RAND

PROJECT AIR FORCE

THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND HOMELAND SECURITY
TRANSPORTATION AND INFRASTRUCTURE
WORKFORCE AND WORKPLACE

This PDF document was made available from www.rand.org as a public service of the RAND Corporation.

Jump down to document

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world.

Support RAND

Purchase this document

Browse Books & Publications

Make a charitable contribution

For More Information

Visit RAND at www.rand.org

Explore RAND Project AIR FORCE

View document details

Limited Electronic Distribution Rights

This document and trademark(s) contained herein are protected by law as indicated in a notice appearing later in this work. This electronic representation of RAND intellectual property is provided for non-commercial use only. Unauthorized posting of RAND PDFs to a non-RAND Web site is prohibited. RAND PDFs are protected under copyright law. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please see RAND Permissions.

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2009	**final**	**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE
Enhancing fires and maneuver capability through greater air-ground joint interdependence

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Jody Jacobs; David Johnson; Katherine Comanor; Lewis Jamison; Leland Joe

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
RAND Corporation,1776 Main Street,Santa Monica,CA,90407

8. PERFORMING ORGANIZATION REPORT NUMBER
MG-793-AF

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Online access http://www.rand.org/pubs/monographs/MG793/ Additional author: Personal name: Vaughan, David.

14. ABSTRACT
Although airpower capabilities have improved dramatically in the past decade, the joint warfighting potential offered by these capabilities is not being fully realized. Service transformation efforts and lessons learned during combat operations in Afghanistan and Iraq highlight doctrinal and technical issues with air and ground integration. The authors propose several alternative options for improving the effectiveness of air and ground fires and maneuver. To compare the potential effectiveness of the options, they develop a methodology that models the essential counterland air-ground interactions under discussion, based on a scenario that focuses on the disruption of enemy ground force maneuver. They suggest a new joint warfighting concept that has design elements specifically put in place to enhance the prioritization and synchronization of joint fires and maneuver. This concept offers important benefits and significant added flexibility for employing joint forces to achieve the commander?s objectives across the entire theater.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**123**	

This product is part of the RAND Corporation monograph series. RAND monographs present major research findings that address the challenges facing the public and private sectors. All RAND monographs undergo rigorous peer review to ensure high standards for research quality and objectivity.

Enhancing Fires and Maneuver Capability Through Greater Air-Ground Joint Interdependence

Jody Jacobs • David E. Johnson • Katherine Comanor
Lewis Jamison • Leland Joe • David Vaughan

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

RAND PROJECT AIR FORCE

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

Library of Congress Cataloging-in-Publication Data

Enhancing fires and maneuver capability through greater air-ground joint interdependence / Jody Jacobs ... [et al.].
p. cm.
Includes bibliographical references.
ISBN 978-0-8330-4605-5 (pbk. : alk. paper)
1. Air power—United States. 2. Unified operations (Military science) 3. Military doctrine—United States. I. Jacobs, Jody.

UG633.E57 2009
355.4'6—dc22

2009006583

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.
RAND® is a registered trademark.

© Copyright 2009 RAND Corporation

Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Copies may not be duplicated for commercial purposes. Unauthorized posting of RAND documents to a non-RAND Web site is prohibited. RAND documents are protected under copyright law. For information on reprint and linking permissions, please visit the RAND permissions page (http://www.rand.org/publications/permissions.html).

Published 2009 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
RAND URL: http://www.rand.org
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Preface

This monograph provides the Air Force and the broader joint community with an analytical framework for thinking about a joint construct for air-ground interdependence in the future. It proposes several options for improving the effectiveness of air and ground fires and maneuver to further the Joint Force Commander's (JFC's) objectives. Notional counterland operations within the context of major combat are used to develop and compare effectiveness estimates for each option. The study examines command and control (C2) organizations, procedures, and equipment to identify changes necessary to implement each option.

The monograph should be of interest to a wide group of Air Force and defense personnel involved in many aspects of counterland operations, including airmen who execute these missions and those responsible for developing counterland doctrine; C2 organizations; tactics, techniques, and procedures; and related employment concepts that link interservice air and ground combat operations. Last, this report should be helpful to those in the larger defense community who desire to enhance operations through increased air-ground interdependence and airpower employment.

This research was sponsored by the commander, Air Combat Command (ACC), and was conducted within the Force Modernization and Employment program of RAND Project AIR FORCE for a fiscal year 2006 study entitled "Improving Air-Ground Integration, Interoperability, and Interdependence." The principal research was completed in 2006 and builds on work done in Project AIR FORCE over the past ten years to provide a better understanding of the air-ground partnership as well as to enhance the Air Force's contribution in operations

against enemy land forces. One particularly relevant report in this area is *Learning Large Lessons: The Evolving Roles of Ground Power and Airpower in the Post–Cold War Era*, by David E. Johnson, MG-405-1-AF, 2007.

RAND Project AIR FORCE

RAND Project AIR FORCE (PAF), a division of the RAND Corporation, is the U.S. Air Force's federally funded research and development center for studies and analyses. PAF provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat readiness, and support of current and future aerospace forces. Research is conducted in four programs: Force Modernization and Employment; Manpower, Personnel, and Training; Resource Management; and Strategy and Doctrine.

Additional information about PAF is available on our Web site:
http://www.rand.org/paf

Contents

Figures

Tables

Summary

This monograph describes PAF research focused on improving air-ground integration, interoperability, and interdependence. We propose a new joint warfighting concept and, using quantitative methods, demonstrate its potential to increase effectiveness during major combat.

Service transformation efforts and lessons learned during combat operations in Afghanistan and Iraq highlight both doctrinal and technical issues with air and ground integration. The key to enhancing future joint collaborative efforts is integrating airpower across the range of military operations, rather than merely deconflicting and parsing capabilities that should be available to the JFC. The challenge is to emphasize the strengths and retain the efficiencies that each service brings to the fight, rather than to subordinate one service to the other. Much of the impetus for change in how the military employs joint forces comes from the fact that airpower capabilities have improved dramatically in the past decade but that the joint warfighting potential offered by these capabilities is not being fully realized.

Therefore, the objective of this research is to provide a framework for thinking about how to improve the effectiveness and efficiency of joint air-ground operations. Our overall research goal was to develop options for military planners, doctrine writers, and force planners that would provide a more interdependent and joint construct for employing ground and airpower in the future. To this end, we propose several alternative options for improving the effectiveness of air and ground fires and maneuver to meet the JFC's objectives. We used the scenario of a meeting engagement with enemy mechanized forces during major combat operations to estimate the effectiveness of each option. We also

examined C2 organizations, procedures, and equipment to identify the changes necessary to realize the different options.

We used as a starting point past research that examined operations in Iraq (1991 and 2003), Bosnia (1995), Kosovo (1999), and Afghanistan (2001).[1] That research showed that a dramatic shift has occurred in the relative roles of ground and airpower in major operations and campaigns and that, while tactical and operational warfighting campaign objectives were generally achieved rapidly, realizing desired U.S. strategic end states has required protracted stability, support, transition, reconstruction, and counterinsurgency operations that place heavy demands on U.S. ground forces. It also noted that fixed-wing aircraft are increasingly effective at operational levels but that there is still a demand for robust ground forces because of the many complex terrain challenges (urban, mountainous, jungle). It concluded that expanded operations across a range of operations and environments require greater service interdependence, which can be enabled by more effective and efficient integration of U.S. advances in intelligence, surveillance, and reconnaissance (ISR); precision strike; and other capabilities.

Expanding on the above concepts, we developed a framework of options that is structured in a way that bounds, by degree, levels of air-ground joint interdependence ranging from the construct implemented during Operation Iraqi Freedom (OIF) to a new construct that embraces enhancements across a number of pertinent dimensions. That framework and the associated analytics are described in this monograph.

We first examine a joint fires and maneuver option that builds incremental improvements into air-ground operations during the march to Baghdad in OIF. These operations were conducted across a large (and deep) area of operations (AO) (characterized by mostly

---

[1] David E. Johnson, *Learning Large Lessons: The Evolving Roles of Ground Power and Airpower in the Post–Cold War Era*, Santa Monica, Calif.: RAND Corporation, MG-405-1-AF, 2007.

closed kill boxes) controlled by the U.S. Army V Corps commander.[2] Within this AO, the Joint Force Air Component Commander (JFACC) allocated fixed-wing aircraft for CAS as prescribed by the ground commander. Beyond the AO, air operations were conducted by the JFACC in accordance with guidance and priorities of the JFC. We examine two incremental variations of this basic option (which we call Option 1A): considering the impact of opening kill boxes and reducing the size (depth) of the AO.

Next, we present a new joint fires and maneuver option (Option 2) that focuses on effects by implementing design elements specifically put in place to enhance the prioritization and synchronization of joint fires and maneuver to achieve the objectives of the JFC across the entire theater. Key features of Option 2 include the following:

- strengthening the relationship between the JFACC and Joint Force Land Component Commander (JFLCC) to achieve the JFC's goals
- replacing the fire support coordination line (FSCL) and other fire support coordination measures with a "surface-maneuver area," similar to the joint special operations area construct
- enhancing Air Force and Army operational and tactical interfaces at the corps and division
- replacing CAS and air interdiction distinctions with a counterland apportionment that is keyed to targets, kill boxes, or joint fires areas[3]
- authorizing the Air Support Operations Center (ASOC) to retask counterland missions for CAS as required from the counterland apportionment.

---

[2] Iraq was divided into "kill boxes," of 30 nm × 30 nm; each kill box was further subdivided into nine 10 nm × 10 nm "keypads." When no friendly troops were present, a ground commander could open a kill box or keypad to enable air interdiction. In the presence of friendly troops, the kill box or keypad was closed, requiring close air support (CAS)procedures. Kill boxes in the V Corps' AO during this period were generally closed.

[3] In particular, Option 2 envisions no aircraft specifically allocated to CAS stacks.

To compare the potential effectiveness of each option, we developed a methodology that models the essential counterland air-ground interactions under discussion, based on a scenario that focuses on the disruption of enemy ground force maneuver. Employing this methodology, we examined each option's potential effectiveness. The analysis shows that prioritizing and synchronizing joint fires and maneuver (important Option 2 characteristics) offers important potential benefits and presents commanders with significant added flexibility for employing joint forces.

Our key findings include the following:

- Option 2 achieves the desired reduction in Red strength, requiring nearly 50 percent fewer aircraft than the next-best option (p. 49).
- Option 2 reduces the number of additional Blue ground forces needed (pp. 47–48).
- The penalty for failing to synchronize fires and maneuver can be quantified and can be as large as 55 additional aircraft (p. 49).
- If CAS stacks are desired as a hedge for the ground commander, Option 2 still requires significantly fewer aircraft than any of the Option 1 variants (p. 51).
- A sensitivity analysis based on nine variables shows that, in every case, Option 2 is able to achieve the goal of reducing Red force strength to 50 percent and can accomplish this goal with fewer aircraft than other options.[4] Furthermore, under similar assumptions, the analysis demonstrates that, in many of the cases examined, the other options are unable to accomplish the goal regardless of aircraft force size (pp. 57–59).

After identifying the joint and Air Force C2 changes required to implement the options, the monograph concludes that Option 2 would require major changes in the organization and operations of the Combined Air and Space Operations Center (CAOC) (p. 63).

[4] The nine variables are Red vehicle spacing, Red move cycle, Red vehicle speed, close combat effectiveness, jamming option, AO, air interdiction delay, available ISR, and C2 throughput at the coalition air operations center.

Enhanced C2 information systems are essential for realizing greater joint interdependence. In addition, increased joint force coordination of fires and maneuver will require net-centric data sharing at operational and tactical levels of command and control. All Option 1 variants are supportable with current information systems, but Option 2 is still beyond reach of the current and programmed organizational and systems structures; information system improvements are essential to realizing joint interdependence (pp. 69–73).

Findings and Recommendations

In summary, our findings are as follows (pp. 75–76):

- Current airspace control measures and ways of allocating air sorties suboptimize the application of aerospace power. The former are too restrictive; the latter result in unused (and therefore wasted) aerospace capacity.
- Modeling indicates that the most effective and efficient use of airpower requires expanding air access to the largest possible AO and consolidating CAS and air interdiction into a single counterland "flow." Doing so effectively, however, requires improvements in the joint force's net-centric command, control, and communications system capabilities—capabilities that are forecasted for 2011 at the earliest and are currently underfunded.
- In the meantime, incremental improvements to the joint force's ability to expand air access to ground areas of operation are feasible and would increase effectiveness but would require adjustment to C2 practices.

We make the following recommendations (p. 76):

- Using the framework described here as a starting point, the Air Force should develop its own vision and framework for enhancing joint interdependence. This should be detailed across the pertinent DOTMLPF dimensions and should be informed by an assessment of their impact on current and planned programs and by an assessment of risks, which should be aligned with any program impacts.[5] Finally, the Air Force should begin to identify desired joint and component responsibilities. All these actions will benefit from additional research expanding on the methodologies described in this monograph. This research should evaluate, with greater scrutiny, the trade-offs in fires options (attack helicopters; GPS-guided multiple-launch rockets, high-mobility artillery rockets and artillery; fixed-wing aircraft) in the CAS–close combat zone and beyond.

- The Air Force should program within itself and advocate within the joint community the development of C2 organizations, procedures, and equipment that are necessary to achieve greater joint interdependence.
- The Air Force should use the framework of options described here as a basis for discussions with the joint community to address current tactical- and system-level issues that involve the joint community.[6]

---

5 DOTMLPF stands for doctrine, organization, training, materiel, leadership and education, personnel, and facilities.

6 Examples of topical issues include airspace control and deconfliction; fire support control measures including kill boxes, JFAs, and FSCLs; C2 arrangements that facilitate joint ISR, fires, and effects; jam-resistant, interoperable, and beyond line-of-sight communications systems; and joint interoperability based on net-centric data sharing between information systems.

Acknowledgments

The authors gratefully acknowledge the following individuals for their assistance during this research. We thank them for making time for us in their busy schedules, sharing their candid views, patiently answering our many questions, and providing us with introductions, documents, and other source material.

We thank our study points of contact at ACC/A3F, Col Louis Bochain, Col Ron Watkins, and Col John Allison, for giving us much appreciated materials, facilitating our introduction to a wide variety of knowledgeable personnel, and helping us gain access to a number of pertinent meetings and conferences. In addition, we thank Curtis Neal, also at ACC/A3F, for sharing his views and perspectives on many topics.

We likewise wish to acknowledge a number of individuals and organizations at Nellis Air Force Base. We thank Col Thomas Webster, JAGOG/CC, for allowing us to visit his facility on numerous occasions to receive updates on Battlefield Airman training and equipment, ASOC and Tactical Air Control Party (TACP) developments, and to get his staff's candid perspectives on related topics. We also thank the commander of the 6th Combat Training Squadron, Lt Col Paul Schmidt, and his staff, including LTC Robert Bailes, Maj Don Oberdieck, Maj. Cary Board, and Capt. John Peterson. At the 505 OG, we thank its commander, Col Byron Risner, for engaging us on a number of issues, spanning his recent experiences and perspectives on the CAOC and division TACP, and we thank Lt Col Seth Bretscher (505 OG/CD) for his insights and innovative ideas regarding the planning and execution of counterland operations at the CAOC. We thank Col Gary Webb, JFCM/JT&E Director, for allowing us to observe the Virtual Flag 06-3 exercise and for sharing his views on a number of subsequent occasions. Last, we thank Capt Paul Maykish (116 ACW/CCE) for sharing his perspective on the Joint Surveillance and Target Attack Radar System (JSTARS) and its role during counterland operations.

We wish to thank Colonel Murray, Greg Gagnon, and a number of other individuals in AFC2ISRC/6D and at the C2 Battle Laboratory for hosting two days of informative briefings and discussions to gain a better understanding of command and control communications and information systems.

At the Air Force Doctrine Center, we wish to thank Lt Col William Peterson and Roger Philipsek for providing us insight into Air Component Coordination Element (ACCE) experiences in recent operations.

We also wish to thank a number of other individuals who shared their varied related experiences and perspectives and provided us with useful documents and material. These include Col Matt Neuenswander (CGSC AFELM), Col David Belote (J-5/DDWOT), Col Mason Carpenter (USNATO/PDO), Col Michael Adams (AF/A3OY), and Steven Buhrow (AF/A3OY).

We want to acknowledge and thank MG David Ralston, Commanding General, U.S. Army Field Artillery Center, and his staff, for their candid views and concerns. We appreciate the invitation for follow-on discussions at Fort Sill with a number of their expert staff. And at Fort Monroe, we wish to thank LTC Kenneth Downer, Fred Biel, and Jim Ferrell at the U.S. Army Training and Doctrine Center (TRADOC) DCSOPS&T for their perspectives and views. We greatly appreciate the time spent in discussion, as well as the materials and introductions they provided.

Our thanks go to Col Darren Medlin, LTC Garrett Heath, and Lt Col Shaun Sadler, all 2006–2007 RAND military fellows, for their greatly appreciated perspectives and guidance. We also wish to thank the following RAND colleagues for adding their unique viewpoints: Tim Bonds, Jim Bonomo, Jim Chow, Bruce Held, Myron Hura, and Jed

Peters. We especially thank Alan Vick, Jeff Hagen, and Wade Markel for their thoughtful reviews. Of course, we alone are responsible for any and all errors or omissions.

Abbreviations

A2C2	Army airspace command and control
AAFIF	Army/Air Force Integration Forum
AAGS	Army Air Ground System
ABCS	Army Battle Command System
AC2	airspace command and control
ACC	Air Combat Command
ACCE	Air Component Coordination Element
ACO	airspace control order
AF	Air Force
AFATDS	Advanced Field Artillery Tactical Data System
AFB	Air Force Base
AFDD	Air Force Doctrine Document
AI	air interdiction
ALSA	Air Land Sea Application
AMD	air and missile defense
AO	area of operations
AoA	analysis of alternatives
AOC	air and space operations center
AODB	Air Operations Data Base
ARCIC	Army Capabilities Integration Center

ASOC	Air Support Operations Center
ASR	air support request
ATACMS	Army Tactical Missile System
ATO	air tasking order
AWACS	Airborne Warning and Control System
BCD	battlefield coordination detachment
BCT	brigade combat team
BIAP	Baghdad International Airport
BCT	brigade control team
C2	command and control
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CAOC	Combined Air and Space Operations Center
CAS	close air support
CBU	cluster bomb unit
CFACC	Combined Forces Air Component Commander
CFLCC	Combined Forces Land Component Commander
COG	center of gravity
COI	community of interest
COIN	counterinsurgency
CONOPS	concept of operations
CRC	Control and Reporting Center
CS	combat support
CSS	combat service support
DLARS	Data Link Automated Reporting System
DoD	Department of Defense
DOTMLPF	doctrine, organization, training, materiel, leadership and education, personnel, and facilities

EP	engagement potential
FAC(A)	forward air controller (airborne)
FLOT	forward line of own troops
FM	field manual
FoS	Family of Systems
FSC	fire support cell
FSCL	fire support coordination line
FSCM	fire support coordination measure
FTP	Functionality Transition Plan
FY	fiscal year
GCCS	Global Command and Control System
GIG	Global Information Grid
GPS	Global Positioning System
HIMARS	High Mobility Artillery Rocket System
ID	infantry division
IPB	intelligence preparation of the battlefield
ISR	intelligence, surveillance, and reconnaissance
JADOCS	Joint Automated Deep Operations Coordination System
JAGC2	Joint Air-Ground Control Cell
JC2	joint command and control
JFA	joint fires area
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JFCM	joint fires coordination measures
JFLCC	Joint Force Land Component Commander
JOA	joint operations area
JP	Joint Publication

JSTARS	Joint Surveillance and Target Attack Radar System
JT	joint test
JTAC	Joint Terminal Attack Controller
JT&E	joint test and evaluation
KB	kill box
LD/LC	line of departure/line of contact
LOS	line of sight
MCDP	Marine Corps Doctrine Publication
MCP	mission capability package
MEF	Marine Expeditionary Force
MLRS	Multiple Launch Rocket System
NAI	named area of interest
NECC	net-enabled command capability
NM	nautical mile
OBJ	objective
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OSD	Office of the Secretary of Defense
PAF	Project AIR FORCE
PASS	Publish and Subscribe Server
PL	phase line
SA	situational awareness
SCAR	strike coordination and reconnaissance
SFW	sensor-fuzed weapon
SMA	surface-maneuver area
SOF	special operations forces
SSTR	stability, support, transition, and reconstruction
TACP	Tactical Air Control Party

TACREP	tactical report
TACS	Theater Air Control System
TAI	target area of interest
TAIS	Tactical Airspace Integration System
TBMCS	Theater Battle Management Core Systems
TOC	Tactical Operations Center
TTP	tactics, techniques, and procedures
UAS	unmanned aerial system
UEX	unit of employment
USAF	United States Air Force
USMC	U.S. Marine Corps
USMTF	U.S. message text format
WMD	weapons of mass destruction

CHAPTER ONE

Introduction

The U.S. joint warfighting "system" is not realizing the full potential that a comprehensive theaterwide approach to air-ground integration could offer. Clearly, developments in all the services across the DOTMLPF[1]—particularly in command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); precision munitions; training; and the operational acumen of leaders—have resulted in a U.S. military that enjoys a marked warfighting advantage over any current adversary. That said, most of these advances are most fully realized in the individual services rather than in the overall joint force. As we discuss later in this chapter, this is largely the result of the continued dominance of service cultures—particularly as they affect the promulgation of their individual warfighting doctrines—and the consensus nature of joint doctrine.

This study suggests and assesses options for realizing a joint U.S. system of integrated fire and maneuver. The purpose is to offer warfighting constructs that are more than a sum of their service parts. We focus on the Army and Air Force because they are responsible for training, organizing, and equipping U.S. forces for sustained ground and air combat.

The obvious questions that must be answered before suggesting new options for integrating ground and airpower are the following: Why bother—in the face of the obvious U.S. warfighting successes of the past decade? Why not let the ground components fight through-

[1] DOTMLPF stands for doctrine, organization, training, materiel, leadership and education, personnel, and facilities.

out large areas of operations (AOs) if they can dominate? What is the problem with letting the Air Force range widely and independently to attack enemy ground forces?

Aside from the fact that U.S. operational victories have not achieved the desired strategic political end states, there is also the issue of the quality of the opponents the United States has faced since the end of the Cold War. Even against an opponent as hapless as Saddam Hussein, operational challenges and issues with intelligence; situational awareness; intelligence, surveillance, and reconnaissance (ISR) coverage; long-range communications; and helicopter vulnerability were obvious in Operation Iraqi Freedom (OIF). Against competent adversaries—for which the U.S. Armed Forces must prepare—these deficiencies could prove disastrous, particularly if the United States does not enjoy the air supremacy to which its forces have become accustomed since World War II.

There are formidable challenges to realizing a comprehensive joint air-ground integration system. Nevertheless, we believe that the potential payoffs in effectiveness and efficiency for major operations and campaigns are substantial.

Although we develop several options for achieving greater air-ground interdependence, they have several common characteristics. First, and most important, they all start from the position that the capabilities of the components within a theater should be integrated to achieve the synergies in joint concepts and doctrine so often touted but not fully realized. We suggest a framework in which there are no component AOs. Instead, the entire theater becomes a joint AO that allows the Joint Force Commander (JFC)—the supported commander—to comprehensively integrate all available operational and strategic ISR, fires, and maneuver across all agencies and components.

Second, the principal roles of ground forces become

- maneuvering to force the enemy to react at the operational and strategic levels, resulting in his movement or concentration of forces, thus making him vulnerable to air attacks
- closing with and finishing enemy tactical remnants, exploiting success, and seizing and holding ground

- dealing with the post-conflict security environment until the desired strategic political end state is reached.

Third, the principal roles of airpower become

- shaping the theater at the operational and strategic levels and controlling the "commons" (air, space, and cyberspace)
- providing counterland capabilities, ISR, and airlift to support ground combat and post-combat operations.

A Shift in the Roles of Airpower and Ground Power Is Warranted

These shifts in air and ground roles in joint operational warfighting are necessary because of the documented changes in the relative effectiveness of airpower and ground power in recent conflicts. The demonstrated capability of U.S. airpower to conduct strike operations at the operational and strategic levels in major operations and campaigns means that the military must develop new options for integrating ground and airpower.

