or consensus C^2
Indications and Warning	Ongoing ISR	Global potential inhibits ISR; ambiguous indicators
Operational Planning	Advance preparation	In reaction and "on the fly"
Rules of Engagement (Friendly Fatalities)	Some tolerance	Very low tolerance
Duration and Intensity of Hostilities	Time limited, high intensity	Variable (perhaps very long); low intensity
End State	Usually clear	Usually unclear

4.1 Operational Challenges

The ASOC document describes the military OPINTEL requirements during conventional war and OOTCW. While the Air Force's GEO strategy was developed after the ASOC was published, the panel felt that the strategy would likely not drastically change the EEI codified in the document.

Based on the ASOC, the primary differences in ISR needs appear to be:

- *Timeliness*. The amount of time from a triggering event to the point when dominant battlespace awareness is achieved is very small. Historically, months of force buildup and ISR preparation of the battlespace precede conventional war operations. OOTCW (as defined for this study) are often required within days or weeks after such an event, driving ISR timelines to as little as minutes or hours.
- *Area of Coverage*. An OOTCW could be required anywhere in the world, and several of them may occur simultaneously. The area of specific interest in a given operation is smaller—on the order of thousands of square nautical miles instead of hundreds of thousands.
- *Level of Detail*. Monitoring the actions and understanding the intentions of very small units (or even individual people) can be critical to mission success.
- *Political or Legal Preparation*. Sudden and surprising events could occur with little warning, placing forces in danger without time for congressional preparation.

4.2 Findings

4.2.1 Finding: Operations other than conventional war have unique information needs during the early phases of global engagement operations

EAF provides an essential element in this nation's ability to respond rapidly to global crises and OOTCW. Successful accomplishment of the early phases of the GEO strategy depends to a large measure on the completeness and currency of both our global situational awareness and the ability to tailor that information to specific areas and missions.

There are several shortfalls in the current capability to establish and maintain global situational awareness. Country handbooks are mostly obsolete and inadequate for OOTCW mission planning. Little effort is apparent in establishing the level of information readiness necessary to effectively support a wide range of potential OOTCW missions and areas. The intelligence community processes for battlespace preparation today emphasize high-priority areas and elements of information biased toward supporting conventional war and large-scale combat operations. Recent experience and anticipated future employment of military force argue strongly for an expansion of our intelligence information readiness posture to include the full spectrum of GEO and, specifically, information needs for OOTCW.

There is a strong likelihood of joint or coalition involvement in most future operations. This fact will introduce dimensions of interoperability and releasability that must receive careful consideration in the development of an intelligence information support architecture.

4.2.2 Finding: OOTCW scenarios overstress ISR platforms (for example, space, U-2, E-3, E-8, and RC-135) and personnel, which are already heavily committed in peacetime

There is such a near unanimity among the various producers and users of ISR data that the demand for quality ISR products dramatically exceeds the Air Force's ability to comfortably supply them. The primary airborne ISR collectors (Airborne Warning and Control System [AWACS]; Joint Surveillance, Target, and Attack Radar System [JointSTARS]; Rivet Joint [RJ], and U-2) are operating at OPTEMPO and PERSTEMPO that put stress on both equipment and personnel. Demands for ISR products exceed supply in OOTCW as well as conventional war (for example, Kosovo). Although the recommendations made in this report focus on OOTCW shortfalls, if these recommendations are acted upon, the resulting new capabilities will help to augment conventional wartime capabilities as well.

OOTCW add particularly stressing additional requirements to ISR systems. First, in the buildup phase (that is, the Shape phase) prior to hostilities, indications and warning (I&W) intelligence information is required to track the activities of potential belligerents and gain early insight into the possibility of imminent military action. ISR products (and, hence, ISR assets) are required months and even years before combat or the GEO Respond phase of a crisis. For example, NATO AWACS had been on patrol for 2 years before the Kosovo crisis came to a head. Twenty-four-hour surveillance of these regions using critically valuable assets such as AWACS and JointSTARS is simply not feasible because of the limited number of aircraft and crews available. The Reshape phase also stresses ISR systems. Enforcement of a resolution to end hostilities might require years of surveillance of the once-belligerent parties. No-fly zones, which were unheard of 10 years ago, are now part of the popular lexicon. Enforcement of no-fly zones (for example, southern Iraq and northern Iraq) is currently placing extraordinary demands on AWACS planes and personnel.

Before examining recommendations to ease the problems described above, it is informative to look at the separate missions performed by the various ISR platforms and the needs for those missions during

various operational phases described in the GEO construct. We first must recognize that there are two main classes of ISR systems:

- Those that do sensing alone—for example, U-2, RJ (that is, RC-135), and most unmanned aerial vehicles (UAVs).
- Those that both sense and have onboard battle management command and control (BMC^2) functionality. AWACS and JointSTARS are the primary examples in this category. Figure 5 shows how these two classes of ISR platforms are used during a conflict. During the Shape and Reshape phases, ISR assets are overtasked because of the need for vigilant I&W, which is a sensing mission (versus a BMC^2 mission). During the hostility phases of the action, both sensing and BMC^2 capabilities are needed simultaneously in theater.

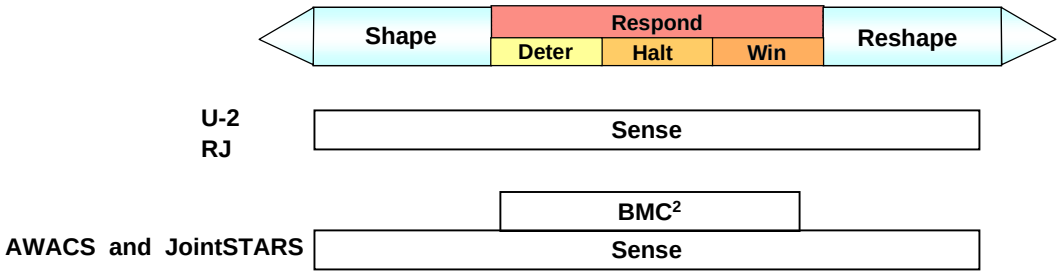

Figure 5. *ISR platforms experience significant OPTEMPO impacts throughout GEO phases, not just in the Respond phase.*

There are two possible strategies for filling the required ISR shortfalls for both conventional war and OOTCW:

- Buy more platforms of the existing types (for example, AWACS and JointSTARS)
- Take advantage of the fact that the sensing mission is very well suited to the use of unmanned platforms and augment the existing system with UAVs

Several previous studies, including the 1997–1998 Office of the Secretary of Defense (OSD) Airborne Radar Study (ARS), the Assistant Secretary of Defense (C^3I) command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) Mission Assessment Study, and six recent SAB studies, examined the acquisition, operating, and life-cycle costs of manned ISR platforms and UAVs. Each of these studies showed convincingly that UAVs are significantly less expensive than manned counterparts. This result should not be interpreted as a statement that UAVs are inherently superior to their manned systems. Because of the BMC^2 capabilities of the manned platforms, any direct comparison of the manned platforms to UAVs is truly an "apples to oranges" comparison.

The ARS suggested a model for manned and unmanned operations that allows the UAVs to augment the manned systems in such a way as to relieve the OPTEMPO problems for the manned platforms in both OOTCW and conventional war. This model is shown on the familiar GEO model in Figure 6 and is depicted in Figures 7 and 8 in cartoon form.

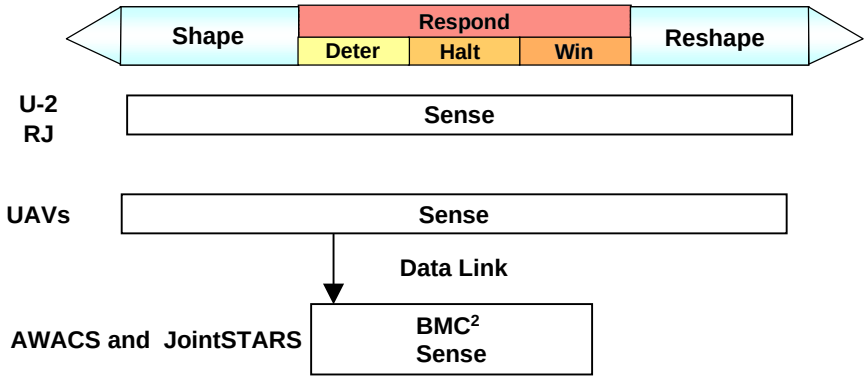

Figure 6. *UAV assets may significantly reduce manned platform OPTEMPO issues in the Shape and Reshape phases.*

During the Shape and Reshape phases, the UAVs provide I&W for long periods. When hostilities begin, the manned platforms are activated to provide both sensing and BMC^2 functions. With the implementation of suitable communication links between the UAV platforms and the manned platforms, a "hen and chicks" architecture can be implemented.

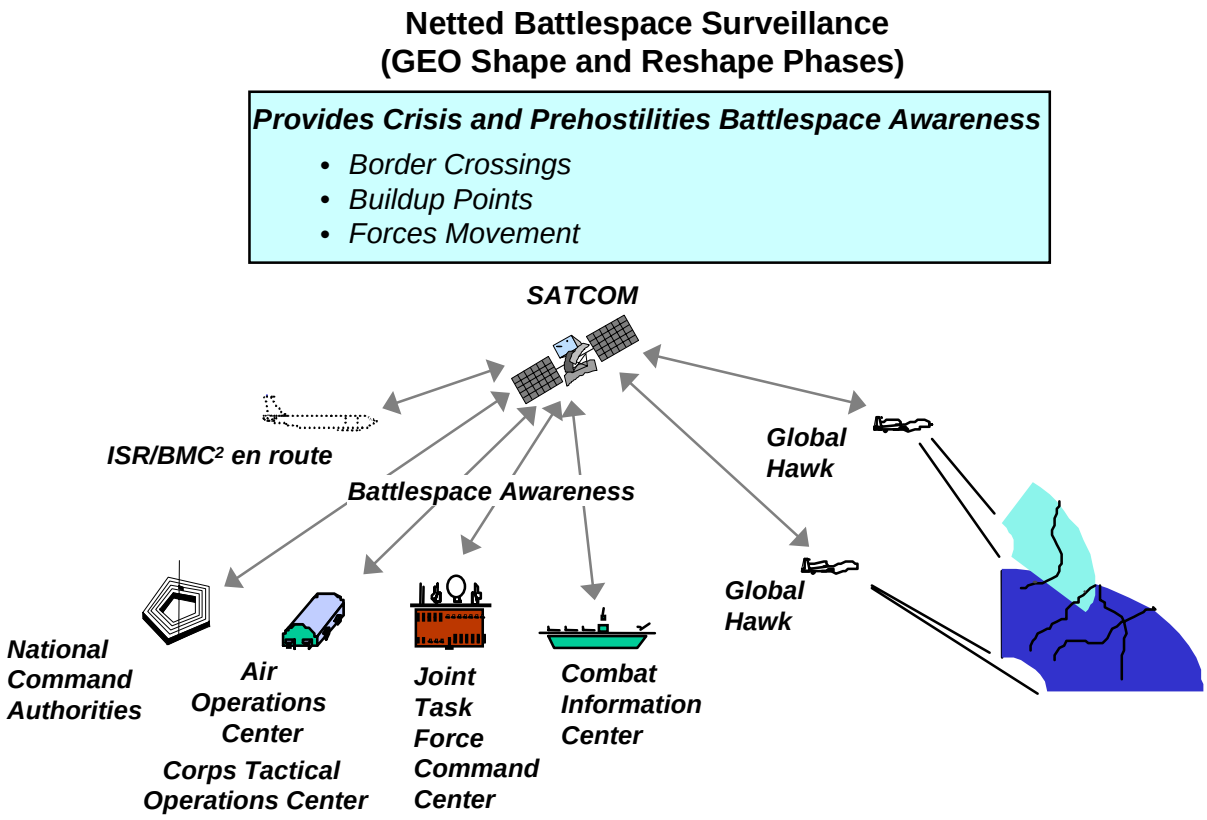

Figure 7. *Netting can allow UAV ISR assets to further augment manned platforms.*

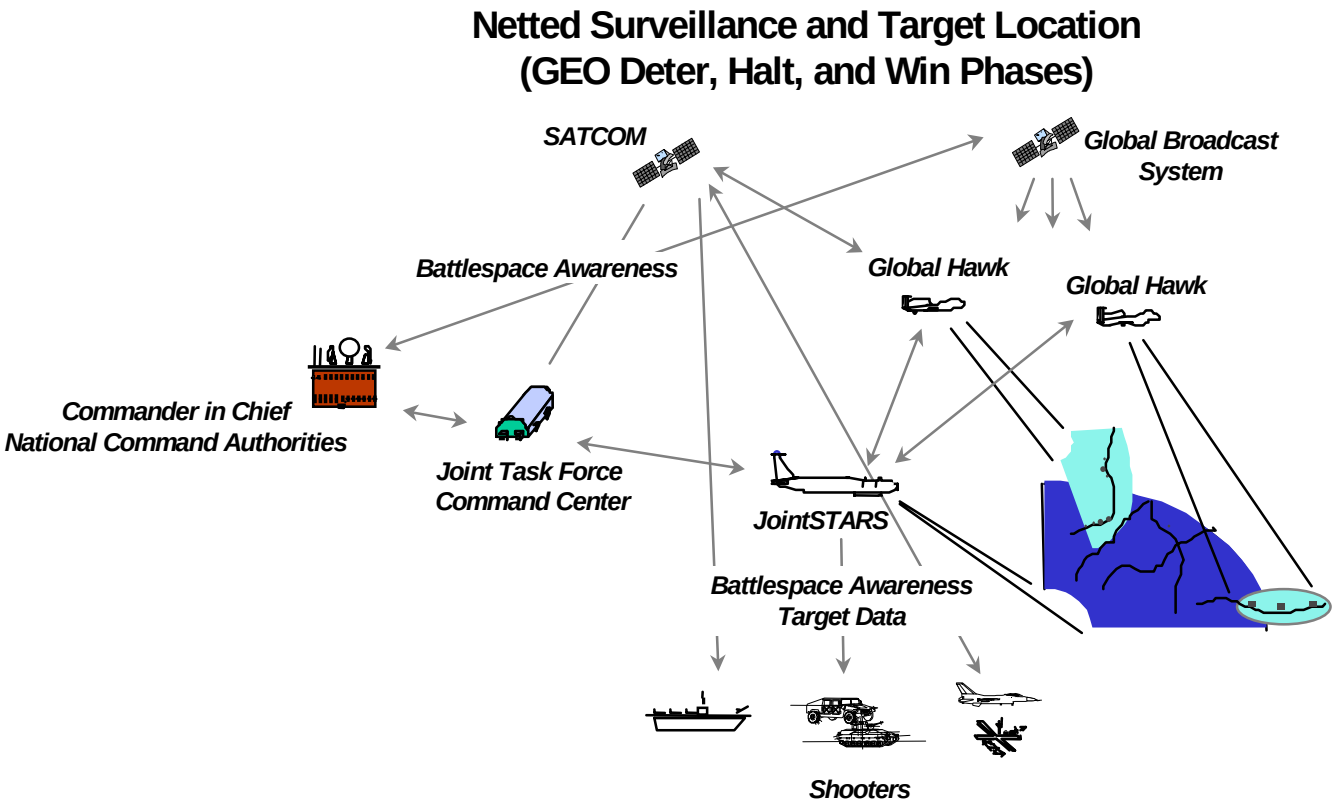

Figure 8. *Netting could allow UAV augmentation in the Respond phase as well.*

With this architecture, the UAVs feed additional sensing inputs into the command and control (C^2) functionality of the manned aircraft. During hostilities, the UAVs can sense more deeply into enemy territory since they can generally be flown very aggressively.

The net effect of this proposed architecture is a reduction in the required OPTEMPO for the manned platforms during the Shape and Reshape phases (with no loss in I&W) and significantly augmented sensor information during the hostility phase.

The panel believes that radar technology is sufficiently mature to allow for the immediate development of the required radar by industry. This belief is substantiated by the results of the ARS, which surveyed radar technology programs and explored the capabilities of the existing Global Hawk airframe and possible improvements to the vehicle and its sensor suite.

4.2.3 Finding: The current intelligence cycle for tasking, collection, processing, exploitation, and dissemination is inadequate for OOTCW

Traditionally, the intelligence cycle is sequential, oriented toward particular systems and security compartments, and isolated from the C^2 environment. For the Cold War, with the world in a bipolar state, this approach was a significant component of the "big win." For the near future, however, U.S. forces will often have to deploy rapidly to areas where little *a priori* understanding of the threat environment, civilian disposition, leadership intentions, and infrastructure are available.

Operations such as in Somalia serve as good examples of the shortfalls of the current modes of interaction between ISR and operations for many of the missions that will confront the United States in

the future. ISR information was prepared using assumptions of the operational details, and operational plans were developed using assumptions of the ISR details, in a non–time coincident manner. As a result, information critical to operational success was often placed in the hands of the warfighter who was out of synch with the operation. Many of the delays were associated with the asynchronous, compartmental, separate management of the force structure and ISR assets. This was further exacerbated by the lack of an interoperable information infrastructure and communications network. In the end, operational commanders were forced into action without the full benefits of our current technology. Lessons from this operation, combined with additional advances in technology, compel us to advocate a concept where ISR and force management are integral to each other—not just "interoperable"—and stand on a consistent information infrastructure, communications, and networks foundation.

4.2.4 Finding: The observables required for evolving targets and environments demand development of new methods and exploitation of new phenomena

The threats that may be present in future conflicts, particularly other than conventional war, will present a broad spectrum of observables requiring new ISR sources and methods. These targets or environments include

- Chemical and biological agents
- Underground facilities
- No-fly zones
- Cantonment areas
- Urban targets
- Networks and cyberspace
- Digital and wireless communications

Several emerging technologies are being developed that can dramatically improve intelligence collection capability against these targets. Some examples of these technologies are

- Miniature chemical and biological detectors based on micro electro-mechanical systems (MEMS), including electro-optical, conductive polymers, and live-cell interactions
- Miniature and sensitive conventional chemical and biological detection techniques such as mass spectrometry and mobility spectrometry
- Millimeter-wave radio frequency (RF) systems for high-resolution imagery from small systems
- Ultra-miniature MEMS acoustic and seismic measurement devices
- Ultra-miniature and ultra-low-power electronics
- Low-power communications, including commercial satellite systems such as Iridium and Orbcomm
- Uncooled infrared detectors

The panel found that new classes of delivery vehicles are required to deploy these sensors from present Air Force assets. Of the military Services, the Air Force is the best positioned to develop the deployment of such sensors because Air Force assets can operate broadly and deeply in denied territory on a short timeline. The panel found that the Air Force is rich in component technology that allows for the development of a broad range of new delivery options for small sensors. Specific example of these vehicles and supporting technologies include:

- Large UAVs such as Global Hawk and Predator

- Small UAVs such as the Defense Advanced Research Projects Agency's (DARPA's) Miniature Air Launched Decoy (MALD) and Micro Air Vehicle (MAV) and guided parafoils
- Land robotics for end-game mobility and sensor placement
- High-g tolerant electronics, which can withstand the shock of gun launch or earth penetration
- Ultra-miniature MEMS Global Positioning System (GPS)/Inertial Navigation System (INS) systems
- Robust, jam-resistant GPS/INS systems

DARPA, the Air Force Research Laboratory (AFRL), and others are developing such sensors and vehicles. However, a cohesive project approach is lacking, and there is little apparent technology push from the technology base to the acquisition system. It should also be stressed that both the sensors and vehicles can enable new capabilities for the delivery of both lethal and non-lethal systems.

4.2.5 Finding: Timely I&W and response to terrorism and transnational threats place unique demands on ISR policy and capability

Transnational and terrorist threats know no national boundaries and require global scrutiny. The threats are broad and embrace ingenious employment of high explosives, nuclear, biological, chemical, and cyber attacks. In each case, classic I&W (for example, force deployments, weapons readiness, and defensive preparations) typically will be absent. Inside knowledge of the hostile decision or preparation process is highly desirable for obtaining sufficient warning time for preventive action but is generally absent. Thus signals intelligence (SIGINT) can be a critical adjunct to high-risk human penetration. Improvement in sensors and sensor platforms is essential in detecting and monitoring nuclear, chemical, and biological preparations (for example, weapons development, training, and dry runs) and for intercepting deployment and execution actions. In all instances the timelines for I&W are likely to be greatly shortened over the pace of conventional war preparations.

While prevention is clearly the goal, reaction may be the reality. Effective reaction can minimize the effect of the hostile action, identify the perpetrators, and prevent hostile follow-up actions. Attribution and attack assessment are immediate intelligence tasks. The need is to significantly improve the timeliness and scope of the intelligence (information) process in confronting a class of threat that can be global in origin, time compressed in generation, and source obscured in execution. In the case of computer network attack, the aggressors loop and weave through multiple systems before reaching an intended target, masking their identity and confronting us with national and international legal constraints.

Chapter 5
Deployment and Sustainment

5.0 Environment

As the Air Force moves toward its vision as an EAF, the importance of robust and complete deployment and sustainment systems increases. For the purpose of this study we define:

- ***Deployment:*** Preparing for, planning, and executing the movement of a military force to one or more operating locations and establishing a base of operations
- ***Sustainment*:** Supporting and protecting the personnel and equipment of a military force to enable the conduct of operations

During the course of the study, the Deployment and Sustainment Panel visited a variety of customers and providers of deployment and sustainment services. The panel developed an understanding of the Air Force approach to satisfying these needs. Much of the current Air Force program is well directed to solving deployment and sustainment problems. Our purpose was to identify problems and make recommendations for solutions. While the focus of this study is technology, we have not limited ourselves to technology because we often found that process or organizational issues overwhelmed anything that technology could provide.

