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Report to Congressional Requesters

July 1996

OPERATION DESERT STORM

Evaluation of the Air War

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Program Evaluation and
Methodology Division

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July 2, 1996

The Honorable David Pryor
Ranking Minority Member
Subcommittee on Post Office and Civil Service
Committee on Governmental Affairs
United States Senate

The Honorable John D. Dingell
Ranking Minority Member
Committee on Commerce
House of Representatives

This study responds to your request that we comprehensively evaluate the use and effectiveness of the various aircraft, munitions, and other weapon systems used in the victorious air campaign in Operation Desert Storm in order to aid the Congress in future procurement decisions.

Over 5 years ago, the United States and its coalition allies successfully forced Iraq out of Kuwait. The performance of aircraft and their munitions, cruise missiles, and other air campaign systems in Desert Storm continues to be relevant today as the basis for significant procurement and force sizing decisions. For example, the Department of Defense (DOD) Report on the Bottom-Up Review (BUR) explicitly cited the effectiveness of advanced weapons used in Desert Storm—including laser-guided bombs (LGBs) and stealth aircraft—as shaping the BUR recommendations on weapons procurement.[1]

This report is an unclassified summary of our classified report. The table of contents for that report is included in appendix I to provide an outline of the breadth of our evaluation.

Background

Operation Desert Storm was primarily a sustained 43-day air campaign by the United States and its allies against Iraq between January 17, 1991, and February 28, 1991. It was the first large employment of U.S. air power since the Vietnam war, and by some measures (particularly the low number of U.S. casualties and the short duration of the campaign), it was perhaps the most successful war fought by the United States in the 20th century. The main ground campaign occupied only the final 100 hours of the war.

[1]Department of Defense, Report on the Bottom-Up Review (Washington, D.C.: October 1993), p. 18.

The air campaign involved nearly every type of fixed-wing aircraft in the U.S. inventory, flying about 40,000 air-to-ground and 50,000 support sorties.[2] Approximately 1,600 U.S. combat aircraft were deployed by the end of the war. By historical standards, the intensity of the air campaign was substantial. The U.S. bomb tonnage dropped per day was equivalent to 85 percent of the average daily bomb tonnage dropped by the United States on Germany and Japan during the course of World War II.

Operation Desert Storm provided a valuable opportunity to assess the performance of U.S. combat aircraft and munitions systems under actual combat conditions. Unlike operational tests or small-scale hostilities, the air campaign involved a very large number of conventional systems from all four services used in tandem, which permits potentially meaningful cross-system comparisons. The combat data in this report can be seen as an extension of the performance data generated by DOD's operational test and evaluation programs that we have previously reviewed.[3]

Objectives

To respond to your questions about the effectiveness of the air campaign; the performance of individual weapon systems; the accuracy of contractor claims, particularly in regard to stealth technology and the F-117; and the relationship between the cost of weapon systems and their performance and contributions to the success of the air campaign, we established the following report objectives.

1. Determine the use, performance, and effectiveness of individual weapon systems in pursuit of Desert Storm's objectives, and in particular, the extent to which the data from the conflict support the claims that DOD and weapon contractors have made about weapon system performance.

2. Describe the relationship between cost and performance for the weapon systems employed.

3. Identify the degree to which the goals of Desert Storm were achieved by air power.

[2]Support sorties comprised missions such as refueling, electronic jamming, and combat air patrol.

[3]See U.S. General Accounting Office, Weapons Acquisition: Low-Rate Initial Production Used to Buy Weapon Systems Prematurely, GAO/NSIAD-95-18 (Washington, D.C.: November 1994); Weapons Acquisition: A Rare Opportunity for Lasting Change, GAO/NSIAD-93-15 (Washington, D.C.: December 1992); Weapons Testing: Quality of DOD Operational Testing and Reporting, GAO/PEMD-88-32BR (Washington, D.C.: July 1988); Live Fire Testing: Evaluating DOD's Programs, GAO/PEMD-87-17 (Washington, D.C.: August 1987); and How Well Do the Military Services Perform Jointly in Combat? DOD's Joint Test and Evaluation Program Provides Few Credible Answers, GAO/PEMD-84-3 (Washington, D.C.: February 1984).

4. Identify the key factors aiding or inhibiting the effectiveness of air power.

5. Identify the contributions and limitations of advanced technologies to the accomplishments of the air campaign.

6. Determine whether the unique conditions of Desert Storm limit the lessons learned.

Summary

Operation Desert Storm was a highly successful and decisive military operation. The air campaign, which incurred minimal casualties while effecting the collapse of the Iraqis' ability to resist, helped liberate Kuwait and elicit Iraqi compliance with U.N. resolutions. However, our analysis of the air campaign against strategic targets revealed several air power issues that require attention before the next campaign. First, the effectiveness of air power in Desert Storm was inhibited by the aircraft sensors' inherent limitations in identifying and acquiring targets and by DOD's failure to gather intelligence on the existence or location of certain critical targets and its inability to collect and disseminate timely battle damage assessments (BDA). Pilots noted that infrared, electro-optical, and laser systems were all seriously degraded by clouds, rain, fog, smoke, and even high humidity, and the pilots reported being unable to discern whether a presumed target was a tank or a truck and whether it had already been destroyed. The failure of intelligence to identify certain targets precluded any opportunity for the coalition to fully accomplish some of its objectives. And the reduced accuracies from medium and high altitudes and absence of timely BDA led to higher costs, reduced effectiveness, and increased risks from making unnecessary restrikes.