Recent Conflicts Show Increased Airpower Effectiveness

The basis for this conclusion is the analysis reported in earlier RAND research that evaluated operations in Iraq (1991, 2003), Bosnia (1995), Kosovo (1999), and Afghanistan (2001).[2] Kosovo, Afghanistan, and Iraq (2003), however, demonstrated most compellingly the shift in the relative roles of ground and airpower in major operations and campaigns. Table 1.1 summarizes these cases in several ways: what type of operation each conflict was initially and what it became over time; coalition objectives; the roles of ground forces and air forces; and the key operational characteristics of each conflict. The table shows that each conflict began with combat operations that rapidly achieved oper-

---

[2] This analysis can be found in David E. Johnson, *Learning Large Lessons: The Evolving Roles of Ground Power and Airpower in the Post–Cold War Era*, Santa Monica, Calif.: RAND Corporation, MG-405-1-AF, 2007, from which much of the material in this chapter is taken.

Table 1.1
Summary of Conflicts

Conflict	Type	Objective	Ground Force Roles	Air Force Roles	Key Operational Characteristics
Kosovo	Major operation and campaign Stability, support, transition, and reconstruction (SSTR) operations	Force Serbian compliance with NATO demands vis-à-vis Kosovo Nation-building	Task Force Hawk the core of an eventual ground component for Kosovo Pose a future threat to Serbia if air action not decisive Principal SSTR operations force	Attack limited objectives in Kosovo (largely ineffective) Attack key infrastructure targets in Serbia (effective) Provide ISR and lift for Task Force Hawk	Dispersed Serbian ground forces in Kosovo difficult to target and strike Air-ground integration not critical to campaign
Afghanistan	Major operation and campaign SSTR and COIN operations	Overthrow Taliban End terrorist sanctuaries Nation-building	SOF act as sensors for aircraft Conventional ground forces root out remnants of Taliban/ al Qaeda Principal SSTR and COIN operations force	Provide decisive edge to Afghan allies Fires for ground forces Theaterwide ISR and lift	Initially, air and ground power not integrated—evolved into tight SOF-air integration During Operation Anaconda, poor initial air-ground integration

Table 1.1—Continued

Conflict	Type	Objective	Ground Force Roles	Air Force Roles	Key Operational Characteristics
Iraq	Major operation and campaign SSTR and COIN operations	Regime change, thereby securing weapons of mass destruction (WMD) and ending terrorist sponsorship Nation-building	Three largely independent ground efforts (V Corps, 1st Marine Expeditionary Force [I MEF], SOF) Close with and destroy Iraqi forces and take down Baghdad Principal SSTR and COIN operations force	Three air efforts: (1) CFACC strategic attack, air interdiction, CAS, "Corps CAS"; (2) Marine Wing support to I MEF; (3) Army deep attack with Apaches Airpower set the conditions for rapid success on the ground—made it suicidal for large Iraqi forces to move	Air-ground not fully integrated at the theater-level (CFACC and CFLCC) Air-ground integrated at the V Corps, I MEF, and SOF levels Service operational concepts and FSCMs (e.g., FSCLs) constrain air-ground integration Overwhelming superiority over Iraqi conventional forces obscures integration issues

NOTES: SSTR = Stability, support, transition, and reconstruction; SOF = special operations forces; COIN = counterinsurgency; FSCM = fire support coordination measure; FSCL = fire support coordination line; CAS = close air support; CFACC = Combined Forces Air Component Commander; CFLCC = Combined Forces Land Component Commander. In some contexts, the "C" in the last two terms may also stand for "coalition" or may sometimes be replaced by "J" for "Joint."

ational objectives. Furthermore, the increasing role and effectiveness of airpower at the operational and strategic levels—compared with Army deep attack capabilities—have become apparent over the past decade, especially in OIF. In that war, the Army's principal organic deep attack assets were the AH-64 Apache helicopter and Army Tactical Missile System (ATACMS). Throughout OIF, the Army's V Corps flew only two deep attack missions, consisting of fewer than 80 Apache sorties by the 11th Attack Helicopter Regiment and the 101st Airborne Division, to shape the V Corps AO. Additionally, U.S. Army field artillery units fired 414 ATACMS. In contrast, the coalition air forces flew 20,733 sorties between March 19 and April 18, 2003, using 735 fighters and 51 bombers, and struck more than 15,592 kill box interdiction/CAS desired mean points of impact.[3]

Finally, although these operational campaigns rapidly accomplished all their initial warfighting objectives, U.S. strategic political objectives have not been realized. U.S. forces are still in Kosovo conducting SSTR operations. In Afghanistan and Iraq, significant levels of violence persist and SSTR and COIN operations are continuing years after the end of major combat. Resolving these tough challenges has fallen mainly to ground forces, particularly in the realms of SSTR and prosecuting the counterinsurgency in each country.

Lessons from Recent Conflicts

Several key lessons from U.S. post–Cold War operations were most obvious in OIF:

---

[3] Johnson, 2007, p. 159; see also pp. 111–135. Apache deep attack operations were executed only at night because of survivability issues. Furthermore, the Apache is limited by the environment in which it operates. During OIF, sandstorms grounded Army aviation for a time. Fixed-wing air equipped with the Joint Direct Attack Munition was not similarly constrained and proved to be an effective day or night, all-weather resource. The number of ATACMS fired is from Michael D. Maples, "FA Priorities After OIF," *Field Artillery,* September–October 2003, p. 1. See also Anthony S. Cordesman, *The Iraq War: Strategy, Tactics, and Military Lessons,* Washington, D.C.: The CSIS Press, 2003, p. 360. Cordesman cites then–MG David H. Petraeus on the utility and limitations of ATACMS in OIF: "First, the ATACMS were tremendous. You obviously have to have a large area to fire them into. . . . Needless to say, we didn't use them anywhere near built-up areas or civilian targets. As I mentioned earlier, those missiles clear a grid square, a square kilometer."

- The strategic and operational levels of warfighting against large conventional enemy forces were dominated by flexible, all-weather, precision-strike airpower, enabled by ISR.
- Tactical warfighting and the exploitation of the operational effects of airpower were the primary domains of ground power. Despite significant increases in ISR-enabled situational awareness at the strategic and operational levels, uncertainty endured at the tactical and close-combat levels.
- Successful major combat operations did not necessarily achieve a strategic political end state or conflict resolution. A protracted postwar U.S. presence in military support for SSTR continues to be the norm.
- The Army and the Air Force experience the greatest interservice tension over the relative roles of ground and airpower in warfighting. This tension largely results from how joint doctrine designates and defines AOs and how the Army views deep operations. Generally, AOs are expansive—to support an aggressive surface maneuver scheme and to enable the maximum use of the organic capabilities of the surface components. The Army's doctrine tends to want it to retain control over a large AO so that a corps can control and shape the battlespace for its fight and employ its organic assets (ATACMS and attack helicopters) to the limits of their capability. Not surprisingly, Army operational commanders want to control the resources used in their AOs. They do this by establishing FSCMs—for example, the FSCL within the corps or combined/joint force land component commander AOs—that are permissive for Army systems but restrictive for the systems of other components. Using airpower short of the FSCL can be inefficient because of coordination requirements.

These facts lead to the broader conclusion that, in deep operations in the three warfighting campaigns executed by the United States in the past decade, fixed-wing airpower was markedly more effective in creating the conditions for rapid success than were existing ground systems. Thus, the joint warfighting system needs to be reformed for the full dimensions of this potential for major campaigns and operations to be realized.[4]

Challenges to Realizing Joint Air-Ground Integration

If the warfighting lessons described above are valid, the key question is why they are not being aggressively incorporated in service and joint doctrine. Three key obstacles must be overcome to realize the full potential of U.S. warfighting capabilities:

- First, joint doctrine defers to surface components in the establishment of AOs.
- Second, the Army's (and the Marine Corps') retention of control over large AOs in support of their preferred warfighting role—offensive operations at the operational level—constrains the potential effectiveness of joint fires across the theater of operations.
- Third, the Air Force's continued push of its decades-long quest for equality (some would say preeminence) creates tension between it and the other services, most notably with the Army.

We discuss each of these in turn.

Joint Doctrine

There are three fundamental issues with joint doctrine that can constrain the integration and effectiveness of airpower within an operational theater. First, joint doctrine, as specified in Joint Publication

[4] Johnson, 2007, also recommends reforms beyond warfighting, noting the following:

> Even more work is needed to adapt American warfighting prowess into capabilities to achieve national objectives after the warfight. This is the strategic realm in which post-warfighting victory is secured for the nation, and it is largely and intrinsically ground centric. Consequently, given the effectiveness of airpower in deep operations, perhaps the time has come to assess whether the Army should be redesigned to prepare for winning and not just fighting the nation's wars. Resources for this redesign should come in part from existing or envisioned deep operations capabilities—from across the services—that can be more effectively provided by airpower (p. 207).

3-0*, Joint Operations*, defers to surface commanders in the establishment of AOs:

> JFCs establish land and maritime AOs to decentralize execution of land and maritime component operations, allow rapid maneuver, and provide the ability to fight at extended ranges. The size, shape, and positioning of land or maritime AOs will be based on the JFC's Concept of Operations (CONOPS) and the land or maritime commanders' requirements to accomplish their missions and protect their forces.[5]

The second issue stems from the first. Within their AOs, surface commanders are the supported commanders, and joint doctrine provides them with sweeping authority:

> Within these AOs, land and maritime commanders are designated the supported commander for the integration and synchronization of maneuver, fires, and interdiction. Accordingly, land and maritime commanders designate the target priority, effects, and timing of interdiction operations within their AOs. Further, in coordination with the land or maritime commander, a component commander designated as the supported commander for theater/JOA [joint operations area]–wide interdiction has the latitude to plan and execute JFC prioritized missions within a land or maritime AO. If theater/JOA-wide interdiction operations would have adverse effects within a land or maritime AO, then the commander conducting those operations must readjust the plan, resolve the issue with the appropriate component commander, or consult with the JFC for resolution.[6]

The third key point is that joint doctrine sanctions an approach that is explicitly an amalgamation of service preferences:

---

[5] Joint Publication (JP) 3-0, *Joint Operations,* Washington, D.C.: U.S. Joint Chiefs of Staff, September 2006, p. V-21.

[6] JP 3-0, p. V-21.

> JFCs should allow Service tactical and operational assets and groupings to function generally as they were designed. The intent is to meet the needs of the JFC while maintaining the tactical and operational integrity of the Service organizations.[7]

Thus, there is no comprehensive joint doctrinal framework through which the JFC can comprehensively integrate service capabilities to realize theaterwide objectives. Indeed, in OIF the Army and Marine Corps component commanders largely fought independent campaigns, with airpower employed as each of these components deemed appropriate.

This is not to say that the services do not recognize the potential benefits of greater interdependence. They do, and a number of activities have been established to address the issues on several fronts. Most recently, the Director of Air Combat Command Plans and Programs (ACC/A5) and the Deputy Director/Chief of Staff, Army Capabilities Integration Center (ARCIC), Training and Doctrine Command, have established an Army/Air Force Integration Forum (AAFIF) to

> assess, prioritize, develop and recommend bilateral solutions for DOTMLPF requirements between the Army and Air Force . . . direct the actions necessary to gain approval of Army and Air Force interdependency and integration solutions through each respective service . . . provide the structure necessary to reach common positions on DOTMLPF interdependence and integration solutions.[8]

One of the first actions of the AAFIF was to develop a working definition for joint interdependence:

---

[7] JP 3-31, *Command and Control for Joint Operations*, Washington, D.C.: U.S. Joint Chiefs of Staff, 2004, p. III-2.

[8] AAFIF Charter: Memorandum of Understanding Between the Director of Air Combat Plans and Programs (ACC/A5) and the Deputy Director/Chief of Staff, Army Capabilities Integration Center (ARCIC), Ft. Monroe, Va.: U.S. Army Training and Doctrine Command, May 2006.

> Interdependence is a Service's purposeful reliance on another Service's capabilities to maximize complementary and reinforcing effects, while minimizing relative vulnerabilities in order to achieve the mission required by the Joint Forces Commander.[9]

The key phrase in this definition is "a Service's purposeful reliance on another Service's capabilities."[10] Such reliance by one service on another implies the need for trust. Because the idea that battlefield priorities are set by the JFC has not been reinforced, the Army does not feel confident that the Air Force will "be there" when it is needed. Alternatively, the Air Force lacks confidence that the Army will employ airpower properly when it controls that resource. To fully understand the challenges in developing a truly joint approach to major operations and campaigns, one must thoroughly understand Army and Air Force cultures and doctrines.

Army Culture and Doctrine

Central to Army culture is the belief that the Army is the " 'supported service,' the one with the primary responsibility to win the nation's wars."[11] This perspective fundamentally shapes the Army's views about itself, its doctrine, and how much it is willing to concede to joint doctrine:

> [T]he Army, a believer in joint operations, perceives the role of the other services as being, fundamentally, to support the Army. The Air Force and Navy get the Army to the theater and provide it such important combat support as naval gunfire, interdiction, and close air support. The Marines are regarded as the "junior partner" in land operations. To be sure, the sister services ful-

[9] AAFIF Charter, 2006.

[10] Put another way, an even stronger and perhaps more direct definition might acknowledge that a service will accept risk in its own capability because another service can provide that capability for it. True interdependence derives from collaborative cooperation to determine who is going to rely on whom, and at what time.

[11] John Gordon IV and Jerry Sollinger, "The Army's Dilemma," *Parameters,* Summer 2004, p. 34.

> fill other roles: clearing the air of enemy aircraft and the seas of enemy vessels. But in the Army view, these are subsidiary roles and ultimately intended to facilitate the Army's mission of winning the land battle. The Army closes with and destroys enemy forces, with the other services in support.[12]

Furthermore, Army doctrine capitalizes on the authorities provided in joint doctrine in its own operational doctrine. During OIF, Army doctrine stated the following:

> An AO is an operational area defined by the JFC for land and naval forces. AOs do not typically encompass the entire operational area of the JFC but should be large enough for component commanders to accomplish their missions and protect their forces. AOs should also allow component commanders to employ their organic, assigned, and supporting systems to the limits of their capabilities. Within their AOs, land and naval commanders synchronize operations and are supported commanders.[13]

One of the key statements in this passage concerns the creation of AOs large enough to accommodate "organic, assigned, and supporting systems to the limits of their capabilities." In OIF, this essentially meant that the V Corps commander, LTG William S. Wallace, was well within his authority to have an AO that enabled the employment of AH-64 Apache helicopters and ATACMS to the limits of their range, which is over 100 kilometers, and to establish fire support coordination measures within his AO (e.g., FSCL) to facilitate their employment in

---

[12] Gordon and Sollinger, 2004, p. 35.

[13] Field Manual (FM) 3-0, *Operations,* Washington, D.C.: Headquarterss Department of the Army, 2001, p. 4-19. See also Marine Corps Doctrinal Publication (MCDP) 1-0, *Marine Corps Operations,* Headquarters United States Marine Corps, 2001, pp. 4-5–4-6. U.S. Marine Corps doctrine concerning AOs is almost the same as that of the Army:

> The AO is the tangible area of battlespace and is the only area of battlespace that a commander is directly responsible for. AOs should also be large enough to allow commanders to employ their organic, assigned, and supporting systems to the limits of their capabilities. The commander must be able to command and control all the forces within his AO.

accord with the Corps' concept of operations. The recent 2008 version of FM 3-0 has similar language concerning AOs to that of the 2001 edition:

> One of the most basic and important control measures is the area of operations. The Army or land force commander is the supported commander within that area of operations designated by the joint force commander for land operations. Within their areas of operations, commanders integrate and synchronize maneuver, fires, and interdiction. To facilitate this integration and synchronization, commanders have the authority to designate targeting priorities and timing of fires within their areas of operations. Commanders consider a unit's area of influence when assigning it an area of operations. An area of operations should not be substantially larger than the unit's area of influence. Ideally, the entire area of operations is encompassed by the area of influence. An area of operations that is too large for a unit to control can allow sanctuaries for enemy forces and may limit joint flexibility.[14]

Coupled with the authority to create large AOs, Army doctrine emphasizes the operational level of war and the centrality of the corps headquarters. Since the 1980s, Army warfighting concepts have envisioned the corps operating in an expansive AO to create conditions for operational success:

> Whatever its mission or exact composition, the corps was to conduct the following critical functions:
>
> - Maintaining surveillance over an area to the corps' front to provide an accurate picture of the enemy as he is deployed 96 hours movement time from the forward line of own troops (FLOT) extending as far as 300 kilometers (km) from the FLOT.

[14] FM 3-0, *Operations,* Washington, D.C.: Headquarters, Department of the Army, 2008, p. 5-14.

- Fighting the enemy throughout the area of influence, 72 hours movement time from the FLOT or from corps objectives.
- Supporting the battle with CS [combat support] and CSS [combat service support] forces
- Sustaining the battle by drawing together forces to carry the fight to successive enemy echelons.[15]

Thus, General Wallace was executing Army doctrine during OIF. His preference for "corps CAS" within the corps AO short of the FSCL was understandable from an Army perspective, because it gave him control over the assets with which he sought to accomplish corps objectives. That said, from a joint force perspective, the V Corps approach made "joint targeting operations in the V Corps area of responsibility extremely restrictive" for other than V corps assets.[16]

Air Force Culture and Doctrine

Air Force doctrine is also shaped by a culture that has struggled for some nine decades to assert its independence and prove the inherent decisiveness of airpower. The centralized control of airpower by air officers is the fundamental Air Force cultural tenet, as seen in Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*:

> Because of air and space power's unique potential to directly affect the strategic and operational levels of war, it must be controlled by a single airman who maintains the broad, strategic perspective necessary to balance and prioritize the use of a powerful, highly desired yet limited force.[17]

Prior to operations in Operation Enduring Freedom (OEF) and OIF, the Air Force largely focused on strategic attack—avoiding direct

---

[15] FM 100-15, *Corps Operations*, Washington, D.C.: Headquarters Department of the Army, 1996, p. xiii.

[16] U.S. Army 3rd Infantry Division, *Third Infantry Division (Mechanized) After Action Report: Operation Iraqi Freedom,* Fort Stewart, Ga., 2003, p. 108.

[17] AFDD 1, *Air Force Basic Doctrine,* Washington, D.C.: Headquarters Department of the Air Force, 2003, p. 28.

engagement in the operational and tactical ground efforts—as the most effective use of airpower:

> Strategic attack is defined as those operations intended to directly achieve strategic effects by striking at the enemy's COGs [centers of gravity]. These operations are designed to achieve their objectives without first having to necessarily engage the adversary's fielded military forces in extended operations at the operational and tactical levels of war.[18]

In the aftermath of the success of airpower in OEF and OIF against enemy fielded forces, the Air Force has, however, pragmatically embraced the counterland mission as an important use of airpower:

> In war, defeating an enemy's force is often a necessary step on the path to victory. Defeating enemy armies is a difficult task that often comes with a high price tag in terms of blood and treasure. With its inherent speed, range, and flexibility, air and space power offers a way to lower that risk by providing commanders a synergistic tool that can provide a degree of control over the surface environment and render enemy forces ineffective before they meet friendly land forces. Modern air and space power directly affects an adversary's ability to initiate, conduct, and sustain ground combat. Counterland operations dominate the surface environment by crushing an enemy's ability to fight on land. Through air interdiction, air and space power can divert, disrupt, delay, or destroy enemy military potential before it can be brought to bear against friendly ground forces. . . .[19]

This statement from AFDD 2-1.3, while acknowledging the importance of dealing with opposing armies, remains true to Air Force culture when it further states that airpower can "achieve joint force commander objectives independently" and, therefore, "counterland

---

[18] AFDD 1, p. 51.

[19] AFDD 2-1.3, *Counterland Operations,* Washington, D.C.: Headquarters Department of the Air Force, 2006, p. ii.

operations can serve as the main attack and be the decisive means for achieving JFC objectives."[20]

In OIF, Air Force counterland operations were particularly devastating against enemy fielded forces that were not yet directly engaged with coalition forces.

> [T]he importance of "shaping" the battlefield with airpower, enabled through high levels of operational situational awareness, was that it created a tactical condition whereby coalition ground forces never faced large conventional Iraqi formations "eyeball-to-eyeball." Enemy forces between Baghdad and Iraq's southern border could not maneuver in large formations without the possibility of being detected and accurately attacked, anytime, anywhere, day or night, *and in any weather*.[21]

This is the realm of aerial interdiction. Again, however, the cultural preference for independent action prevails in AFDD 2-1.3, which was published after OIF:

> The Air Force defines AI [air interdiction] as air operations conducted to divert, disrupt, delay, or destroy the enemy's military potential before it can be brought to bear against friendly forces or to otherwise achieve JFC objectives. These operations are conducted at such distance from friendly forces that detailed integration with those forces is not required.[22]

The Air Force's reluctance to integrate itself deeply with ground operations likely reflects a culture wary of jeopardizing its independence—and of relinquishing its newly realized capacity to be decisive in theater-level counterland operations. Nevertheless, absent the detailed integration of AI with ground maneuver, airpower will not be able to fully exploit the operational opportunities created by enemy forces uncovering themselves in reaction to ground maneuver.

---

[20] AFDD 2-1.3, p. viii.

[21] Johnson, 2007, pp. 115–116. Emphasis in the original.

[22] AFDD 2-1.3, p. viii.

More Effective Air-Ground Integration Will Require Joint Direction

Thus, the development of the comprehensive U.S. air-ground integration concepts that are the subject of the remainder of this monograph faces many challenges. This is principally because they are contingent on the realization of greater jointness at the expense of deeply rooted service preferences. Consequently, they will face resistance. Nevertheless, as the analysis in this monograph shows, the potential increases in effectiveness and efficiency offered by greater air-ground integration are substantial and should be pursued. U.S. Joint Forces Command should logically provide an institutional home for the development of these concepts, but strong leadership and persistence from the Office of the Secretary of Defense (OSD) and the Joint Staff will also be required.

Monograph Structure

The remainder of this monograph focuses on presenting options for a framework for improving air-ground integration. Chapter Two describes two potential options for enhancing joint fires and maneuver. The discussion begins with an examination of a joint fires and maneuver option that introduces incremental improvements into the current system of air-ground operations. We then present a fundamentally different joint fires and maneuver option that significantly expands the joint air component's freedom of action to influence the land battle. In Chapter Three, we provide an effectiveness analysis of the various air-ground integration options and describe our methodology. Chapter Four assesses the command and control implications of the proposed options, while Chapter Five examines the information and information systems implications. Finally, Chapter Six presents the overall observations and recommendations arising from the study.

CHAPTER TWO

Options for Enhancing Joint Fires and Maneuver

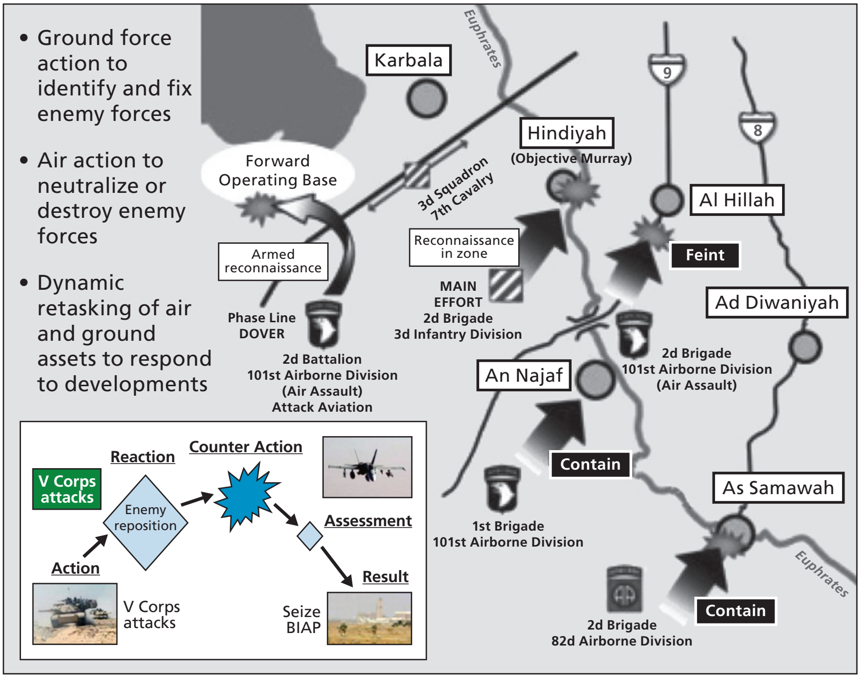
This chapter develops potential options for enhancing joint fires and maneuver. The five simultaneous attacks on Karbala Gap by V Corps during the march to Baghdad in OIF, illustrated in Figure 2.1, is a good example and point of departure for the discussion that follows. These attacks against primarily Iraqi Medina Republican Guard Division forces occurred on March 31, 2003. An important objective of the five simultaneous attacks was to reduce the enemy force strength as a precursor to the coalition force's final push toward Baghdad. Based on the successes of earlier operations that teamed Army unmanned air vehicles with coalition air forces to find and destroy enemy targets, V Corps developed the March 31 plans to create operational deception and to draw out the remaining enemy forces by employing a full spectrum of joint capabilities.[1] Taken together, the attacks describe the reciprocal relationship that evolved between ground maneuver and joint fires during OIF and provide a glimpse of the potential that even greater joint interdependence might produce in the future.[2]

---

1 Joint capabilities included Air Support Operations Center (ASOC)- and Tactical Air Control Party (TACP)-directed CAS at the corps and division levels, respectively, integrated with organic corps and division artillery and attack aviation. During these attacks, Army unmanned air vehicles were used extensively to find and track individual systems that were subsequently destroyed by ASOC-vectored aircraft (Lt Col Michael B. McGee, *Air-Ground Operations During Operation Iraqi Freedom: Successes, Failures and Lesson of Air Force and Army Integration,* Washington, D.C.: Air Warfare College University, February 25, 2005).