5.1 Challenges

There is no war without deployment and sustainment of our forces. Successful commanders throughout history have learned this lesson, or have failed to win. The United States has unparalleled capability to place a military force anywhere in the world, as well as the capability to sustain that force. C-5s, C-17s, and C-130s routinely move thousands of tons of supplies to and from airbases throughout the world, 24 hours a day, 7 days a week.

Airlift assets have some unique properties that present challenges in force management and requirements during OOTCW. The characteristics of the airlift force during OOTCW are often typical of low-density, high-demand (LD/HD) assets like AWACS, JointSTARS, RJ, and others. They too suffer from the OPTEMPO demands of the other LD/HD forces. During humanitarian missions, airlift forces must interoperate with other governments and private organizations. The majority of airlift capability exists outside the active-duty forces, in the Reserve, National Guard, and civilian fleets.

Customers for OOTCW airlift are diverse, sometimes uncoordinated, and seek often conflicting objectives. Contingency operations must often be satisfied without affecting the basic support functions, which would keep the fleet substantially occupied even if there were no ongoing contingencies. Satisfying this customer base is an incredible feat.

The Air Force airlift forces do an outstanding job of satisfying much of their tasking, but there is much room for, and need for, improvement. This chapter addresses opportunities to improve our airlift force capability and to improve the lives of the men and women who engage the “enemy” every day of their career.

5.2 Findings

5.2.1 Finding: The new EAF is being implemented initially with a revised organizational structure composed of 10 Aerospace Expeditionary Forces and five Humanitarian Expeditionary Forces; however, the emphasis to date has been on combat forces, and the logistics dimensions of expeditionary operations have not received enough attention

The deployment and sustainment portion of the EAF should be developed in parallel with the other operational elements. These forces are part of the LD/HD assets the Air Force possesses, and they need to be treated that way. In particular, the nonmobilized contingency coupled with normal daily peacetime operations presents significant challenges to deployment and sustainment forces.

During virtually all of the Air Force's existence, it has been forward deployed with an expansive permanent base structure to support operations and life style. To implement the EAF, the traditional thought processes must change. "Expeditionary" is a state of mind and not merely a word; it is new to many Air Force communities. The goal should be a capability to deploy mission-tailored forces anywhere they are needed and rapidly establish operations. Especially in OOTCW, this will often involve going to austere forward bases or sites. Recent AEF rotations to prepared bases are important steps but do not represent a fully expeditionary model. Only Red Horse, special operations forces, and operators of low-density high-value assets (including transporters and lifters) are routinely expeditionary today and thus truly understand the concept.

5.2.2 Finding: OOTCW consume the majority of the day-to-day, month-to-month, and year-to-year Air Force tasking; however, forces are sized according to two nearly simultaneous MTWs, and the assumption is that these forces will then be adequate to conduct all smaller operations

The weakness in this process is that it does not use the different forces conducting the two different operations, OOTCW and MTW. In an MTW, mobilized forces are available from the air reserve components, the Air National Guard, and the Civil Reserve Air Fleet (CRAF). During OOTCW, the active-duty force bears the brunt of the tasking. For cost and political reasons, the ratio of the active forces to the ARC has decreased from 1.4:1 to 0.6:1 (or from more than 5:1 to about 2:1, counting only strategic airlift) during the past decade. Figure 9 describes the problem in the way forces are sized. Fundamentally there is no relationship between the forces servicing the day-to-day OOTCW demands and the sizing methodology for the forces conducting those operations. We expect that the OOTCW requirements would justify increased active-duty mobility aircraft and crews.

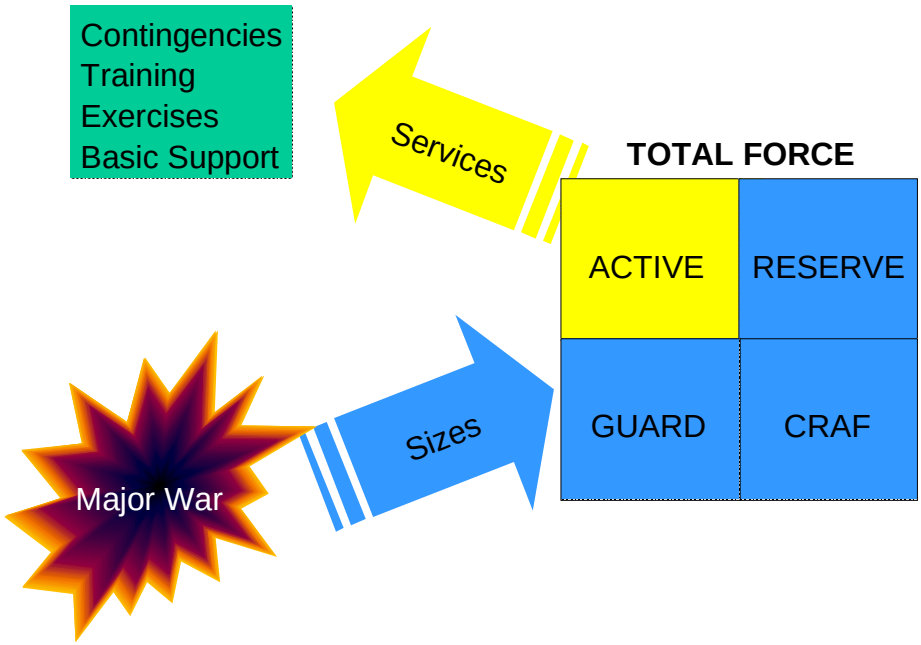

Figure 9. *Force sizing.*

5.2.3 Finding: The focus of today's Air Force exercises and training is typically major combat operations. Exercises and training do not adequately address logistic issues.

For a variety of reasons, training and exercises routinely ignore significant parts of real operations. For example, most exercises start at the beginning of hostilities instead of exercising the planning, execution, and deployment phases. Many problems in OOTCW are associated with deployment and sustainment—issues also routinely ignored or assumed away in exercises and training. It is a fallacy to believe that all other missions are simple subsets of MTW and thus covered by this preparation. For the Air Force to transform itself into an expeditionary force, it will require a paradigm shift that touches all areas of the force.

5.2.4 Finding: The emphasis in GEO has been on the operational and strategic aspects of future aerospace force applications. Better balance is needed between combat and combat support.

The Air Force is moving toward adoption of the GEO construct as a strategy-to-task framework. The phases of GEO reflect both the expeditionary model and the changing role of American military power in the emerging global security environment. The combat force's culture is apparent in the functional breakdown of GEO. Explicit acknowledgement of logistics functions must be included in GEO elements and functions during Shape, Respond, and Reshape phases. Some of the more important logistics processes and considerations are as follows:

- *Shape*. Forces designated as prime for deployment for MTW or OOTCW must have their logistics status brought to and kept at full readiness. This includes filling Readiness Spares Packages, ensuring full support equipment inventories, and properly managing aircraft phase inspections. Tanker and airlift assets must be postured (for example, by establishing tanker task forces at staging bases) to support deployment timelines. Training and exercises must realistically incorporate mobility and sustainment. Deployment databases must constantly be updated to support crisis action planning.

- *Respond.* Fast, integrated crisis action planning, supported by current data and incorporating logistics feasibility analysis, is critical at the start of any operation. The air bridge and in-theater airhead(s) must rapidly be established and complemented by cargo forwarding to theater delivery points. As the deployed force is established, it must be given agile combat support, including reachback, time-definite delivery of personnel and materiel, retrograde transport of personnel casualties and failed equipment, and a robust sustainment pipeline. Sustainment of deployed forces must include all aspects of maintenance, base operations and support, and security and force protection. Theater assets, including regional contingency center stocks and war readiness materiel, must be maintained and effectively allocated to operations.
- *Reshape.* Once the situation is stabilized, some or all of the deployed forces may be redeployed and will then require reconstitution, including replenishing of stocks and eliminating accumulated backlogs in maintenance and training. The logistics functions associated with the initial deployment are essentially repeated in reverse to execute the redeployment.

5.2.5 Finding: During OOTCW there is a significant demand on the airlift fleet. For a variety of reasons this demand creates unacceptable OPTEMPO and PERSTEMPO issues. Additional aircraft, while desirable, are not necessarily required to solve the problem; more efficient use of the existing fleet is the highest priority.

Inadequate aircraft reliability, particularly the C-5 reliability, is a detriment to efficient operations. High-priority C-5 sorties require several spare aircraft. The Air Force has a program under way to improve C-5 reliability, and the panel strongly supports that effort. However, the present 75 percent reliability goal should be revisited; it appears to be based on a need to satisfy a particular MTW ton-mile goal that may no longer be relevant. Fixing the C-5 to only a 75 percent reliability level will improve the fleet capability but will not be adequate to eliminate backup aircraft scheduling requirements. This calculation can and should be made by addressing the lowest-cost way of providing the necessary force capability. Fixed-cost options that could be evaluated include purchasing C-130J-30s and additional C-17s and fixing some or all of the C-5 fleet to higher (than 75 percent) reliability.

Training sorties tie up a large number of airlift aircraft. Some of these training requirements could be completed in simulators if enough high-quality simulators were available. Crew ratios are calculated according to wartime requirements. This should provide adequate crews for both peacetime and wartime; however, the active-reserve mix is not sufficient for peacetime demands.

5.2.6 Finding: Integrated planning and real-time connectivity issues still need to be addressed. Integrated planning should be expanded beyond the bounds of deployment and include integration among deployment, employment, and sustainment to fully realize the vision of the EAF.

Within the logistics community, numerous stovepipes exist across the planning systems. Efforts are under way to solve many (but not all) of these problems. The resulting system may eventually provide integrated logistics planning, but it will not provide integration across deployment, employment, and sustainment planning systems. This is a difficult problem because of the mindset common in developing planning systems. Generally, these systems have been developed module by module with well-defined module functions. This approach needs to change.

The concept of effect-driven planning must be firmly established as the root of the integrated planning system. This concept implies that only those assets that contribute to effects-based operations should be deployed, and only in the appropriate sequence and quantity to achieve the desired effect. It also includes the need to source elements of that deployment as close (in time) to the employment site as possible. In this context, many items currently shipped by air could go by other transportation. Today's

planning and prioritization tools and organizational structures allow this to happen. Mobility customers should have tools available that allow proper prioritization of their cargoes.

Today, unit type codes (UTCs) and the tools to work with them are inconsistent with the EAF philosophy. The entire UTC tends to be given the same priority and transportation mode. Also, UTCs are still structured with a Cold War mentality—that is, they include long-duration (30–60 days rather than the desired 3–7 days with reachback) support packages and large force packages. Core UTCs should reflect the EAF philosophy with small standard pieces and easy incremental tailoring. Planning tools should facilitate and support this approach. A robust sustainment plan incorporating just-in-time resupply will give commanders confidence that they can deploy with minimum equipment and supplies.

5.2.7 Finding: Significant threats to OOTCW forces exist today, and they will increase in the future. The primary threats that require additional protective measures include man-portable air defense (MANPAD) missiles, blinding or dazzling lasers, and chemical and biological agents.

Airlift aircraft today fly into and out of airbases where high levels of security are not available. For OOTCW in particular, the ability to provide adequate security around airfields is questionable. Threats such as blinding lasers and MANPAD are readily available, and it is only a matter of time until one of our aircraft is lost to these weapons. Airlift and tanker aircraft need some degree of self-protection. Technology is available today, or could be available in the immediate future, to negate or ameliorate these threats.

Weapons of mass destruction, particularly chemical and biological weapons (CBW), will be more prevalent in Third World countries where OOTCW frequently occur. Mobility forces must have the capability to operate in these environments and to provide decontamination. Several new decontamination techniques show great promise against CBW.

5.2.8 Finding: In many OOTCW operations, the ability to sustain operations at forward locations is likely to be a limiting factor in mission success

Two major sustainment categories are addressed in this study. The first is sustainment of the mobility fleet and associated support equipment, which suffers from the same support shortfalls that exist throughout the Air Force. The second is the ability of the mobility fleet to sustain other operational forces.

Shortfalls in logistics support to mobility systems limit their effectiveness and capacity. C-5 reliability problems stem from spares shortfalls and obsolete and unreliable components. The 1997 SAB Study on Aerospace Expeditionary Forces provides extensive recommendations on personnel support, force protection, waste disposal, power production, and other logistics functions. These recommendations are still relevant.

Materiel-handling equipment availability is often a limiting factor for OOTCW. The Air Force has made great strides with the Tunner 60K loader. Because Tunners are providing both transport and loading, there is potential that they may show excessive wear compared to separate transporters and stationary loaders. The additional benefits of the Tunner justify this risk if it is not excessive.

The Air Force has not been equipped for humanitarian missions despite the frequent need to perform them. Several systems are repeatedly required but not available. Kosovo once again reinforced the need for an inexpensive precision airdrop capability. Rapid remote survey and autonomous landing capability at remote sites are continuing requirements the Air Force should pursue.

Many deployed items are large and require a great deal of airlift and maintenance support. Shelters, air traffic control, power production, earth-moving equipment, petroleum, oil, and lubricants (POL), and many others fall into this category. A balanced program to identify such items and to develop and deploy smaller, lighter replacements should be undertaken.

5.2.9 Finding: The Combat Search and Rescue (CSAR) mission is especially important to effective use of aerospace power in OOTCW as well as conflict associated with MTWs. Therefore, the CSAR mission has an important overall impact on the success of the GEO construct.

CSAR has been an emotional issue because of conflicting mission tasking, inconsistent resourcing, and changing organizational structures. CSAR forces are neither the best equipped and trained to perform the mission nor always the most available to the commanders in chief.

Chapter 6
Non-Lethal Weapons

6.0 Environment

Non-lethal warfare is fast emerging as an important new arrow in the warrior's quiver. DoD has established policy[7] for non-lethal weapons (NLW), the Defense Planning Guidance has decreed consideration of NLW in planning,[8] and the Joint Non-Lethal Weapons Directorate has been established with the U.S. Marine Corps as executive agent for the development of equipment and procedures.

One of the first matters that the Non-Lethal Effects Panel had to deal with was exactly what a non-lethal weapon was considered to be and what the limitations on the application would be. Much of the latter will be dealt with in further detail, but it is appropriate that some overview be provided early.

The most recent official definition of non-lethal weapons comes from the DoD Directive 3000.3,[9] which states:

> ***Non-Lethal Weapons.*** *Weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment.*
>
> 1. *Unlike conventional lethal weapons that destroy their targets principally through blast, penetration and fragmentation, non-lethal weapons employ means other than gross physical destruction to prevent the target from functioning.*
> 2. *Non-lethal weapons are intended to have one, or both, of the following characteristics:*
> a. *They have relatively reversible effects on personnel or materiel.*
> b. *They affect objects differently within their area of influence.*

This definition contains an important phrase concerning use against personnel; "incapacitate personnel … while minimizing fatalities," which suggests that some fatalities could occur (that is, non-lethality is not guaranteed). A similarly important phrase regarding use in an antimateriel role is "non-lethal weapons employ means other than gross physical destruction to prevent the target from functioning" (that is, some level of destruction of the materiel is likely). Ambiguous phrases such as "intended to" and "relatively reversible effects" are included. So there is some latitude regarding the actual effects, as long as the intents are non-lethal.

The next issue is the actual law and policy that dictates the situations in which non-lethal means may be employed. The nature of OOTW (OOTCW and small-scale contingencies) is such that war is not declared; hence the international laws that restrict many forms of non-lethal warfare are not operative. The DoD, however, has decreed[10] that all non-lethal weapons programs must be reviewed by the General Counsel/Judge Advocate General before approval. The DoD requires a three-question test:

1. Does the weapon cause unnecessary suffering?
2. Is the weapon discriminating?
3. Does the weapon violate a specific treaty law?

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[7] DoD Directive 3000.3, "Policy for Non-Lethal Weapons," 9 July 1996.
[8] DoD Defense Planning Guidance 2000–2005.
[9] "Policy for Non-Lethal Weapons," Department of Defense Directive 3000.3, 9 July 1996.
[10] Ibid.

For laser weapons, yet another policy[11] applies:

> The Department of Defense prohibits the use of lasers specifically designed to cause permanent blindness of unenhanced vision and supports negotiations prohibiting the use of such weapons. However, laser systems are absolutely vital to our modern military. Among other things, they are currently used for detection, targeting, range-finding, communications and target destruction. They provide a critical technological edge to U.S. forces and allow our forces to fight, win and survive on an increasingly lethal battlefield. In addition, lasers provide significant humanitarian benefits. They allow weapons systems to be increasingly discriminate, thereby reducing collateral damage to civilian lives and property. The Department of Defense recognizes that accidental or incidental eye injuries may occur on the battlefield as the result of the use of legitimate lasers systems. Therefore, we continue to strive, through training and doctrine, to minimize these injuries.

Having established that there are circumstances in which non-lethal weapons can be employed, we turn next to the motivation for their use. There is evidence available in the public media that non-lethal weapons have been used in recent conflicts, including Desert Storm and the Kosovo crisis. The details and corroboration of the media reports are not in the literature made available to us. However, numerous directives have indicated that future use of non-lethal weapons is encouraged. Thus, we have the basis for the consideration of non-lethal weapons in the conduct of OOTCW.

Non-lethal warfare should not generally be considered in itself as an alternative to lethal warfare, but as an element of a continuum of lethality at the hands of the commander. We found that the range of opportunities to apply levels of non-lethal weapons in the general realm of OOTCW is exceptionally broad, and an area that has not been adequately addressed by either the planners or the developers within the Air Force. In general, we would expect that non-lethal effects might more likely be associated with earlier phases of the engagement spectrum, while lethal effects might more likely be associated with later stages. Figure 10 depicts this notion in the Global Engagement Operations context.

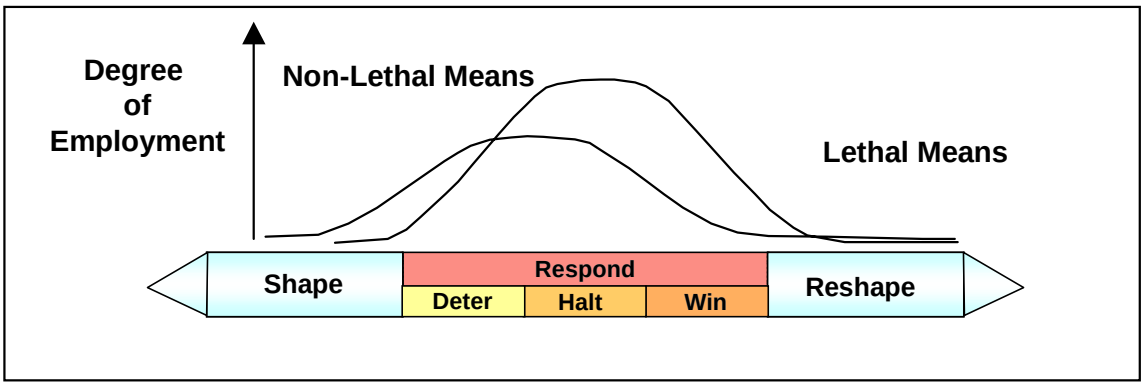

Figure 10. *Non-lethal effects in the GEO construct.*

[11] Revision of 1995 DoD Policy on Blinding Lasers; Secretary of Defense William J. Perry, 17 January 1997.

This panel believes that a continuum of weapons lethality is essential for the small-scale contingencies and OOTCW facing the U.S. military. In fact, the Commander, Air Combat Command (ACC), suggested a conventional equivalent to a "dial-a yield" weapon as a need. The range should include, progressively, effects that

- Intimidate
- Warn
- Scare
- Incapacitate (personnel or materiel)
- Disable
- Damage (materiel)
- Destroy

6.1 Challenges

Policy and law have established certain guidelines for the development and use of non-lethal weapons of various types. As the ensuing discussion will show, these guidelines are not overly restrictive; they allow employment of such weapons if the intent is that they be non-lethal, though the outcome might be otherwise.

One of the key concerns in determining whether a particular agent or device is suitable as an incapacitating means is the likelihood of causing death or permanent damage. This aspect is best understood by considering the probability-versus-dosage graphs predicted for the agent or device. A generalized graph is shown in Figure 11. The left-hand curve depicts the probability of incapacitation against the dosage for the particular agent or device. The curve should have a steep slope so that the dosage can be made relatively standard. The right-hand curve represents the likelihood of death or other permanent damage. The separation between the curves is the safety factor—that is, the distance represents the magnitude, relative to the normal dose, of a damaging or otherwise undesirable outcome. Thus, the most desirable situation for the military is to have a relatively large distance (safety factor) between the curves. The non-lethal weapon designer searches for this condition.

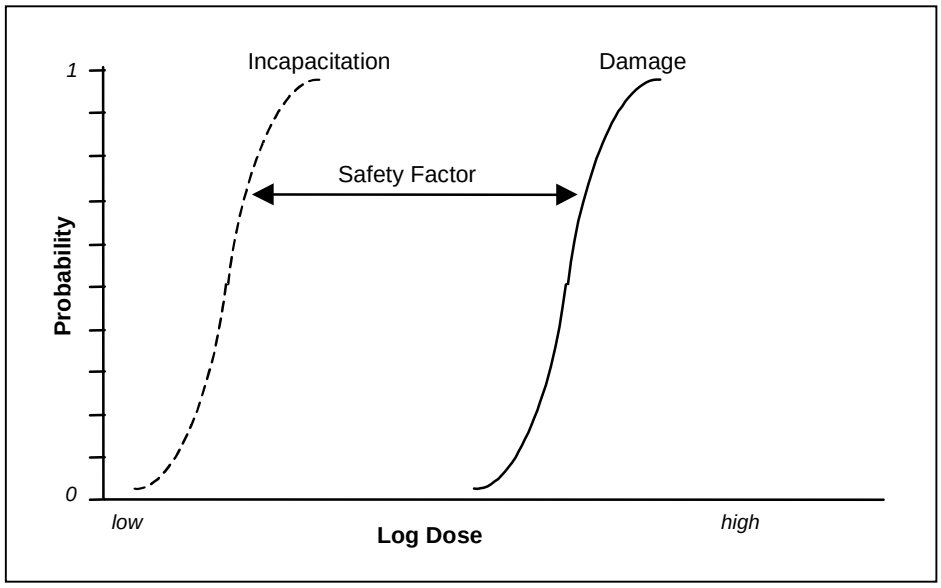

Figure 11. *Dosage chart.*

General considerations in the selection of non-lethal effects concepts include

- Likelihood of collateral damage
- Development time
- The life of the effect
- The reversibility of the effect
- Accessibility of effectiveness
- Range of delivery
- Required precision of delivery
- Radius of effectiveness
- Vulnerability to simple countermeasures
- Vulnerability to simple antidotes

The panel visited various commands and agencies: the U.S. Special Operations Command, U.S. Southern Command, U.S. Central Command, U.S. Atlantic Command[12] (USACOM), Air Force Special Operations Command, Air Intelligence Agency, and the ACC to gain their perspective on the use of non-lethal weaponry. To varying degrees, they were active in their thinking on the matter, and in some cases actual planning was in progress. We also visited the Air Armament Center and Munitions Directorate at Eglin Air Force Base (AFB) and the Directed Energy Directorate at Kirtland AFB, Sandia Laboratories. We received briefings from the Joint Non-Lethal Weapons Directorate, from the Army Research Armament Development and Engineering Center, and the Air Staff. To fill us in on policy and law as they relate to the development and use of non-lethal weapons, we heard from OSD (Policy and Law).