Second, U.S. commanders were able to favor medium- to high-altitude strike tactics that maximized aircraft and pilot survivability, rather than weapon system effectiveness. This was because of early and complete air superiority, a limited enemy response, and terrain and climate conditions generally conducive to air strikes. Low-altitude munitions deliveries had been emphasized in prewar training, but they were abandoned early. The subsequent deliveries from medium and high altitudes resulted in the use of sensors and weapon systems at distances from targets that were not optimal for their identification, acquisition, or accuracy. Medium- and high-altitude tactics also increased the exposure of aircraft sensors to man-made and natural impediments to visibility.

Third, the success of the sustained air campaign resulted from the availability of a mix of strike and support assets. Its substantial weight of effort was made possible, in significant part, by the variety and number of air-to-ground aircraft types from high-payload bombers, such as the B-52, to platforms capable of delivering guided munitions such as the stealthy F-117, to high-sortie-rate attack aircraft such as the A-10. A range of target types, threat conditions, and tactical and strategic objectives was best confronted with a mix of weapon systems and strike and support assets with a range of capabilities.

Fourth, despite often sharp contrasts in the unit cost of aircraft platforms, it is inappropriate, given aircraft use, performance, and effectiveness demonstrated in Desert Storm, to characterize higher cost aircraft as generally more capable than lower cost aircraft. In some cases, the higher cost systems had the greater operating limitations; in some other cases, the lower cost aircraft had the same general limitations but performed at least as well; and in still other cases, the data did not permit a differentiation.

Fifth, "one-target, one-bomb" efficiency was not achieved. The air campaign data did not validate the purported efficiency or effectiveness of guided munitions, without qualification. On average, more than 11 tons of guided and 44 tons of unguided munitions were delivered on targets assessed as successfully destroyed; still more tonnage of both was delivered against targets where objectives were not fully met. Large tonnages of munitions were used against targets not only because of inaccuracy from high altitudes but also because BDA data were lacking. Although the relative contribution of guided munitions in achieving target success is unknowable, they did account for the bulk of munitions costs. Only 8 percent of the delivered munitions tonnage was guided, but at a price that represented 84 percent of the total munitions cost. During Desert Storm, the ratio of guided-to-unguided munitions delivered did not vary, indicating that the relative preferences among these types of munitions did not change over the course of the campaign. More generally, Desert Storm demonstrated that many systems incorporating complex or advanced technologies require specific operating conditions to operate effectively. These conditions, however, were not consistently encountered in Desert Storm and cannot be assumed in future contingencies.

Lastly, many of DOD's and manufacturers' postwar claims about weapon system performance—particularly the F-117, TLAM, and laser-guided

bombs—were overstated, misleading, inconsistent with the best available data, or unverifiable.

Scope and Methodology

Scope

In this report, we evaluate the aircraft and munitions that we deemed to have had a major role in the execution of the Desert Storm air campaign by virtue of their satisfying at least one (in most cases, two) of the following criteria. The system

- played a major role against strategic targets (broadly defined),
- was the focus of congressional interest,
- may be considered by DOD for future major procurement,
- appeared likely to play a role in future conflicts, or
- even if not slated currently for major procurement, either was used by allied forces in a manner or role different from its U.S. use or used new technologies likely to be employed in the future.

These criteria led us to assess the A-6E, A-10, B-52, F-111F, F-117A, F-15E, F-16, F/A-18, and British Tornado (GR-1).[4] We examined both guided and unguided munitions, including laser-guided bombs, Maverick missiles, Tomahawk land-attack (cruise) missiles (TLAMS), and unguided "dumb" bombs.

We assess the effectiveness of various U.S. and allied air campaign aircraft and weapon systems in destroying ground targets, primarily those that fall into the category of "strategic" targets.[5] We focused our analysis on strategic targets in part because they received the best documented BDA, although there was substantial variation from target to target and among

[4]The AV-8B, A-7, and B-1B were not included. Both the AV-8B and the A-7 were excluded because of their relatively few strikes against strategic targets. The B-1B did not participate in the campaign because munitions limitations, engine problems, inadequate crew training, and electronic warfare deficiencies severely hampered its conventional capabilities.