2 Charles E. Kirkpatrick, *Joint Fires as They Were Meant to Be: V Corps and the 4th Air Support Operations Group During Operation Iraqi Freedom,* Land Warfare Paper No. 48, Arlington, Va.: The Institute of Land Warfare, Association of the United States Army, October

Figure 2.1
Reciprocal Relationship Between Ground Maneuver and Joint Fires Secured the Path to Baghdad



SOURCE: Kirkpatrick, 2004; McGee, 2005.
RAND *MG793-2.1*

The interdependence between joint forces described by these attacks was initiated by 2nd Brigade 3rd Infantry Division (2d Bd 3 ID) in a ground maneuver and attack on Hindiyah and reconnaissance into the Karbala Gap that caused an enemy reaction: movement and repositioning of its forces south of "Objective (OBJ) Murray." Enemy movement and repositioning enabled coalition air-delivered fires to destroy large numbers of enemy tanks. Facing a much weaker enemy, coalition ground and air forces were able to subsequently secure the

2004; and COL Gregory Fontenot, LTC E. J. Degen, and LTC David Tohn, *"On Point": The United States Army in Operation Iraqi Freedom*, Ft. Leavenworth, Kan.: Center for Army Lessons Learned, May 26, 2004.

path to Baghdad. General Wallace, the V Corps commander, described the operations as follows:

> My current thinking is that those actions caused the enemy commander to think that series of attacks was our main effort, that our main attack had started, and that we were attacking from west to east across the Euphrates to gain Highway 8 [south of Karbala] so we could turn north into Baghdad. That was never our intention. But having done that, I believe our attacks caused him to react to our actions, fully knowing that if he did not react to them, given the limited successes that we had in those actions, then he would be out of position. So he started repositioning—vehicles, artillery, and tanks on [heavy equipment transporters]—in broad daylight, under the eyes of the U.S. Air Force.
>
> I believe it was one of those classic cases of a maneuver action setting up operational fires, which in turn set up for a successful decisive maneuver, which took place the following day and over the following 48 hours. Just 48 hours later, we owned Baghdad International Airport and Objective SAINTS. We had begun the encirclement of Baghdad. From my perch, my perspective, my retrospection, that was a tipping point in the campaign.[3]

The sections that follow present a series of options that build on the attributes described during the march to Baghdad. We then expand this framework to include an altogether new option, whose attributes are purposefully designed to promote greater levels of effectiveness and flexibility through enhanced joint interdependence.

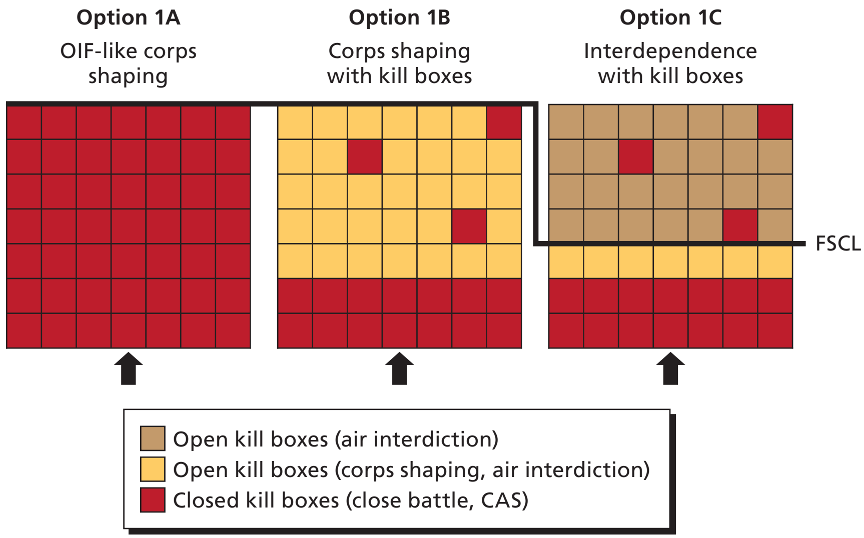
Option 1: Incremental Improvements That Evolve from the Present Concept of Operations

A logical first question in designing a new system for joint air-ground interdependence is: How do we get there from here? In the analysis that follows, two options are examined. Option 1, shown in Figure 2.2,

---

[3] Fontenot, Degen, and Tohn, 2004.

Figure 2.2
Option 1: Make Incremental Improvements, Continue to Emphasize CAS and AI



RAND *MG793-2.2*

evolves from the present concept. A second option that is developed subsequently represents a new interdependent and integrated joint warfighting concept that capitalizes on existing and evolving U.S. ISR, air, and surface maneuver capabilities along the lines discussed previously.

Option 1 includes three variations (A, B, and C) that make incremental improvements to the current air-ground CONOPS that uses a FSCL as a FSCM for facilitating air-delivered fires across a land or amphibious commander's battlespace. It also reflects current counterland employment arrangements that emphasize separate CAS and air interdiction (AI) sortie allocations: CAS allocations used for short-of-the-FSCL engagements[4] and AI otherwise.

[4] CAS-allocated aircraft, often assigned to CAS stacks, provide an on-call rapid response to immediate CAS requests and also preplanned CAS and ASOC-directed air interdiction sorties short of the FSCL. CAS allocations are designated for use in short-of-the-FSCL engagements, although exceptions to this rule occasionally arise.

Two distinguishing Option 1A characteristics are depicted: a notionally deep FSCL that is well beyond the forward line of friendly forces and their organic ground fires, and kill boxes that remain closed (red squares in the figure) short of the FSCL. Closed kill boxes require CAS control procedures, which are more command and control (C2) intensive than other operations (e.g., CAS execution typically takes more time and requires more people with specialized training and equipment).[5] Option 1B assumes a similarly deep FSCL but closes kill boxes only when friendly troops are nearby.[6]

Option 1C is characterized by a shallow FSCL that is sized to the range of a division's organic surface fires, similar to the battlefield coordination line used by I MEF in OIF. In all variations of Option 1, kill boxes are closed beyond the FSCL only when friendly troops are nearby.

From the ground commander's perspective, Option 1B, while desirable, requires greater situational awareness, which continues to be problematic. Because Option 1C pulls in the FSCL, the question a ground commander will wrestle with is whether, by reducing the area under his control, it will undercut his ability to responsively and effectively shape the battlespace that he must eventually fight in. The ground commander must also weigh the potential benefits of Option 1C against his ability to quickly coordinate FSCL changes. For example, a deeper FSCL that changes less often may currently be more practical, since FSCL changes can often take many hours to coordinate.

From the perspective of the Joint Force Air Component Commander (JFACC), continuing the OIF-like utilization of airpower (particularly Options 1A or 1B) undercuts the principle of centralized management of airpower. As a result, this option will likely necessitate a significantly enhanced ASOC and TACP. The OIF-like utilization of

---

5 During OIF, Iraq was divided into 30 nm × 30 nm kill boxes, and each kill box was further subdivided into nine 10 nm × 10 nm keypads. Option 1A illustrates the V Corps' OIF AO during its corps shaping operations. Especially early in this fight, FSCL placement was deep, and most kill boxes were closed, requiring CAS control procedures for air-delivered fires.

6 The battlespace environment during the five simultaneous attacks on Karbala Gap was characterized by Option 1A and, occasionally, 1B.

airpower (Options 1A and 1B) also continues to constrain the potential of increased ISR and strike capabilities and limits the JFACC's capability to support the overall theater plan. Although this is less of an issue for the JFACC in Option 1C, even this variant still has airpower supporting two possibly very different surface component warfighting concepts rather than engaging in an integrated and interdependent joint fires and maneuver scheme.

Option 1 basically adheres to current joint doctrine, which, as we have already noted, tends to defer to service (particularly Army and Marine Corps) preferences. This is Option 1's principal weakness, and the result is its inability to realize the full potential afforded by a truly joint construct.

The next series of figures presents one example of such a construct.

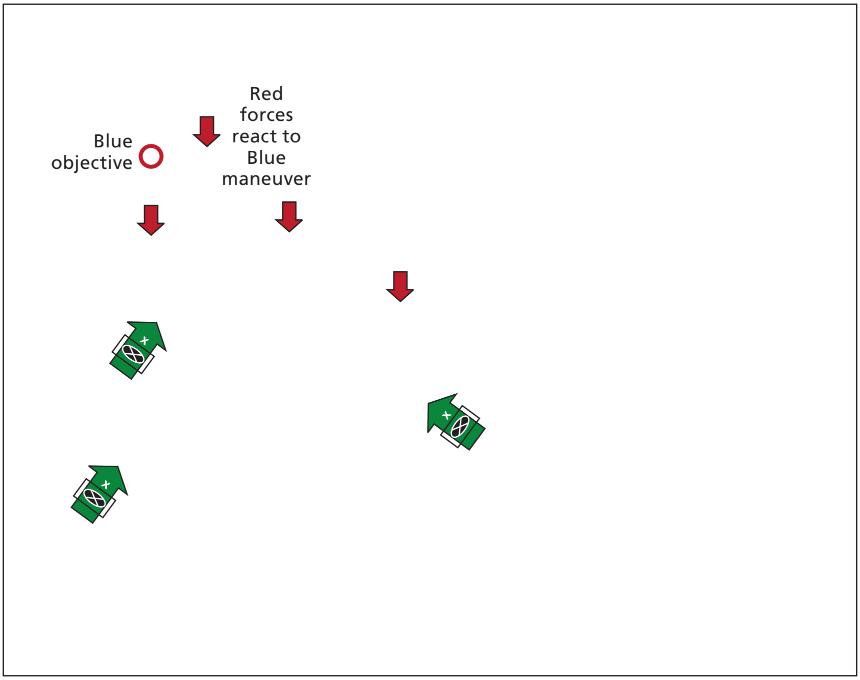
Option 2: Focus on Effects—Prioritize and Synchronize Joint Fires and Maneuver

Figures 2.3 and the next five figures ("builds") propose a new option for joint air-ground interdependence that is centered on a conceptual approach emphasizing theaterwide joint fires and maneuver. We initially limit the sequential discussion to defining key Option 2 features and develop the idea in more detail thereafter. Appendix A describes two Option 2 vignettes illustrating joint fires and maneuver integration and interdependence.

We begin by showing a notional theater-level engagement scenario consisting of Blue (friendly) and Red (enemy) ground forces. In this example, three brigade combat teams are shown maneuvering toward an objective. An enemy force consisting of a number of ground forces is also shown, reacting to Blue maneuver. As the following figures more clearly illustrate, this example depicts some of the complexity of nonlinear and noncontiguous operations envisioned for future Army concepts.[7]

[7] FM 3-0, 2001, p. 4-20.

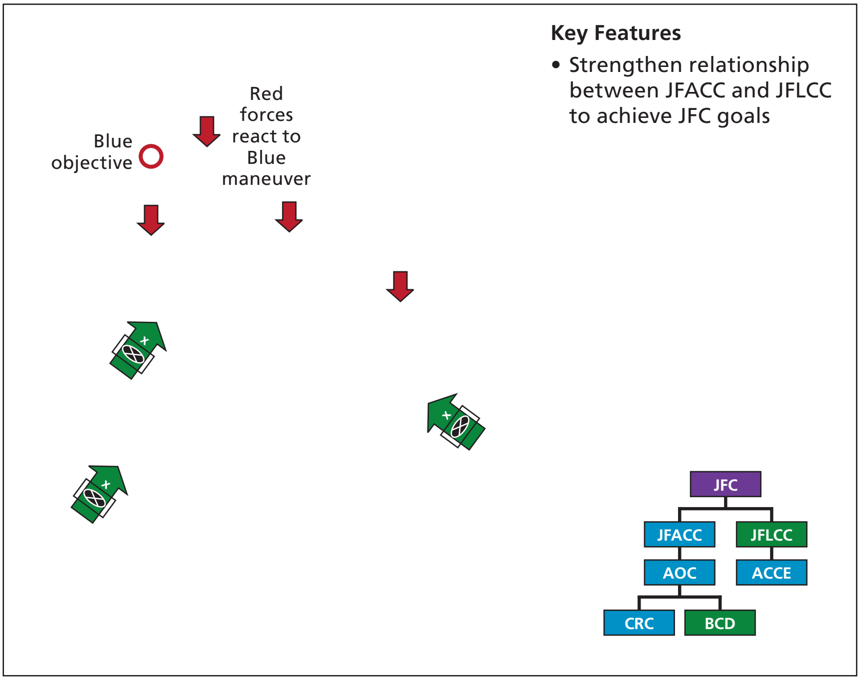
Figure 2.3
Option 2 (Build 1): Notional Scenario



RAND *MG793-2.3*

Option 2 has several important key features; the first is highlighted in Figure 2.4. This option will require strengthened ties between the JFACC and the Joint Force Land Component Commander (JFLCC), who are the JFC's executive agents for the integration of ground and air. One obvious example that benefits from this strengthened relationship is early JFACC–JFLCC collaboration to develop plans for emplacing air assets (or ground units) in overwatch positions during high-risk operations. Chapter One described recent conflicts that had multiple operational phases (e.g., major combat followed by stability and recon-

Figure 2.4
Option 2 (Build 2): Strengthened JFACC and JFLCC Ties



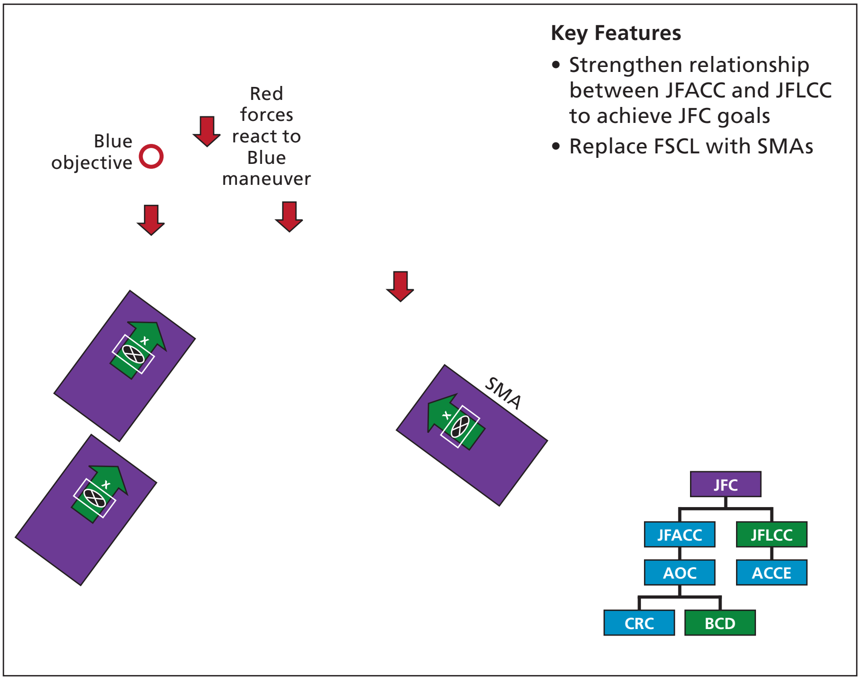
RAND *MG793-2.4*

struction operations); we note that the JFACC–JFLCC collaboration described in Option 2 is essential regardless of phase.

A second Option 2 feature, shown in Figure 2.5, is the creation of a notionally named surface-maneuver area (SMA). This is a significant revision to existing joint doctrine, which now states the following:

> Area of Operations. JFCs may define AOs for land and maritime forces. AOs typically do not encompass the entire operational area of the JFC, but should be large enough for component commanders to accomplish their missions and protect their forces. Component commanders with AOs typically designate subordinate AOs within which their subordinate forces operate. These commanders employ the full range of Joint and Service control measures and graphics as

Figure 2.5
Option 2 (Build 3): Surface-Maneuver Area



RAND *MG793-2.5*

> coordinated with other component commanders and their representatives to delineate responsibilities, deconflict operations, and achieve unity of effort.[8]

Instead of the current practice of apportioning parts of the operational environment to the components, the SMA construct considers the entire theater a joint AO. Component schemes of fires and maneuver are integrated and truly interdependent with the goal of achieving the JFC's intent. Consequently, the deconfliction of operations is not necessary, because such a concept guarantees unity of effort. Another critical difference with existing joint doctrine is that of synchronizing

---

[8] JP 3-0, p. V-21.

fire, maneuver, and interdiction within the theater. Currently, JP 3-0 notes,

> Within these AOs, land and maritime commanders are designated the supported commander for the integration and synchronization of maneuver, fires, and interdiction. Accordingly, land and maritime commanders designate the target priority, effects, and timing of interdiction operations within their AOs.[9]

In Option 2, the JFC is the supported commander at the operational and strategic levels of war, and the theaterwide scheme of fires and maneuver—including interdiction and strategic attack—is designed to employ the most capable systems to achieve the JFC's desired effects. The JFACC, JFLCC, and Joint Maritime Component Commander (JMCC) are his agents in this effort.

Thus, AOs are not determined as currently described in Army and Marine Corps doctrine, both of which state exactly the same thing: AOs should be large enough "to allow commanders to employ their organic, assigned, and supporting systems to the limits of their capabilities."[10] In the case of the Army, FM 3-0 gives it the authority to create AOs that extend to the outer range of AH-64 Apache helicopters and ATACMS. For the Marine Corps, MCDP 1-0 includes fixed-wing aircraft and, potentially, the V-22 Osprey.

The intent of Option 2 and the SMA is to design a theater-level scheme of fires and maneuver, including interdiction, that maximizes the effectiveness of the tools available to the JFC, regardless of which component owns them. In this regard, it embraces a recommendation contained in the 3rd Infantry Division's OIF afte-action report: "The U.S. Army must redefine the battlespace based on our ability to influence it."[11]

The SMA is essentially a joint ground maneuver area; its dimensions are determined by the ranges of systems that are most effective

---

[9] JP 3-0, p. V-21.

[10] FM 3-0, 2001, p. 4-19, and MCDP 1-0, 2001, p. 4-4.

[11] U.S. Army 3rd Infantry Division, 2003, p. 108.

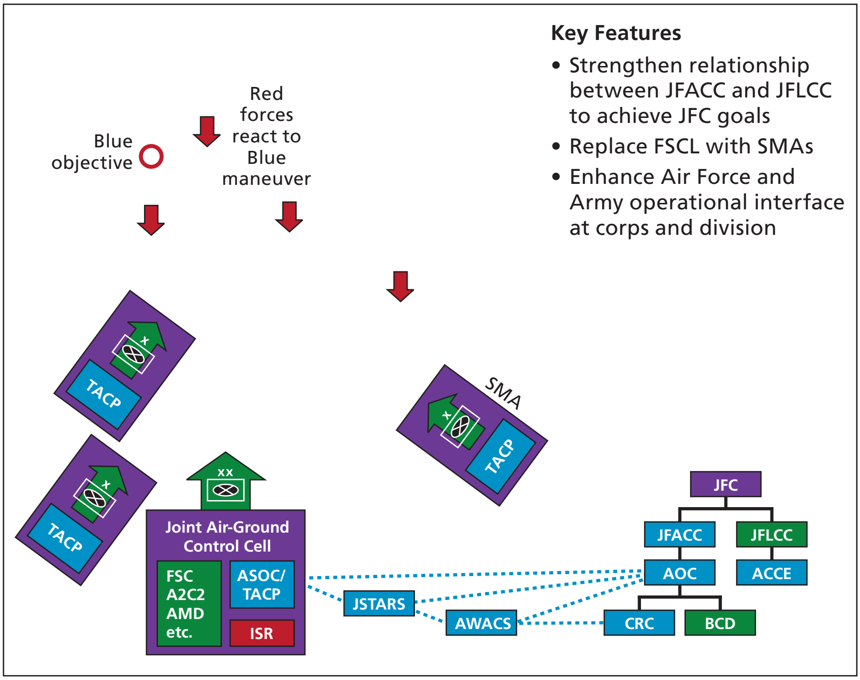
and responsive in a rapidly developing offensive operation. While the specific dimensions of the SMA are beyond the scope of this study, it is our sense that its outer limits would be determined by the range of organic cannons or Multiple Launch Rocket System (MLRS) fires, perhaps with a buffer to accommodate rapid operations. Thus, the SMA is similar to an AO in that, within its boundaries, the surface commander controls fires and maneuver, including CAS. There would also likely be an extension of the SMA to the rear of the direction of attack (not depicted in Figure 2.5) that recognizes the need to protect ground and air (helicopter) lines of communication.

The SMA feature will require a rethinking of the size of component AOs and existing FSCMs. Again, the services will need to sort out what the specifics of the SMA should be for the various ground maneuver units, what fires are most effective within the SMA (e.g., what systems are best for counterfire), and what C4ISR capabilities and processes are most effective and efficient. Clearly, the complex integration area with respect to joint fires where the green and purple intersect within each SMA is the area that will need the greatest attention. The SMA should also influence requirements for future C4ISR systems and how they are integrated. Specifically, surface maneuver unit location systems (e.g., Blue Force Tracker) must be integrated into the overall joint network. A goal should be the ability to display SMAs in real time inside the cockpits of strike aircraft conducting CAS or AI.[12]

[12] We recognize that the services will need to identify and enhance a number of critical interactions in the SMA at the tactical levels of combat aircrew, JTAC, and lower-echelon Tactical Operations Centers (TOCs), although this was not the focus of our research. Besides the Blue Force Tracker discussed above, such interactions will benefit from other new technologies and tactics that allow, for example, a JTAC to remotely view real-time imagery, find and identify targets, fix their locations, and quickly and accurately communicate the information to aircrews. In future operations, these new concepts could result in routine placement of lowest-echelon JTACs at a battalion TOC, working closely with the battalion S-3 to coordinate CAS, including assessing whether noncombatants or friendly troops are nearby. A recent service agreement to standardize training for forward-located joint fires observers—to provide, among other things, timely and accurate targeting data to a JTAC—will enhance other critical service-to-service tactical-level interactions within the SMA. See Bruce R. Pirnie, Alan Vick, Adam Grissom, Karl P. Mueller, and David T. Orletsky, *Beyond Close Air Support: Forging a New Air-Ground Partnership,* Santa Monica, Calif.: RAND Corporation, MG-301-AF, 2005; and Jody Jacobs, Leland Joe, David Vaughan, Diana

Enhanced Air Force and Army operational interfaces at the corps and/or division are another important Option 2 feature, as illustrated in Figure 2.6. One way to achieve these improved interfaces is through an integrating cell, such as the recently proposed Joint Air-Ground Control Cell (JAGC2).[13] The JAGC2 is composed of various staff sections (functional cells or elements) and C2 elements. The JAGC2,

Figure 2.6
Option 2 (Build 4): Enhanced Air Force and Army Interfaces



RAND *MG793-2.6*

Dunham-Scott, Lewis Jamison, and Michael Webber, *Technologies and Tactics for Improved Air-Ground Effectiveness,* Santa Monica, Calif.: RAND Corporation, 2008.