These visits and briefings produced a general finding that the highest levels of the Air Force have not devoted sufficient effort to developing a vision and the attendant plans for the use of non-lethal weaponry. As a starter, a central focal point[13] at Air Force Headquarters should be established within the office of the Deputy Chief of Staff for Operations. This office should be tasked with developing a vision regarding non-lethal weaponry and with directing the planning and development of a wide range of air-delivered non-lethal weapons.

Related recommendations address the need to develop acquisition plans as well as tactics for Air Force applications and to become more involved in joint activities for the operational employment of non-lethal weaponry.

The panel reviewed tasks for OOTCW to determine where particular technologies might be applied. We then paired specific application approaches (delivery methods) available to the Air Force with the technologies that might be used and, from that, we provide recommendations to the Air Force for research and development (R&D) initiatives.

Once again, we must include the caveat that the security restrictions surrounding specific plans and developments may have precluded a complete picture of extant, non-lethal weapons development within the Air Force.

[12] Now called the U.S. Joint Forces Command (USJFCOM).

[13] At this time, the Directorate of Security Forces (AF/XOF) is the named non-lethal weapons focal point; however this tends to be oriented to the ground-based force protection aspect of non-lethal weapons rather than offensive non-lethal weaponry.

6.2 Findings

6.2.1 Finding: The Air Force lacks a comprehensive strategic vision or plan for the inclusion of non-lethal weapons in OOTCW operations

We devoted considerable effort to determining the structure of the non-lethal effects development and planning process within the Air Force. In our review, we determined that

- There is a clear need for integrating non-lethal air warfare into strategic and tactical doctrine and planning
- Development efforts in non-lethal means are fragmented, and there is no indication of a focal point for the development or use of non-lethal weapons, in the either the development or operational staff (outside security forces)
- Little thinking has been given to operational concepts involving air delivery of non-lethal effects
- Virtually no effort has been devoted to the development of measures of effectiveness, "battle" damage assessment concepts, and integrated effects-based planning tools for non-lethal warfare

6.2.2 Finding: The Air Force needs a capability to disable or destroy electronic equipment (for example, computers and ignition systems) and other materiel, and an active denial capability without producing blast effects, death, or collateral physical damage

The use of HPM in a large aircraft application will soon be possible. We believe that the development of a non-lethal gunship option will be valuable to the Air Force. The integration of an HPM capability into an aircraft is not a trivial problem. Power, weight, and antenna location and drag issues must be addressed. We believe that these problems have an operationally useful solution, and we encourage the Air Force to demonstrate the HPM aircraft application in the near future.

A second high priority for application of HPM is for the self-protection of aircraft. Both pulsed and continuous wave (CW) systems may be useful for this application. At present there is no capability, other than EW, for defeating radar-guided missiles, and only flares are available for defeating IR missiles. IR seekers are becoming more effective so that flares will eventually be nearly useless. HPM offers the possibility of upsetting missile electronics to defeat both radar and IR seekers.

- *Pulsed HPM*. Interdiction is an important Air Force mission. A primary part of interdiction is the stopping of vehicles to prevent supplies from reaching enemy units. We do not now have a non-lethal option for vehicle stopping, but pulsed HPM may offer a possibility, at least for vehicles with electronic ignition systems. A non-lethal, air-deliverable, HPM antivehicle "mine" is a possibility. Such a device could stop a large fraction of passing vehicles, at least those with electronic ignition systems. It could also disable electronic instruments passing by on their way to the front. There are significant questions of alignment, power, tamper resistance, and target discrimination to be solved, but sensor-triggered, explosively driven power supplies should nonetheless be developed. It may be that the issues cannot be resolved, but the possible payoff will justify some consideration.
- *High-Power Lasers*. Laser development has proceeded to the point that laser power sufficient to damage aircraft and ground targets will soon be available in packages small enough to carry aboard an aircraft. For large aircraft, such as a Boeing 747, the acceptable gross weight can be 170,000 pounds, but for smaller aircraft, the maximum weight may be as low as 20,000 pounds. The lower end of the weight range is appropriate for the Fotofighter application described in *New World Vistas*. The long ranges enabled by atmosphere compensation and speed-of-light delivery will transform a large airplane into a tactical aircraft.

- *Low-Power Lasers.* Low-power lasers have been used as target designators for precision-guided munitions and as crowd-confusing devices during the extraction of Marines from Somalia. The precision-guided munitions application is now institutionalized within the entire U.S. military, but other uses are not yet widely accepted. Some laboratory work on lasers having power levels below the eye damage limit, but above the levels required for disorienting sensor systems, is ongoing. Optimum designs have not yet been determined, but the technology has developed to the point where devices should be demonstrated to establish utility and determine requirements.
- *Electric Generation.* HPM and laser weapons will need significant amounts of power. Power levels in the megawatt range will be required. Analyses of the performance of generators using high-temperature superconductors have shown that significant power can be extracted from a turbine engine using superconducting wires in a magnetic field. The development of conductors and new fabrication techniques is necessary to make the superconducting generator a reality, but this appears to be within our current capabilities of materials development and fabrication.

6.2.3 Finding: It is essential that the Air Force have a robust capability to disrupt operational effectiveness of terrorists, groups, and nations by attacking critical communications nodes at the personal, unit, and command level

Though we did not look deeply into this area, we sensed that there is insufficient leveraging of airpower for offensive counter-information against OOTCW targets. Specifically, there appears to be inadequate attention paid to capabilities suited to smaller operations for which large strategic actions are not appropriate and where small local actions must be disrupted.

6.2.4 Finding: The Air Force should have alternatives to the use of lethal force to attack a broad range of important materiel targets

Current non-lethal attack systems focus on targets with electronic and electrical vulnerabilities. No comparable capability or planning appears to exist for the broader class of materiel targets that are not vulnerable to this attack mode. Included are shielded and older motor vehicles and mechanized equipment, artillery, transportation systems, roads, bridges, and airfields.

6.2.5 Finding: The Air Force should exploit the potential of UAVs for delivery of non-lethal effects

Flexible, modular UAVs and unmanned combat air vehicles (UCAVs) can provide low-cost, long-endurance delivery platform capabilities for a wide range of lethal and non-lethal weapons or effects. They should be developed with modularity in mind since we expect that operational concepts and specific payload modules (to house the weapons, guns, and “effects dispensers,”) will evolve rapidly. Furthermore, mission-to-mission changeouts of modules are likely to offer a low-cost and flexible approach to complement the continuum of force application.

Chapter 7
Lethal Weapons

7.0 Environment

Broad trends in the international environment will continue to stress forces dedicated to OOTCW:

- Small-scale conflicts
- Terrorism
- Concern about the proliferation, threat, or use of WMD
- Concern about the proliferation, threat, or use of ballistic and cruise missiles

7.0.1 Generic Characteristics of OOTCW

The panel concluded that some key characteristics of OOTCW differentiate them from MTWs and can result in constraints being imposed on the conduct of the operation. Among these are the following:

- Coalitions
- Minimal or no collateral damage
- Minimal or no friendly casualties
- Nongovernmental organizations

7.0.2 Types of Operations Included in OOTCW

As conceived by the panel, OOTCW include the following types of operations:

- Enforcement of no-fly zones
- Support to peace operations
- Counterterrorist strikes
- Destruction of WMD
- TBMD/theater cruise missile defense (TCMD)

7.1 Challenges

From the standpoint of lethal effects, the foregoing suggests both the need for precision and an environment in which the importance of survivability can outweigh that of effectiveness.

The current environment increases the need for five types of precision:

1. Target information in three dimensions
2. Timing
3. Delivery
4. Tailored effects
5. Rapid effects assessment

The panel defined four general areas in which operational challenges and capability shortfalls exist for lethal operations: intelligence, attack, no-fly zones, and aircraft survivability.

7.1.1 Intelligence

In the area of intelligence, the following operational challenges and capability shortfalls were identified:

- Precise timely intelligence about target location above or below ground, with details about construction, interior spaces, and equipment or stores
- Timely damage assessment, especially in building or bunker interiors, and for WMD storage sites
- Remote sensing of chemical and biological agents
- Detection of non-emitting threats (RF)

7.1.2 Attack

In the area of attack, the following operational challenges and capability shortfalls were identified:

- Ability to attack a variety of military targets in areas where collateral damage is unacceptable (including fratricide)—mobile, fixed, buried
- Capability to attack non-emitting RF targets, for example, surface-to-air missile (SAM) launch systems
- Weapons or concepts to neutralize WMD without collateral effects
- Effective capability to defeat ballistic missiles and launchers in the prelaunch and boost phases
- Capability to defeat theater cruise missiles

7.1.3 No-Fly Zones

In the area of no-fly zones, attention should be given to

- Dramatically reduced demand for people in aircraft for surveillance of no-fly zones
- Reduced demand for people in fighters for enforcement of no-fly zones

7.1.4 Identification of Noncooperative Targets

In the area of aircraft survivability, the following issues were identified:

- Spoof-proof identification–friend or foe (IFF) and positive ID
- Aircraft self-defense against infrared (IR) missiles
- Non-emitting passive navigation

7.2 Findings

7.2.1 Intelligence

7.2.1.1 Finding: To support precision strikes with the necessary lethal effects and without unacceptable levels of collateral effects, there has to be an exponential increase in the level of detail and precision of intelligence information.

Information needs will increasingly include precise target location, precise information on the environment and surroundings of the target, details of the target interior, and the location of particular equipment, functions, or stores. In the case of underground facilities, details of the underground layout will be needed, along with details about the construction and materials used. Details about the electrical and electronic equipment are needed to facilitate an electronic attack, and details about WMD storage

(materials, storage conditions, and locations) are necessary to design an attack that results in low collateral damage.

In addition to all of this, knowledge of hostile capabilities along ingress routes will become more important to ensure survivability or to maintain surprise. The detection of non-emitting threats is an especially important and challenging aspect of this problem. This allows an adversary to deny the Air Force the use of low-altitude airspace with just the threat of SAM capability, as was done in Yugoslavia.

These needs for information pose great challenges for the collection and dissemination of intelligence information. New approaches to the intelligence processes will be required, along with substantial technology development for data collection, processing, and communication. The Intelligence Panel will be addressing all these issues at some length. However, there are some innovative long-term technical possibilities for data collection:

- The use of laser sensors for the long-range detection of chemical or biological agents in the atmosphere.

  The sensing of chemical and biological warfare agents from remote locations has many advantages, not the least of which is a more timely and effective application of lethal force for neutralization. Existing efforts to detect chemical and biological warfare agents from a distance of a few kilometers should continue. Extending these ranges to tens and hundreds of kilometers is very challenging but may be possible using high-energy laser interaction with the molecular and atomic species involved. Low and resonant wavelengths from the ultraviolet to the far infrared will probably be necessary. But these wavelengths are becoming available and eventually may be scaled to sufficient powers to allow detection ranges that would allow application from satellite or high-altitude UCAV platforms. However, it is likely that such applications may not be affordable if dedicated single-purpose systems are required but rather should be considered as part of multipurpose sensor suites. Two such concepts have recently been proposed. An important adjunct to these concepts is the use of such sensors for BDA following an attack on the storage location to determine leakage into the atmosphere.

  The placing of a few mirrors in low Earth orbit would precisely point laser beams to designated areas on Earth. A ground station (or several) could then shine a laser to the nearest orbital mirror and reflect the beam to any point on Earth either directly (so-called single bounce) or through other relay optics. Keeping the laser system on the ground means that essentially any wavelength, power, or waveform could be transmitted and reflected to and from any unobscured point on Earth. There are many applications of such a “virtual presence” capability, but certainly one possibility is chemical and biological detection. After detection, other nearby sensors could detect locations for attack. Such a concept has been studied under the AFRL Low Cost Autonomous Attack System (LOCAAS) study just completed. Another possibility is a multifunction laser distancing and ranging sensor suite on board a UCAV. Again, one of the functions could be chemical and biological weapon detection. A concept for such a sensor suite is now being considered under the AFRL Directed Energy Application to Tactical Air Combat study. These studies should identify enabling technologies to guide AFRL research programs.

- Development of a wireless integrated network of MEMS sensors that can detect chemical and biological agents.

  Methodologies for the detection and identification of hidden and passive systems require special technological development to meet these challenges. In peacetime, the detection and identification of chemical and biological agents requires systems to determine the presence of these substances and to communicate their findings. Another complex issue is that of

determining the location of missile sites and launch facilities that are mobile but not emitting, which makes detection difficult.

A possible approach is to distribute MEMS devices over the area of concern. In MEMS, sensors are integrated with low-power electronics and high-speed wireless communication and signal processing. MEMS are ultra-small but quite inexpensive. These systems are to fuse the data collected by the sensors and possibly shared over the network to determine the presence of a substance or motion. The proposed systems would be extremely reliable, having a high probability of false alarms as a system even though some of these elements might fail. Also, in the presence of possible jamming, the system's frequency should be quite agile. Finally, the system should use high-density power systems such as fuel cells, scavenge energy (such as local vibrations, electro-magnetic fields, and fluids) from the environment, or have resonant circuits to receive directed energy.

These microsystems may be dispensed in extremely large numbers and be randomly distributed over a desired region. UAVs systematically following an efficient pattern could perform constant monitoring of these systems.

7.2.1.2 Finding: There is an increasing need for substantially better damage assessment, including real-time assessment.

The information needed can be stated in hierarchical order as follows:

- Where did the weapon strike?
- For an earth penetrator, where did the weapon go underground?
- Did the weapon function as described?
- What were the effects of the attack?
- For a chemical or biological attack, did any agent escape?

There is very little technology available for most of the tasks identified above, and this offers a significant challenge to the intelligence world, although some technologies offer some promise of being able to provide some of this information. The technologies fall into two categories: (1) sensors that accompany the weapon and (2) off-board sensors.

Survivable sensors that accompany the weapon can include imaging sensors, geolocation sensors with a trailing wire for transmission, or a detachable sensor that remains on the surface. Off-board sensors can include sensors on a following weapon, sensors on a UAV, unattended ground sensors, or a remote laser to detect agent escape.

7.2.2 Finding: Delivery methods are needed to precisely place munitions in order to defeat deeply buried and hardened targets

This means getting the munitions into the "right room." It will continue to be necessary to penetrate and fuse to within a few meters of the desired target location. As these capabilities become known and demonstrated, it will undoubtedly be necessary to penetrate farther and against material specifically hardened against kinetic energy penetration. Thus attack of these deeply buried hardened bunkers will continue to be extremely challenging, requiring continued research with innovative solutions. Smarter fuses will also be necessary as countermeasure techniques to current technology are fielded.

7.2.3 Finding: Weapons and delivery methods are needed to destroy contained chemical and biological agents

To attack these agents in underground structures is more difficult than just attacking a hardened, deeply buried target, because of the possible collateral damage from an agent released into the atmosphere. This possibility has given priority to the development of concepts, such as sticky foam, that would delay access to the stored materials or warheads.

There is considerable work under way on technology for the neutralization of chemical and biological agents. The specific conditions necessary for neutralization are agent dependent. Some biological agents are resilient enough to survive extreme physical conditions. Neutralization concepts are significantly affected by the physical state and the containment of the agent.

A recent study by the Directorate of Nuclear and Counter-Proliferation (AF/XON) has examined a wide variety of technologies for agent destruction and access denial. There are current means for neutralization of small exposed quantities of agents. However, this study provides the basis for concluding that no system today can reliably ensure the neutralization of all the agent stored in a bunker with no external release.

The study also concluded that the technological solution most likely to succeed in neutralization without agent release is intense heat—"hot enough for long enough." A weapon would have to be able to penetrate the bunker and deliver such a heat source to the right location. The study also concluded that conventional sources such as thermite could not successfully neutralize some major biological agents.

7.2.4 Finding: The destruction of very specific targets with minimal collateral damage will likely continue to be an important part of OOTCW

Smaller, more precise smart bombs should be developed to tailor the lethality and precision to the intended target and nowhere else. Initial capability has been demonstrated in the Small Smart Bomb, currently weighing 250 lb. Intended for either shallow penetration or surface targets, it can be carried either internally or externally. For mobile targets, adaptive multimode warheads should be developed. Tailoring of the blast and fragment warhead effects should be adaptive in flight based on the identification of the target. Initial capability is being demonstrated in LOCAAS, which if successful should be transitioned into development.

Fuzing and fire control of munitions must adapt the lethality footprint of the munitions to maximize damage to the target. This involves not only knowing and precisely hitting the aimpoint but also the relation of the aimpoint to the most vulnerable aspect of the target. This would allow picking aimpoints that are easier to detect and track and focusing the blast and fragmentation to the vulnerable area.

7.2.5 Finding: Threat environments and long sortie duration in no-fly zones require large numbers of support aircraft such as tankers and AWACS, suppression of enemy air defenses (SEAD), and electronic warfare (EW) platforms

The high OPTEMPO/PERSTEMPO is wearing out personnel and airframes. UAVs (unarmed) and UCAVs (armed) offer capabilities that may replace or augment the assets required for implementation of no-fly zones. Examples of these capabilities include

- Long-dwell (Global Hawk–type) UAVs with flexible plug-and-play sensor suites that provide AWACS, JointSTARS, EC-130, and RJ-like capabilities

- UCAVs equipped with directed-energy weapons such as the Airborne Tactical Laser (ATL) that provide kill capability against ground and airborne targets, including theater cruise missiles (TCMs)

Current R&D efforts focus on UAVs and UCAVs as stealthy, Global Hawk–like "trucks" with long range and long endurance, carrying small, highly sophisticated packages of equipment and weapons that enable them to perform across the entire spectrum of Air Force missions with both autonomous and reachback capabilities. The requirements for such systems include

- Long endurance
- AWACS, JointSTARS, EC-130, and RJ-like capabilities
- Lethal SEAD
- Autonomous operations
- ATL for attack of ground and air targets
- Small munitions or submunitions for attack

UAVs and UCAVs, when combined with space systems, increased computing power, and secure communications, and when operating seamlessly with staffed systems, may offer important new capabilities to the warfighter within the next 25 years.

7.2.6 Finding: Significant improvements may be required for aircraft survivability and self-protection. Identification of noncooperative targets (both air and ground), defenses against IR missiles (air-to-air and ground-to-air), and non-emitting navigation modes appear to be important future requirements.

7.2.7 Finding: Positive ID of both air and ground targets by both manned and unmanned systems is feasible

Such capabilities require high-speed computers that apply artificial intelligence to acquire and assess signatures and to attack targets. Wideband, secure, long-range communications will be required for reachback and C^2.

Chapter 8
Force Management

8.0 Environment

According to General Michael E. Ryan, Air Force Chief of Staff, the EAF concept provides three key things for the Air Force, for warfighting commanders, and for the nation.[14] First, the EAF provides a known, rapid response capability tailored to support a wide range of contingencies. This is important because, since the end of the Cold War, contingency operations have increased fourfold. Second, the EAF provides predictability and stability across the force, improving morale and retention. This is achieved through a schedule of rotations, allowing Air Force personnel to plan for deployments. Third, the EAF provides further integration of the active, Guard, Reserve, and civilian forces.

The EAF organizationally links geographically separated forces into standing AEFs. Communication through networks allows the coordination of dispersed groups that is needed to provide the envisioned response—deployable combat power. Communication within an AEF requires Global Grid access to support joint, distributed operations in a collaborative environment with reachback support.

The AEFs are anticipated to operate in a split-base manner with combat power forward and reachback for support. This puts increased demands on communications, information displays, and shared databases. The C^2 system for the AEFs is evolving through spiral development and the Joint Expeditionary Force Experiment (JEFX) series of experiments. This process spurs innovation but imposes additional constraints on the systems engineering disciplines.

The environment for communications in general is changing rapidly. Areas of the world without commercial broadband connectivity are being reached through the global fiber net and satellite networks. Use of these capabilities for OOTCW is inevitable because of the additional capabilities these resources enable and the fact that many participants do not have access to military networks. This implies that the military also needs access to these communications networks.

Use of commercial networks implies potential vulnerabilities that must be addressed. In some cases the adversary may be using the same network, which presents interesting considerations in forms of offensive and defensive information warfare. The physical vulnerabilities of the commercial networks will probably decrease over time as the networks proliferate, but network assurance and control may become more difficult.

8.0.1 The Force Management Process

The concept of force management[15] as used in this study is broader than C^4ISR. Force management is defined as the process of developing, executing, and assessing the application of aerospace power to meet mission requirements. Consequently, it includes the strategy-to-task analysis of the mission, the development and evaluation of alternative courses of action (COAs), and the selection of a particular COA that drives the planning and execution cycle. However, the nature of OOTCW is such that early

[14] MSgt. Jim Katzaman, "Air Force Launches Into Expeditionary Mission," Air Force News Service, 3 August 1998.

[15] The 1999 Joint Warfighting Science and Technology Plan references the Advanced Battlespace Information System (ABIS) Study that first used the concept of Integrated Force Management. Per the ABIS Study, commanders need information superiority to shape and control conflicts, and Integrated Force Management represents "the capabilities needed to achieve dynamic synchronization of missions and resources from components and multi-national forces located anywhere."

and timely assessment of the operation's effects needs to be emphasized so that changes in the selection of the COA can be made.

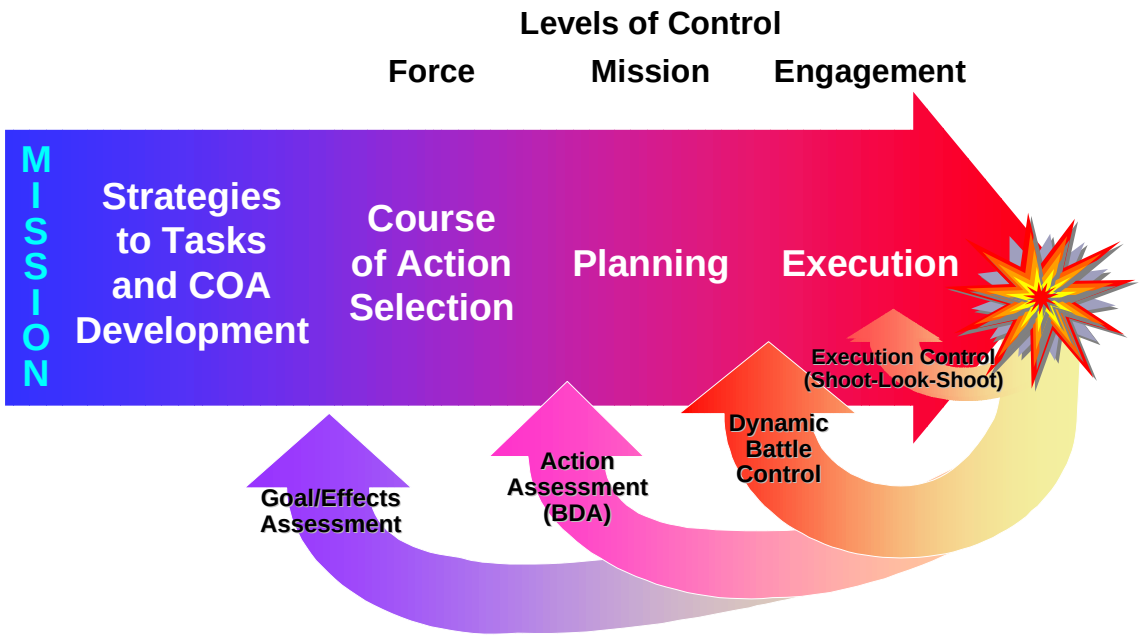

Figure 12. *A notional representation of force management.*

Force Management in OOTCW requires a very rapid response to multiple, simultaneous missions in unforeseen situations where multiple coalition partners, NGOs, and agencies conduct actions under strong political oversight.

Additionally, the Air Force offers a wide range of effects-based alternatives. Effects-based planning determines desired effects, selects a COA, and assesses the resulting effects before selecting an alternative. Specific elements of effects-based planning as it relates to applying aerospace power include

- Determining *what* effects best achieve desired goals and policy end states
- Linking and integrating effects into a theater-wide scheme of maneuver
- Directing maneuver through dynamic, real-time, predictive C^2
- Precision attack of mobile and fixed targets
- Precision assessment—supporting force, mission, and engagement control

The rapidly changing commercial telecommunications and computer industries have given rise to a potential opportunity and have posed a significant challenge to force management systems. The opportunity afforded force management systems is characterized by being able to leverage the extensive infrastructure of commercial systems, including the large research investment of the industry. Challenges resulting from commercial technology use include (1) acquisition reform[16] required to implement a successful program, (2) offsetting the technology "leveling" of products available to anyone, and (3) long-term support and "tech refresh" strategies required to keep systems capable and affordable.

Fielding a force management capability to support AEFs will *not* require a significant shift in the Air Force mission, vision, or goals. However, force management of AEFs in OOTCW scenarios will require

[16] See also the SAB 1999 Commercial Off-the-Shelf study.

a significant expansion of the existing scope of Air Force C^2 doctrine given the increasing number of uncertainties associated with OOTCW missions. As concepts and doctrine for the EAF deployments and OOTCW missions continue to evolve, appropriate operational, systems, and technical architectures must be developed in order to ensure that AEFs are equipped to accomplish their missions. Likewise, technological innovations must be developed, tailored, and fielded to support the personnel using the communications systems needed to dynamically plan, execute, and assess OOTCW missions.

8.0.2 Communications

Since global communications have become a reality, the importance and impact of communications has grown, and military operations have not been immune. During Desert Storm, the primary U.S. advantage was in information technology—an advantage that will need continued attention if it is to be maintained. The evolution into the EAF concept represents attention to this and other concerns.

The EAF concept was used as the context for the Force Management Panel's evaluation of communication needs and technology solutions. Additionally, increased demand for communication needs for OOTCW were considered to be more demanding but required the same basic capability as MTW. OOTCW were considered more stressing in five areas:

First, communication to support AEF units must be rapidly configurable and deployable to uncertain locations anywhere on Earth. This creates demands on methods of supplying power and connecting forward communications back to the continental United States and sharing information.

Second, bandwidth and user interface at deployed locations need to be equivalent to the home station environment, so that AEF units "fight the way they train." Sharing critical information in real time across the spectrum of users, from National Command Authority to the shooter, places demands on bandwidth. Additionally, the presentation of information across the spectrum of users needs to consider the human-system interface (HSI). Information support to shooters requires increased visibility of appropriate data to prevent fratricide and collateral damage. Appropriate data to push to shooters includes situational assessment, target description, rules of engagement (ROE), and combat identification and geolocation.

Third, OOTCW require full connectivity and interoperability with joint, combined, and civil authorities in the area of responsibility and allied nodes. OOTCW place greater emphasis on coalition forces and coordination with NGOs.

Fourth, capability needs more flexible pull to get the right information in a usable form to the right place at the right time without regard to barriers of human language, computer protocols, formats, or intelligence discipline. Currently, the potential for technology to overcome barriers to interoperability has not matched the need. This is most apparent in current operations with the lack of multilevel-security, configurable networks. These networks need to be virtual so that validated users can access information from remote locations.

Finally, military communications will depend on commercial systems. Currently, the U.S. military relies on commercial satellites for approximately 95 percent of its communications.[17] One example is the Predator UAV used for surveillance.[18] Another is the growing importance of morale calls, including voice calls, video teleconferencing, and e-mail. The advantage of commercial communications is that they provide redundancy to military systems and also decrease demand for military systems. The

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[17] David S. Alberts and Daniel S. Papp, eds., *The Information Age: An Anthology on Its Impacts and Consequences*, Washington, DC: National Defense University, 1997, p. 524.

[18] Major Schafer, USAF. "UAV Challenges in Bosnia," briefing, AC2ISR Center, Langley, VA, 1 March 1999.

primary disadvantage of commercial systems is that links are set up by commercial vendors, which may not be responsive enough to military needs.

8.1 Operational Challenges

The application of aerospace power across the spectrum of conflict and to OOTCW in particular represents specific challenges to force management and to communications. The challenges in each area are further developed in the following paragraphs.

8.1.1 Force Management Process

The EAF mission supporting the joint vision for Global Engagement requires the Air Force leadership to be prepared to respond to a broad spectrum of contingencies, ranging from MTW to small, short-term, localized conflicts. Operational requirements associated with OOTCW tend to be unique, dynamic, and highly situation-specific, often *imposing novel and largely unpredictable demands on Air Force resources*. Successful execution of OOTCW will require that the Air Force C^2 architecture, doctrine, processes, and systems effectively adapt to these operational demands. Some implications for Air Force force management are

- Effective response will require unprecedented levels of flexibility on the part of the command authority in pursuit of mission goals. An agile force management structure will be required to rapidly assemble, deploy, and support a tailored force with the right mix of operational capabilities to achieve the intended outcome. The C^4ISR elements of the force must also be scalable to the need, maintaining a minimum forward footprint.
- Development and maintenance of a common operating picture (COP) will require a high degree of integration of C^4 and ISR assets, supported by real-time information collection, processing, dissemination, and feedback mechanisms.
- The Air Force will continue to be required to support multiple, concurrent operations that may involve remote and widely separated geographic locations with varying infrastructure.
- Response to future contingencies will undoubtedly involve joint or combined operations with shared C^2 authority. The ability to collaborate and interoperate with other Services, government agencies, coalition partners, and NGOs while maintaining effective operational security is an essential requirement for force management in OOTCW.

8.1.2 Communications

Communication, in its purest form, is the process of transmitting and receiving data and information. In its simplest form, communication is accomplished within a closed loop of cognition, transmission, reception, and cognition. Communication systems provide the ways and means to transmit and receive data and information between intended participants. Information architectures provide, in turn, the end-to-end capability to transmit and receive data and information among intended participants. Outside this closed loop are the sender's intent and the recipient's perception of the desired intent for the data and information. Thus, the focus of communication is data and information.

To meet data and information requirements for future military operations ranging from MTW to OOTCW, technology innovations are required to provide communications that balance timeliness, accuracy, flexibility, and security. For the purpose of this discussion, working definitions of these fundamental and enduring characteristics are provided as follows:

- *Timeliness*. Data and information move as fast as necessary to arrive within a prescribed time window
- *Accuracy*. Data and information content are not changed within the architecture
- *Flexibility*. "Plug and fight" capability with other systems and architectures
- *Security*. Data and information are not accessible by unauthorized users

Several technology innovations are needed to meet current and projected military communications requirements for OOTCW: wireless, multilevel secure communications; a high-capacity, deployable telecommunications port; a fully integrated "kill chain" of information sources; automated network management tools; and remotely reprogrammable hardware and software.

In addition to the technological innovations needed to enable communications for EAF missions in OOTCW scenarios (for example, hardware end-items), many nontechnological innovations that support the technology must be developed. For example, personnel who will eventually operate the "new and improved" communications equipment must be adequately educated and trained to meet their mission requirements. Likewise, personnel who are developing and integrating the technologies must have adequate tools to support their research and development efforts and estimate the military worth or operational utility of a given technology innovation. These tools include computer-based modeling and simulation programs that can be used to support study, analysis, assessment, and visualization efforts. Finally, the synergistic benefits of influencing and leveraging commercial practices and products to meet EAF mission requirements need to be realized. For example, database standardization initiatives not only improve mission effectiveness by allowing interoperability between and among systems; database standardization will also benefit the *intra*operability of systems and should improve the utility of computing innovations such as field-programmable gate arrays and intelligent agents.

Some important attributes for OOTCW communications are

- Wireless, multilevel secure communications
  - Wireless, multilevel secure communications will enable military forces to operate in a full spectrum of operational conditions ranging from remote, bare-base locations to bases with relatively mature communications infrastructure (for example, regularly scheduled AEF deployment locations).
- A high-capacity, deployable telecommunications port
  - A high-capacity, deployable telecommunications port will enable the movement of increasing amounts of data and information to an increasing number of end users operating in an increasing number of geographically separated locations.
- A fully integrated "kill chain" of information sources
  - Historically, the focus of most military communications systems has been the movement of data and information to an end user. Recent advances in communications technology fielded on ISR, C^2, and shooter platforms should enable full-duplex broadcast communications. The intent of integrating the kill chain in this manner is to improve the feedback and mission assessment process for all OOTCW missions—at the engagement, mission, and campaign levels.

- Automated network management tools
  - Decision makers and information managers at all levels readily admit that they are usually "data rich and information poor." To help alleviate this problem, which is compounded by decreasing numbers of military personnel and increasing OPTEMPO, tools such as intelligent agents have been developed that reduce the workload for tasks that are relatively menial and tasks that can be very complex.
- Remotely reprogrammable hardware and software
  - The uncertainties associated with current and future OOTCW missions require that hardware, software, and algorithms be increasingly flexible and robust in order to adapt to prevailing conditions and operating environments regardless of deployment, location, duration, intensity, or force composition (for example, joint or combined forces). The design of communications hardware will continue to evolve and will be robust with respect to accommodating new software and algorithms and with respect to operating in diverse environments (for example, modular designs).

8.2 Force Management Findings

There are two primary considerations in addressing force management issues. First, the EAF concept poses new challenges in C^2, communications, information management, and force protection. Second, the diversity of missions included in OOTCW requires a total systems approach to the design of a C^4ISR system. Taken together, these two considerations point to the need for *developing a capability well beyond that required for conventional MTW*. Specific findings are discussed in the following paragraphs.

8.2.1 Finding: With the rapid changes in the past several years, the Air Force has not yet had an opportunity to develop and articulate an operational concept for the EAF in conducting OOTCW

The GEO construct is a major step in the right direction, but the Shape and Reshape stages need to be developed further to cover OOTCW elements and functions.

8.2.2 Finding: The JEFXs with the underlying spiral development process are an excellent way of evolving operational concepts and systems

These experiments generate and test ideas and concepts, and they allow new components and systems to be tested by the operators. However, for the results of the JEFXs to be truly useful in the long term, they need to be framed within an evolving operational architecture and the corresponding systems architecture. The spiral development process is not a substitute for systems engineering but one part of the systems engineering process.

This is an environment in which operational concepts are evolving and technology is changing, offering new opportunities. At the same time, the variety of missions that the EAF is expected to do is expanding. An operational architecture for C^4ISR is an essential tool to ensure that user requirements will be met and that interoperability will be achieved.

8.2.3 Finding: Current systems along with systems to be deployed in the near future, were conceived and designed to support conventional MTW

These systems will not adequately support either the force management needs of the EAF or the application of appropriate aerospace power to OOTCW. Specifically, systems, doctrine, and tactics,

techniques, and procedures for information support of an AEF in OOTCW are not yet sufficiently mature to support rapid response to nontraditional missions in unanticipated locations and environments.

8.2.4 Finding: The Theater Battle Management Core System (TBMCS) version 1.0x will not adequately support either the EAF force management needs or the application of aerospace power to OOTCW

TBMCS was designed to address deficiencies observed in Desert Storm; its design precedes the evolution of the concept of an Expeditionary Aerospace Force and the realities of OOTCW with their many operational constraints. Furthermore, an OOTCW, more often than not, requires the careful integration of information operations with non-lethal and lethal weapons application. Also, an OOTCW will be a joint operation and will probably include allies, coalition nations, and NGOs. This finding reflects on the suitability of TBMCS version 1 and is independent of the current implementation effort.

A related finding is that inadequate attention has been focused on the HSI of the TBMCS version 1.x implementation, making the use of the system cumbersome and, especially, inhibiting training. The lack of elementary features—such as hourglass icons or sliders showing that the system is working on the user's request—in the TBMCS version seen at the C^2 Training and Innovation Group causes frustration and leads to human responses that result in deterioration of system performance. The lack of a consistent user interface across software modules limits efficiency in the cross-training of operators in the use of multiple tools. Similarly, realization of the COP requires substantial attention on cognitive and HSI issues.

8.3 Communications Findings

The Air Force has not implemented an appropriate systems strategy for the communications architecture necessary for the 21st century—neither in general nor for the EAF concept. This lack of an appropriate overview is particularly acute for OOTCW preparations.

Providing the communications support for the Air Force EAF requires fundamentally different communications architectures from in the past, particularly with regard to OOTCW. The panel's findings are grouped into two general areas. First, providing the communications to enable EAF force units to engage in a carefully controlled real-time battlespace with extremely low risks of fratricide and collateral damage plus high assurance of force protection. Second, providing the rapidly deployable communications to support AEFs worldwide and the backbone to allow split-base operations with reachback that make possible a small forward footprint.

8.3.1 Finding: The Air Force lacks a network-based architecture for combat information in a deployed status (AEF)

The necessary feedback loops between information nodes, force units, platforms, and weapons to support low-fratricide, low–collateral damage strikes have not been considered, much less implemented.

Specific findings are as follows:

- Current Air Force fighters, including most F-15s and F-16s, do not have datalink connectivity
- No plans have been made for 21st-century fighters, including the F-22 and the Joint Strike Fighter, to have two-way connectivity with the Air Force or joint information sources
- The superior sensors of the AC-130 and Air Force position-location information plus the commercial air picture are not netted for protection of the deployed force against asymmetric threats

- Communications to support direct imagery to the cockpit are not in place
- Inadequate attention is being paid by the Air Force to the ready access by potential adversaries to commercial, space-based systems and services for communication, remote sensing, and navigation

8.3.2 Finding: The concept of split-base operations places extraordinary demands on communications deployability and capacity

The required communications connectivity and capacity are not being planned or implemented to support the Air Force Battlespace InfoSphere as defined by the recent Air Force Science Advisory Board 1999 *ad hoc* study on this topic. Specific findings are given below:

- Communications for support of EAF deployment currently depend on heavy, obsolete Tri-Service Tactical Communications equipment.
- Deployed (and some in-garrison) squadron personnel lack modern connectivity such as cellular telephones, pagers, and other elements of connectivity and information support.
- Even communications squadron personnel lack home-station connectivity and information support when deployed. This reduces their ability to provide information support to the deploying units.
- Commercial satellite communications services in all orbital regimes (low Earth orbit, medium Earth orbit, and geosynchronous Earth orbit) will provide the backbone of the future Air Force communications architecture.
- Conformal phased-array antennas may allow satellite connectivity to aircraft with little sacrifice of aircraft performance.
- Inadequate attention is being paid to planning for implementing remotely reprogrammable hardware and software units and systems.
- The potential Air Force reliance on the commercial telecommunications and space sector for meaningful long-term R&D investments is unfounded and unrealistic.

Chapter 9
Experiments, Training, and Exercises

9.0 Environment

The need for effective approaches for experiments, training, and exercises (ETE) is evident from the broad range of missions that fall under the heading of OOTCW. These missions can combine force elements into tasks, at relative levels, and with constraints atypical of MTW. For example, in the context of this study's Somalia 2010 vignette, the gradually escalating nature of the scenario avoids the introduction of combat forces early on except for limited defensive purposes. However, the need for integration of airlift with ISR resources—to get supplies to the intended recipients and to conduct evacuations quickly and securely—dominates the mission requirements. As the events of the scenario escalate, additional specialized missions are introduced in concert with limited engagement requirements to produce an environment that demands extremely complex force employment and coordination.

In addition to the variability and potential complexity of the OOTCW mission space, the current acquisition and operational environment introduces other issues and constraints for applying ETE to OOTCW. Declining budgets have squeezed the resources available for range exercises and unit training. Equipment and personnel are being overtasked by deployments and increasing OPTEMPO, further eroding the opportunities for training and exercises. Live practice with modern weapon systems is limited because of their extended range, as well as for safety and security reasons. In the middle of these issues is the introduction of the new operational concept of the EAF, with its distributed force elements having to learn to function as a team.

All these aspects of ETE have prompted an evaluation of the potential that simulations can be used to enhance current individual and unit training and exercises. These simulations, when combined with current training practices, should help to manage the complexity, constraints, and personnel considerations that would otherwise make ETE for OOTCW practically impossible. In addition, low-cost modifications to current education, experiment, and exercise programs in both the Air Force and USACOM have been assessed.

9.1 Operational Challenges

The motivation for considering ETE as a part of this study derives directly from Air Force requirements for GEO, of which OOTCW are a significant part. A sampling of these requirements is summarized in Table 3.

Table 3. *An example of Global Engagement Operations elements for readiness*[19]

GEO Phase	*Element Related to Experiments, Training, and Exercises*
Shape	Maintain readiness, home defense, and deterrence through aerospace power
Respond/Deter	Respond rapidly with forward and home-based Aerospace Expeditionary Forces, and arrive ready to execute the mission
Respond/Halt	Find, fix, track, target, and engage anything significant in near–real time, and assess effects
Respond/Win	Enforce political, economic, and military sanctions with aerospace power
Reshape	Enhance post-crisis stability with skilled and motivated aircrew Sustain heightened readiness to react decisively to a renewed crisis

9.2 Findings

9.2.1 Finding: There is little to no institutional attention in the Air Force to ETE needs for OOTCW.

It is increasingly difficult to meet readiness requirements for MTW missions, let alone the additional factors introduced by OOTCW. This extends from professional military education through wargaming, training, and exercises.

9.2.2 Finding: The most promising enabler for meeting the mission readiness needs for OOTCW and MTW—besides live training—appears to be the Distributed Mission Training (DMT) concept.

DMT would provide a fully integrated simulation environment tying together geographically dispersed force elements (for example, combat, airlift, C^2, ISR assets, installation logistics, and force protection) in a common or correlated synthetic "battlespace" environment. This would allow mission training in numerous scenarios beyond those afforded by live exercises and would eventually support mission rehearsal. DMT would augment live training in a manner that would make those live opportunities more effective.

The advantages of DMT are obvious. The simulation environment allows a timely and cost-effective means for addressing a wide variety of missions, and it permits operations not possible in live exercises. The distributed architecture provides a "stay at home" feature to relieve OPTEMPO demands and offers the ability to draw from common databases to present reasonable facsimiles of the mission environment to all players. Pushed to its full potential, DMT could enable mission rehearsal in predeployment, en route, and deployed situations. Probably the most important feature of DMT is the opportunity it affords for development of interteam skills among heterogeneous and geographically dispersed mission elements characteristic of an AEF.

Current DMT focuses on the aircrew, reflecting ACC leadership's emphasis on upgraded fighter simulation training. Modules under development are the cockpit, image generator, visual display, and terrain-threat-event databases. In addition, Air Mobility Command (AMC) is starting to introduce its current simulators into the DMT environment. The addition of other force elements—for example, C^2, all ISR assets, and logistics—and the integration of all force elements has not yet been seriously undertaken.