[13] JAGC2 was first introduced in the recently approved U.S. Air Force (USAF) ASOC Enabling Concept and is included in newly revised USAF doctrine as a vignette. See USAF Air Support Operations Center Enabling Concept, June 1, 2006; AFDD 2-1.3; and Curtis Neal, "JAGC2: A Concept for Future Battlefield Air-Ground Integration," *Field Artillery,* November–December 2006.

notionally illustrated on this figure at division headquarters, includes a Fire Support Cell (FSC), Army Airspace Command and Control (AC2) and Air and Missile Defense (AMD) organizations, and, joint intelligence elements. It also incorporates the Air Force ASOC and TACP.

Besides the JAGC2, there are a number of Theater Air Control System (TACS)–related improvements that can facilitate the operational interfaces that enable Option 2 joint fires and maneuver.[14] For example, the Joint Surveillance and Target Attack Radar System (JSTARS) could play a greater role providing battle management of airborne assets operating beyond the normal communications coverage of ground elements. In such situations, JSTARS (but only when ordered) could function as an ASOC extension, to direct aircraft to targets, to open kill boxes or joint fires areas (JFAs), or to direct JTACs to control CAS execution.[15]

Independent of JSTARS augmentation, ASOC enhancements are also needed. An example is the air battle manager function, which was recently incorporated into the ASOC to deconflict and control airspace in response to shortfalls identified during OIF—essentially an Option 1A and 1B environment.[16] This function will link to the controlling and reporting centers (CRCs) and the airborne warning and control

[14] The TACS gives the commander, Air Force forces, the capability to plan and conduct joint air operations. The Air Force air and space operations center is the senior element of the TACS. See JP 3-09.3.

[15] Air Land Sea Application (ALSA) Center, *JSTARS Multi-Service Tactics, Techniques, and Procedures for Joint Surveillance Target Attack Radar System*, Langley Air Force Base (AFB), Va., November 2006. The JFA is a proposed three-dimensional, permissive, FSCM used by the JFC to focus and facilitate the rapid engagement of targets with air-to-surface fires and/or surface-to-surface indirect fires. The Joint Fires Coordination Measures (JFCM) Joint Test and Evaluation (JT&E) project is currently investigating, evaluating, and recommending improvements to the effectiveness of JFA coordination measures, with a focus on establishing standardized tactics, techniques, and procedures (TTPs) at the operational level. Because these developments are ongoing and have not yet been established in doctrine or joint TTPs, we use the kill box and JFA constructs interchangeably for purposes of the present discussion, although in practice they will have different characterizations (JFCM JT&E, Tactics, Techniques, and Procedures, draft, no date).

[16] JP 3-09.3.

system (AWACS). The air battle manager function is equally important for operations that have the characteristics of Option 2.

Another important Option 2 characteristic is its focus on prioritizing and synchronizing joint fires and maneuver in an integrated and interdependent series of actions and effects.[17] To illustrate this focus, Figure 2.7 lists a number of operational effects (interdict, block, neutralize, destroy) described in Army and Marine Corps guidance documents and notionally associates them in time and space. For example, blocking effects that deny an enemy access to a given area or prevent its advance may be appropriate on day 1.[18] On the other hand, depending on the campaign plan developed to achieve the JFC's objectives, enemy destruction may be a required effect on day 3.[19]

One way for the JFACC to manage assets to achieve these effects is to replace today's distinction between CAS and AI sorties with a single counterland apportionment that is planned against targets, kill boxes, or JFAs located in areas of second- and third-echelon enemy forces.[20] Implementing this strategy will demand new procedures to assure responsiveness to immediate requests for air support from the ground commander.[21]

Thus, in Option 2, counterland airpower is apportioned as a continuum that incorporates the dynamics of the near and far fights. To respond quickly to an immediate need that may arise in the close fight, the ASOC is authorized to pull aircraft from the counterland flow as required by the ground commander. This situation is illustrated in Figure 2.8.

---

[17] Although Option 2 enhances coordination between the land and air component commanders, the JFC's ability to synchronize and integrate ground and air operations must also be enhanced. We discuss this subject in Chapter Four.

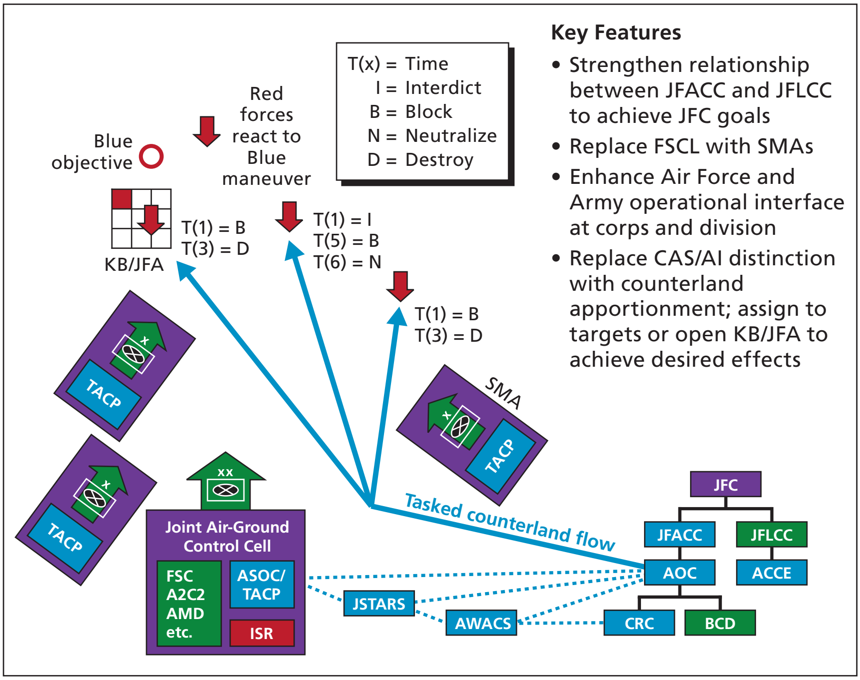
[18] These effects could be achieved through ground maneuver, joint fires, or both.

[19] For more discussion, see Appendix A and FM 1-02 (FM 101-5-1)/MCRP 5-12A, *Operational Terms and Graphics,* Washington, D.C.: Headquarters, Department of the Army and Marine Corps Combat Development Command, 2004.

[20] As is the case today, this counterland apportionment is separate from other activities, such as strategic attack and time-sensitive targeting.

[21] Discussions with and materials from Lt Col Seth Bretscher, 2006.

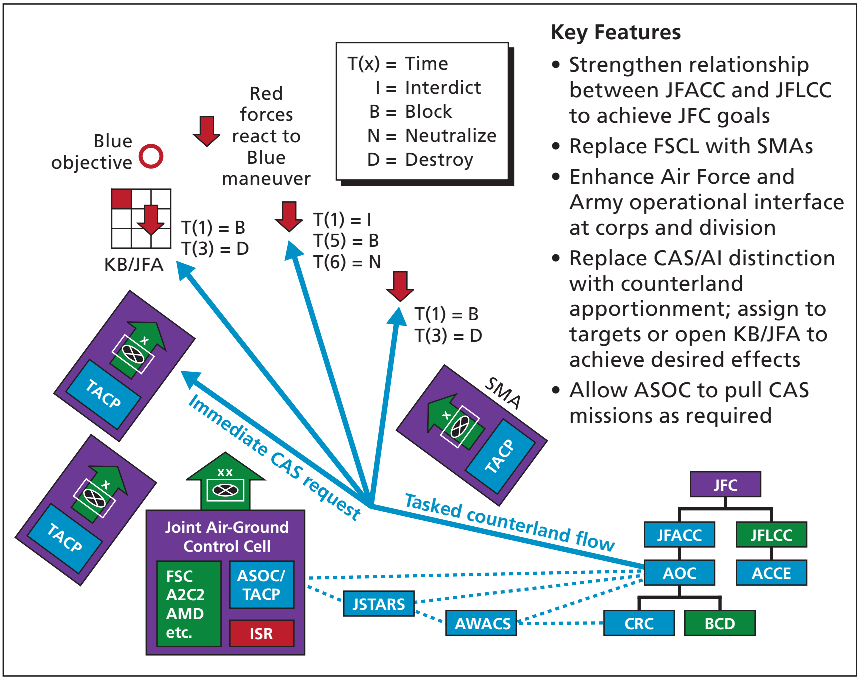
Figure 2.7
Option 2 (Build 5): Tasked Counterland Flow



RAND *MG793-2.7*

Because Option 2 does not use CAS stacks, ensuring responsiveness to support the ground commander's needs in the close fight will depend on developing a continuous flow of aircraft into second- and third-echelon AOs that are also close enough in distance to enable quick response to any projected ASOC requests. Communications must be assured between aircraft and C2 elements. Adequate numbers of aircraft must be apportioned; planners need to ensure that an appropriate subset of aircraft carries a weapon mix that includes some "CAS-friendly" munitions (e.g., Maverick or Global Positioning System[GPS]–guided bombs) and that their aircrews are CAS-qualified. Sufficient numbers of targets, kill boxes, or JFAs must be identified, and air dominance must be established in all cases to create the necessary permissive

Figure 2.8
Option 2 (Build 6): ASOC Pulls from Counterland Flow as Required



RAND *MG793-2.8*

environment for conducting these operations. In addition, TTP will need to be developed so that aircraft can be appropriately redirected.

Options 1 and 2 differ in a number of ways. Seven key characteristic dimensions, listed in the first column in Table 2.1, are used to distinguish the options. Taken together, these distinctions create a framework of potential alternatives for achieving enhanced effectiveness through greater joint interdependence. We first discuss the distinguishing features of this framework qualitatively. In the next chapter, we develop and further explore them quantitatively.

FSCL and kill box distinctions have already been described and are repeated in the first two rows of the table. Options 1A is characterized by a deep FSCL and closed kill boxes. The deep FSCL also characterizes Option 1B. However, in this variation, as well as in Options

Table 2.1
Options 1 and 2 Differ on Key Dimensions

Dimension	1A	1B	1C	2
FSCL	Deep	Deep	Shallow	Replaced with SMA
KB or JFA	Closed KB	Open/closed KB	Open/closed KB/JFA	Open/closed KB/JFA
Air sortie allocation	AI CAS stacks sized to assure response	AI CAS/AI stacks sized to assure response	AI CAS stacks sized to assure response	Counterland apportionment ASOC authority to pull CAS from counterland flow
C2	Doctrinal TACS CAS control inside FSCL	TOC-based ASOC operations CAS control in closed KBs	TOC-based ASOC operations with JSTARS C2 augmentation CAS control in closed KB/JFA	JAGC2 with JSTARS C2 augmentation CAOC counterland cell CAS control in closed KB/JFA
ISR, fires and effects	Air- delivered fires use joint ISR	Air-delivered fires use joint ISR	Air-delivered fires use joint ISR	Effects tied to synchronized joint maneuver using joint ISR and fires
Communications	LOS for CAS control Jam sensitive	LOS for CAS control ASOC uses airborne relays/networks Jam resistant	LOS for CAS control ASOC uses airborne relays/networks Jam resistant	LOS for CAS control ASOC/CAOC uses airborne relays/network Jam resistant
Information and information systems	Current information sharing for JTAC–aircrew exchange	SA and systems for dynamic KB execution and airspace deconfliction	SA and systems for dynamic KB/JFA execution and airspace deconfliction	Information sharing to support joint collaboration Net-centric structure and data strategy

NOTE: LOS = line of sight; CAOC = Combined Air and Space Operations Center.

1C and 2, kill boxes or JFAs are open unless friendly troops are nearby. Option 1C also assumes a shallow FSCL. Option 2 replaces the FSCL with an SMA.

Counterland apportionment and allocation of assets have also been discussed. Option 1 assumes that CAS aircraft are allocated to CAS stacks in sufficient numbers to provide a timely response (either as CAS or as ASOC-directed air interdiction) to targets or kill boxes inside the FSCL that have been requested by the ground commander. The remaining Option 1 counterland-apportioned sorties fly air interdiction missions against targets or kill boxes located beyond the FSCL.

CAS and air interdiction sortie apportionment and allocation distinctions are eliminated in Option 2. In this option, all counterland air is apportioned in a single category—counterland—and is tasked to flow into the AO continuously. There are no pre-identified CAS aircraft flying in stacks; instead, aircraft carrying CAS-appropriate munitions (and flown by CAS-qualified crews) are integrated into the overall counterland flow. The ASOC is given the authority to pull these aircraft from the counterland flow to satisfy immediate requests for air by the ground commander.

C2 is another key distinction that separates the options. In Option 1A, C2 is characterized by the TACS structure that is defined in doctrine today.[22] Options 1B and 1C implement the ad hoc interfaces used in OIF during the march to Baghdad to better integrate the Air Force ASOC and Corps TACP into V Corps' targeting and intelligence operations.[23] These arrangements are informally referred to as "TOC-based ASOC operations." To support the shallow FSCL in Option 1C, the C2 structure is additionally enhanced by greater integration of JSTARS into the TACS, allowing it to function as a communications relay or as an extension to the ASOC and TACP.

---

[22] Joint doctrine defines the TACS as providing an Air Force command and control presence at each Army echelon. Together with the Army Air Ground System (AAGS), the combined TACS-AAGS provides the structure for command and control during close air support operations. See JP 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support,* Washington, D.C.: Joint Staff, September 3, 2003.

[23] Kirkpatrick, 2004.

C2 in Option 2 is further distinguished by a number of changes. First, it assumes a formalization of joint interfaces at the corps or division through creation of the JAGC2 described earlier. Second, as with Option 1C, it better integrates JSTARS into the TACS. Third, forward air controller (airborne) (FAC(A)) and strike coordination and reconnaissance (SCAR) missions are extensively employed to provide local and tactical situational awareness (and control in the case of the FAC(A)) and to further coordinate JFA and kill box operations, especially those near the transition areas that bound the SMA.[24] Finally, Option 2 incorporates changes into the organization and processes at the CAOC by creating a counterland cell to focus on the execution of the counterland aircraft flow at the operational level that also meets the needs of the changing dynamics on the battlefield, at both the tactical and operational levels.[25] The Army battlefield coordination detachment (BCD) (this organization already sits at the CAOC) should be a member of this cell and should be fully integrated into the planning and execution of all counterland fires. The BCD chief should be the Deputy Counterland Cell Chief. This cell could include positions with responsibility to manage the counterland missions assigned to kill boxes or JFAs; monitor CAS missions stripped from the counterland flow by the ASOC; operate the JSTARS workstation and perform interface functions between the cell and JSTARS; perform continuous updates on unmanned aerial system (UAS) locations; and perform interface functions between the UAS and JSTARS. Technically, the cell should also include other distributed TACS elements (externally connected to the cell via phone, MIRC [Mardam-Bey's Internet Relay Chat], Theater Battle Management Core Systems [TBMCS], radio, etc.), including the ASOC (or Marine Corps Direct Air Support Center, if appropriate), CRC, and JSTARS.

---

[24] As defined in current doctrine, SCAR aircraft detect targets for dedicated air interdiction missions in a specific geographic zone. SCAR missions provide coordination (but not control) and are normally a part of the C2 interface. See AFDD 2-1.3.

[25] Alternatively, according to Lieutenant Colonel Bretscher, this could be a notionally defined counterland specialty team.

Finally, with respect to C2, we note that all options assume that CAS control procedures (Type 1, 2, or 3) are used when air-delivered fires are employed inside closed kill boxes or JFAs. Because Option 1A assumes that kill boxes are always closed inside the FSCL, CAS control procedures for this option are followed for all air-delivered fires in this region of the battlespace.

Another important aspect of counterland operations is the planning and execution of joint ISR and air-delivered fires and their integration with respect to achieving desired effects on the battlefield. We assume that, for all Option 1 variants inside the FSCL, air-delivered fires benefit from the full spectrum of joint ISR—including ISR organic to tactical ground units; CFACC-provided ISR-coded assets; and ISR provided by tasked strike, CAS, and FAC(A) aircraft using onboard sensors. Likewise, we assume that Option 2 also has the benefit of the full spectrum of joint ISR inside the surface-maneuver area.

The key related difference between the options lies in the assumption that Option 2 integrates and synchronizes effects and maneuver beyond the SMA using joint ISR and fires. Option 1's lack of these characteristics has two main implications. First, air-delivered fires beyond the FSCL are not always synchronized and prioritized with the dynamics of the ground battle. Second, because ISR assets usually have a number of other taskings, ISR is not always available to support Option 1 air-delivered fires beyond the FSCL.

Communications is another important dimension that distinguishes the options. Regardless of option, closed kill boxes require air-delivered fires to be controlled by a JTAC using CAS procedures; currently, this means the JTAC normally requires line-of-sight to the aircrew to communicate and situational awareness of the target.[26] This becomes especially problematic for Option 1A because its kill boxes are always closed and the deep FSCL could place targets beyond LOS of the JTAC. Option 1A is additionally challenged because of the potential for enemy jamming of LOS communications links. Options 1B, 1C, and 2 pose fewer communications challenges because open kill boxes

[26] Non-LOS solutions (e.g., joint tactical radio system using networked communications) that could be fielded in the next decade could alleviate this shortfall.

eliminate the need to use CAS control procedures, with their associated limitations. By eliminating CAS control requirements, JTAC-to-aircrew communications are also eliminated and most communications with the aircrew can be facilitated through the ASOC, CRC, JSTARS, AWACS, and CAOC, which also have many more robust resources and alternatives (airborne relays, networks, etc.) at their disposal.

A final dimension that distinguishes the options is their information and information systems characteristics. Option 1A information needs are described by current methods of information exchange. It is characterized by information that is exchanged during the planning process, by immediate requests that are approved depending on the availability of aircraft as allocated in the air tasking order (ATO), and by the CAS 9-line information exchange between the JTAC and the aircrew during weapon delivery. Options 1B and 1C increase flexibility by relieving air-delivered fires in open kill boxes from using CAS procedures. Real-time coordination between the Army and the Air Force is required to ensure that there are no conflicts with ground operations. Real-time SA is required throughout the C2 system to ensure that ground force locations and the location and status of airspace coordination measures are accurately known at all times. To accomplish this, a kill box or JFA manager tool and associated TTP are needed to ensure that kill box and JFA establishment and status are rapidly coordinated with the affected components, and that information is disseminated quickly.

Option 2 also requires information sharing to support greater joint collaboration. This option develops and employs ground surface-maneuver areas in the same vicinity of kill boxes and JFAs. Air-to-ground sorties are allocated to counterland missions and dynamically allocated to targets or to kill boxes and JFAs as needed. Use of CAS procedures is dynamically chosen, depending on knowledge of the air and ground situation. As with Options 1B and 1C, real-time awareness of the situation is needed for Option 2. However, Option 2 also requires real-time knowledge and monitoring of attack execution, with distributed authority to nominate targets and abort missions in real time, based on the situation rather than on location. Because of the above factors, Option 2 will demand information systems that are net-centric and that support database-to-database sharing.

CHAPTER THREE

Potential Effectiveness of Air-Ground Options

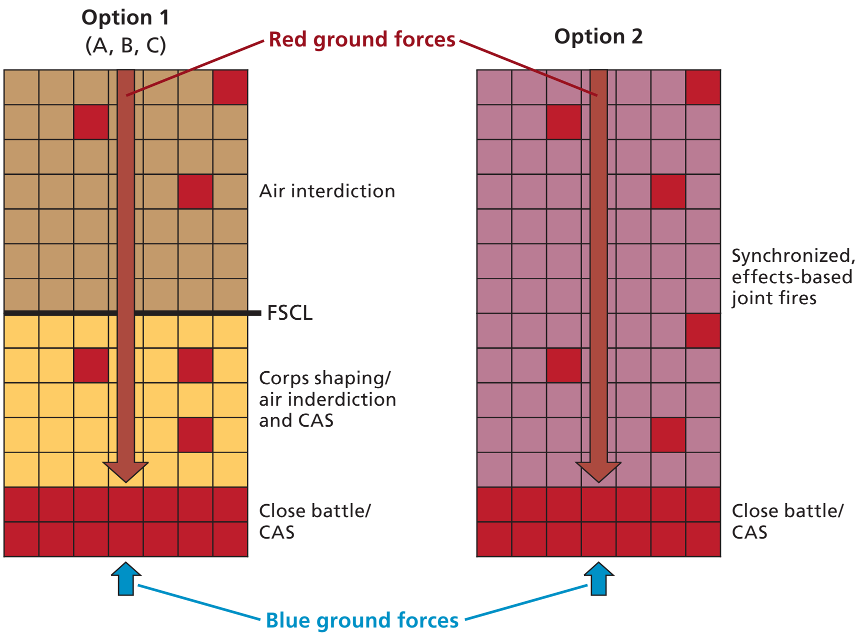
We have discussed the recent motivation for greater joint interdependence—often at odds with long-standing service doctrines and cultures—and have established a framework of alternatives for new concepts that enhance joint fires and maneuver. This framework consists of a number of options that differ across many key dimensions. We now turn to a discussion of each option's potential effectiveness.

Methodology

To compare option effectiveness, we developed a methodology that models the previously discussed essential counterland air-ground interactions. This methodology is illustrated in Figure 3.1. We constructed a scenario that focuses on disruption of Red (enemy) ground force maneuver. This is achieved through the application of Blue (friendly) ISR and air- and surface-delivered fires against a Red ground force that is moving toward contact with the Blue ground force.[1] Over time, Red and Blue force strength may be reduced, depending on the capabilities

[1] Although we model Red ground force movement, it is actually the absolute distance and relative motion between Red and Blue ground forces that create the standard for assignment of input values. Thus, the model could be applicable to a scenario where Blue ground forces also move, since it is the distance between the ground forces that is important for these calculations. For purposes of comparing and contrasting the options, we assume Red and Blue ground forces are initially sized at 75 and 15 battalions, respectively. We also assume the total AO measures 100 nm wide × 150 nm deep, although we will also examine variations to this assumption.

Figure 3.1
Model to Analyze Each Option's Effectiveness



Model Characteristics

Objective: Disrupt enemy ground force maneuver

Measure of effectiveness: Number of fighter aircraft needed to reduce Red strength to 50% and ensure that 90% or more Blue ground forces remain

RAND *MG793-3.1*

of the opposing force. Although there are a number of ways to measure effectiveness, we compare each option's effectiveness by measuring the number of aircraft needed to reduce (i.e., draw down) Red force strength to 50 percent while ensuring that 90 percent or more of Blue's ground forces remain.[2] At the core of the methodology is a calcula-

[2] Our modeling of counterland air-to-ground interactions as a drawdown of force strength does not capture the potential of greater effectiveness of effects-based concepts of operation. Exploitation of effects should be a goal, but effects are difficult to capture analytically. Our analysis provides a conservative approach to force planning. Future analyses are recom-

tion of the drawdown in Red and Blue force strength that is based on assignment of input values that capture the key distinctions between the options. These distinctions are battlespace dependent. As a result, the mechanics of the model are implemented by creation of three zones of combat (two for Option 2). For Option 1, air interdiction sorties are employed against targets or kill boxes in the interdiction zone, initiating a drawdown of Red force strength. These sorties end after Red crosses the FSCL, at which point the model transitions into a corps shaping/air interdiction/CAS zone that restarts Red force drawdown calculations using only aircraft that fly in CAS stacks. The final transition is into a close battle/CAS zone that also relies on aircraft pulled from the CAS stack. Only two zones characterize Option 2, a zone beyond the SMA described earlier that accommodates synchronized effects-based joint fires and maneuver, and a close battle/CAS zone that is essentially representative of the SMA itself. Because Option 2 implements a counterland apportionment that does not distinguish between CAS and AI, a single continuous flow of counterland aircraft is used to task sorties in both Option 2 zones.

Regardless of option, force drawdown calculations in all but the close combat portion of the battlespace are based on a simple differential equation that assumes the rate of Red force attrition is proportional to a constant factor, the engagement potential (EP) rate, that is option- and zone-dependent. Within the close combat/CAS zone, calculations of the drawdown of Red and Blue ground forces are also based on differential equations, but ones that follow a slightly modified Lanchester square law that includes the effects of Blue air and Blue ground forces on Red ground forces. This approach relies on Lanchester coefficients to account for Red and Blue effectiveness and assumes that the rate at which a force is reduced in strength is proportional to the size of the force that is shooting.[3]

---

mended to explore the impact of other measures of merit as well as other scenarios that might expand on the one examined in this research.