[19] Elements from MGen Don Cook, USAF, "USAF GEO Supporting the National Military Strategy," June 1999.

Several technical problems in DMT remain unsolved. Given adequate funding, however, there appear to be no technical barriers to the development and deployment of effective DMT. The areas needing technical solutions include

- Developing adequate and timely information for the synthetic environment
- Representing effective threat and response environments
- Incorporating joint capability to accommodate the nature of MTW and OOTCW
- Understanding and accommodating network latencies
- Providing security
- Improving standards for DMT

The current commitment of planning and resources for DMT extends only to aircrew training and, in fact, is being called DMT-A to denote its scope. Motivated by many of the environmental factors highlighted in Section 9.0, ACC jumpstarted DMT with DMT-A, but the limits on what the command could initiate rapidly have introduced some potential downstream problems. The current DMT-A acquisition plan and operation and integration concept are not robust enough to be (nor were they intended to be) a proxy Air Force–wide acquisition strategy and integration architecture. The development and use of new simulators is being handled by individual fee-for-service contracts for each airframe, and as such, funding comes out of operations and maintenance accounts versus acquisition accounts, the former being highly vulnerable to overriding operational disruptions such as a Kosovo startup.

Integration of different airframes is starting to be addressed through the Aeronautical Systems Center, Training Systems Product Group efforts to select an operating and integration contractor to work on the first two simulator platforms (F-15 and F-16) being developed. However, the process did not start with an overall architecture, and hence integration is expected to encounter any number of simulator interoperability problems. For example, the fee-for-service arrangement for the ACC simulators does not permit specification of the battlespace environment to the contractor, making qualification testing of the underlying models impossible and correlation between different simulator platforms problematic. In contrast the AMC approach is acquisition based, giving Air Force evaluators full access to the contributing modules. However, affordability is dictating that AMC upgrade its legacy systems, which another study panel has found to be inadequate for effective training.

Moving beyond DMT-A, there is a DMT Capstone Requirements Document that was developed by ACC (in October 1998), but there exists no Air Force–wide integrating architecture, roadmap, or acquisition plan. A newly formed integrated product team for DMT is hoping to address many of these issues and enjoys participation from not just ACC and AMC representatives, but all the major Air Force commands, policy, and implementation offices. However, the user participants outside of ACC and AMC have no resource commitments, and XO and AQ have no clear champions in senior leadership to enforce integration.

9.2.3 Finding: Expeditionary Force Experiment (EFX) transition to doctrine, training, and exercises is ill defined.

There is not a clear transitional process for moving from EFX findings and recommendations to new technology insertion programs or doctrine changes within the Air Force. In the joint environment, USACOM conducts training for doctrine development and assessment through its Joint Training and Doctrine Program. This simulation-based effort allows for new joint doctrine development. More important, OOTCW doctrine development leadership is assigned to USACOM. A more recent program assigned to USACOM is the Joint Experimentation Program, which emphasizes transformation and

innovation and in which ideas for both MTW and OOTCW operations in the joint environment can be wrung out. The relative immaturity of the Joint Experimentation Program provides an opportunity for influencing the areas of focus.

Chapter 10
Recommendations

10.0 Recommendation Summary

The study resulted in 60 separate recommendations. Each of these is considered to be specifically defined and executable. Twelve are considered "major" recommendations with clearly identified actions and are described below. In addition, the study found seven recommendations involving overall Air Force policy or broad areas of technology or capability. The remaining recommendations are covered in the separate panel sections of Volume 2. The major recommendations are grouped in the following categories:

- Enable persistent ISR
  - Recommendations that allow the flexible, scalable, long-dwell ISR that OOTCW demand, while reducing the OPTEMPO impacts on the forces
- Develop and integrate ISR and dynamic planning
  - Recommendations that will improve or develop the integrated tools needed to apply ISR and battle management and planning in the effects-based operations environment
- Develop a spectrum of tailored weapons effects
  - Recommendations that will improve the lethal and non-lethal applications of aerospace power
- Maintain readiness and presence within OPTEMPO constraints
  - Recommendations that will reduce the impact on airlift, logistics, and training systems

While there is a relatively large number of recommendations, it should not be concluded that the Air Force must undertake a major overhaul to conduct OOTCW. To the contrary, the Summer Study concludes that the majority of the recommendations are applicable across the spectrum of operations. The recommendations are intended to build on current force structure and policy in ways that enhance the ability to conduct OOTCW while avoiding unique solutions applicable only to OOTCW.

Also, several of the recommendations are essentially in common with the results of the SAB's other major 1999 study effort on the Joint Battlespace InfoSphere (JBI). The Summer Study recommendations in this category offer specific, potential uses for the JBI and are identified as JBI-related for cross-reference to that study.

The following is a summary of the major and overarching recommendations.

10.1 Enable Persistent ISR

10.1.1 Recommendation 1: Expand ISR capabilities for UAVs to augment long-duration data collection. Start with air surveillance on Global Hawk.

Military Need: A robust capability is needed to supplement ISR functions currently performed by the LD/HD platforms. This capability will significantly reduce stress on current platforms and personnel while performing the same missions. It will be particularly useful for I&W in the Shape phase and for no-fly zone enforcement in the Reshape phase.

Capability Initiative:

Begin immediate development of a low-cost radar/IFF system for the Global Hawk UAV, based on the current technology base (AF/XO and SAF/AQ). Such a sensor and platform could provide augmentation of manned systems and provide I&W for air target situational awareness in situations such as no-fly zone enforcement. They would be self-deployable and immediately operable in theater.

In parallel, begin work on multi-intelligence (for example, SIGINT and measurement and signature intelligence) technologies suitable for deployment on UAVs (AF/XO and SAF/AQ).

10.1.2 Recommendation 2: Develop sensors and air-launched vehicles for ISR, targeting, and BDA

Military Capability: Capabilities are needed to provide long-duration, low-cost ISR, targeting, and BDA in a variety of OOTCW situations. Tasks include monitoring and defeat of new threats and shaping of the battlefield through knowledge and psychological operations. Subsystems exist to satisfy many of these needs. However, equally important is development of an integrated capability for delivering and employing such subsystems. Such a capability could also be useful for precise delivery of lethal and non-lethal effects.

Technology Initiative:

Develop a program to integrate newly developed low-cost sensors and air-launched and airdropped deployment vehicle technology for ISR, targeting, real-time BDA, and the delivery of both lethal and non-lethal systems (SAF/AQ).

- UAVs (high-altitude and medium-altitude) with standardized payload interfaces
- Small air vehicles (MALD, MAVs, and parafoils)
- Ultraprecision (< 1m), robust navigation
- High-g electronics
- Ultraminiature guidance systems
- Ultraminiature low-power electronics
- Microsensors (fuses, seekers, and MEMS: guidance, chemical and biological, acoustic and seismic, RF, IR)
- Modern communications (low-power, internetted, satellite) and C^2
- Robotics for end-game mobility

10.2 Develop and Integrate ISR and Dynamic Planning

10.2.1 Recommendation 3: Implement a force management capability for the EAF and for OOTCW

Military Capability: A force management system that supports the EAF in the application of aerospace power to OOTCW and enables dynamic effects-based planning, execution, and assessment, including strike, airlift, and training. Feedback consists of dynamic battle control, action or BDA, and effects assessment.

Capability Initiative:

Continue selective deployment of the TBMCS, but

- Immediately begin preparation of an operational architecture to ensure that TBMCS meets the needs of the EAF in OOTCW. Include logistics, training, and lift aspects (AC2ISRC).
- Assess the proper course of action for TBMCS according to this architecture (AF/XO and SAF/AQ)
- Establish a new function equivalent to AF/XOR for architectures and concept of operations for integrated force management systems (AF/XO)
- Develop C^2ISR education within the Air Force and establish appropriate specialty codes (AF/DP)

10.2.2 Recommendation 4: Lead the development and deployment of an integrated ISR-C^2 Information Management System

Military Capability: Meet stringent timelines for tailorable and continuously updated information on demand for warfighters worldwide. Provide dynamic ISR response to rapidly and significantly changing situations.

Capability Initiative:

Develop the operational architecture, functional requirements, and an implementation roadmap (AC2ISRC).

Pursue Air Force–owned elements of the roadmap (SAF/AQ).

Lead a joint DoD-intelligence community initiative for development and deployment (Air Force).

Use a demo to drive development of the following relevant technologies (SAF/AQ):

- Representation of information
- Information fusion
- Dynamic allocation of sensing assets
- Interaction with the user
- Performance assessment

10.2.3 Recommendation 5: Implement AEF communications for rapidly emerging crises

Military Capability: Provide EAF communications enabling immediate combat power for OOTCW crisis response anywhere, Global Grid access communications to support JBI, and direct links to operational platforms.

Capability Initiatives:

Multilevel secure communications architecture and requirements for OOTCW should be the same as for MTW with the added features of *rapid reconfigurability, scalability, and deployability*. The AEF hardware, software, and bandwidth environment should be the same as the home station so that we "fight the way we train" (AF/SC).

- Plan, program, and budget for implementing coalition interoperability for joint, combined, and civil EAF operations

- Implement a user requirements–driven acquisition process with an emphasis on the controller and shooter
- Conduct a top-level requirements review for aircraft antennas for a unified and integrated approach

10.3 Develop a Spectrum of Tailored Weapons Effects

10.3.1 Recommendation 6: Provide a capability for delivery of directed-energy effects

Military Capability: Provides the Air Force with a capability to disable or destroy electronic equipment (for example, computers and ignition systems) and other materiel, along with an antipersonnel capability without producing blast effects, death, or collateral physical damage.

Technology Initiatives:

Develop a family of air-deliverable directed-energy effects, including CW and pulsed HPM devices and high-energy lasers (SAF/AQ).

- Demonstrate an HPM "gun" integrated into airborne platforms
- Demonstrate air-delivered "mines" to halt or delay movement of enemy forces
- Accelerate development of all-solid-state laser devices for anti-materiel gunship and Fotofighter applications
- Accelerate development of compact high-efficiency aircraft electric prime power sources to enable directed-energy applications
- Demonstrate HPM self-defense devices for aircraft

10.3.2 Recommendation 7: Develop anti-materiel agent technologies, weapons, and delivery methods

Military Capability: A non-lethal capability to disable or deny the enemy the operation of mechanized vehicles, artillery, and communications equipment and to disrupt airfield operations and roadways.

Technology Initiatives:

Accelerate development of high-precision, air-deliverable non-lethal "munitions" from manned aircraft and UAVs (SAF/AQ).

Develop a family of supporting payload technologies incorporating aggressive, biodegradable agents such as (SAF/AQ):

- Supercaustic foams
- Conductive foams
- Embrittlement and depolymerization agents
- POL contaminants
- Superlubricants

Simultaneously develop key attendant elements (effectiveness models, planning tools, BDA, ROE, and countermeasures) (AF/XO, SAF/AQ).

10.3.3 Recommendation 8: Develop methods for destroying or neutralizing chemical and biological agents in bunker storage

Military Capability: Neutralization of chemical and biological agents in bunker storage situations, with no collateral effect.

Technology Initiatives:

Develop the intelligence capability to provide precise storage location in three dimensions—"the right room" (AF/XO).

Develop the capability to deliver a weapon into the storage location (SAF/AQ).

- Precision delivery of the survivable penetrating body
- Precision fuzing to function in the right place

Conduct an R&D program on an intense heat source (SAF/AQ).

10.3.4 Recommendation 9: Exploit the potential of UAVs for delivery of lethal and non-lethal effects

Military Capability: Flexible modular UAVs and UCAVs provide low-cost, long-endurance delivery platforms for a broad spectrum of weapon effects. They provide a low-risk means to fill the gaps in the continuum of required force capability.

Capability and Technology Initiatives:

Develop a family of UAVs and UCAVs with standard payload modules for air delivery of lethal and non-lethal effects (AF/XO and SAF/AQ):

- Define and develop low-cost, modular UAV and UCAV platform systems
- Develop a family of UCAV weapons for the deep precision attack of mobile targets
- Define and develop HPM, laser, gun, dispenser, and jamming modules
- Develop associated external systems for C^4I and logistics support

Simultaneously develop key attendant elements (effectiveness models, planning tools, BDA, ROE, and countermeasures) (AF/XO and SAF/AQ).

Continue development of the UAV and UCAV technology base (SAF/AQ).

10.3.5 Recommendation 10: Accelerate development of air-deliverable lethal miniature munitions

Military Capability: Tailored lethal effects on fixed and mobile targets with low collateral effects. Requires autonomous miniature munitions with high precision for effective use on manned and unmanned platforms.

Capability Initiative:

Develop a family of miniature munitions (SAF/AQ):

- Accelerate initiation of LOCAAS engineering and manufacturing development (EMD).
- Accelerate initiation of Small Smart Bomb EMD

10.4 Maintain Readiness and Presence Within OPTEMPO Constraints

10.4.1 Recommendation 11: Create a Distributed Mission Readiness System from the Distributed Mission Training concept

Military Capability: A robust and flexible Air Force–wide Distributed Mission Readiness System (DMRS) that integrates all force elements to help train AEF personnel and help them rehearse for full-spectrum global engagement (MTW and OOTCW).

Capability Initiatives:

Establish overall Air Force leadership for DMRS (AF/XO).

Implement the Capstone Requirements Document for DMT and develop it into the Air Force DMRS.

- Air Force–wide plans, architecture, and roadmap (AF/XP and AF/XO)
- Formal acquisition strategy and force management plan (SAF/AQ)
- DMRS system program office to manage transition and integration (SAF/AQ)

Maintain priority of current DMT efforts to bridge to DMRS (SAF/AQ and AF/XO).

Address major DMRS technical issues (SAF/AQ).

- Multilevel security/need-to-know, latency issues, and behavioral models
- Leverage related efforts in other services, USACOM, DARPA, and outside agencies

10.4.2 Recommendation 12: Improve airlift responsiveness to OOTCW situations while reducing OPTEMPO impacts

Military Capability: Deliver people and cargo on time. Meet the mobility requirements of OOTCW without the benefit of mobilization or CRAF activation.

Process Initiatives:

- Size the airlift force structure on the larger of OOTCW or MTW requirements (AF/XP)
- Reevaluate the active/ARC force mix; increase the active crew ratio (AF/XO)
- Examine alternative depot maintenance concepts for the KC-135 fleet (AF/IL)
- Procure the right mix of C-130Js, C-130s, and C-17s (AF/XP)

Capability Initiatives:

- Upgrade the C-5 to the most cost-effective reliability (AF/XP)
- Install C-17 center wing tanks (SAF/AQ)
- Continue the C-130 Avionics Modernization Program (SAF/AQ)
- Pursue simulator alternatives to proficiency flight training (SAF/AQ)
- Accelerate the KC-135 multipoint, soft-basket refueling capability to free KC-10s (AF/XP)
- Procure the Next Generation Small Loader (SAF/AQ)

10.5 Overarching Recommendations

10.5.1 Global Positioning System: GPS is critical to OOTCW. As recommended by the SAB since 1993, the Air Force should improve the accuracy and survivability.

Most of the weapons that will be used by the Air Force in the 21st century will depend on the GPS for guidance in at least part of their trajectories. The use of GPS guidance has resulted in significant reductions in cost of precision-guided munitions and a substantial improvement in accuracy. GPS guidance is also all weather, and all-weather terminal seekers are more expensive than GPS systems by a factor of as much as ten. The use of GPS-guided munitions will produce desired effects while saving billions of dollars in weapon costs.

It is well known, however, that the GPS signal received at the surface of the earth is very weak. The raw signal, before processing, is well below the thermal noise. Commercial interests in several countries, including Russia, France, and Germany now produce GPS jammers. We are aware of ways to increase the jam resistance of GPS receivers substantially to the point where jammers will become so large that they will become expensive and will be targets for radiation-seeking weapons. Accomplishing this goal requires modernization of both satellites and user equipment. The path to improved jam resistance is well known, but it is not free. The civil GPS signals also require updating.

Proposals have been made to modify the Block II R satellites, which are currently being launched, and the next generation of satellites, the Block II F, to include both military and civil enhancements. On the military side, enhancements include the addition of a new military ranging code and a new data message and increases in the power transmitted by the satellite. Civil enhancements include addition of a civil code on existing frequencies and the generation of an additional civil frequency. The proposed enhancements will result in more protection for this essential weapon system and will make it easier for us to deny the capability to our enemies.

We recommend that the Air Force collaborate with the Department of Transportation to upgrade both the civil and military capabilities of the GPS. If the Block II R and early Block II F satellites are not modified, it will be at least 2015 before enhanced capabilities can be made available. It is essential to begin the modernization process now.

The need for higher precision in weapon delivery has been widely publicized. The development of smaller explosive devices that will produce effects equivalent to, or better than, current guided munitions is under way. The least expensive and most accurate method of guiding the new generation of highly accurate weapons is by use of GPS. GPS-guided weapons can provide high precision at a cost approximately one-tenth that of a terminal sensor of similar accuracy. Thus, GPS guidance will save the Air Force tens of billions of dollars during the next decade. Cost savings will be more than the cost of the necessary system upgrades.

The key to realizing the full advantages of GPS guidance, though, depends on the achievement of adequate accuracy. The next generation of bombs, which are likely to be in the 500-pound class or smaller, will need to be delivered with errors of 2 meters or less. At present, the GPS is not capable of delivering positioning information at this precision, but achieving such accuracy is possible if straightforward improvements are made in the GPS constellation and ground systems. Positioning accuracy of 1 meter, or better, with high jamming resistance can be achieved during the next decade if proposed improvements are made.

We recommend, therefore, that the Air Force support upgrades to satellites, ground stations, and user equipment to achieve a basic system accuracy of 1 meter, or better, without the aid of secondary accuracy enhancements, such as local differential GPS.

10.5.2 EAF: To successfully transition to an EAF the Air Force should broaden its focus to encompass training, communications, deployment, weapons, and forward support basing recommendations from the 1997 SAB Summer Study and this current Summer Study.

The Air Force move toward becoming "expeditionary" will be a great contributor toward more success in conducting OOTCW. However, the EAF is only starting to crawl, and several areas need more emphasis. These areas include training, communications, deployment, weapons, and basing options. The 1997 study on Aerospace Expeditionary Forces presented many recommendations in these areas that have not yet been implemented, but are needed to successfully and efficiently conduct OOTCW.

The culture of the Air Force must adapt to the rapid small operations characteristic of OOTCW, even while it maintains its traditional capabilities. In many instances OOTCW is not a lesser included case of MTW, although it is treated as such in virtually every Air Force function, including planning, training, equipping, and organizing.

The necessary tools, databases, support structure, and organization needed to embrace OOTCW do not exist in places in the Air Force. In particular, the unique planning, logistics, and training aspects unique to OOTCW need to be developed, fielded, and exercised throughout the Air Force.

The Air Force should review and act upon the recommendations of the 1997 SAB Aerospace Expeditionary Forces Study including

- Exercising with minimal notice and including logistics aspects and OOTCW unique weapons
- Establishing appropriate worldwide databases for deployment
- Fielding rapid-planning tools
- Pre-negotiating diplomatic clearances and host nation support where possible
- Establishing Regional Contingency Centers

10.5.3 Non-Lethal Weapons: The Air Force should develop a comprehensive vision and strategy that takes into full account all potential roles of non-lethal weapons, including "variable effect" and delivery from air and/or space. Integration into the overall response continuum is essential.

Non-lethal warfare is fast emerging as an important new arrow in the warrior's quiver. DoD has established policy for non-lethal weapons, the Defense Planning Guidance has decreed consideration of non-lethal weapons in planning, and the Joint Non-Lethal Weapons Directorate (JNLWD) has been established with the U.S. Marine Corps as the DoD executive agent for the development of equipment and procedures.

The Air Force can and will be a major component of the nation's capability in future OOTCW. Its strategy, vision, and plans must reflect how aerospace power can contribute using non-lethal weapons and means to avoid being less relevant in the 21st century. Toward that end, Air Force leaders must be educated on non-lethal weapons, and aerospace-delivered non-lethal weapons must be included in the development of Air Force capabilities. During the course of the panel's study, no such strategy, vision, or plans were found to exist within the Air Force.

In order to be a significant player in non-lethal warfare, the Air Force needs a strategic vision and strategy for integrating non-lethal means into its arsenal. This includes (1) a doctrinal basis for the Air Force's strategic plans and vision, (2) plans to include the development of non-lethal weapons to be delivered from aerospace platforms, (3) educating Air Force leadership on non-lethal weapons/means, and (4) the Air Force taking its place with the other Services in the development and integration of joint Services (the Air Force should be more involved in the JNLWD).

Specifically, the Air Force should

- Develop a comprehensive strategy that takes into full account all potential roles and uses of non-lethal weapons, including delivery of non-lethal effects from air and/or space for strategic and/or tactical purposes
- Develop a vision that realizes the "variable lethality" concept
- "Catch up" and cooperate with the other Services in the ability to effectively employ non-lethal capabilities
- Develop a comprehensive acquisition strategy to develop, test, and procure non-lethal weapons for air operations

10.5.4 Ensure the RRP remains viable to define, develop, and deploy urgent, time-sensitive systems identified by the commanders in chief (CINCs) as critical to combat operations, including OOTCW.

OOTCW require development and fielding of urgent, time-sensitive, and new capabilities by use of a very rapid and responsive acquisition process. To give operational commanders a means to meet urgent wartime requirements, a process was developed and implemented by DoD. The RRP had its origins in Desert Shield and Desert Storm and has continued in use during the crises in Bosnia and Kosovo. It is implemented in Air Force Instruction 63-114, dated 5 May 1994. Compliance is mandatory. The RRP recognizes the ability of the CINCs, major commands, and headquarters to identify the critical situations that require urgent, time-sensitive solutions for OOTCW as well as conventional war.

Use of the RRP in crises such as Bosnia and Kosovo (where over 20 combat mission need statements were acted on) shows its utility for OOTCW.

The RRP provides results across a wide variety of mission areas and is generally regarded as a success; however, some have argued that its limitation to critical and urgent war fighting needs allows the other acquisition programs to remain unaffected and thus too far removed from the CINC's influences.

This Summer Study reiterates the need, expressed in earlier SAB reports, to improve the cycle times for system development and to continue other essential acquisition process reforms for the normal acquisition process and procedures. However, in our judgment there are no unique requirements for additional acquisition process changes that are driven solely by OOTCW. We fully endorse continued use of the RRP in meeting critical, urgent, time-sensitive, and theater-specific OOTCW requirements.

10.5.5 Offensive/Defensive Information Warfare: Ensure that the development of strategies, concepts, and techniques for offensive and defensive information warfare are closely coupled for maximum effectiveness.

Defensive and Offensive Information Warfare have different objectives and are carried out by different organizations. The Force Management Panel examined Defensive Information Warfare and Information Assurance, while the Non-Lethal Effects Panel examined Offensive Information Warfare. At the execution level, the distinction and separation of the two areas are proper. However, at the science and technology level, at the development of strategies, concepts, and techniques, the two areas should be closely linked and, indeed, each community should provide an intellectual and operational challenge to the other. The argument in favor of the close linking of the two is perceived to be much stronger than the argument in favor of separation for security reasons.

The rapidly changing information collection, storage, and dissemination environment, where the means (hardware and software) for access are becoming widely available and inexpensive, indicates that a

substantial advantage may be obtained by the timely exploitation of a new capability or vulnerability. That advantage, however, will last only a short period of time: until it becomes widely known and countermeasures are taken. The exploitation of a temporary advantage rewards those who can identify and act in a timely manner—whether to exploit the adversary's temporary vulnerability or to protect our information from that vulnerability, or both.

Consequently, it stands to reason to encourage cross fertilization of ideas, strategies, and techniques from both offensive and defensive points of view. At the same time that a perceived vulnerability appears, we should be developing simultaneous techniques for exploiting it and techniques for protecting ourselves, were the adversary to recognize the same vulnerability. Similarly, the identification of a temporarily effective technique used by an adversary should lead to the rapid analysis and exploitation of the technique by our forces in appropriate situations.

The key notion here is that a sequence of narrow windows of opportunity will be appearing as the information systems become more complex and more integrated. The timely recognition of these windows, and their concurrent exploitation in Offensive information operations (IO) and protection of our systems through Defensive IO, mandate that the Defensive and Offensive IO communities be closely coupled, sharing concept definition, science and technology investments, and the development of strategies and techniques.

10.5.6 Defensive Information Warfare: The critical requirement for information superiority suggests increased emphasis on defensive information warfare, including assessment of detected threats and development of responses.

The rapid development and proliferation of information technology and the availability of the means and the knowledge to attack military information systems and civilian ones on which military operations depend, has made information assurance one of the pillars of information superiority. Effective information assurance requires the reduction—to the extent that is technologically and operationally feasible—of the vulnerability of our networks and the information they carry, and the ability to detect, assess, and take effective action against attacks.

Defensive Information Warfare was an area that was addressed by the Force Management Panel to the extent possible within the classification parameters of the study. It was observed that the Air Force has made substantial progress in addressing selected aspects of the problem in parallel with related DoD efforts. Firewalls, network monitoring, and website reviews are in place. The requirements of OOTCW require enhanced vigilance because such operations generally require collaboration and sharing of information with a wide variety of civilian and nongovernmental organizations.

One of the complexities of the problem is that it is very dynamic; once a defense to a problem has been found and implemented, the adversary will seek to exploit a new vulnerability. Furthermore, layering all available safeguards may degrade performance. Therefore, protection mechanisms have to be employed selectively so as to minimize vulnerability while not causing a decrease in capability.

One can safely assume that our information systems cannot be made perfectly invulnerable so as to discourage attacks from adversaries, that is, protection cannot be complete and absolute. We need to focus on how to detect, assess, and respond to threats, whether they consist of isolated intermittent attacks over a long period of time or massive attacks over a short period. The panel observed that major progress has been achieved in the detection part. But that is not sufficient. Tools and techniques need to be developed that will allow a timely assessment of the effect of the attack, both in terms of identifying specific system vulnerabilities but also in terms of the information and systems that may have been compromised. Furthermore, there is need for a whole spectrum of responses as well as a set of guidelines

for matching the type of threat with the appropriate response so as not to compromise our information assets. While significant efforts along these lines have been undertaken within AFRL in concert with other relevant DoD entities (for example, DARPA and Defense Information Systems Agency), the panel observed that while protection and detection efforts are moving forward, attack assessment and especially response selection (for example, whether to contain, deny, or destroy the attacker) need an infusion of ideas and concepts. Particular attention should be paid to the attack from within—to assess its (potential) damage and develop strategies for its containment.

10.5.7 Technology Funding: Ensure that funding is available to laboratory managers to focus on promising technologies and revolutionary capabilities. Encourage industry-independent research and development managers to do the same.

There are a number of factors that currently hinder the Air Force's ability to engage in the necessary "technology push" for revolutionary OOTCW-related capabilities. These include the current defense planning process and the focus in the research, development, and acquisition process on users ("customers") who are quite unlikely to generate requirements for new and revolutionary capabilities ("technology pull") which take full advantage of the possibilities offered by enabling technologies.

Because the current defense planning paradigm tends to focus on major theater wars and tends to treat OOTCW operations as "lesser-included cases", it is incumbent on the Air Force to ensure that the unique or more stressing requirements of OOTCW operations are considered carefully in the requirements, research, development, and acquisition process. Because of the high peacetime OPTEMPO and budget pressures, there is tension between current operations and extant tasking. Investing in, or even considering, requirements for new and revolutionary OOTCW (or even MTW) capabilities that might dramatically improve performance or reduce costs tends to be neglected. This will require constant attention.

Finally, the need for improving the technology push for OOTCW-relevant capabilities includes the need to improve the Air Force's process for developing revolutionary technology breakthroughs that can provide the precision, survivability, and other performance characteristics of aerospace power that are needed in an OOTCW setting, and can provide forces that are more suitable to the tight constraints (for example, on friendly casualties and collateral damage) that are frequently imposed on aerospace operations.

We recognize that fiscal constraints and acquisition policy drive the acquisition community to expend most of their effort on user requirements, rather than pursuing revolutionary technology breakthroughs. Nevertheless, science and technology (S&T) resource allocations must assure a balance between technology pull and technology push. It should be remembered that without an unyielding technology push, the Air Force would not have the E-3 AWACS, the E-6C JointSTARS, and the F-117 Stealth Fighter.

The Air Force should continue its efforts to anticipate the emerging requirements of the OOTCW mission area, as well as enabling technology push solutions. This will require changing the incentives and resources that are available to technology developers to better ensure that the technology base will continue to provide revolutionary breakthroughs. A system of incentives and exchanges is required to reduce the constraints on researchers who are doing long-term (revolutionary) work and to make a more systematic effort to educate consumers (the warfighters) about the possible operational concepts that might be enabled by technology breakthroughs.

More specifically, SAF/AQ must ensure the balance of resource allocations such that the S&T community

- Is responsive to the long-term operational capability requirements formally established by the warfighter
- Is responsive to short-fuse urgent breakthrough needs identified by operational and technical activities
- Can conduct developments under the discretion of the Lab Directors to take into account both innovative technical concepts and anticipated future warfighter needs

Chapter 11
Relevance

11.0 Study Recommendations Mapped to GEO

Tables 4 through 8 present the 19 major achievable recommendations in a GEO context. Listed across the top of each matrix are our study recommendations. The rows of each matrix represent the phases of GEO and the next major level of indenture, the GEO elements. If a particular recommendation has relevance to a GEO element, an entry is shown at that intersection. The entry is the abbreviation for the study panel that proposed the recommendation. Additional detail on the recommendation can be found in that panel's chapter of Volume 2.

Table 4. *GEO Matrix, Shape Phase*

	Enable Persistent ISR					**Develop and Integrate ISR and Dynamic Planning**				**Develop and Integrate Lethal/ Non-Lethal Weapons Effects**						**Enable Enduring Presence Within OPTEMPO Constraints**			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Shape Phase																			
Maintain readiness, home defense, and deterrence through aerospace power	I&V LE	LE	I&V	LE	I&V		I&V		D&S		LE	LE	LE	LE		ETE	D&S	ETE	D&S LE
Enhance global awareness from air and space	I&V LE	LE	I&V		I&V		I&V								NLE			ETE	
Rely on air mobility to underwrite global presence and forward basing									D&S							ETE	D&S	ETE	D&S
Provide tailored aerospace expeditionary forces worldwide	I&V LE	I&V LE		LE	I&V	FM	I&V		D&S	NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE
Deliberate planning and force structure requirements development **(new SAB recommended element)**	LE				I&V	FM		FM	D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE		ETE	
Train and exercise for all missions **(new SAB recommended element)**	LE	LE		LE	I&V				D&S	NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	LE

Table 5. *GEO Matrix, Deter Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Deter Phase																			
Focus aerospace intelligence, surveillance, and reconnaissance to conduct appropriate information operations	I&V LE	I&V LE	I&V	LE	I&V		I&V						NLE	NLE	NLE	ETE		ETE	
Conduct integrated crisis action planning **(new SAB recommended element)**	LE	LE				FM			D&S	NLE	NLE	NLE	NLE		NLE	ETE		ETE	
Strengthen the strategic air bridge	LE						I&V	FM	D&S				NLE			ETE	D&S	ETE	D&S
Respond rapidly with forward and home-based Aerospace Expeditionary Forces and arrive ready to execute the mission	I&V LE	I&V LE	I&V		I&V		I&V		D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Employ dynamic command and control and agile logistics	LE					FM	I&V	FM	D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	

Table 6. *GEO Matrix, Halt Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Halt Phase																			
Exploit information operations	I&V LE	I&V	I&V		I&V		I&V	D&S	D&S				NLE		NLE			ETE	LE
Employ precise and decisive aerospace power	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE
Master asymmetric strategies	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE			ETE	D&S LE
Sustain deployed forces **(new SAB recommended element)**	LE								D&S							ETE	D&S	ETE	D&S LE
Find, fix, track, target, and engage anything significant in near–real time and assess effects	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE		ETE	LE

Table 7. *GEO Matrix, Win Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Win Phase																			
Continue to counter adversary capabilities with precision	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE			ETE	LE
Hold at risk strategic, operational, and tactical targets	I&V LE	I&V LE	I&V	LE			I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE		ETE	LE
Enforce political, economic, and military sanctions with aerospace power	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	LE	NLE LE	NLE	NLE	ETE	D&S	ETE	D&S LE
Sustain deployed forces through agile combat support **(new SAB recommended element)**	LE							FM								ETE	D&S	ETE	D&S
Integrate aerospace forces into the combined counteroffensive	I&V LE	I&V LE	I&V	LE		FM	I&V			NLE	NLE LE	NLE LE	NLE LE	NLE LE	NLE	ETE	D&S	ETE	D&S LE

Table 8. *GEO Matrix, Reshape Phase*

	Enable Persistent ISR					Develop and Integrate ISR and Dynamic Planning				Develop and Integrate Lethal/ Non-Lethal Weapons Effects						Enable Enduring Presence Within OPTEMPO Constraints			
Elements	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	Improve ISR for Transnational and Terrorist Threats	Noncooperative Target Identification Techniques	Global Intelligence Guide	Force Management Capability for the EAF	Shift From the ISR TCPED to a Warfighters' Information Management Process	EAF Communications for Rapidly Emerging Crises	Integrate Planning and Execution Systems	Directed-Energy Non-Lethal Effects	Antimateriel Agent Technologies	Neutralize a Chem/Bio Attack	UAVs for Delivery of Lethal and Non-Lethal Effects	Air-Deliverable Lethal Miniature Munitions	Air-Deliverable Information Warfare Capability	Create a DMRS From the DMT Concept	Increase Airlift Capacity	OOTCW in Experiments, Training, Exercises, Doctrine, and Education	Personnel and Aircraft Protection in OOTCW scenarios
Reshape Phase																			
Enhance post-crisis stability with a skilled and motivated aircrew	LE								D&S	NLE					NLE	ETE	D&S	ETE	LE
Redeploy and reconstitute forces **(new SAB recommended element)**	LE					FM			D&S								D&S	ETE	D&S LE
Sustain heightened readiness to react decisively to a renewed crisis	I&V LE	I&V	I&V			FM	I&V		D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Rely on agile combat support to react rapidly with Aerospace Expeditionary Forces	LE								D&S	NLE	NLE	NLE	NLE	NLE	NLE	ETE	D&S	ETE	D&S LE
Maintain global and situational awareness	I&V LE	I&V	I&V				I&V								NLE			ETE	LE

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Appendix A
Terms of Reference

USAF Scientific Advisory Board 1998 Study on
Technology Options to Leverage Aerospace Power in Other Than Conventional War Situations

BACKGROUND: In the 21st century as in the past, the nation will continue to rely on the Air Force to be ready to fight and win historically conventional conflicts, such as Desert Storm. This will compel the composition of the major portion of our force structure. As evidenced by the decade of the 1990s, though, the country will increasingly be involved in less-traditional situations and conflicts, such as those in Bosnia, Kosovo, and others. We will need to be able to prevent the employment of weapons of mass destruction, forestall adversary actions against civilians, operate in urban areas occupied by many civilians, or accomplish any number of less-traditional missions. These operations will often include joint and coalition forces. Rules of engagement may be politically constrained. Success or failure will be known worldwide in real time. It is essential that the nation be able to rely upon the Air Force in all these situations, especially for the flexibility and responsiveness that aerospace power provides. Viewed in the context of the evolution into an expeditionary force structure, it will become increasingly essential that our ability to respond in these nontraditional situations not be limited to only one segment of the Aerospace Force. To ensure this, the Air Force must be able to use the full array of aerospace forces, to understand orders of battle for the varied environments in which we may be called upon to enter, and then to provide appropriate enabling actions to achieve theater commander objectives or pave the way for follow-on forces that may be necessary.

STUDY PRODUCTS: Briefing to SAF/OS and the Air Force Chief of Staff in October 1999. Publish report in December 1999.

CHARTER: In the near (2005), mid (2010) and far (2015) time frames:

1. Review operations conducted in the past decade (Rwanda, Somalia, Kosovo, Bosnia, and others) and identify successes and limitations of force application where aerospace forces, as is or modified, could have improved outcomes.

2. Posit future situations or vignettes that are representative of “less-traditional” operations that the nation is likely to depend on the Air Force to support.
   - Identify the objectives and tasks to be performed
   - Assess the capability of the programmed Air Force force structure to accomplish the tasks within operational concepts
   - Identify deficiencies
   - Survey sister Services’ capabilities and programs to see whether they mitigate deficiencies
3. Survey the technology options available and suggest the technologies that should be pursued.
   - For the near term emphasize those more in accord with current operational art
   - For the farther terms, highlight the scientific and technological trends
   - Note those which will be accordant with current Air Force force structure plans and those that may require accommodation in plans
   - Consider destructive and non-destructive methods, as well as lethal and non-lethal
4. Identify testing or demonstrations being planned or conducted necessary for testing the concepts and systems. Recommend appropriate Air Force involvement.

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Appendix B
Study Organization

Study Chair
Mr. Tom McMahan

Deputy Study Chair
Dr. Peter R. Worch

SAB Military Director
Lt Gen Gregory Martin

Senior Officer Participant
Brig Gen Ben Robinson

Senior Civilian Advisor
Mr. John Welch

SAB Executive Director
Col Robert J. Schraeder, Jr.

SAB Study Executive Officer
Maj Douglas L. Amon, AF/SB

Navy Advisor
CDR Terrance Jones

Army Advisor
Col Robert Stewart

Panel Chairs
Intelligence and Vigilance Panel: Dr. Matthew W. Ganz
Deployment and Sustainment Panel: Dr. Ronald P. Fuchs
Non-Lethal Effects Panel: Dr. Peter R. Worch
Lethal Effects Panel: Maj Gen George B. Harrison, USAF (Ret)
Force Management Panel: Prof. Alexander H. Levis
Experiments, Training, and Exercises Panel: Dr. Miriam E. John

Intelligence and Vigilance Panel

Dr. Matthew W. Ganz, Chair
Vice President, Programs
The Charles Stark Draper Laboratory, Inc.

Dr. Darryl P. Greenwood, Deputy Chair
Senior Staff Member, Aerospace Division
Massachusetts Institute of Technology Lincoln Laboratory

Dr. Peter A. Swan
Chief Engineer and Vice President
SouthWest Analytic Network, Inc.

Prof. Alan S. Willsky
Professor, Electrical Engineering and Computer Science
Massachusetts Institute of Technology

Dr. Michael I. Yarymovych
Chief Scientific Advisor
ANSER, Inc.

RADM Thomas C. Betterton, USN (Ret)
Space Technology Chair
Naval Postgraduate School

Lt Gen Lincoln D. Faurer, USAF (Ret)
Consultant

Mr. Rich Haas
Principal Director, System of Systems Architecture Directorate
The Aerospace Corporation

Executive Officer: Maj Todd A. Brooks, AFIWC/OSR
Technical Writer: Maj Sarah E. Zabel, USAFA

Deployment and Sustainment Panel

Dr. Ronald P. Fuchs, Chair
Director, System of Systems Architecture Development
The Boeing Company

Mr. Bernard L. Koff
Private Consultant

Prof. Ann R. Karagozian
Department of Mechanical and Aerospace Engineering
University of California, Los Angeles

Mr. Harry P. Arnold
Consultant

Dr. John M. Borky
Chief Engineer, Information and Technical Services Strategic Business Unit
TRW Systems and Information Technology Group

Lt Gen Gordon E. Fornell, USAF (Ret)
Dayton Aerospace Inc.

Maj Gen Ray M. Franklin, USAF (Ret)
Consultant

Lt Gen Edwin E. Tenoso, USAF (Ret)
Deputy Director, C-130 AMP
Lockheed Martin Corporation

Lt Gen John Fairfield, USAF (Ret)
DynCorp

Government Participant: Maj Lewis E. Butler, AF/ILX

Executive Officer: Maj Stephen D. Walters, AMC/XPXST
Technical Writer: Capt Kevin L. Berkompas, USAFA/DFPS

Non-Lethal Effects Panel

Dr. Peter R. Worch, Chair
Systems Development Consultant

Dr. Gene H. McCall, Deputy Chair
Laboratory Fellow
Los Alamos National Laboratory

Dr. Elsa Reichmanis
Head, Polymer and Organic Materials Research Department
Bell Laboratories, Lucent Technologies

Dr. Alan C. Eckbreth
Director, Aeromechanical, Chemical, and Fluid Systems
United Technologies Research Center

Dr. Armand J. Chaput
Company Specialist
Lockheed Martin

Dr. James D. Lang
Consultant

Mr. Don Wurzel
Corporate Senior Engineer
Areté Associates

Maj Gen Hugh L. Cox, III, USAF (Ret)
Consultant

Dr. Shari Thomas
AFRL Commander's Representative to HQ AFSOC
AFRL/XPW

Executive Officer: Capt Daniel F. Dailey, AFSOC/XPPP
Technical Writer: Maj John R. Higgs, USAFA

Lethal Effects Panel

Maj Gen George B. Harrison, USAF (Ret), Chair
Director, Research Operations
Georgia Tech Research Institute

Mrs. Natalie W. Crawford
Vice President and Director, Project AIR FORCE
RAND

Dr. Robert W. Selden
Consultant

Dr. Jason L. Speyer
Department of Mechanical and Aerospace Engineering
University of California, Los Angeles

Maj Gen Donald L. Lamberson, USAF (Ret), Ph.D.
Consultant

Dr. John P. Howe, III
President
University of Texas Health Science Center

Dr. Eric Larson
Policy Analyst
RAND

Maj Gen Donald Shepperd, USAF (Ret)
Consultant

Executive Officer: Maj Robert Johnson, ACC/XOFM
Technical Writer: Maj Timothy M. Scully, USAFA

Force Management Panel

Prof. Alexander H. Levis, Chair
Professor
George Mason University

Dr. Thomas A. Brackey, Deputy Chair
Executive Director, Technical Operations
Hughes Space and Communications Company

Mr. Jeffery B. Erickson
Manager, Crew Systems
The Boeing Company

Mr. Roger Carter
Program Manager, Advanced Information Systems
Lockheed Martin Corporation

Dr. Michael G. Sovereign
Consultant

Maj Gen John A. Corder, USAF (Ret)
Consultant

Col Mike Nowlin, USAF
Director of Operations
AFCIC

CDR Terry Jones, USN
N-88-CNA

Government Participant: Maj Michael K. Taylor, USAF
National Reconnaissance Office

Executive Officer: Capt Loretta Krakie, AC2ISRC/C2A
Technical Writer: Capt David R. King, USAF Academy (Department of Management)

Experiments, Training, and Exercises Panel

Dr. Miriam E. John, Chair
Vice President, California Division
Sandia National Laboratories

Dr. William F. Ballhaus, Jr., Deputy Chair
Vice President, Science and Engineering
Lockheed Martin Corporation

Prof. M. Elisabeth Pate-Cornell
Department Chair, Industrial Engineering and Engineering Management
Stanford University

Lt Gen Everett Pratt, USAF (Ret)
Consultant

Ms. Carol A. Yarnall
Director, Military Liaison and Knowledge Management Center
Sandia National Laboratories

Executive Officer: Capt Cameron D. Humphres, DET2/53WG
Technical Writer: Capt Wade H. Vaught, USAFA/DFEM