[3] We recognize that this simple approach does not allow us to evaluate, with greater scrutiny, the trade-offs in fires options (attack helicopters; GPS-guided MLRS, High Mobility Artillery Rocket System [HIMARS] and artillery; fixed-wing aircraft) in the CAS–close combat zone and beyond. We recommend that these trade-offs be a subject of future research.

The EP rate describes aircraft target destruction potential (e.g., the number of Red targets destroyed per hour) and is a function of the weapon potential rate. It is also influenced by factors relating to ISR, C2, and communications—all key dimensions that distinguish the joint interdependence options that were qualitatively described earlier.

Weapon potential rate is a function of weapon type and rate of weapon delivery, which itself is a function of total number of aircraft, weapons per sortie, and sorties per day per aircraft. The analysis assumes that cluster bomb unit (CBU)-97/sensor-fuzed weapons (SFW) are used for engagements beyond the FSCL, or—in the case of Option 2—beyond the SMA. For engagements inside the FSCL or SMA, we assume a one-on-one weapon such as Maverick. In all cases, we assume four weapons per sortie and two sorties per day per aircraft. An equivalent damage expectancy of 0.7 is assumed for both weapons, as well as an additional 0.59 degradation that results from a number of other factors (e.g., weather, operations, the fog of war).[4]

The ISR factor depends on the relative rate at which the Red targets can be found per unit of time compared with the rate at which they can be destroyed. In all cases, we assume the continuous presence of JSTARS to provide target location cues using its Ground Moving Target Indicator radar. Additionally, inside the FSCL or SMA, we assume that sufficient joint ISR assets are always available to find targets for aircraft. During Option 1 engagements beyond the FSCL, we assume two Predator B–equivalent UASs. This can have a negative impact on the Option 1 EP rate beyond the FSCL because these UASs are not task-synchronized with the strike sorties and therefore may provide target detections to strike aircraft at a lower rate than desired.[5]

---

[4] Our calculations assume a 0.7 damage expectancy to the extent that damaged targets would require repair and are rendered at least temporarily incapable of continued effective operations. This is sometimes referred to as "availability-kill." See David Ochmanek, Edward R. Harshberger, David E. Thaler, and Glenn A. Kent, *To Find, and Not to Yield: How Advances in Information and Firepower Can Transform Theater Warfare*, Santa Monica, Calif.: RAND Corporation, MR-958-AF, 1998, pp. 36–42.

[5] These UASs execute search patterns that uniformly cover the entire AO beyond the FSCL. The FSCL depth is set at 60 nm for Options 1A and 1B, and at 30 nm for Option 1C. The close combat zone or SMA is 15 nm deep. As a result, in combination with the assumed 150-

However, because Option 2 has at its disposal joint ISR assets beyond the SMA, and because ISR and fires are synchronized, we assume that Red targets are found at the same (or greater) rate as they can be destroyed. Thus, ISR is not a limiting factor for Option 2.[6]

Finally, although we assume that all strike, FAC(A), and SCAR aircraft are equipped with Litening/Sniper–class targeting pods, we also assume that these pods are of primary benefit during weapon delivery and do not support effective independent search beyond the FSCL or SMA, even with an initial JSTARS or UAS cue.[7] Table 3.1 summarizes our ISR assumptions and their relationship to the battlefield methodologies previously described.

The C2 factor represents constraints on weapon potential rate that may arise due to throughput limitations at key levels of air-to-ground C2. In the case of the CAOC, this translates into the number of aircraft it can manage per unit of time. In the case of the ASOC and JTAC, throughput is measured by the amount of CAS control and/or open-kill-box ASOC-directed AI that can be conducted per unit of time. For Option 1A, we assume an ASOC can manage eight missions per hour; we increase this to 20 per hour for Options 1B, 1C, and 2, as a result of the various ASOC and CAOC enhancements (and enhancements to the TACS, in general) that we incorporated into the definition of these options.[8] The throughput calculations further assume a nominal three-minute JTAC talk-on time, an additional three minutes to

nm total depth of operations, Options 1A and 1B UASs beyond the FSCL must search 100 nm × 90 nm (100 nm × 120 nm for Option 1C).

6 ISR can be a limiting factor for Option 1 if insufficient ISR assets are allocated beyond the FSCL. However, we intentionally choose a baseline ISR capability level so that, for Option 1 (and for our nominal performance goal), ISR supply is not limiting but has very little excess capability. We show the effects of varying ISR baseline assumptions in later sections.

7 We have already noted, however, the important control and coordinating roles played by FAC(A) and SCAR aircraft, respectively, enhanced in large measure by these very sensors.

8 "Transformation to Support UEx," briefing to Joint Air/Ground Operations ASOC Tiger Team Conference, Nellis AFB, Nevada, January 25–27, 2005; Curt Neal, ACC/CCJ, "ASOC/TACP Transformation and Modernization," briefing to the TACP Enabling Concept Meeting, Fayetteville, N.C., January 31, 2006; and *USAF Air Support Operations Center Enabling Concept*, June 1, 2006.

Table 3.1
Summary of Baseline C2 and ISR Assumptions

	Option			
Characteristic	**1A**	**1B**	**1C**	**2**
Depth of operations (nm)	150	150	150	150
Interdiction zone (nm)	90	90	120	NA
FSCL depth (nm)	60	60	30	NA
Close combat zone[a] (nm)	15	15	15	15
KB or JFA	Closed KB	Open/closed KB	Open/closed KB/JFA	Open/closed JFA
ISR	Joint, full-spectrum ISR within FSCL (i.e., no ISR limitation); 2 Predator B equivalents beyond FSCL	Joint, full-spectrum ISR within FSCL; (i.e., no ISR limitation); 2 Predator B equivalents beyond FSCL	Joint, full-spectrum ISR within FSCL; (i.e., no ISR limitation); 2 Predator B equivalents beyond FSCL	Joint, full-spectrum ISR everywhere (i.e., no ISR limitation)
ISR search rate beyond FSCL[a]	300 km**2 /hour	300 km**2/hour	300 km**2/hour	No limitation

[a] For Option 2, SMA.

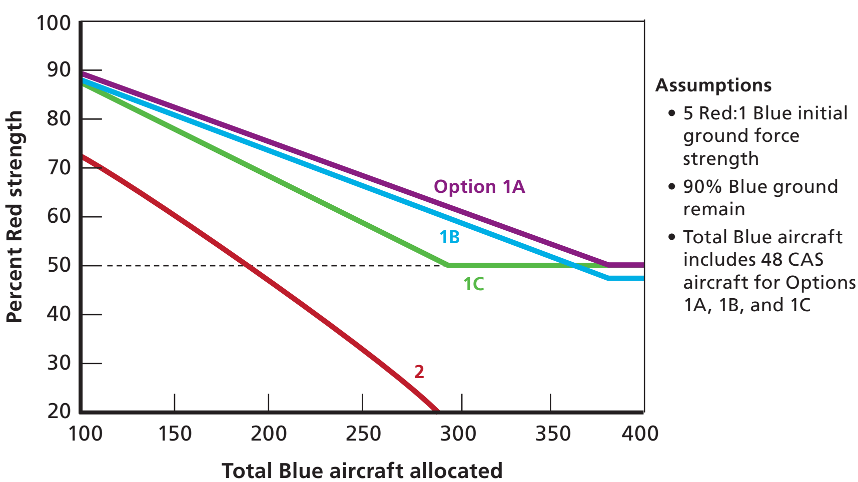
deliver each weapon, and as many as 12 concurrent CAS engagements, depending on option and zone within the AO. Aircraft flight time is also a consideration, although this is simplified by applying an average time of 4.5 minutes. To account for operational issues relating to CAS stack and counterland flow management due to unpredictable variation in demand, we applied a 0.6 degradation factor.

Communications can also constrain weapon potential rate, although we address this narrowly and simplistically for purposes of comparing and contrasting joint interdependence options by focusing primarily on communications limitations that may arise between a JTAC and aircrew during closed-kill-box CAS. These operations rely on voice communications (e.g., those used by the JTAC to convey 9-line information to the aircrew) that are subject to LOS restrictions and that may be susceptible to enemy jamming. For the calculations that follow—and only in those situations that require CAS control by a JTAC—we assume a LOS range of 43 nm (80 km), corresponding to an aircraft altitude of 10,000 ft. We also examine the impact of reduced range due to jamming. Although other C2 elements—for example, the ASOC and CAOC—may communicate by voice, they have (or will have in the near future) alternative communications options that are less problematic. These are not addressed in this analysis.

Effectiveness Estimates

Using the methodologies described previously, in Figure 3.2 we show our estimate of Red force strength at the time the Blue ground force is reduced to 90 percent of its original strength. It is presented as a function of aircraft allocation for each of the joint interdependence

Figure 3.2
Aircraft Allocation Affects the Reduction of Red Force Strength



RAND *MG793-3.2*

options under consideration. For Option 1, total aircraft include 48 set aside for CAS and air interdiction inside the FSCL.[9] For Option 2, total aircraft represent aircraft in the entire counterland flow that may also be used by the ASOC for immediate CAS and AI as requested by a ground commander. These estimates reflect a number of other assumptions that are key to the computed results and are listed in Table 3.2. We examine the impact of variations to these assumptions later in this chapter.

Figure 3.2 demonstrates the benefits derived from greater joint interdependence. The calculations show that Option 2 always reduces Red force strength by a greater amount than Option 1 does under conditions of equal total aircraft apportionment. Alternatively, for a fixed reduction in Red force strength, Option 2 requires fewer aircraft than Option 1.[10]

The calculations also show that there is a limit to the number of aircraft that can contribute to greater Option 1 effectiveness. In the

Table 3.2
Key Variables and Assumptions

Variables	Assumptions
Red vehicle spacing	150 m
Red move cycle	50% move, 50% stop
Red vehicle speed	4 nm (7.4 km) per hour
Close combat effectiveness	4 Blue:1 Red
Jamming	43 nm (80 km) communications range
Delay in start of blue AI (e.g., SEAD campaign)	None
Area of operations	150 nm (278 km) deep
Available ISR	2 Predator B equivalents
CAOC C2 throughput	No limit

9 Based on analyses in Jacobs et al., 2008.

10 Although our interpretation of these potential benefits is subjective, a difference of up to ten aircraft is not important, whereas a difference of 25 to 50 or more is significant.

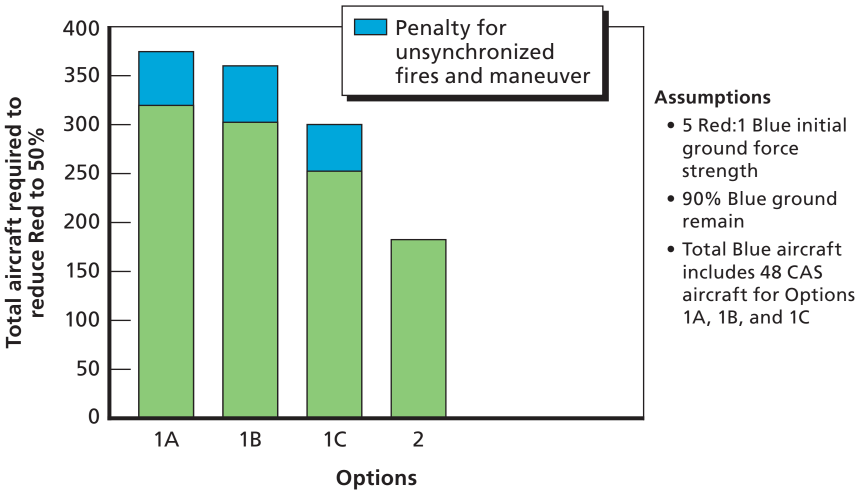
example shown here, Options 1A and 1B realize no additional effectiveness beyond approximately 375 aircraft and Option 1C effectiveness is capped at about 300 aircraft. The primary reason that effectiveness is capped is that additional aircraft introduced into the fight are not matched with additional ISR resources to support the strikes. We address this shortfall in later analyses.

An important but implicit benefit of adopting enhanced joint interdependent concepts of operation is that they can reduce the need to insert additional Blue ground forces into the fight (we assume 15 battalions for this discussion) to overcome shortfalls in achieving a JFC's goals. For example, if a JFC establishes a goal of 50 percent Red ground force reduction, the calculations suggest that, depending on option and on number of aircraft apportioned to the counterland fight, this goal may be exceeded in some cases (Option 2; greater than 187 aircraft) but may not be achieved in others (Option 1C; fewer than 300 aircraft). In other words, when 300 or fewer aircraft are apportioned to Option 1 counterland operations, additional Blue ground forces are required to meet the example JFC goal of 50 percent remaining Red forces. Alternatively, for Option 2, using a number of aircraft that results in more than 50 percent Red force strength reduction (greater than 187 aircraft in this example) gives the ground commander flexibility to employ fewer Blue forces while still meeting the 50 percent requirement.

Figure 3.3 summarizes, for each option, the total number of aircraft required (top of each bar) to reduce Red ground force strength by 50 percent while ensuring that 90 percent of the Blue ground force survives. This number corresponds to the 50 percent point for each option in Figure 3.2.

Additionally, we overlay on the Option 1 bars the penalty incurred for unsynchronized fires and maneuver beyond the FSCL. For example, of the 375 total Option 1A aircraft required to reach the goal of reducing Red force strength to 50 percent (90 percent Bl\\ue force strength remaining), approximately 55 can be attributed to this lack of synchro-

Figure 3.3
Option 2 Requires Fewest Aircraft to Achieve 50 Percent/90 Percent Objective



RAND *MG793-3.3*

nization. More broadly, a significant penalty is incurred in all Option 1 variations because joint fires are not synchronized with Blue ground maneuver beyond the FSCL. Computationally, we implemented these penalties by assuming a 20 percent CAOC uncertainty about the rate of ground maneuver advance, so that in Option 1, counterland air interdiction is not always executed as planned with respect to time and target or kill box location.[11]

Option 2 is built on the key characteristic that there are no CAS aircraft set aside in CAS stacks to provide CAS and AI for the ground commander. Instead, CAS and AI distinctions are eliminated and replaced by one counterland aircraft apportionment. These aircraft are streamed continuously into the battlespace against targets, open kill boxes, or JFAs, and the ASOC is given the authority to pull from this counterland flow as needed to support immediate CAS requests from the ground commander.

---

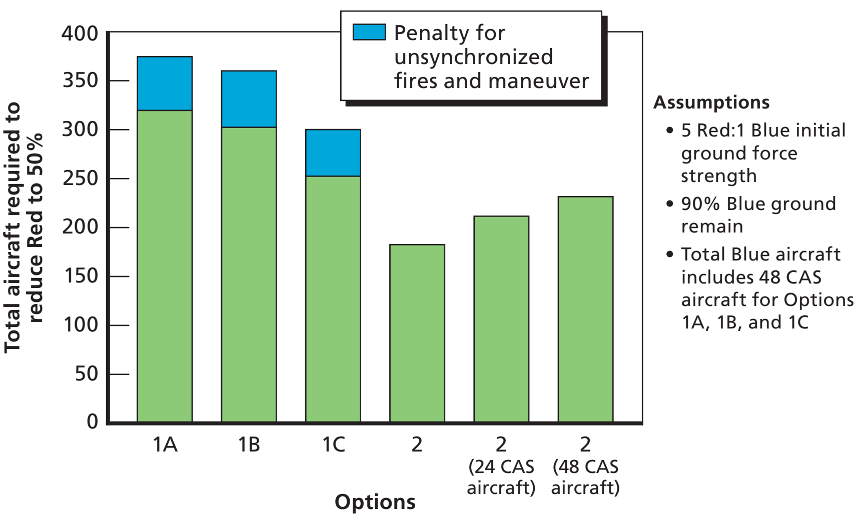
[11] That is, the Option 1 CAOC believes that the Red advance rate is 4.8 nm/hour when in fact it is 4 nm/hour.

An important feature of CAS stacks is that they provide the ground commander an assured and responsive source of CAS. Although inefficient at times, they act like an insurance policy to provide commanders a hedge against uncertainty. Thus, even with the implementation of Option 2's counterland flow, a commander may still desire a CAS stack.

In Figure 3.4, we demonstrate Option 2's effectiveness when CAS stacks of 24 and 48 aircraft augment the counterland flow. As before, each bar represents total aircraft required and includes aircraft set aside in the CAS stack. In this example, Option 2 CAS stack aircraft are available for use only inside the SMA. Remaining aircraft in the Option 2 counterland flow continue to be tasked as described previously.

The estimates show that more total aircraft are required to achieve the same 50 percent goal when CAS stacks augment the Option 2 construct. In other words, the price for the insurance hedge of CAS stacks is the inefficiencies that arise when aircraft are restricted to a

Figure 3.4
Option 2 Requires Fewest Aircraft Even When CAS Stacks Are Employed



RAND *MG793-3.4*

particular zone (in this case, the SMA) or held in reserve. In these examples, it is more efficient to maintain a singular unrestricted force that can be employed anywhere in the battlespace.[12]

The analysis suggests that even with the addition of CAS stacks, Option 2 requires significantly fewer aircraft than any of the Option 1 variants. This is primarily a result of the Option 2 characteristics that prioritize and synchronize joint ISR, fires, and effects with ground maneuver. This result is evident in the figure when we compare the difference in total aircraft required between Option 2, augmented with 48 CAS stack aircraft, and Option 1C.

We now turn to a greater scrutiny of the many variables that affect our estimates and comparison of options. For this purpose, we assume a modified Option 2 that includes 24 set-aside CAS aircraft.

Effectiveness Sensitivity Analyses

A number of variables, along with the corresponding input values we assumed, play an important role in the resultant effectiveness estimates. The impact of these assumptions is discussed in the next few figures, which we present as a series of progressive "builds." Our intent is to examine the sensitivity of the results to varying assumptions to see how the relative effectiveness estimates may change between options. The discussion expands on the important differences that define each option and is organized around the following variables: Red vehicle spacing, move cycle, and vehicle speed; Red and Blue ground close combat effectiveness; jamming; delay in start of air interdiction; AO; number of Option 1 UASs beyond the FSCL; and CAOC C2 throughput.

We begin with a discussion of Red vehicle spacing, to which we have assigned a baseline value of 150 meters. Associated effectiveness estimates for each option variant, shown previously, are repeated in

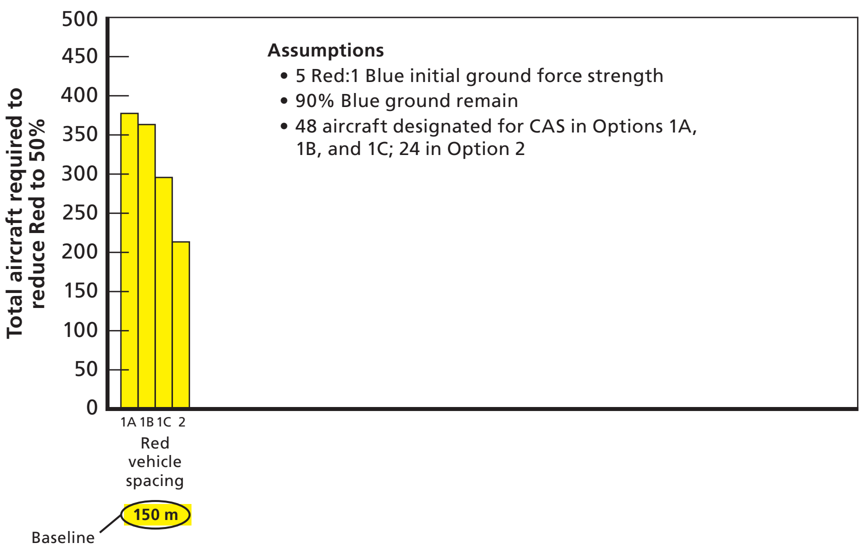
[12] For all Option 2 excursions with the exception of the 48 CAS aircraft excursion, more aircraft are available beyond the SMA—a more effective allocation. Moreover, there is no corps shaping zone in any of the Option 2 cases, thereby eliminating inefficient partition of aircraft.

Figure 3.5. For this discussion, we assume a modified Option 2 that includes 24 set-aside aircraft.

Vehicle spacing is important in these calculations because we employ the CBU-97/SFW for engagements beyond the FSCL (or outside the SMA in the case of Option 2). The SFW is a 1,000-pound-class weapon used for attacking armor. Each CBU-97 dispenser contains ten BLU-108 submunitions that subsequently each release four Skeet submunitions along a predetermined pattern. The effectiveness of SFW, an area weapon whose precise coverage is dependent on a number of factors, is also dependent on an enemy's choice of vehicle spacing. We assume that a dispenser's SFW submunitions are deployed in a nominal 400-meter-long elliptical footprint. Based on tests, it was judged that one-half of the armored vehicles within the pattern would be damaged to at least an availability kill (A-kill).

However, since we required a 70 percent damage expectancy to disable a battalion, multiple dispensers were needed to achieve this higher

Figure 3.5
Aircraft Required Assuming Baseline Red Vehicle Spacing

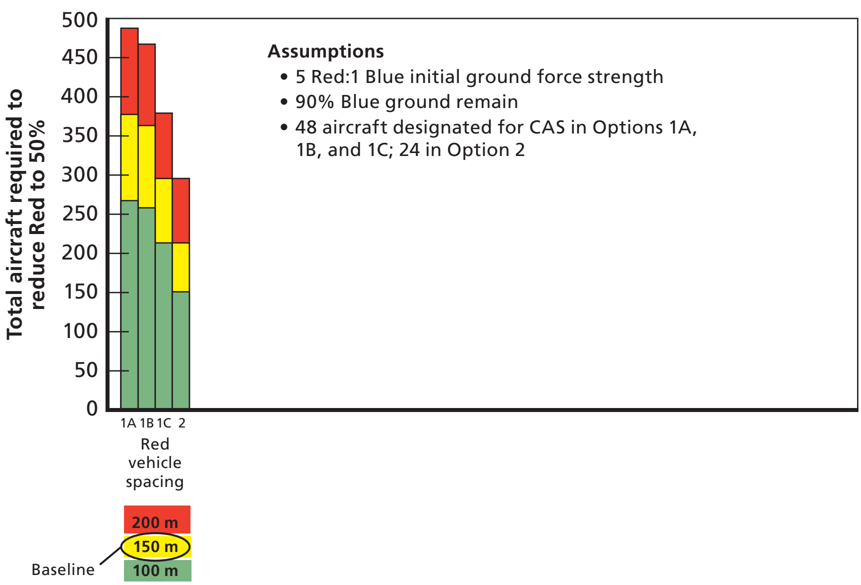


RAND *MG793-3.5*

damage expectancy. When a moderate footprint misalignment and the effect of "unordered fire" also are accounted for, the requirement increases to ten SFWs per kilometer.[13] Since the length of road occupied by a battalion increases in proportion to the armored vehicle spacing, the number of weapons required to maintain the 70 percent damage expectancy increases in direct proportion to the spacing. As mentioned earlier, we applied a further degradation factor of 0.59.

Although, from the viewpoint of Red vehicle survivability, a large spacing between vehicles is desirable when facing attack from SFW, the enemy must balance the choice of vehicle spacing against other imperatives—for example, forward movement and force cohesiveness. Figure 3.6 shows how effectiveness is sensitive to enemy vehicle spacing in terms of total aircraft required to reduce the Red force strength to 50 percent.

Figure 3.6
Aircraft Required Assuming Variations in Red Vehicle Spacing



RAND *MG793-3.6*

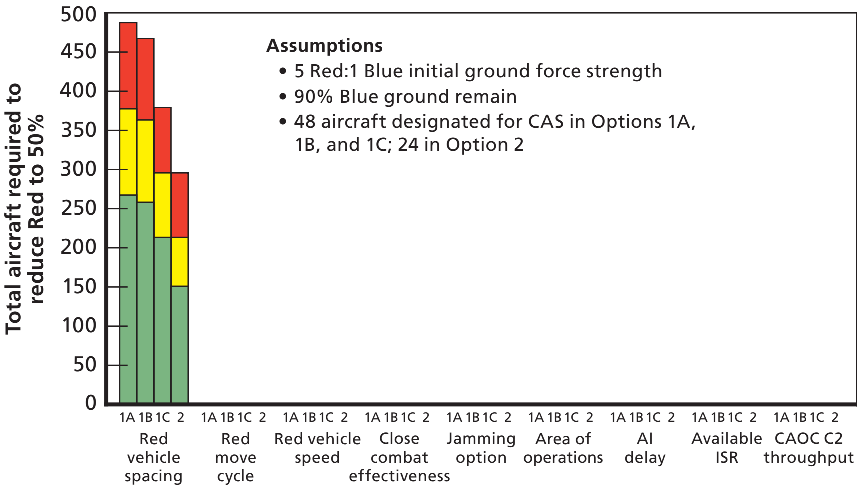
13 Ochmanek et al., 1998, pp. 36–42.