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Appendix C

Acronyms and Abbreviations

ABIS	Advanced Battlespace Information System
AC2ISRC	Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center
ACC	Air Combat Command
AEF	Aerospace Expeditionary Force
AFB	Air Force Base
AFRL	Air Force Research Laboratory
AF/DP	Air Force Deputy Chief of Staff, Personnel
AF/IL	Air Force Deputy Chief of Staff, Installations and Logistics
AF/SC	Air Force Deputy Chief of Staff, Communications and Information
AF/XO	Air Force Deputy Chief of Staff, Air and Space Operations
AF/XOF	Air Force Directorate of Security Forces
AF/XON	Air Force Directorate of Nuclear and Counter-Proliferation
AF/XOR	Air Force Directorate of Operational Requirements
AF/XP	Air Force Deputy Chief of Staff, Plans and Programs
AMC	Air Mobility Command
ARC	Air Reserve Component
ARS	Airborne Radar Study
ASOC	Assured Support to Operational Commanders
ATL	Airborne Tactical Laser
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
BMC^2	Battle Management Command and Control
C^2	Command and Control
C^4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CBW	Chemical and Biological Weapons
CINC	Commander in Chief
COA	Course of Action
COP	Common Operating Picture
CRAF	Civil Reserve Air Fleet
CSAR	Combat Search and Rescue
CW	Continuous Wave
DARPA	Defense Advanced Research Projects Agency
DMRS	Distributed Mission Readiness System
DMT	Distributed Mission Training
DMT-A	Aircrew Distributed Mission Training
DoD	Department of Defense
EAF	Expeditionary Aerospace Force
EEI	Essential Elements of Information
EFX	Expeditionary Force Experiment
EMD	Engineering and Manufacturing Development
ETE	Experiments, Training, and Exercises
EW	Electronic Warfare

GEO	Global Engagement Operations
GEO	Global Expeditionary Operations
GPS	Global Positioning System
HPM	High-Power Microwave
HSI	Human-System Interface
HUMRO	Humanitarian Relief Operation
I&W	Indications and Warning
IFF	Identification–Friend or Foe
INS	Inertial Navigation System
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
JBI	Joint Battlespace InfoSphere
JEFX	Joint Expeditionary Force Experiment
JFC	Joint Force Commander
JNLWD	Joint Non-Lethal Weapons Directorate
JointSTARS	Joint Surveillance, Target, and Attack Radar System
LD/HD	Low-Density, High-Demand
LOCAAS	Low Cost Autonomous Attack System
MALD	Miniature Air Launched Decoy
MANPAD	Man-Portable Air Defense
MAV	Micro Air Vehicle
MEMS	Micro Electro-Mechanical Systems
MTW	Major Theater War
NATO	North Atlantic Treaty Organization
NEO	Noncombatant Evacuation Operation
NGO	Nongovernmental Organization
NLW	Non-Lethal Weapons
NMS	National Military Strategy
OOTCW	Operations Other Than Conventional War
OPINTEL	Operational Intelligence
OPTEMPO	Operational Tempo
OSD	Office of the Secretary of Defense
PERSTEMPO	Personnel Tempo
POL	Petroleum, Oil, and Lubricants
QDR	Quadrennial Defense Review
R&D	Research and Development
RF	Radio Frequency
RJ	Rivet Joint
ROE	Rules of Engagement
RRP	Rapid Response Process
S&T	Science and Technology
SAB	Air Force Scientific Advisory Board
SAF/AQ	Assistant Secretary of the Air Force, Acquisition
SAM	Surface-to-Air Missile
SAR	Special Access Required
SEAD	Suppression of Enemy Air Defenses
SIGINT	Signals Intelligence
TBMCS	Theater Battle Management Core System
TBMD	Theater Ballistic Missile Defense
TCMD	Theater Cruise Missile Defense

UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Air Vehicle
UN	United Nations
USACOM	U.S. Atlantic Command
UTC	Unit Type Code
WMD	Weapons of Mass Destruction

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Appendix D
Top-Level Organizations Visited

21st Air Force

33rd Fighter Wing

36th Special Reconnaissance Squadron

53rd WG/EW

58th Special Operations Wing

621st Air Mobility Operations Group

Aeronautical Systems Center, Training Systems Product Group

Aerospace Command and Control, Intelligence, Surveillance, and Reconnaissance Center

AFDC/DR

AF/IL

AF/XO Air Force DCS/Air and Space Operations
- AF/XOC
- AF/XOCA
- AF/XOOS, Special Operations Division
- AF/XOOT

Air Armament Center

Air Combat Command
- ACC/DOOE
- ACC/XO
- ACC/XODZ
- ACC/XOT
- Network Operations Security Center

Air Education and Training Center

Air Force Agency for Modeling and Simulation

Air Force Command and Control Battlelab

Air Force Command and Control Training and Innovation Group

Air Force Experimentation Office

Air Force Information Warfare Center

Air Force Operational Test and Evaluation Center Det1

Air Force Research Laboratory
- AFRL/DE, Directed Energy Directorate
- AFRL/EW, Electronic Warfare Directorate
- AFRL/HEA
- AFRL/HED, Directed Energy Bioeffects Division
- AFRL/IF, Information Directorate
- AFRL/MN, Munitions Directorate

Air Force Special Operations Command
Air Intelligence Agency
Air, Land, Sea Application Center
Air Mobility Warfare Center
AMC/DOT
Ballistic Missile Defense Organization
Central Intelligence Agency
Defense Advanced Research Projects Agency
    WISSARD Facility
Defense Intelligence Agency
Defense Logistics Agency
Department of State, Office of Foreign Disaster Assistance
Director of Military Support
Electronic Systems Center
EUCOM, Joint Operations Division
IDA/Joint Advanced Warfighting Program
Joint C^4ISR Battle Center
Joint Command and Control Warfare Center
Joint Non-Lethal Weapons Directorate
Joint Warfare Analysis Center
Joint Staff, J-4
    Deployment Division
    Logistics Information Systems Division
    Logistics Readiness Center
    Sustainability, Mobilization, Plans, Exercises
Joint Warfighting Center
JTF Joint Advanced Distributed Simulation
JTF Joint Combat Search and Rescue
MITRE
National Reconnaissance Office
National Security Agency
Naval Surface Warfare Center
Naval Sea Systems Command
Office of the Secretary of Defense, Legal
Red Horse
Sandia National Laboratory
Theater Air Command and Control Simulation Facility
United Nations, High Commission on Refugees

U.S. Air Forces in Europe

U.S. Army Training and Doctrine Command

U.S. Atlantic Command (now called U.S. Joint Forces Command)

J6 and J9

U.S. Central Command

U.S. Pacific Command

U.S. Southern Command

U.S. Special Operations Command

U.S. Transportation Command

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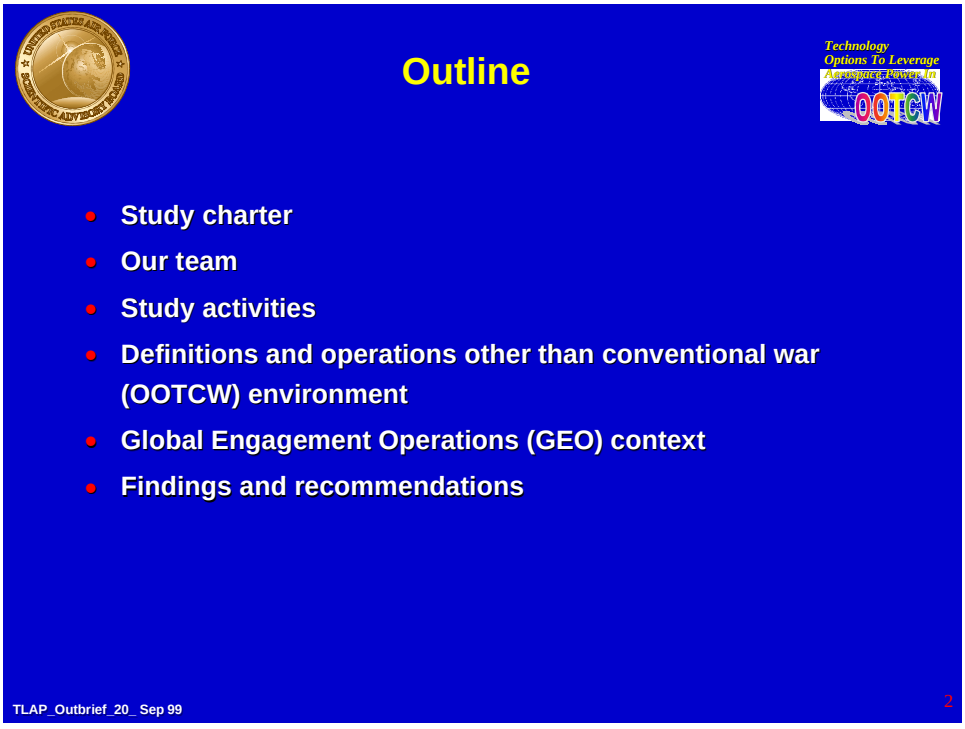
Appendix E

Technology Options to Leverage Aerospace Power in Other Than Conventional War Situations Briefing



Study Charter

Technology Options To Leverage Aerospace Power to OOTCW

- ✓ Review operations conducted in the past decade
  - Identify successes and limitations
  - Ideas to enable aerospace forces to improve outcomes
- ✓ Posit future situations/vignettes that are representative of "less-traditional" operations
  - Assess capabilities of programmed forces
  - Identify deficiencies
- ✓ Survey the technology options available and suggest the technologies that should be pursued
  - Near term - current operational art
  - Farther term - identify technology options
  - Consider lethal and non-lethal
- ✓ Identify testing or demonstrations necessary for testing the study recommendations; recommend appropriate Air Force involvement

Technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment

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Our Team

Technology Options To Leverage Aerospace Power to OOTCW

Study Chairman - Mr. Tom McMahan

Vice Study Chairman - Dr. Peter R. Worch
Senior Officer Participant - Brig Gen Ben Robinson
Senior Civilian Advisor - Mr. Jack Welch
Navy Advisor - CDR Terrance Jones
Army Advisor - Col Robert Stewart
SAB Study Executive Officer - Maj Douglas Amon
Technical Editing Support (ANSER) - Mrs. Kristin Lynch

Panel Chairs:

Intelligence and Vigilance Panel: Dr. Matthew W. Ganz	Mission	Members
Deployment and Sustainment Panel: Dr. Ronald P. Fuchs	Mission	Members
Non-Lethal Effect Panel: Dr. Peter R. Worch	Mission	Members
Lethal Effects Panel: Maj Gen (Ret) George B. Harrison	Mission	Members
Force Management Panel: Prof. Alexander H. Levis	Mission	Members
Experiments, Training, and Exercises Panel: Dr. Miriam E. John	Mission	Members

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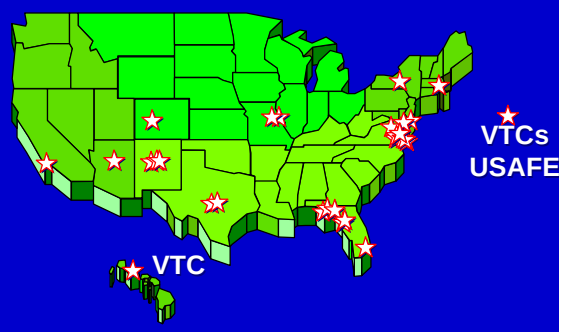
Study Activities

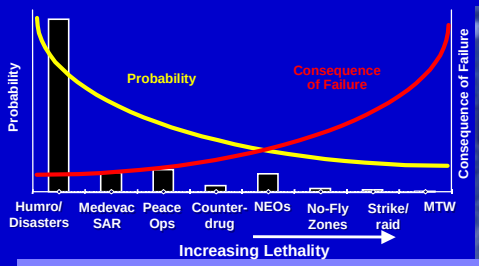
Technology Options To Leverage Aerospace Power in OOTCW

- Panels conducted 33 visits
- Total study effort of over 12,000 hours
- Met with 71 organizations (visits / briefings / meetings)
  - CINCS
  - MAJCOMs
  - Labs
  - Bases
  - Other Services
  - Joint Agencies
  - Non-DoD Agencies



The "OOTCW" Environment

Technology Options To Leverage Aerospace Power in OOTCW



- Increasing involvement in unconventional situations
  - Bosnia, Somalia, Iraq No-Fly, Kosovo, etc.
  - WMD non-proliferation
  - Separation of combatants, restoration of order
- Diversity of operating environments
  - Inability to predict location, geography, conditions for next operation
  - High likelihood of urban operations
  - Extremely high sensitivity to collateral damage
  - Need to sense/target/ID individuals and small groups
  - Multi-national coalitions
  - Potential for very long duration of "hostilities" with large excursions of intensity

GEO Phases

Technology Options To Leverage Aerospace Power In OOTCW

Shape	Respond			Reshape
	Deter	Halt	Win	

Crisis

Assure agile combat support in all phases

SHAPE Objective: Engage globally to shape the international environment
- **Task:** Promote deterrence, awareness and regional stability to support U.S. and allies' interests

DETER Objective: Employ quick, measured reactions to a crisis
- **Task:** Expand situational awareness and operational capabilities to enhance deterrence and prepare for future operations

HALT Objective: Gain strategic control to change the existing conditions …Across the full spectrum of military operations
- **Task:** Rapidly apply military power to seize the initiative

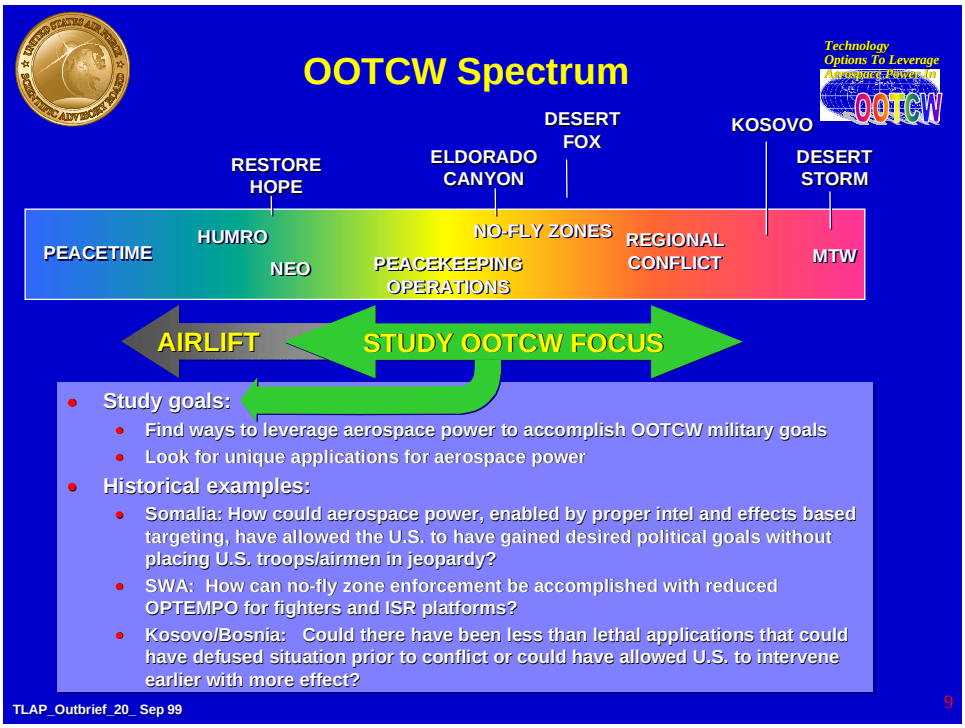
WIN Objective: Leverage control to end the crisis
- **Task:** Create and exploit options to achieve objectives rapidly

RESHAPE Objective: Create a better state of peace
- **Task:** Prevent a return to crisis and maintain an enhanced security environment

Recommendations By GEO Phase

Technology Options To Leverage Aerospace Power In OOTCW

Elements	Enable Persistent ISR					
	Expand ISR for UAVs	Sensors and Air-Launched Vehicles for ISR and Targeting	IM ISR for Trans-National and Terrorist Threats.	Non-cooperative target identification techniques	Global Intelligence Guide	20 More Major SAB Recommendations
Shape Phase						
Maintain readiness, home defense and deterrence through aerospace power	✓	✓	✓		✓	
Enhance global awareness from air and space	✓	✓	✓	✓	✓	
Rely on air mobility to underwrite global forward basing		✓			✓	
Deter Phase						
Element 1...						
Element 2...						
Element n						
Halt Phase						
Element 1...						


OOTCW Spectrum
Technology Options To Leverage Aerospace Power In OOTCW
DESERT FOX
KOSOVO
RESTORE HOPE
ELDORADO CANYON
DESERT STORM
PEACETIME
HUMRO
NO-FLY ZONES
REGIONAL CONFLICT
NEO
PEACEKEEPING OPERATIONS
MTW
AIRLIFT
STUDY OOTCW FOCUS
Study goals:
Find ways to leverage aerospace power to accomplish OOTCW military goals
Look for unique applications for aerospace power
Historical examples:
Somalia: How could aerospace power, enabled by proper intel and effects based targeting, have allowed the U.S. to have gained desired political goals without placing U.S. troops/airmen in jeopardy?
SWA: How can no-fly zone enforcement be accomplished with reduced OPTEMPO for fighters and ISR platforms?
Kosovo/Bosnia: Could there have been less than lethal applications that could have defused situation prior to conflict or could have allowed U.S. to intervene earlier with more effect?
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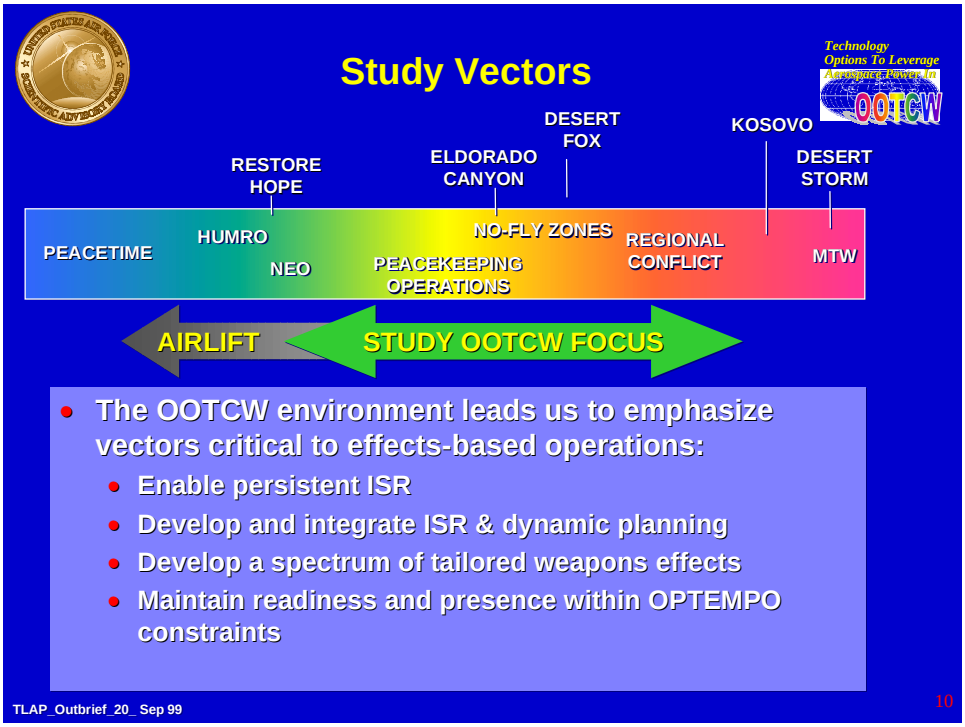
Study Vectors
Technology Options To Leverage Aerospace Power In OOTCW
DESERT FOX
KOSOVO
RESTORE HOPE
ELDORADO CANYON
DESERT STORM
PEACETIME
HUMRO
NO-FLY ZONES
REGIONAL CONFLICT
NEO
PEACEKEEPING OPERATIONS
MTW
AIRLIFT
STUDY OOTCW FOCUS
The OOTCW environment leads us to emphasize vectors critical to effects-based operations:
Enable persistent ISR
Develop and integrate ISR & dynamic planning
Develop a spectrum of tailored weapons effects
Maintain readiness and presence within OPTEMPO constraints
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Recommendation Summary

Technology Options To Leverage Aerospace Power in OOTCW

- Recommendations represent set of options that will leverage OOTCW
  - Do not require reinvention of the Air Force
  - Most not uniquely OOTCW
  - Can consider as a menu of options to implement as resources allow
- Major recommendations
  - 12 specific, actionable recommendations in the outbrief
  - 7 overarching recommendations in outbrief
  - 7 other high priority, specific, actionable recommendations
- Strong relationship of OOTCW and JBI recommendations

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Technology Options To Leverage Aerospace Power in OOTCW

Enable Persistent ISR

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Expand ISR capabilities for Unmanned Aerial Vehicles to augment long duration data collection - start with air surveillance on Global Hawk

Technology Options To Leverage Aerospace Power In OOTCW

I&V/LE

Military Capability:

A robust capability to supplement ISR functions currently performed by the "Low density/High demand (LD/HD)" platforms. Will significantly reduce stress on current platforms and personnel while performing the same missions. Particularly useful for Shape phase I&W and Reshape phase no-fly zone enforcement.

Technology Initiatives:

Begin immediate development of low-cost Radar/IFF system for Global Hawk UAV based on current Tech Base. (AF/XO, SAF/AQ)

- I&W
- Air target situational awareness
- No-fly zone enforcement
- Self deployable and immediately operable in theater

In parallel, begin work on multi-INT (e.g., SIGINT, MASINT) technologies suitable for deployment on UAVs. (AF/XO, SAF/AQ) Outside agency involvement

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Develop sensors and air-launched vehicles for ISR, targeting, and BDA

Technology Options To Leverage Aerospace Power In OOTCW

I&V/LE/NLE

Military Capability:

- Long-duration, low-cost ISR, targeting, BDA
- Monitoring and defeat of new threats
- Shaping of the battlefield through knowledge and PSYOPS
- May also be used for precise delivery of lethal and non-lethal effects

Technology Initiatives:

Develop a program to integrate newly developed low-cost sensors and air-launched/air-dropped deployment vehicle technology for ISR, targeting, real-time BDA. (SAF/AQ)

- UAVs (high altitude, medium altitude) with standardized payload interfaces
- Small air vehicles (MALD, MAVs, Parafoils)
- Ultra-precision (< 1m), robust navigation
- High-G electronics
- Ultra-miniature guidance systems
- Ultra-miniature low-power electronics
- Micro-sensors (fuzes, seekers, MEMS: Guidance, Chem/Bio, Acoustic/Seismic, RF, IR)
- Modern comms (low power, internetted, satellite) and C2
- Robotics for end-game mobility

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Technology Options To Leverage Aerospace Power in OOTCW

Develop and Integrate ISR & Dynamic Planning

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Implement a force management capability for the EAF and for OOTCW

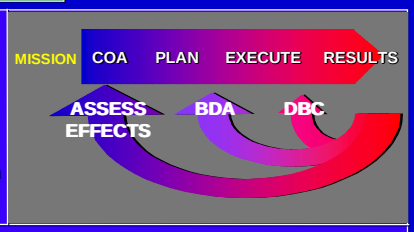
Technology Options To Leverage Aerospace Power in OOTCW

FM

Link to BI Study

Military Capability:

A force management system that supports the EAF in the application of aerospace power to OOTCW and enables dynamic effects-based planning, execution, and effects assessment to include strike, airlift, and training. Feedback consists of Dynamic Battle Control (DBC), Action or BDA, and effects assessment.



Capability Initiative:

Continue selective deployment of Theater Battle Management Core System (TBMCS), but:

- Immediately begin preparation of an operational architecture to assure TBMCS meets the needs of the EAF in OOTCW. Include logistics, training and lift aspects. (AC2ISRC)
- Assess the proper future course of action for TBMCS based on this architecture. (AF/XO, SAF/AQ)
- Establish a new function equivalent to AF/XOR for architectures and CONOPS for integrated force management systems. (AF/XO)
- Develop C2ISR education within the Air Force and establish appropriate specialty codes. (AF/DP)

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Lead the development and deployment of an integrated ISR - C2 Information Management System

Technology Options To Leverage Aerospace Power In OOTCW

I&V

Link to BI Study

Military Capability:

Meet stringent timelines for tailorable and continuously updated information on demand for warfighters worldwide. Dynamic ISR response to rapidly and significantly changing situations.

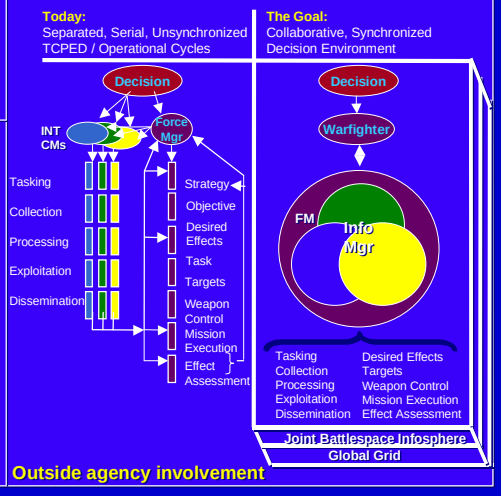
Technology / Implementation:

Develop operational architecture, functional requirements, and implementation roadmap. (AC2ISRC)

Pursue AF-owned elements of the roadmap. (SAF/AQ)

Lead joint DoD-Intel Community initiative for development and deployment. (AF)
- JBI & Global Grid provide foundation

Use demo to drive development of relevant technologies: (SAF/AQ)
- Representation of Information
- Information Fusion
- Dynamic Allocation of Sensing Assets
- Interaction with the User
- Performance Assessment



Implement AEF communications for rapidly emerging crises

Technology Options To Leverage Aerospace Power In OOTCW

FM

Link to BI Study

Military Capability:

EAF communications enabling:
- Immediate combat power for OOTCW crisis response anywhere
- Global Grid access
- Communications to support JBI
- Direct links to operational platforms

Technology Initiatives/Enablers:

Multi-level secure communications architecture and requirements for OOTCW are the same as for MTW with the added features of *rapid reconfigurability, scalability, and deployability.* AEF HW/SW/BW environment should be the same as home station so that we "fight like we train." (AF/SC)
- Develop and implement coalition interoperability for Joint/ Combined/ Civil EAF operations
- Implement a user requirements driven acquisition process with an emphasis on the controller/shooter

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Technology Options To Leverage Aerospace Power In OOTCW

Develop a Spectrum of Tailored Weapons Effects

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Provide a capability for delivery of directed energy (DE) effects

Technology Options To Leverage Aerospace Power In OOTCW

NLE

Military Capability:

Provides the Air Force with a capability to disable or to destroy electronic equipment (e.g., computers and ignition systems) and other materiel and an anti-personnel capability without producing blast effects, death, or collateral physical damage.

Technology Initiatives:

Develop a family of air deliverable directed energy effects including CW and pulsed HPM devices and high energy lasers. (SAF/AQ)

- Demonstrate a HPM "gun" integrated into airborne platforms
- Demonstrate air-delivered "anti-materiel mines" to halt or delay movement of enemy forces
- Accelerate development of all-solid-state laser devices for anti-materiel gunship and fotofighter applications
- Accelerate development of compact high-efficiency aircraft electric prime power sources to enable directed energy applications
- Demonstrate HPM self-defense devices for aircraft

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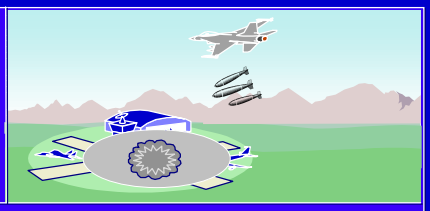
Develop anti-materiel agent technologies, weapons and delivery methods

Technology Options To Leverage Aerospace Power In OOTCW

NLE

Military Capability:

A non-lethal capability to disable/deny operation of mechanized vehicles, artillery, communications equipment, and disrupt airfield operations and roadways.



Technology Initiatives:

Accelerate development of high precision, air-deliverable non-lethal "munitions" from manned aircraft and UAVs. (SAF/AQ)

Develop a family of supporting payload technologies incorporating aggressive, biodegradable agents such as: (SAF/AQ)

- Supercaustic foams
- Conductive foams
- Embrittlement/depolymerization agents
- POL Contaminants
- Superlubricants

Simultaneously develop key attendant elements (effectiveness models, planning tools, BDA, ROE, and countermeasures). (AF/XO, SAF/AQ)

Outside agency involvement

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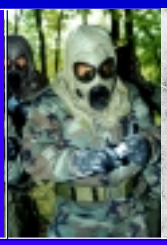
Develop methods for destroying or neutralizing chemical/biological agents in bunker storage

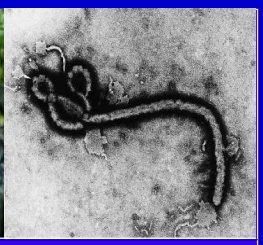
Technology Options To Leverage Aerospace Power In OOTCW

LE

Military Capability:

A capability for neutralizing chemical and biological agents in bunker storage situations - with no collateral effect.





Technology Initiatives:

Develop the intelligence capability to provide precise storage location in 3 dimensions (AF/XO)

- "The right room"

Develop the capability to deliver a weapon into the storage location (SAF/AQ)

- Precision delivery of the survivable penetrating body
- Precision fusing to function in the right place

Conduct an R&D program on an intense heat source. (SAF/AQ)

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Exploit potential of UAVs for delivery of lethal & non-lethal effects

Technology Options To Leverage Aerospace Power In OOTCW

NLE/LE

Military Capability:

Flexible modular UAVs and UCAVs provide low cost, long endurance delivery platform capabilities for a broad spectrum of weapon effects. They provide a low risk means to fill the gaps in the continuum of required force capability.

System & Technology Initiatives:

Develop a family of UAVs and UCAVs with standard payload modules for air delivery of lethal and non-lethal effects: (AF/XO, SAF/AQ)

- Define and develop low cost, modular UAV & UCAV platform systems
- Develop a family of UCAV weapons for deep precision attack of mobile targets
- Define and develop HPM, laser, gun, dispenser, and jamming modules
- Develop associated external systems for C4I, and logistics support

Simultaneously develop key attendant elements (effectiveness models, planning tools, BDA, ROE, and countermeasures). (AF/XO, SAF/AQ)

Continue development of UAV & UCAV Technology Base. (SAF/AQ)

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Accelerate development of air deliverable lethal miniature munitions

Technology Options To Leverage Aerospace Power In OOTCW

LE

Military Capability:

Tailored lethal effects on fixed and mobile targets - low collateral effects

- Autonomous miniature munitions
- High precision
- High loadout

Technology Initiatives:

Develop a family of miniature munitions: (SAF/AQ)

- Mobile and relocatable targets
  - Low Cost Autonomous Attack System (LOCAAS)
  - Accelerate demonstration and EMD of LOCAAS
- Fixed Targets, Buried or Surface
  - Small Smart Bomb
  - Demonstration successful; accelerate into EMD the Small Smart Bomb

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Technology Options To Leverage Aerospace Power In OOTCW

Maintain Readiness and Presence Within OPTEMPO Constraints

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Create a Distributed Mission Readiness System from the Distributed Mission Training Concept

Technology Options To Leverage Aerospace Power In OOTCW

ETE

Link to BI Study

Military Capability:

A robust and flexible AF-wide Distributed Mission Readiness System (DMRS) which integrates all force elements to help train and rehearse AEF personnel for full spectrum global engagement (MTW and OOTCW).

Force Protection

C^4ISR

Airlift

Initiatives:

Establish overall AF leadership for DMRS. (AF/XO)

Implement Capstone Requirements Document for DMT and grow it into AF DMRS
- AF-wide plans, architecture and roadmap (AF/XP, AF/XO)
- Formal acquisition strategy and force management plan (SAF/AQ)
- DMRS SPO to manage transition and integration (SAF/AQ)

Maintain priority of current DMT efforts to bridge to DMRS (SAF/AQ, AF/XO)

Address major DMRS technical issues (SAF/AQ)
- Multi-level security/need-to-know, latency issues, behavioral models
- Leverage related efforts in other services, ACOM, DARPA and outside agencies

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Improve airlift responsiveness to OOTCW situations while reducing OPTEMPO impacts

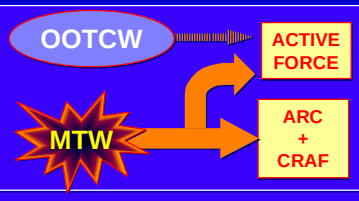
Technology Options To Leverage Airlift Power In OOTCW

D&S

Military Capability:

Deliver people and cargo on time.

Meet mobility requirements of OOTCW without the benefit of mobilization or CRAF activation.



Process Initiatives:

- Encourage Services to review mobility requirements in order to reduce the need to repeatedly move identical equipment and material. (AF/XO)
- Reevaluate force sizing, crewing, and balance of active, reserve, CRAF, and commercial airlift for the larger of MTW and OOTCW demands. (AF/XP)

Capability Initiatives:

- Continue airlift upgrade programs on a prioritized basis consistent with the above. (AF/XO, SAF/AQ)
  - Upgrade C-5 to most cost effective reliability
  - Pursue simulator alternatives to proficiency flight training
  - C-130AMP, C-17 center wing tank, and KC-135 soft basket refueling

Other High Priority Recommendations

Technology Options To Leverage Airlift Power In OOTCW

- Improve technical capability and modify ISR policy to provide timely I& W response to trans-national and terrorist threats (AF/XO, SAF/AQ)
- Intensify research in non-cooperative target identification techniques (AF/XO, SAF/AQ)
- Develop a global intelligence guide usable for specific OOTCW areas and missions (AF/XO, SAF/AQ)
- Integrate planning and execution systems for employment and sustainment (AF/XO, AF/IL)
- Enhance air-deliverable information warfare capability (AF/XO, SAF/AQ)
- Integrate OOTCW into experiments, training, exercises, doctrine, and education (AF/XO)
- Give higher priority to personnel and aircraft protection in OOTCW scenarios (AF/XO, SAF/AQ, AF/SG)

Technology Options To Leverage Aerospace Power In OOTCW

Overarching Recommendations

Overarching Recommendations

Technology Options To Leverage Aerospace Power In OOTCW

- The Global Positioning System (GPS) is critical to OOTCW. As recommended by the SAB since 1993, the Air Force should improve the accuracy and survivability (SAF/AQ)
- To successfully transition to an EAF, the Air Force should broaden its focus to encompass training, communications, deployment, weapons, and forward support basing recommendations from the 1997 SAB AEF Study and this Study. (AF/XO)
- Develop a comprehensive vision and strategy that takes into full account all potential roles of non-lethal weapons, including "variable effect" and delivery from air and/or space. Integration into the overall response continuum is essential. (AF/XO)
- Ensure the Rapid Response Process (RRP) remains viable to define, develop, and deploy urgent, time-sensitive systems identified by the CINC as critical to combat operations, including OOTCW. (SAF/AQ, AF/XO)

Overarching Recommendations
(continued)

Technology Options To Leverage Aerospace Power In OOTCW

- Assure the development of strategies, concepts, techniques for offensive and defensive information warfare are closely coupled for maximum effectiveness (AF/XO, SAF/AQ)
- The critical requirement for information superiority suggests increased emphasis on defensive information warfare, including assessment of detected threats and development of responses (AF/XO, SAF/AQ)
- Assure discretionary funds are available to laboratory managers to focus on promising technologies and revolutionary capabilities. Encourage industry IRAD managers to do the same (SAF/AQ)

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Application of Recommendations To Historical Examples

Technology Options To Leverage Aerospace Power In OOTCW

RECOMMENDATION	SOMALIA	KOSOVO	SWA
ISR UAVS to augment long duration data	X	X	X
Sensors for ISR, targeting, and BDA	X	X	
Force management capability for OOTCW	X	X	X
Integrated ISR/ C2 information management	X	X	X
Flexible AEF communications	X	X	
Capability for delivery of DE effects	X	X	
Anti-materiel agent technologies/delivery		X	
Destroying chemical/biological agents			X
UAVs for lethal & non-lethal effects	X	X	X
Air deliverable lethal miniature munitions		X	X
Distributed Mission Readiness System	X	X	X
Improve airlift responsiveness to OOTCW	X	X	
ISR for trans-national and terrorist threats	X		
Non-cooperative target identification		X	
Global intelligence guide	X	X	
Integrated planning and execution systems	X	X	X
Air-deliverable information warfare	X	X	
OOTCW in experiments, training, exercises	X	X	X
Personnel and aircraft protection in OOTCW		X	

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Recommendation Summary

- Recommendations represent set of options that will leverage OOTCW
  - Do not require reinvention of the Air Force
  - Most not uniquely OOTCW
  - Can consider as a menu of options to implement as resources allow
- Major recommendations
  - 12 specific, actionable recommendations in the outbrief
  - 7 overarching recommendations in outbrief
  - 7 other high priority, specific, actionable recommendations
- Strong relationship of OOTCW and JBI recommendations

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The End

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Initial Distribution

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AF/CV	Vice Chief of Staff
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AF/SG	Surgeon General
AF/SF	Security Forces
AF/TE	Test and Evaluation

Assistant Secretary of the Air Force

SAF/AQ	Assistant Secretary for Acquisition
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SAF/AQI	Information Dominance
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SAF/AQQ	Global Reach
SAF/AQR	Science, Technology and Engineering
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SAF/SX	Deputy Assistant Secretary (Space Plans and Policy)
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AFPEO/C2	Air Force Program Executive Office for Command and Control
AFPEO/FB	Air Force Program Executive Office for Fighter and Bomber Programs
AFPEO/LI	Air Force Program Executive Office for Logistics Information Systems
AFPEO/SP	Air Force Program Executive Office for Space
AFPEO/WP	Air Force Program Executive Office for Weapons

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/XOP	EAF Implementation
AF/XOR	Operational Requirements

Deputy Chief of Staff, Installations and Logistics

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

Initial Distribution (continued)

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

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
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
BMDO	Ballistic Missile Defense Organization

Other Air Force Organizations

AC2ISRC	Aerospace Command, Control, Intelligence, Surveillance, and Reconnaissance Center
ACC	Air Combat Command
– CC	- Commander, Air Combat Command
– 366th Wing	- 366th Wing at Mountain Home Air Force Base
AETC	Air Education and Training Command
– AU	- Air University
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
– DIT	Technology Applications
– ASC	- Aeronautics Systems Center
– HSC	- Human Systems Center
– AFOSR	- Air Force Office of Scientific Research
AFOTEC	Air Force Operational Test and Evaluation Center
AFSAA	Air Force Studies and Analyses Agency
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
AIA	Air Intelligence Agency
AMC	Air Mobility Command
NAIC	National Air Intelligence Center
NGB/CF	National Guard Bureau
PACAF	Pacific Air Forces
USAFA	U.S. Air Force Academy
USAFE	U.S. Air Forces in Europe

Initial Distribution (continued)

U.S. Army

ASB	Army Science Board
SAAL-ZA	Assistant Secretary of the Army for Acquisition, Logistics, and Technology

U.S. Navy

ASN (RDA)	Assistant Secretary of the Navy for Research, Development, and Acquisition
NRAC	Naval Research Advisory Committee
Naval Studies Board	

U.S. Marine Corps

DC/S (A)	Deputy Chief of Staff for Aviation

Joint Staff

JCS	Office of the Vice Chairman
J2	Intelligence
J3	Operations
J4	Logistics
J5	Strategic Plans and Policies
J6	Command, Control, Communications, and Computer Systems
J7	Operational Plans and Interoperability
J8	Force Structure, Resources and Assessment

Other

21st Air Force
33rd Fighter Wing
36th Special Reconnaissance Squadron
53rd WG/EW
58th Special Operations Wing
621 Air Mobility Operations Group
Aeronautical Systems Center, Training Systems Product Group
Aerospace Corporation
AFDC/DR
AF/XOCA
AF/XOOS, Special Operations Division
AF/XOOT
Air Armament Center
ACC/DOOE
ACC/XO
ACC/XODZ
ACC/XOT
Air Force Agency for Modeling and Simulation
Air Force Command and Control Battlelab
Air Force Command and Control Training and Innovation Group
Air Force Experimentation Office
Air Force Information Warfare Center
Air Force Operational Test and Evaluation Center Det-1
Air Force Research Laboratory
AFRL/DE, Directed Energy Directorate

Initial Distribution (continued)

Other (continued)

AFRL/EW, Electronic Warfare Directorate
AFRL/HEA
AFRL/HED, Directed Energy Bioeffects Division
AFRL/IF, Information Directorate
AFRL/MN, Munitions Directorate
Air, Land, Sea Application Center
Air Mobility Warfare Center
AMC/DOT
ANSER
Central Intelligence Agency
DARPA WISSARD Facility
Defense Intelligence Agency
Defense Logistics Agency
Defense Systems Management College
Department of State, Office of Foreign Disaster Assistance
Director of Military Support
Electronic Systems Center
Electronic Systems Center/DIT
EUCOM, Joint Operations Division
IDA/Joint Advanced Warfighting Program
Joint C^4ISR Battle Center
Joint Command and Control Warfare Center
Joint Non-Lethal Weapons Directorate
Joint Warfare Analysis Center
Joint Staff, J-4
- Deployment Division
- Logistics Information Systems Division
- Logistics Readiness Center
- Sustainability, Mobilization, Plans, Exercises

Joint Warfighting Center
JTF Joint Advanced Distributed Simulation
JTF Joint Combat Search and Rescue
MITRE
National Reconnaissance Office
National Security Agency
Naval Surface Warfare Center
Naval Sea Systems Command
Network Operations Security Center
Office of the Secretary of Defense, Legal
RAND
Red Horse
Sandia National Laboratory
Study Participants
Theater Air Command and Control Simulation Facility
United Nations, High Commission on Refugees
U.S. Army Training and Doctrine Command
U.S. Joint Forces Command, J6 and J9
U.S. Central Command
U.S. Pacific Command

Initial Distribution (continued)

Other (continued)

U.S. Southern Command
U.S. Space Command
U.S. Special Operations Command
U.S. Transportation Command

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Mr. Tom McMahan, Dr. Peter R. Worch, Dr. Matthew W. Ganz, Dr. Ronald P. Fuchs, Maj Gen George B. Harrison, USAF (Ret), Professor Alexander H. Levis, Dr. Miriam E. John

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ABSTRACT (Maximum 200 Words)

Technology Options to Leverage Aerospace Power in Operations Other Than Conventional War

The 1999 Air Force Scientific Advisory Board (SAB) Summer Study focused on potential future environments that may involve the Air Force in Operations Other Than Conventional Warfare (OOTCW). The SAB was asked to provide technology options that could leverage the application of aerospace power in such operations.

The outcome of the study was a set of technology options to apply aerospace power to fight and win in the increasingly unconventional conflict environment. The team was to look at concepts, ideas and technologies that would allow United States forces to prevail while minimizing the number of airmen and ground troops that would have to be put at risk in OOTCW.

The study considered the past and potential future OOTCW environments and considered operations from humanitarian relief (HUMRO), noncombatant evacuation (NEO), peacekeeping, and no-fly zone maintenance, through regional conflict. The upper range of operations for the study, regional conflict, was understood to be just short of the very significant level of conflict encountered in Kosovo. While the study did not in general emphasize the lower-intensity operations (HUMRO and NEO), it did become clear early on that such "peacetime" operations have significant operational tempo impacts. The study attempted to define these impacts and to offer mitigation ideas.

14. SUBJECT TERMS
Operations Other Than Conventional War (OOTCW), peacekeeping, intelligence, surveillance, reconnaissance, deployment, sustainment, non-lethal weapons, lethal weapons, command and control, force management, experiments, exercises, training

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