As expected, additional aircraft are needed to reduce Red force strength to 50 percent when vehicle spacing is increased from 150 meters to 200 meters (illustrated in red). While the increases in additional aircraft vary in absolute magnitude, they are approximately constant for all options from the perspective of percentage (28–30 percent). When vehicle spacing increases to 200 meters, Option 2 again achieves the goal with fewest total aircraft compared with the other alternatives.

When vehicle spacing is reduced to 100 meters (illustrated in green), SFW is more effective, and fewer total aircraft are needed to achieve the goal compared with the vehicle spacing cases already examined. The decreases are approximately constant across the options and, as before, Option 2 requires the fewest total aircraft.

The remaining variables that we examined are listed in Figure 3.7, which also shows the range of values analyzed.

Figure 3.7
Assumptions That Distinguish Options



	Red vehicle spacing	Red move cycle	Red vehicle speed	Close combat effectiveness	Jamming option	Area of operations	AI delay	Available ISR	CAOC C2 throughput
	200 m	.75 move/ .25 stop	4.8 nm/hr	3B:1R	22 nm	90 nm	24-hr delay	1	250
	150 m	.5/.5	4 nm/hr	4B:1R	32 nm	120 nm		2	
Baseline	100 m	.25/.75	3.2 nm/hr	5B:1R	43 nm	150 nm	No delay	3	No limit

RAND *MG793-3.7*

The effects of variations in Red tactics are illustrated in three ways. One tactic Red may choose is to vary its vehicle spacing to reduce the effects of such Blue weapons as SFW. We also considered two other tactical variations, Red motion cycle and speed. Taken together, motion cycle and speed determine Red transit time to the close battle or SMA zone. Slow transit speeds or long stop phases may be a result of poor road conditions, or they could represent Red attempts to move off-road and hide, to increase its survivability in the face of Blue fires.

We model movement as a series of cycles, each consisting of a move phase and a stop phase. Our baseline total motion cycle is 12 hours, with each phase being six hours. We considered two additional variations of this 50/50 assumption: movement cycles of 75/25 percent and 25/75 percent (i.e., nine hours moving and three hours stopping or three hours moving and nine hours stopping, respectively). When Red is in motion, its speed is assumed to be constant. In the previous analysis, this rate was set at 4 nm per hour. We examine the effects of different rates by considering speeds that are 20 percent faster or slower (i.e., 4.8 and 3.2 nm per hour, respectively).

We also examine relative Red and Blue close combat effectiveness more closely. Blue close combat effectiveness was previously set at four times that of Red. We now vary this to consider the impact of decreased or greater relative Blue close combat effectiveness (3:1 and 5:1 Blue:Red close-combat effectiveness ratios, respectively).

Jamming by Red is another factor that can influence Blue's ability to reduce Red ground forces. Blue may be particularly vulnerable to jamming when JTACs communicate with strike aircraft during closed–kill box CAS operations. In these instances, Red may employ mobile ground-based jammers that limit the JTAC-to-aircraft communication range. Previous discussion assumed an absence of jamming, allowing JTACs to communicate with aircrews at the maximum range, limited by LOS (assumed to be 43 nm when aircraft are at 10,000 ft). We examined the effects of Red jamming by reducing this maximum communication range to 32 and 22 nm, respectively.

We also looked at four additional factors that influence the effectiveness estimates: size of the area of operations, delay in the start of the AI campaign, ISR force size, and CAOC throughput. For the basic analysis, we fixed the area of operations at 100 nm wide by 150 nm deep. Because our methodology focuses on a Red ground force that transits through these 150 nm, the assumed depth directly impacts the available time for Blue air-delivered fires to engage these forces prior to meeting Blue ground forces in the close battle. We also considered two shallower depths—120 nm and 90 nm.

Delay in start of the air interdiction campaign also imposes constraints on available time for Blue air strikes. We considered the impact of a 24-hour delay that could be caused by a number of factors, including the decision to precede the counterland strikes with a campaign to suppress enemy air defenses.

Option 1, defined earlier, assumes two Predator B–class UASs to support counterland strike operations beyond the FSCL. The importance of synchronizing ISR and strike assets has already been noted, and this is further examined by considering the impact of more or fewer UASs.

Finally, an important assumption that has characterized the basic analysis is the CAOC's ability to exercise C2 over counterland operations with no throughput constraints. We show the effects of CAOC throughput by limiting it to 250 aircraft per day.[14]

Summary of Effectiveness Analysis Findings

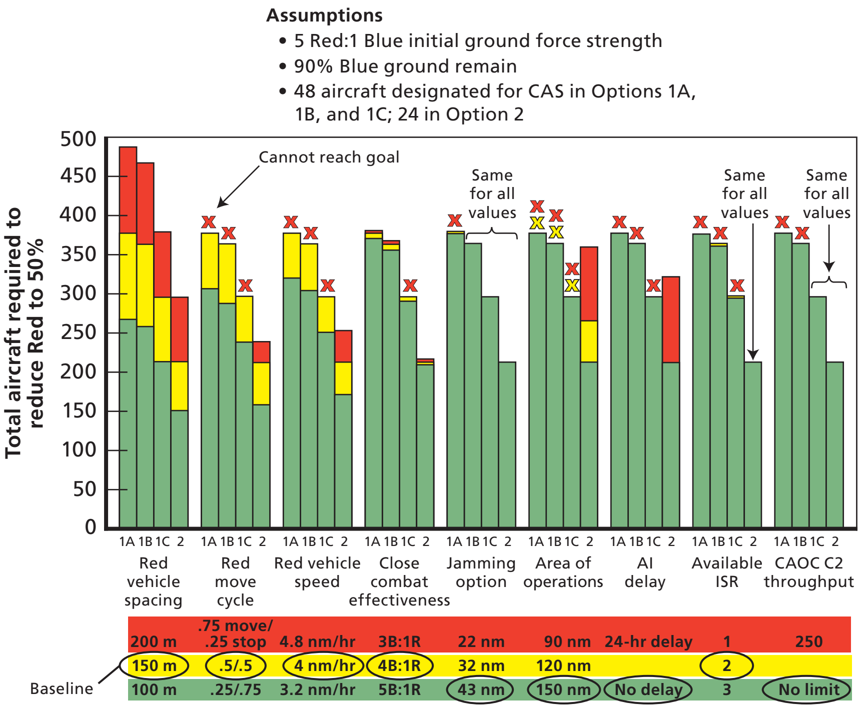
The effectiveness estimates for each of the sensitivities examined is summarized in Figure 3.8 and further discussed in the pages that follow. In all cases, we assumed baseline values, with the exception of the specific sensitivity under consideration.

Our first observation is that Option 1 is unable to achieve the goal of reducing Red force strength to 50 percent in many situations. These are indicated in Figure 3.8 with a red or yellow "X," color-coded to correspond to a particular sensitivity value. For example, with other assumptions being equal, no amount of additional aircraft enables

---

[14] This translates into 500 sorties per day since we assumed that aircraft fly a nominal two sorties each day.

Figure 3.8
Aircraft Required for Sensitivities Examined



RAND *MG793-3.8*

Options 1A, 1B, and 1C to achieve the goal when Red chooses a motion cycle that proportionately increases its move phase to 75 percent. This is because the addition of aircraft are not supported by sufficient UASs(assumed to be two) to provide target detections rapidly enough in relation to the increased Red transit rate associated with this motion cycle.

Other sensitivities (e.g., Red vehicle speed, area of operations, air interdiction delay) result in more or less time available to strike aircraft, depending on the value chosen; the same observations apply. In other words, when available time is reduced absent a corresponding increase in sensor detection rates (i.e., more UASs), Option 1 cannot achieve the goal with more aircraft.

The analysis confirms the importance of allocating sufficient numbers of UASs for Option 1 and compares the impact on potential effectiveness when one or three UASs are employed instead of the baseline assumption of two. Whereas two or more UASs are sufficient in the example shown here, we see that one UAS does not support an Option 1 solution.

The issue of C2 throughput is also shown to affect Option 1 and to preclude solutions in some situations. This is illustrated in Option 1A where Red jams JTAC-to-aircraft communications, reducing the maximum range at which CAS is conducted to 22 nm. In this case, any effectiveness improvements due to increased aircraft are constrained in the absence of an associated increase in C2 throughput capacity (e.g., more JTACs, faster C2 response time).

Finally, we see that CAOC throughput limits can also influence the achievement of reducing the Red force strength to 50 percent. For example, a CAOC throughput defined as 250 total aircraft per day (500 sorties per day) precludes any solutions for Options 1A and 1B. Although not explored explicitly, CAOC throughput capacity can constrain all options, depending on circumstances (even Option 2 would not be able to achieve the goal when CAOC throughput is limited to 250 aircraft per day and Red increases its vehicle spacing to 200 meters).

Across the sensitivities examined, our analysis demonstrates that Option 2 is always able to support a solution that achieves the goal of reducing Red force strength to 50 percent. Furthermore, it meets this goal with fewer aircraft than the other options. Option 2 has the potential to be more "forgiving" with respect to the many uncertainties of war and offers the commander more flexibility in the conduct of operations.

In summary, we have shown that Option 1 can have difficulty achieving the goal of reducing Red force strength to 50 percent in a number of situations, and that these are often associated with reduced available time. In these cases, absent a corresponding increase in sensor detection rate (i.e., more UASs), additional aircraft are insufficient to achieve the goal. On the other hand, at least for the specific sensitivities examined, Option 2 is always able to support a solution that achieves the goal of reducing Red force strength to 50 percent. Furthermore, Option 2 meets this goal with fewer aircraft than the other options.

Whereas reduced available time is a factor that often cannot be controlled by Blue and can negatively impact Blue's effectiveness, other factors are within Blue's control. We showed that two of these factors—synchronization of ISR, fires, and maneuver and C2 throughput—are important considerations that can produce significant effectiveness dividends when implemented to Blue's benefit. In particular, effectiveness is enhanced when ISR is prioritized and synchronized with fires and when joint fires and maneuver are synchronized. These are both characteristics of Option 2. The analysis also reinforces the importance of maximizing C2 throughput at all levels of counterland C2. This was shown implicitly for ASOC and JTAC throughput for engagements inside the FSCL during close combat, since these characterizations are embedded in the basic distinctions among the options. The importance of CAOC throughput for engagements beyond the FSCL or Option 2 SMA was developed explicitly.

CHAPTER FOUR

Command and Control Implications

The previous discussion described an analytical framework, consisting of alternative options, for thinking about air-ground joint interdependence. Each option's potential effectiveness was examined. Prioritization and synchronization of joint fires and maneuver (Option 2) was shown to offer important potential benefits. The monograph concludes with a discussion of the C2 implications of each option. We first discuss the C2 implications with respect to organization, processes, and procedures; then we discuss information and information system implications as they relate to the execution of command and control.

Option 1 Command and Control Adjustments

A number of C2 adjustments are built into Option 1. These include the dynamic utilization of open kill boxes and JFAs inside the FSCL (Options 1B and 1C), and the closer alignment of the FSCL with forward friendly units and organic fires (Option 1C).

Options 1B and 1C also feature incremental enhancements to the Air Force–Army air-ground C2 interfaces at corps and division. As discussed earlier, these are characterized by the TOC-based ASOC operations during OIF I and, for Option 1C, an expanded JSTARS role that provides an augmenting battle management capability to the TACS when airborne assets are beyond the normal communications coverage of ground elements.

Although the Option 1 adjustments above address some immediate C2 shortfalls, they do not address the larger problem characterized by operations that do not realize the full potential of the capabilities that an integrated and interdependent joint fires and maneuver scheme could afford the JFC. Furthermore, these adjustments are not expected to overcome the problems posed by future Army concepts.

Because the Option 1 air and ground space is divided (as shown by a FSCL that delineates battlespace ownership), future nonlinear and noncontiguous ground force operations are likely to strain an already complicated C2 situation. Joint ISR and fires options are also likely to increase, further straining the FSCL construct, and Option 1 C2 does little to integrate these joint ISR and fires options to achieve desired effects.

Finally, increased decentralization of ground force planning and execution has implications for Air Force TACS structures and processes. For example, current means of airspace allocation and control across noncontiguous ground forces that may be separated by great distances could create command and control confusion, resulting in enemy sanctuaries in those areas of confusion. Increased decentralization also magnifies inefficiencies inevitably associated with CAS stacks and essentially calls into question the entire scheme of distinct AI and CAS sortie allocations.

Option 2 Will Require Significant Command and Control Changes

As a result of these and other shortfalls, a number of fundamental changes are necessary to implement Option 2 from a C2 perspective. Some of the key changes, summarized in Table 4.1, will involve a rethinking of certain aspects of Air Force and joint C2 as it relates to counterland operations.

Table 4.1
Option 2 Requires a Paradigm Shift in Air Force and Joint C2

JFC
Make JFACC and JFLCC executive agents for JFC
Organize for rapid decisionmaking
Community-of-interest collaboration nets
Operations and Effects Division
Apportion forces, ISR, communications spectrum, and logistics
Own all theater air- and ground-space
JFA for all ISR and attack
Establish SMA FSCM around noncontiguous ground units
Revalidate and publish as an ACO to update SA displays
CAOC
Create a counterland cell that integrates ISR and fires
Develop C2 and ISR plans to support dynamics of the fight
Full BCD participation to integrate ISR, fires, and maneuver
Replace CAS and AI tasking distinctions with a single-tasked counterland flow
Give ASOC authority to pull CAS from flow
Configure some aircraft, and brief CAS-ready aircrews, for possible CAS tasking
Task ISR and fires in a single process
Hand off ISR to ground forces for use within the SMA
ASOC–Corps/Division FSC
Establish the JAGC2 for joint intelligence, targeting, and effects coordination
JTAC, FAC(A), and SCAR control/coordination inside SMA as directed

At the JFC level, we identified five characteristics that support Option 2:

1. JFC empowerment of the JFACC and JFLCC as his executive agents for integrating ground and air. This will require a strengthening of relationships between the JFACC and JFLCC, and with the JFC.[1]
2. Better organization of the JFC for rapid decisionmaking. This could be accomplished by establishing lead community of interest (COI) collaboration nets—for example, in the domains of land, air, maritime, and space C2; intelligence and targeting; effects; and logistics.
3. Rapid decisionmaking as a result of better organization and procedures, perhaps in an Operations and Effects Division, to adjust and adjudicate force maneuver, phasing, JFA establishing authority, and fires conflicts.
4. JFC ownership of all surface and airspace in the theater. JFC should require component control authorities to request JFAs for all ISR and attack assets.
5. Procedures for establishing a surface-maneuver area FSCM around all noncontiguous ground units, to be created by the JFC and revalidated and published as an airspace control order (ACO) rapidly and often to update situation displays.[2]

---

[1] One important way to strengthen these relationships is through more collaboration, enabled by the information systems to support the enhanced collaboration. This is the focus of the next section. Colocating JFACC and JFLCC headquarters might also further enable collaboration.

[2] The degree to which the joint force could improve its effectiveness by improved practice, e.g., through the restriction of ground commanders' areas of operation and the choice of less-restrictive control measures, was shown analytically in the previous chapter. There is nothing in joint doctrine that prevents the JFC from adopting these practices to exploit the capabilities of his air component. Ultimately, however, enhanced synergy between air and ground operations depends on the JFC's intimate involvement in the fight, specifying what effects he wants each component to achieve, under which conditions, and at each point in the campaign. These and other examples could be the subject of more in-depth future research.

Nearly all Option 2 characteristics will affect the CAOC and its operations. Many of the related changes needed to accommodate these characteristics have already been discussed. Recommended changes include replacing CAS and AI tasking distinctions with a single-tasked counterland flow of aircraft (with authority given to the ASOC to pull CAS from this aircraft flow), tasking ISR and effects resources in a single combined process that also supports ISR handoff to ground forces inside a SMA, and the creation of a counterland cell to focus on the execution of the counterland aircraft flow. A key member of this cell should be the Army BCD and it should be fully integrated into the planning and execution of counterland fires. Other elements of change to enable more effective response to battlefield dynamics could be the development of an integrated, theaterwide, counterland air strike plan that synchronizes efforts among C2, ISR, and strike assets.[3]

We have already discussed the need to enhance Army and Air Force C2 interfaces at the corps and division levels of operation. This could be accomplished through establishment of a Joint Air Ground Control Cell. This organization could be given primary responsibility for corps- or division-level joint intelligence, targeting, and effects coordination. The JAGC2 concept is vital to achieving the level of trust inherent in Option 2 where the CFLCC essentially cedes the Option 1A "deep fight" to a joint C2 element, and cedes the close fight in the SMAs to the brigade or division within that SMA.[4] As is the case today for CAS and kill box operations inside the FSCL, JTAC and FAC(A) should have responsibility for control as directed inside the surface-maneuver areas. Although SCAR aircraft are technically used

---

[3] Discussion with and written materials from Maj Don Oberdieck, October, 2006. This C2 interface could associate metadata with each JFA and kill box. The metadata would be transmitted to other systems and possibly to aircraft. In addition to JFA and kill box physical dimensions, these metadata could identify JFA and kill box status, controlling agencies, and communications frequencies.

[4] JAGC2 could have the authority to open or close JFAs (JFA status based on SMA location and movement) because it would operate closely with the corps/division fires and effects cells, ASOC, JSTARS, CRC, and AWACS.

to coordinate interdiction missions, these aircraft could be an important additional enabler to further coordinate JFA and kill box operations, especially those near the transition areas that bound the SMA.

CHAPTER FIVE

Information and Information System Implications

In previous chapters, we presented and discussed several options for air-ground operations. These discussions focused on the doctrinal, organizational, and procedural changes required to implement those options. In this chapter, we consider current and future information needs and system capabilities for exchanging the information required to support the options. The analysis focuses on the performance of C2 systems supporting operational-level commanders.

Information Exchange Requirements for Each Option

Increased synchronization of air and ground operations requires that a great amount of information be exchanged between the Army and Air Force. At a planning level, intended operations need to be known and visible to both services. Execution of CAS missions are monitored and controlled through an air-ground C2 system consisting of TACPs and an ASOC located with Army TOCs. Currently, maneuver plans and air sortie allocations are developed and exchanged infrequently during a day. In this monograph, we consider new air-ground options that are more dynamic, with air sorties and Army fire support continually monitored and controlled to coordinate fires to maneuver forces. The options increasingly require both real-time exchange of plans as they change and real-time monitoring of ongoing operations.

Table 5.1 summarizes the operational level command and control concepts and required information exchange for each of the options defined earlier. Each of the options requires a different level

Table 5.1
Net-Centric Data Sharing Is Critical for Joint Interdependence

Option	Operational C2 Concept	Information Implications
1-A (Deep FSCL, closed KB)	Sorties allocated using ATO process	Plans exchanged during planning cycle
	Requests for air support made through Army/CAOC/ASOC structure	Immediate requests approved depending on allocations and coordination measures
1-B (Deep FSCL, open/closed KB)	Sorties allocated using ATO process	Plans exchanged during planning cycle
	KBs dynamically opened and closed through Army/CAOC/ ASOC structure	SA supports KB process and airspace deconfliction
1-C (Shallow FSCL, open/closed KB and JFA)	Sorties allocated using ATO process	Plans exchanged during planning process
	KBs and JFAs controlled through CAOC and coordinated with Army	SA supports KB process and airspace deconfliction
2 (SMAs, open/closed KB and JFA)	Sorties allocated to counterland missions and dynamically tasked	Plans and changes dynamically exchanged during planning and execution
	JFC/JFACC/JFLCC coordination on tasking	SA supports mission tasking and dynamic reallocation

of information exchange. In general, net-centric data sharing is critical for the information exchanges that are characteristic of greater joint interdependence.

Option 1A entails a deep FSCL with mostly closed kill boxes within the FSCL. Sorties are allocated using the ATO process, and requests for air support are made through the Army Corps/ASOC/ CAOC structure. Information is exchanged during the planning process, and immediate requests are approved depending on the availability of aircraft as allocated in the ATO.

Option 1B differs from 1A in that kill boxes are opened and closed dynamically short of the FSCL. This option increases flexibility by loosening the control restrictions on air-ground attacks within open kill boxes and eliminating the requirement to use CAS procedures. Real-time coordination between the Army and Air Force is required to ensure integration with ground force operations. Real-time situational awareness is required throughout the C2 system to ensure that ground force locations and the location and status of airspace coordination measures are accurately known at all times. Decentralized execution is required for tactical flexibility.

Option 1C is characterized by a shallow FSCL. This option also employs kill boxes and JFAs beyond the FSCL. Air-ground attacks are centrally planned and controlled by the CAOC beyond the FSCL and coordinated with the Army to avoid fratricide. Information exchange is similar to Option 1B. Awareness of the air and ground situation is needed at all headquarters to decide on targets and to avoid fratricide.

Option 2 does not use the FSCL as a coordination measure. Instead, it develops and employs SMAs that may be in the same vicinity of kill boxes and JFAs. Air-ground sorties are allocated to counterland missions and dynamically tasked to targets as needed. These taskings will require greater JFC, JFACC, and JFLCC coordination. Use of CAS procedures is dynamically chosen depending on knowledge of the air and ground situation. Option 2 requires real-time awareness of the situation at all operational levels, as do Options 1B and 1C. However, Option 2 also requires real-time knowledge and monitoring of attack execution with distributed authority to nominate targets and abort missions in real time based on the situation rather than on location. Option 2 balances the need for centralized control of airpower (for maximum effect) with decentralized execution (for tactical flexibility).

Assessment of Information Systems' Ability to Support the Air-Ground Options

From a system perspective, real-time exchange of planning and execution data requires connection of the Army Battle Command System (ABCS) used by the Army for maneuver and fire support with the TBMCS used for air C2.[1] Currently, the Army and Air Force C2 systems are message-based. The ATO is shared with ABCS through a text

[1] ABCS also supports a wide range of Army battle command functionality. For purposes of this monograph, we focus on capabilities used for fire support and maneuver.

file and air support requests come in the form of messages.[2] Future plans call for eventual database-to-database visibility that would allow air and ground planners and controllers to know in real time what each other is doing. These plans, however, are still in the discussion stage and have not yet been formally adopted into programs.

Table 5.2 summarizes our assessment of current organizations and systems to support the air-ground options. A brief rationale is shown next to each assessment.

Option 1A basically uses the current C2 system described by doctrinal organizations and procedures. At present, Army ABCS com-

Table 5.2
Current Information Systems Support Only Limited Air-Ground Improvements

Option	Assessment	Performance
1A (Deep FSCL, closed KB)		Information sharing is message based Current systems are adequate
1B (Deep FSCL, open/closed KB)		Real-time ability to open/close KBs is limited by AFATDS/TBMCS message exchange
1C (Shallow FSCL, open/closed KB and JFA)		Real-time ability to open/close KBs is limited by AFATDS/TBMCS message exchange Information sharing at joint level is limited by GCCS
2 (SMAs, open/closed KB and JFA)		C2 is limited by lack of GCCS air-ground C2 capabilities Real-time ability to open/close KBs and JFAs is limited by AFATDS/TBMCS message exchange and limited sharing of common operational picture with joint commanders using GCCS

NOTE: AFATDS = Advanced Field Artillery Tactical Data System; GCCS = Global Command and Control System.

[2] T. Cahill, "Current Status of TBMCS-ABCS Interfaces," briefing presented to TBMCS SPO-PM BC Air-Space Common Services Meeting, Eatontown, N.J., December 4, 2007.

municates with Air Force TBMCS using AFATDS, the fire support subsystem within the ABCS family of systems.[3] AFATDS-TBMCS links rely on exchange of messages for air support requests. Individual requests for air support are considered on a one-by-one basis, with no information given on other existing requests, status of fire and air support assets, and overall context of maneuver. A mutual exchange or access to databases between AFATDS and TBMCS would more easily provide the total operational context for deciding whether to attack a target and with what means. Despite these shortfalls, however, the current method of message-based information sharing is adequate for this option.

Option 1B also uses the current C2 system. However, it is limited by the ability of AFATDS and TBMCS to rapidly view information in the overall context needed to make decisions on opening and closing kill boxes.

Option 1C relies on the current C2 system and has the same limitations as Option 1B for opening and closing kill boxes in real time. Because of its greater need to rapidly exchange information compared with Option 1B, and because current information sharing at the joint level using GCCS is inadequate (given the force deployment and readiness focus of GCCS), it is rated as red.

The C2 focus for Option 2 is at the joint and service component level. It is assessed as red for the same reasons as C2 for Option 1C is, but its Option 2 inadequacies are magnified because of the increased need to share the common operating picture with joint commanders and the inability of GCCS to do so.

Table 5.3 shows our assessment of future capabilities to support air-ground options. The assessment is based on capabilities that could be available five or more years from now, and indicates that although future capabilities are expected to be better, they will not be adequate

---

[3] TAIS, the U.S. Army Tactical Airspace Integration System, is another recent system addition that now exchanges messages with TBMCS, to support tasks relating to Airspace Control Means Requests and to share data with ABCS via the Army's Publish and Subscribe Server.

Table 5.3
Assessment of Future Capabilities

Option	Assessment	Performance
1-A (Deep FSCL, closed KB)		Information sharing is message based Current systems are adequate
1B (Deep FSCL, open/closed KB)		Increased JADOCS/AFATDS/TBMCS information sharing of databases
1C (Shallow FSCL, open/closed KB and JFA)		Increased JADOCS/AFATDS/TBMCS information sharing of databases Increased joint information sharing using NECC
2 (SMAs, open/closed KB and JFA)		Increased information sharing at joint and service-specific levels using NECC, DLARS, JADOCS, and AFATDS/TBMCS C2 is still limited by lack of NECC air-ground C2 capabilities

NOTES: NECC = net-enabled command capability; DLARS = Data Link Automated Reporting System; JADOCS = Joint Automated Deep Operations Coordination System.

to support the air-ground joint interdependence features described by Option 2.

Our assessment is that Options 1A, 1B, and 1C are supportable. This assessment relies on closer ties between Army AFATDS and Air Force TBMCS (and also, possibly, enabled by enhancements to TAIS and by other joint systems such as JADOCS), and, the initial fielding of the NECC increment 1 (a follow-on to GCCS) improvements in SA and intelligence.[4]

Option 2 is still beyond reach of the supporting organizational and systems structure. It requires greatly increased capabilities at the joint and component levels. Even if the Air Force were to reinstate funding for TBMCS 1.1.4 and proceed with Air Operations Center (AOC) enhancements as originally envisioned, overall capabilities would still

4 A more detailed discussion of information systems is contained in Appendix B.

be limited by the Army's capabilities to replace the ABCS quickly (or to enhance systems such as TAIS, to support additional required capabilities like Web exchanges), and by NECC-prioritized developments beyond increment 1.

Summary and Recommendations

Information system improvements are essential to realizing joint interdependence. In particular, the ability to conduct truly effective air-ground options will require Air Force, Army, and joint-level improvements to C2.

Our current ability to support the air-ground options is limited, due mostly to limitations in interoperability between Army and Air Force systems (AFATDS with TBMCS).[5] There is also limited information sharing with joint users and a lack of joint command and control capability in GCCS.

Future ability to support air-ground options will rely on

- planned improvements of TBMCS (which are currently unfunded) to move toward net-centric command and control (DLARS, a key enhancement, could provide real-time monitoring of ATO execution)
- improved Army battle command capabilities
- planned improvements to share situational awareness at the joint level using NECC
- improvements to NECC to support C2 of air-ground operations at the joint level—but these improvements are not programmed.

---

[5] Recent activity using the JADOCS and other system interfaces will improve interoperability through workaround solutions, but these are still message based.

CHAPTER SIX

Observations and Recommendations

We conclude with a brief review of our observations and conclusions and a short list of suggested recommendations to the Air Force for advancing the concept of greater joint interdependence.

Observations

The relative shift in the roles of ground power and airpower over the past decade presents an opportunity for greater joint warfighting effectiveness and flexibility across a range of military environments that include major combat operations and SSTR operations. We have described operations that need new joint concepts and processes because—despite the many improvements in ISR, strike, and other capabilities—airpower's potential is not being fully realized and joint forces are less effective than they could be.

We developed a framework of options for thinking about new joint concepts, including associated characteristics across a number of related dimensions. We used this framework to show, through quantitative methods, that greater joint interdependence offers important benefits—including increased effectiveness and greater flexibility. Based on a scenario that focuses on the disruption of enemy ground force maneuver, the analysis shows that prioritizing and synchronizing joint fires and maneuver can offer important benefits and give commanders significant added flexibility for employing joint forces. However, the benefits of greater joint interdependence come at a price. Changes in joint and service component C2 arrangements, processes, and programs are necessary; without them, joint interdependence and the resulting benefits cannot be attained.

Recommendations

In summary, we make three recommendations.

First, the framework of options we describe is a starting point for joint interdependence concept development. In preparation for discussions in the joint arena, the Air Force should develop its own vision and framework for enhancing joint interdependence. This should be detailed across the pertinent DOTMLPF dimensions and should be informed by an assessment of its impact on current and planned programs and any risks should be aligned with program impacts. Finally, this vision should identify joint and component responsibilities that would benefit from new research that expands on the methodologies described in this monograph. Such research should examine, with greater scrutiny, the trade-offs in fires options (attack helicopters; GPS-guided MLRS, HIMARS and artillery; fixed-wing aircraft) in the CAS–close combat zone and beyond.

Second, the Air Force should program within itself, and advocate within the joint community, the development of C2 organizations, procedures, and equipment that are necessary to achieve greater joint interdependence.

Third, the Air Force should consider using the framework of options described here for discussions with the joint community. As already noted, many current tactical- and system-level issues involve the joint community, and a number of activities are under way to resolve them.[1] This analytical framework could provide greater insight into these issues and lead to potential resolution.

---

[1] Examples of topical issues include airspace control and deconfliction; FSCMs including kill boxes, JFAs, and FSCLs; command and control arrangements that facilitate joint ISR, fires, and effects; jam-resistant, interoperable, and beyond-LOS communications systems; and joint interoperability based on net-centric data sharing of information systems.

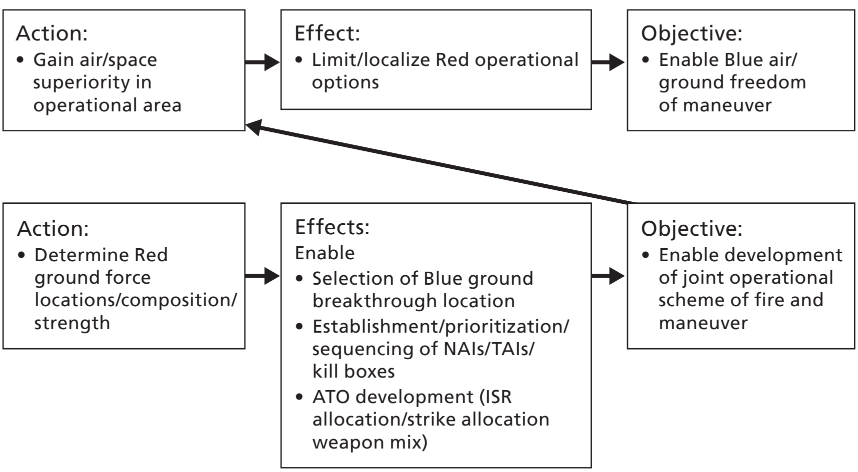
APPENDIX A

Option 2 Vignettes

This appendix describes, in more detail, two Option 2 vignettes that illustrate joint fires and maneuver integration and interdependence.

Figure A.1, beginning in the lower left, presents a conceptual approach for using joint fires and maneuver in an actions-effects-objectives methodology. The figure focuses on setting the stage for effective joint major combat operations. The first action is to do an intelligence preparation of the battlefield (IPB) with the operational goal

Figure A.1
Actions-Effects-Objectives for Joint Fires and Maneuver



RAND *MG793-A.1*

of determining the locations and dispositions of enemy fielded forces. The direct effect of this activity will enable the selection of Blue ground breakthrough locations; establishment, prioritization, and sequencing of named areas of interest (NAI), target areas of interest (TAI), kill boxes; and ATO development (ISR allocation, strike allocation, and weapon mixes). This all leads to the accomplishment of the JFC's initial objective of developing a theater scheme of fires and maneuver.

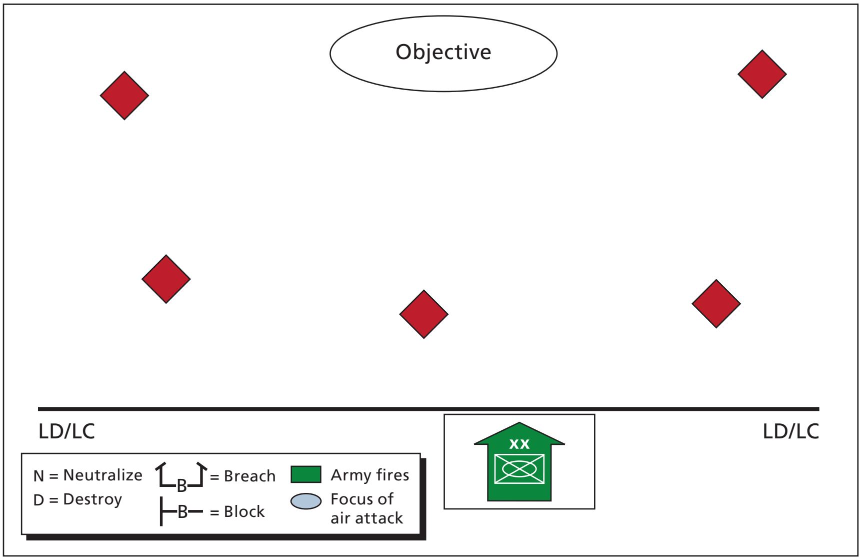
The next critical action is to gain air, space, and cyberspace superiority in the area of operations. This will have the necessary effect of limiting and/or localizing Red operational options, with the objective of enabling Blue air and ground freedom of maneuver.

Figure A.2 reflects the results of the theater IPB within the area where an army division maneuvers. In this simplified depiction, enemy locations, an objective, and the initial line of departure/line of contact (LD/LC) are portrayed. Also shown is a key to the graphics (in the lower-left portion of the figure), which we will use as we develop the concept to describe air actions against enemy fielded forces.

These graphics represent symbols for the following U.S. Army and Marine Corps (USMC) terms that come from FM 1-02:

- Neutralize: As applies to military operations, to render ineffective or unusable; to render enemy personnel incapable of interfering with a particular operation.
- Interdiction: An action to divert, disrupt, delay, or destroy the enemy's surface potential before it can be used effectively against friendly forces.
- Block: Denies the enemy access to a given area or to prevent his advance in a direction or along an avenue of approach.
- Destroy: Physically render an enemy force combat-ineffective until it is reconstituted.
- Breach:
  - (Army) A tactical mission task in which the unit employs all means available to break through or secure a passage through an enemy defense, obstacle, minefield or fortification
  - (USMC): The employment of any means available to break through or secure a passage through an obstacle.

Figure A.2
Results of Theater IPB

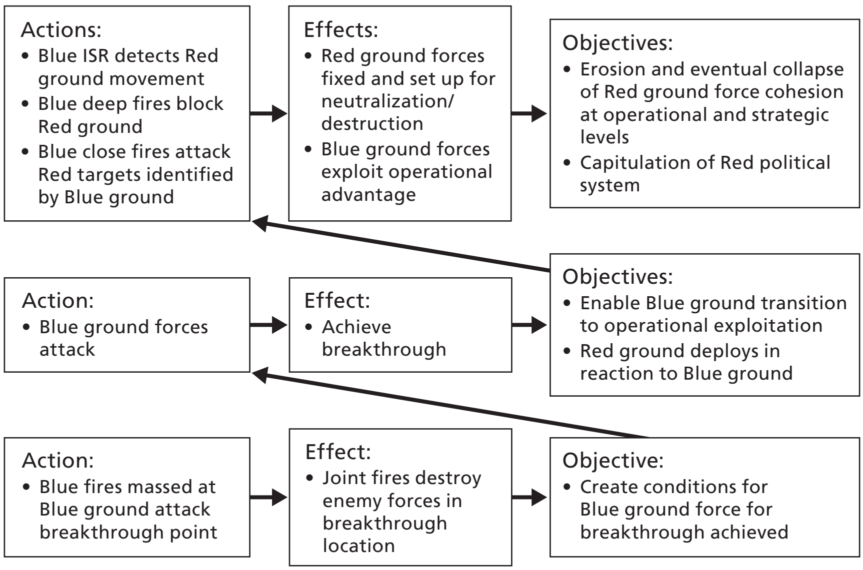


RAND *MG793-A.2*

Figure A.3 extends the actions-effects-objectives discussion. It begins with the assumption that joint airpower controls the commons, the theater IPB has identified enemy fielded forces, a joint scheme of fires and maneuver has been developed, and a breach location for ground maneuver has been selected as a result.

Beginning in the lower left, the integrated joint scheme of fires and maneuver begins a highly integrated and interdependent series of actions that starts by creating the conditions for a Blue ground breach and breakout, enabled by joint fires. This approach also enables the apportionment of air and ISR resources focused on specific NAI, TAI, and kill boxes, and a tight linkage of these resources to the theater scheme of fires and maneuver. Subsequent to the breakout, Blue transitions to the exploitation. Red fielded forces are faced with a dilemma: react to Blue maneuver or be bypassed. If Red maneuvers, it is detected by Blue air

Figure A.3
Joint Fires and Maneuver Actions-Effects-Objectives—Decisive Maneuver Enabled by Precision Fires



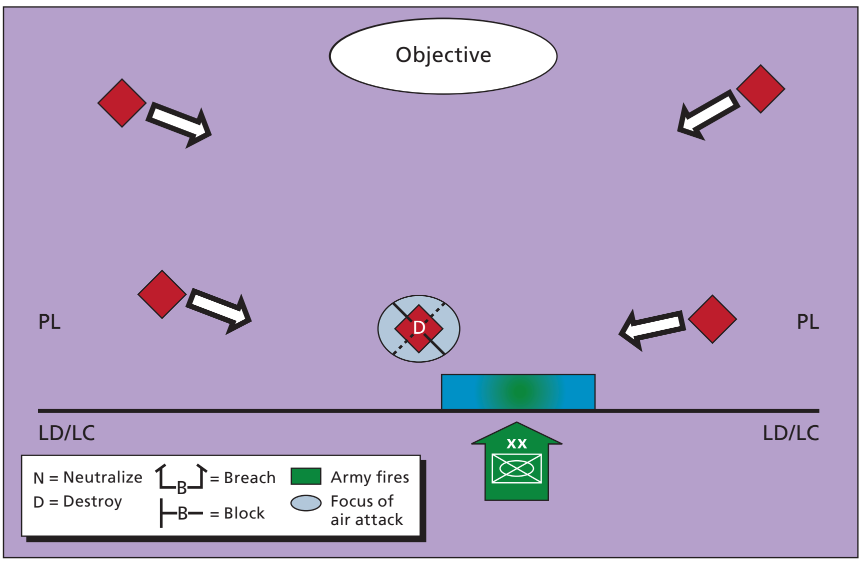
RAND *MG793-A.3*

and attacked by Blue fires—air in deep attack, and ground direct and indirect systems and air in close attack. Thus, Blue ground maneuver forces Red reaction, which is then thwarted by fires and maneuver—and the Blue joint team continues the exploitation in a synchronized fires and maneuver scheme that finds, attacks, or bypasses enemy fielded forces (to block, interdict, neutralize, or destroy).

Furthermore, Blue ISR keeps tabs on Red maneuver, enabling the JFC to make decisions about what further action to take. If the strategic objective is to reconstitute the Red military as a stabilizing force in the postwar regime, then destruction of the Red fielded force might not be desired. In such a case, Blue information operations could be used to persuade the Red fielded force to surrender or face destruction. The ultimate objective of this joint scheme of fires and maneuver is to attain Blue's operational and strategic warfighting objective, e.g., erosion and eventual collapse of Red fielded force cohesion at the operational and strategic levels to produce Red political capitulation.

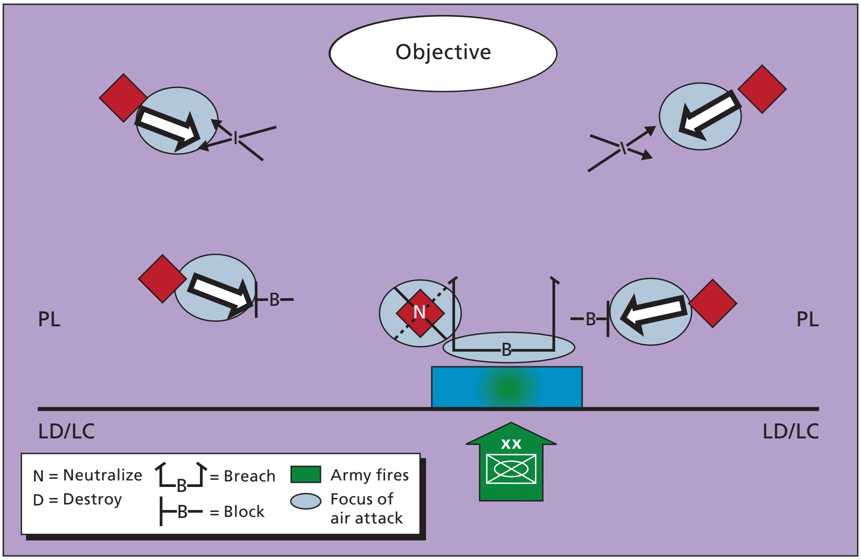
Figures A.4–A.7 show how the joint fires and maneuver actions-effects-objectives effort play out over time. There are several important points to make. First, all the space is joint space. Second, the box around the maneuver force (notionally labeled an SMA) is in essence a joint ground-maneuver area similar to the FSCMs currently used between U.S. air and special operations forces. The complex integration area of this SMA is where the green and blue intersect within the SMA. Further analysis of this area is needed to sort out the dimension of the SMA for various ground maneuver units and operations,

Figure A.4
Build 1: Results of Decisive Maneuver Enabled by Precision Fires



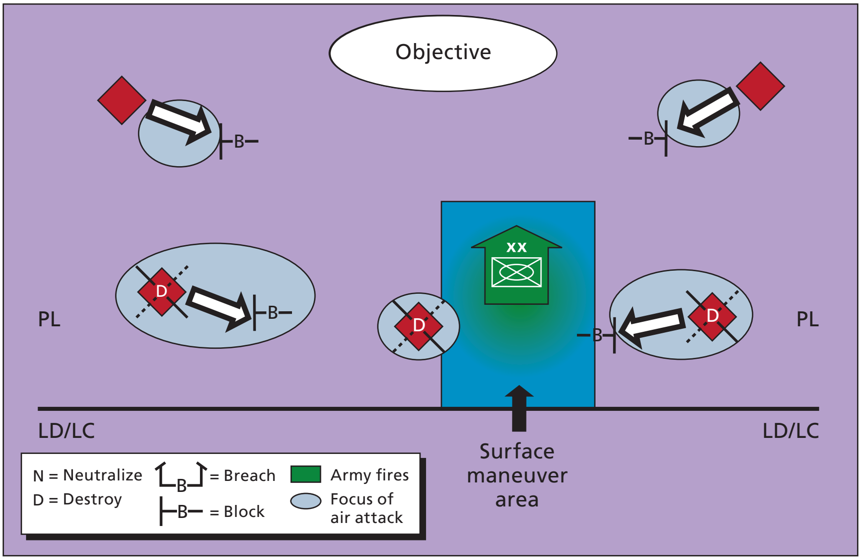
RAND *MG793-A.4*

Figure A.5
Build 2: Results of Decisive Maneuver Enabled by Precision Fires



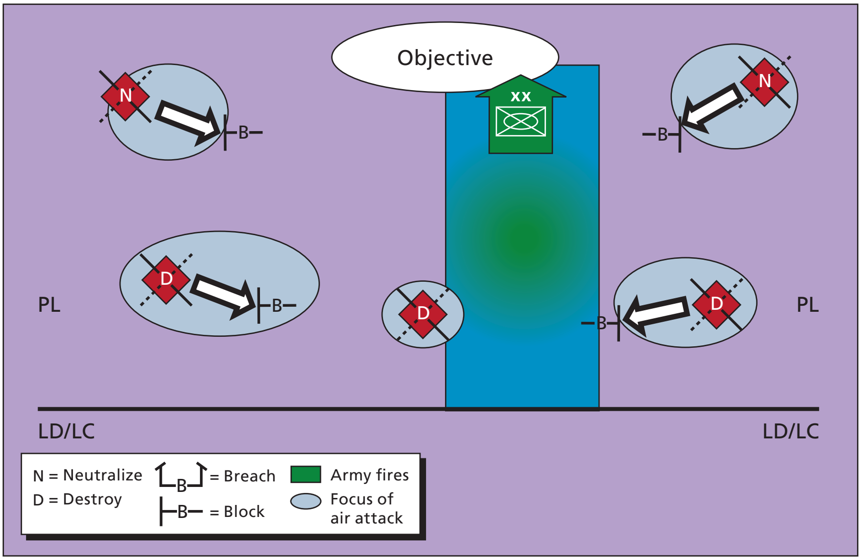
RAND *MG793-A.5*

Figure A.6
Build 3: Results of Decisive Maneuver Enabled by Precision Fires



RAND *MG793-A.6*

Figure A.7
Build 4: Results of Decisive Maneuver Enabled by Precision Fires

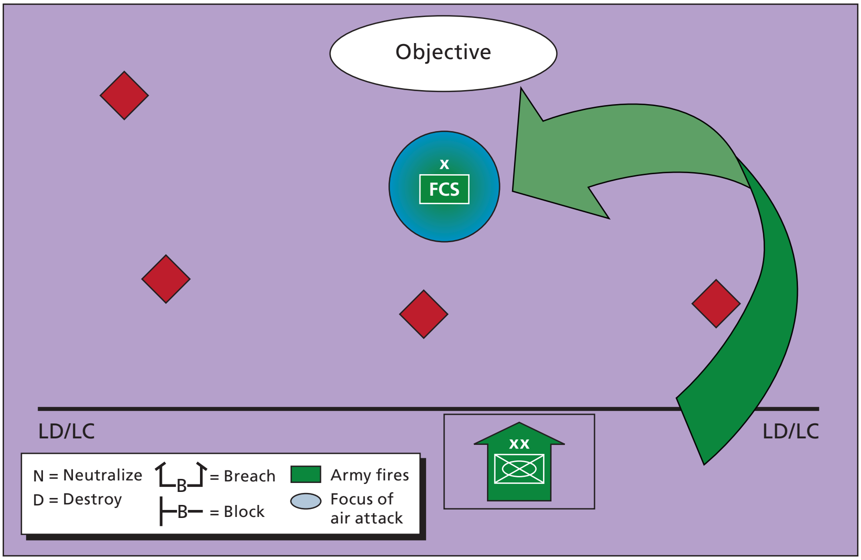


RAND *MG793-A.7*

and to understand what fires are most effective within the SMA (e.g., what systems are best for counterfire) and what C4ISR capabilities and processes are most effective and efficient.

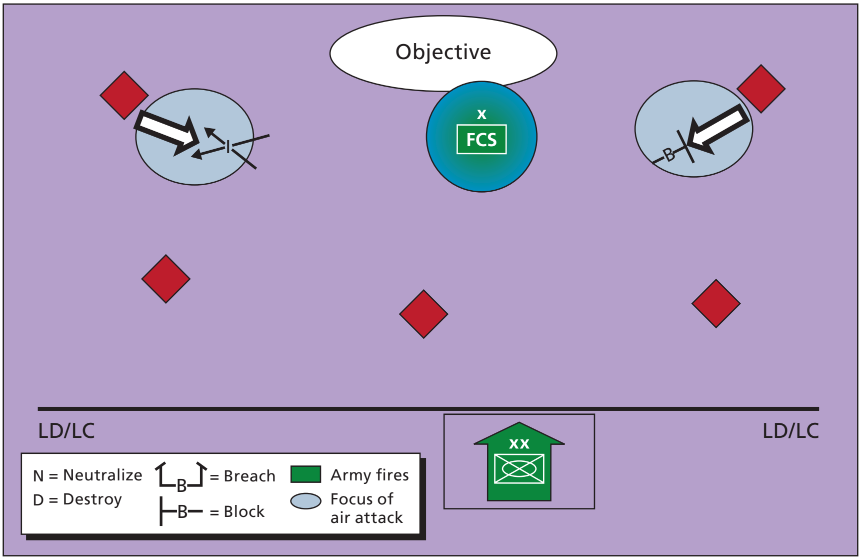
Figures A.8–A.10 show how the actions-effects-objectives effort might be realized in an operation in which surface maneuver units employ air assault as a component of the scheme of maneuver. This could apply with today's air assault capabilities: helicopters in the U.S. Army and Marine Corps or emerging future Army and Marine Corps concepts that use advanced lift technologies for deeper "operational" vertical envelopment. The key point is that C4ISR and airpower will likely be even more important to integrate in these types of operations, given the increased reliance on airpower for these capabilities at ranges past currently available or envisioned indirect fire and attack helicopter ranges, particularly in the Army.

Figure A.8
Build 1: Results of Decisive Maneuver Enabled by Precision Fires—Air Assault Example



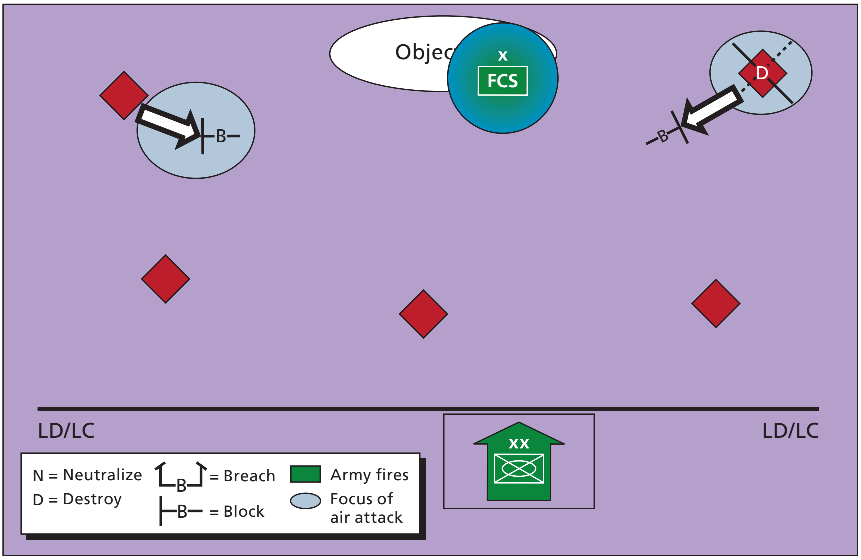
RAND *MG793-A.8*

Figure A.9
Build 2: Results of Decisive Maneuver Enabled by Precision Fires—Air Assault Example



RAND *MG793-A.9*

Figure A.10
Build 3: Results of Decisive Maneuver Enabled by Precision Fires—Air Assault Example



RAND *MG793-A.10*

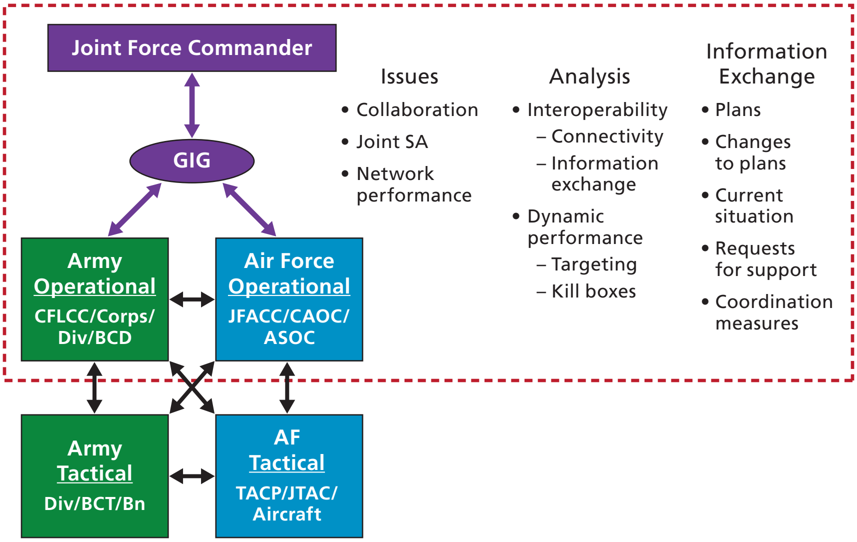
APPENDIX B

Information Systems

Information System Issues

Command and control of air-ground operations requires coordination and information exchange across multiple echelons of both Army and Air Force headquarters. At the operational level (indicated in the top half of Figure B.1), the JFC relies on inputs from subordinate compo-

Figure B.1
Information System Issues: Focus on the Operational Level



RAND *MG793-B.1*

nent commanders to develop plans and subsequently execute them. These headquarters are typically stationary and are supported by the Global Information Grid (GIG) for communications using a combination of landlines and satellites. At this level, the principal issues are the ability of the headquarters to use the network to share information, such as situational awareness, in order to collaborate to develop and execute plans. Our analysis focuses on the ability to perform these functions.

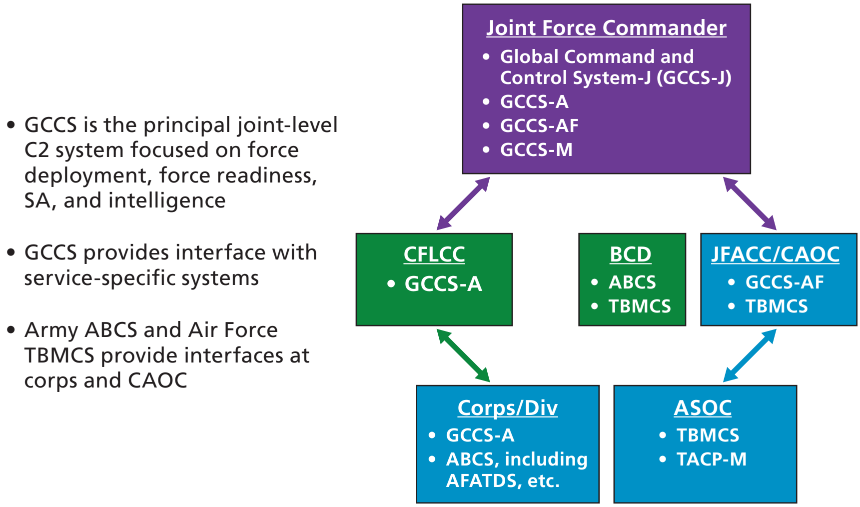
At the tactical level (indicated in the bottom portion of the figure), users are more mobile (either temporarily stationary or moving). Communications are more point-to-point and use specially developed data links to exchange data through gateways that connect users. Since tactical users are typically engaged with enemy forces, the vulnerability of communications to electronic countermeasures and physical attack is an issue. System performance is measured by the ability to connect users to the flow of information, the timeliness of the information, the capacity of the data links, and the robustness of the information to countermeasures.

The remainder of this appendix focuses on operational-level system performance and issues.

Air-Ground Battle Command Information Systems

Figure B.2 shows how systems support the elements of the air-ground structure. At the joint and component level of C2, the GCCS manages forces. GCCS has Army (GCCS-A), Air Force (GCCS-AF), and Maritime (GCCS-M) versions to support the respective components. In the past, GCCS was primarily used to support force deployment and readiness functions. Operations in Iraq and future plans call for a larger role for GCCS to link situational awareness at the tactical, operational, and strategic levels. GCCS thus serves as the linkage to the C2 systems used by the individual components, thereby supporting the development of plans and exchange of information throughout the entire C2 structure.

Figure B.2
Many Systems, Not All Interoperable, Support Air-Ground Battle Command



RAND *MG793-B.2*

The components have their individual command and control systems, as shown in the figure. The ABCS supports Army command and control of specific functions such as fire support, air defense, intelligence, and maneuver. ABCS ties together the myriad Army C2 systems to support tactical and operational C2. The Air Force TBMCS provides the necessary data and planning tools to the CAOC, ASOC, and unit levels to develop and monitor ATO execution.

As indicated in the figure, colocated Army and Air Force C2 is located at Army Corps (i.e., the Air Force ASOC) and Air Force CAOC (i.e., the Army Battlefield Coordination Detachment). This colocation provides a liaison and coordinating capability with system interfaces, providing shared understanding of the situation and plans. Because these systems are typically not directly connected, database sharing is not normally accomplished at the machine-to-machine level. In most cases, information is exchanged through messaging between machines; e.g., U.S. message text format (USMTF) exchanges. This less-than-optimum means of exchanging information induces significant latencies into the information exchange.

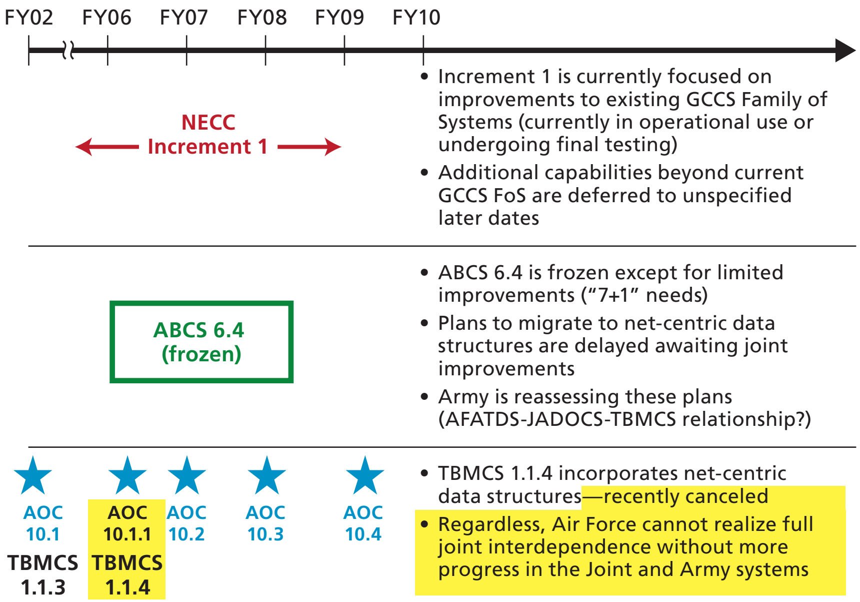
The current system support, while proliferated through the command and control structure, does not provide for the automated interfaces and information sharing that is required for all the air-ground options. The remaining discussion describes the systems in more detail including future plans, with an assessment of future capabilities at the end of this section.

Future Information Systems

Figure B.3 summarizes the evolutionary path of the joint, Army, and Air Force information systems under discussion.

GCCS is being replaced by NECC. The Defense Information Systems Agency is developing NECC to support the joint and component commanders with new software designed to improve interoperability through the use of common services. NECC will be built joint

Figure B.3
Information Systems Are Evolving



RAND *MG793-B.3*

from the beginning to support a number of mission capability packages (MCPs). The MCPs span functionality at the joint and component level with some supporting strategic functions of force projection and force readiness; some supporting intelligence and situational awareness; and some supporting operational and tactical functions required for force protection and force employment (air/space, land, and maritime/littoral operations) MCPs.

NECC is being developed in increments, with the first increment currently under development. Increment 1 focuses on improvements to functions currently performed within GCCS, namely areas of situational awareness, force projection, force readiness, and intelligence. These improvements address many of the operational gaps identified in the Joint Command and Control Analysis of Alternatives (JC2 AoA) conducted for NECC. The increment 1 improvements in situational awareness and intelligence will lay the foundation for improvements in force employment MCPs.

NECC plans beyond increment 1 will add functionality beyond current capabilities, but the timing of these improvements is yet to be determined and depends on available funding.[1]

The Army uses ABCS for tactical and operational command and control. ABCS consists of a family of systems, each supporting a specific functional area (e.g., air defense, fire support, intelligence). The ABCS has experienced a number of problems in exchanging information across functional areas and with the Air Force. For these reasons, the Chief of Staff of the Army has frozen development of ABCS with the exception of stated "Top 7+1 Commander's Needs." These include friendly locations, current enemy situation, running estimates, graphic control measures, fragmentary orders, commander's situation reports, fire support control measures and capability overlays, and joint interoperability. The last two of these priorities directly affect joint fire support interoperability.

---

[1] The current version of the GCCS Functionality Transition Plan (FTP) is a living document that changes with new operational demands and technology improvements. The original FTP specified multiple improvement increments, but key stakeholders in August 2007 redirected the plan to improve current capabilities in one step (NECC Joint Program Management Office, 2008).

Currently, ABCS communicates with TBMCS through the Army's Publish and Subscribe Server (PASS) that links ABCS systems including AFATDS.[2] Preplanned air support requests are shared between TBMCS and AFATDS using PASS and are considered on a one-by-one basis, with no information given on other existing requests, the status of fire and air support assets, and overall context of maneuver. A mutual exchange or access to databases between AFATDS and TBMCS would more easily provide the total operational context for deciding whether to attack a target and with what means.

The Army plans to migrate ABCS to a net-centric environment, implementing a new data strategy to foster interoperability and a service-oriented architecture for software development. These plans currently rely on the joint development of NECC. In the interim, however, AFATDS will continue to be used at least through FY17. The Army and Air Force have discussed specific strategies for tying AFATDS and TBMCS data together in the near term, but the schedule for this is still being determined.

TBMCS is the primary operational level C2 system for the Air Force. TBMCS systems, or workstations, are located at the CAOC and ASOC and at the unit level. TBMCS is used to exchange information needed for developing the ATO (unit status, fire support coordination measures, ground force plans) and executing the ATO (air support requests). The ASOC is also equipped with the Tactical Air Control Party-Modernization equipment to support JTACs and TACPs at lower echelons.

TBMCS exchanges information with the Army command and control organizations using GCCS-A and the AFATDS, an element of ABCS. Planning information (ATO, ACO), SA data (tactical reports [TACREPs]), and execution data (air support requests) are exchanged between the Air Force and Army. The AFATDS-TBMCS link uses

---

[2] TAIS is another recent system addition that can interface with TBMCS via the PASS. When fully developed and implemented, TAIS is expected to digitally support Army airspace command and control planning and execution, and intra- and intercorps and division air traffic service support. Using USMTF messages, TAIS transmits Airspace Control Means Requests to TBMCS and receives and parses airspace control order and air tasking order data from TBMCS.

USMTF for Army requests for air support. USMTF messages do not support automatic database linkage, which could be used to monitor real-time changes to the situation. In addition to this problem, Army air support requests are stripped of their Army numbering so that Army visibility into the status of requests is lost.

TBMCS is part of a larger effort to support the AOC. The Air Force has defined a sequence of AOC versions (from 10.1 to 10.4) to manage development over the next five years. As shown in the figure, AOC 10.1 uses the current version of TBMCS (1.1.3) to begin the standardization of Air Force support across AOCs. The ASOC receives real-time ACO and ATO information through its TBMCS implementation. Digital CAS requests go directly into the TBMCS Air Operations Data Base (AODB), and actions the ASOC takes through its Web Air Support Request (ASR) Processor are directly linked to the AODB in TBMCS 1.1.3.

AOC 10.1.1 was to include upgrades to TBMCS (version 1.1.4). This funding was suspended in March 2007. AOC 10.1.1 was supposed to add functionality, especially the DLARS, which displays real-time air situational awareness by monitoring and displaying information on Air Force data links. Version 1.1.4 was also supposed to implement a database structure that conforms to Department of Defense (DoD) net-centric requirements, which are specified to support database-to-database visibility and information sharing. With the elimination of AOC variant 10.1.1, AOC variants 10.2 to 10.4 are now planned to gradually add additional improvements to net-centricity (data structure and planning functions), and other improvements such as interoperability with some coalition partners, multilevel security, and fusion of information. The Air Force is currently reevaluating its priorities for future improvements; these are expected to span a period greater than the five years shown on the figure.

Even if functionalities envisioned for TBMCS version 1.1.4 were reinstated, the focus would still be on AOC improvements to air operations planning and execution. While this will improve Air Force operations, support to the air-ground options as described in this monograph will require additional improvements to system interfaces between the Air Force, Army, and joint headquarters.

In summary, the lower priority for NECC air/space operations would not have had a great impact on the Air Force at the operational and tactical level, if the Air Force had continued its development of TBMCS, which was also envisioned to become integrated into NECC. However, with the cancellation of TBMCS 1.1.4, the Air Force is more dependent on NECC. The Army is likewise highly dependent on NECC in providing the strategic-operational command and control capability for the future. Because the NECC air and ground operations MCPs are lower in priority, the Army and Air Force are currently revising their plans in order to improve capabilities sooner.

References

Air Force Doctrine Document (AFDD) 2-1.3, *Counterland Operations,* Washington, D.C.: Headquarters Department of the Air Force, September 11, 2006.

Air Land Sea Application (ALSA) Center, *Kill Box Multi-Service Tactics, Techniques, and Procedures for Kill Box Employment*, Langley AFB, Va., June 2005. Not releasable to the general public.

———, *JSTARS Multi-Service Tactics, Techniques, and Procedures for Joint Surveillance Target Attack Radar System*, Langley AFB, Va., November 2006.

Cahill, T., "Current Status of TBMCS-ABCS Interfaces," briefing presented to TBMCS SPO-PM BC Air-Space Common Services Meeting, Eatontown, N.J., December 4, 2007.

Cordesman, Anthony S., *The Iraq War: Strategy, Tactics, and Military Lessons,* The CSIS Press, Washington, D.C., 2003.

Director, Air Combat Plans and Programs (ACC/A5) and Deputy Director/ Chief of Staff, Army Capabilities Integration Center (ARCIC), *AAFIF Charter*, Memorandum of Understanding, Training and Doctrine Command, May 2006.

Field Manual (FM) 1-02 (FM 101-5-1)/MCRP 5-12A, *Operational Terms and Graphics,* Washington, D.C.: Headquarters Department of the Army and Marine Corps Combat Development Command, 2004.

——— 3-0, *Operations,* Washington, D.C.: Headquarters Department of the Army, 2001.

———, *Operations,* Washington, D.C.: Headquarters Department of the Army, 2008.

Fontenot, COL Gregory, LTC E. J. Degen, and LTC David Tohn, *On Point: The United States Army in Operation Iraqi Freedom*, Ft. Leavenworth, Kan.: Center for Army Lessons Learned, 2004. As of February 28, 2008: http://www.globalsecurity.org/military/library/report/2004/onpoint/index.html

Gordon, John IV, and Jerry Sollinger, "The Army's Dilemma," *Parameters,* Summer 2004, pp. 33–45.

Headquarters Air Combat Command, *United States Air Force Air Support Operations Center Enabling Concept,* June 1, 2006.

Irwin, Sandra I., "Navy Artillery: No New Weapons on the Horizon," *National Defense*, March 2006. As of October 18, 2006:
http://www.nationaldefensemagazine.org/archive/2006/March/Pages/navy3038.aspx

Jacobs, Jody, Leland Joe, David Vaughan, Diana Dunham-Scott, Lewis Jamison, and Michael Webber, *Technologies and Tactics for Improved Air-Ground Effectiveness,* Santa Monica, Calif.: RAND Corporation, 2008. Not releasable to the general public.

Johnson, David E., *Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917–1945*, Ithaca, N.Y.: Cornell University Press, 1998.

———, *Learning Large Lessons: The Evolving Roles of Ground Power and Air Power in the Post–Cold War Era*, Santa Monica, Calif.: RAND Corporation, MG-405-1-AF, 2007. As of September 23, 2008:
http://www.rand.org/pubs/monographs/MG405-1/

Joint Fires Coordination Measures (JFCM) Joint Test and Evaluation (JT&E), *Tactics, Techniques, and Procedures* (TTP), draft, no date.

Joint Publication (JP) 3-0, *Joint Operations*, Washington, D.C.: Joint Staff, September, 2006.

——— 3-09, *Joint Fire Support,* Washington, D.C.: Joint Staff, November 13, 2006.

——— 3-09.3, *Joint Tactics, Techniques, and Procedures for Close Air Support,* Washington, D.C.: Joint Staff, September 3, 2003.

JP 3.52, *Joint Doctrine for Airspace Control in the Combat Zone,* Washington, D.C.: Joint Staff, August 30, 2004.

Kinne, Gary S., John A. Tanzi, and Jeffrey W. Yaeger, "FA PGMs: Revolutionizing Fires for the Ground Force Commander," *Field Artillery*, May–June 2006, pp. 16–21.

Kirkpatrick, Charles E., *Joint Fires as They Were Meant to Be: V Corps and the 4th Air Support Operations Group During Operation Iraqi Freedom*, Land Warfare Paper No. 48, Arlington, Va.: The Institute of Land Warfare, Association of the United States Army, October 2004.

Maples, Michael, "FA Priorities After OIF," *Field Artillery,* September–October 2003.

McGee, Lt Col Michael B., *Air-Ground Operations During Operation Iraqi Freedom, Successes, Failures and Lesson of Air Force and Army Integration,* Air Warfare College University, Washington, D.C., February 25, 2005.

Moore, Richard, John Stillion, et al., *Next-Generation Gunship Analysis of Alternatives: Final Report—Volume I*, Santa Monica, Calif.: RAND Corporation, 2004. Not releasable to the general public.

Neal, Curtis, ACC/CCJ, "ASOC/TACP Transformation and Modernization," briefing to the TACP Enabling Concept Meeting, Fayetteville, N.C., January 31, 2006.

———, "JAGC2: A Concept for Future Battlefield Air-Ground Integration," *Field Artillery*, November/December 2006.

NECC Joint Program Management Office, "GCCS Family of Systems to NECC Functionality Transition Plan (FTP)," Version 1.4, June 30, 2008.

Ochmanek, David, Edward R. Harshberger, David E. Thaler, and Glenn A. Kent, *To Find and Not to Yield: How Advances in Information and Firepower Can Transform Theater Warfare*, Santa Monica, Calif.: RAND Corporation, MR-958-AF, 1998. As of October 5, 2008:
http://www.rand.org/pubs/monograph_reports/MR958/

Pirnie, Bruce R., Alan Vick, Adam Grissom, Karl P. Mueller, and David T. Orletsky, *Beyond Close Air Support, Forging a New Air-Ground Partnership*, Santa Monica, Calif.: RAND Corporation, MG-301-AF, 2005. As of October 5, 2008:
http://www.rand.org/pubs/monographs/MG301/

Training and Doctrine Command (TRADOC), Pamphlet 525-3-0, *The Army in Joint Operations: The Army Future Force Capstone Concept*, Version 2.0, Fort Monroe, Va., April 7, 2005.

———, Pamphlet 525-3-1, *The Army Operating Concept for Operational Maneuver, 2015–2024*, Version 1.0, Fort Monroe, Va., October 2, 2006.

———, Pamphlet 525-3-2, *The Army Operating Concept for Tactical Maneuver, 2015–2024*, Version 1.0, Fort Monroe, Va., October 2, 2006.

———, Pamphlet 525-3-4, *The Army Functional Concept for Strike*, Fort Monroe, Va., April 30, 2007.

"Transformation to Support UEx," briefing to JAGO ASOC Tiger Team Conference, Nellis AFB, Nev., January 25–27, 2005.

Vick, Alan, Richard Moore, Bruce Pirnie, and John Stillion, *Aerospace Operations Against Elusive Ground Targets*, Santa Monica, Calif.: RAND Corporation,

MR-1398-AF, 2001. As of October 5, 2008:
http://www.rand.org/pubs/monograph_reports/MR1398/

Vick, Alan, David T. Orletsky, Bruce Pirnie, and Seth G. Jones, *The Stryker Brigade Combat Team: Rethinking Strategic Responsiveness and Assessing Deployment Options*, Santa Monica, Calif.: RAND Corporation, MR-1606-AF, 2002. As of October 5, 2008:
http://www.rand.org/pubs/monograph_reports/MR1606/