[5]In Operation Desert Storm, some targets were clearly strategic, such as Iraqi Air Force headquarters in Baghdad, while others, essentially the Iraqi ground forces in the Kuwait theater of operations, could be considered both strategic and tactical. For our purposes, we concentrated on the effects achieved by the air campaign before the start of the ground offensive, including successes against ground forces in Kuwait. Unlike most previous large-scale conflicts, the air campaign accounted for more than 90 percent of the entire conflict's duration. Therefore, what we have excluded from our analysis is the role of air power in supporting ground forces during the ground offensive ("close air support"), as well as such nonstrategic missions as search and rescue.

target types in the quantity and quality of BDA. The 12 categories of strategic targets in Desert Storm are listed in appendix II.

Historically, studies of air power have articulated differing points of view on the relative merits of focusing air attacks on targets deemed to be strategic (such as government leadership, military industry, and electrical generation) and focusing them on tactical targets (such as frontline armor and artillery). These contending points of view have been debated in many official and unofficial sources.[6] In this study, we did not directly address this debate because data and other limitations (discussed below) did not permit a rigorous analysis of whether attacks against strategic targets contributed more to the success of Desert Storm than attacks against tactical targets.

Methodology

Data Sources

A primary goal of our work was to cross-validate the best available data on aircraft and weapon system performance, both qualitative and quantitative, to test for consistency, accuracy, and reliability. The data we analyzed in this report are the best information collected during the war. They were compiled for and used by the commanders who managed the air campaign. These data also provided the basis for postwar DOD and manufacturer assessments of aircraft and weapon system performance during Desert Storm. We balanced the limitations of the data, to the extent possible, against qualitative analyses of the systems. For example, we compared claims made for system performance and contributions to what was supportable given all the available data, both quantitative and qualitative.

We collected and analyzed data from a broad range of sources, including the major DOD databases that document the strike histories of the war and cumulative damage to targets; numerous after-action and lessons-learned reports from military units that participated in the war; intelligence reports; analyses performed by DOD contractors; historical accounts of the war from the media and other published literature; and interviews with participants, including more than 100 Desert Storm pilots and key

[6]Examples include: Edward C. Mann, III, Thunder and Lightning (Maxwell Air Force Base, Ala.: Air University Press, April 1995); John A. Warden, III, The Air Campaign (Washington, D.C.: Pergamon-Brassey's, 1989); and Richard T. Reynolds, Heart of the Storm: The Genesis of the Air Campaign Against Iraq (Maxwell Air Force Base, Ala.: Air University Press, April 1995).

individuals in the planning and execution of the war.[7] We also interviewed key Desert Storm planners and analysts from a wide spectrum of organizations, both within and outside DOD. (See appendix III.)

After we collected and analyzed the air campaign information, we interviewed DOD, Joint Chiefs of Staff, and service representatives and reviewed plans for the acquisition and use of weapon systems in future campaigns to observe how the lessons learned from Desert Storm have been applied. Our analyses were also reviewed by several experts on either air power issues in general or the conduct of Operation Desert Storm in particular. (See appendix IV.)

Data Analysis

To compare the nature and magnitude of the power that Operation Desert Storm employed against strategic targets to the nature of outcomes, we analyzed two databases—the "Missions" database generated by the Air Force's Gulf War Air Power Survey (GWAPS) research group (to assess inputs) and the Defense Intelligence Agency's (DIA's) phase III battle damage assessment reports (to assess outcomes). The Missions database represents a strike history of air-to-ground platforms and ordnance in the Persian Gulf war.[8] There are data on 862 targets, with basic encyclopedia (or BE) numbers, that together comprise more than 1 million pieces of strike information. The phase III reports provided the best cumulative all-source functional BDA for each strategic target available to planners during the course of the war.

To determine the use of aircraft and munitions in achieving air campaign objectives, we used the Missions database to determine weight-of-effort

[7]We did not select pilots randomly, given constraints on their availability, travel, and time. The only requirement was that a pilot had flown the relevant type of aircraft in a Desert Storm combat mission. In most cases, the pilots had flown numerous missions. The purpose of interviewing pilots was to receive as direct input as possible from the aircraft and munition user rather than views filtered through official reports. In U.S. General Accounting Office, Operation Desert Storm: Limits on the Role and Performance of B-52 Bombers in Conventional Conflicts, GAO/NSIAD-93-138 (Washington, D.C.: May 1993), we assessed the B-52 role in detail. Where they were relevant, we incorporated the data and findings from that report into our comparisons. The British government denied our requests to interview British pilots who had flown in Desert Storm. However, we were able to obtain some official assessments of the British role in the air campaign, and we interviewed U.S. pilots about their interactions with British pilots.

[8]GWAPS researchers compiled a very large computerized database on aerial operations in the Persian Gulf war from existing records. It documents aircraft strikes on ground targets, number and type of ordnance, date, and time on target information, target names and identifiers, desired mean point of impact, and additional mission-related information. It contains strike history information across the duration of the air campaign for most of the air-to-ground platforms that participated.

(WOE) and type-of-effort measures (TOE) at two levels.[9] First, we calculated WOE and TOE at the broad level of the target category for each of the 12 strategic target categories shown in appendix II. Second, we calculated WOE and TOE for each aircraft and TLAM across the 12 categories.

We used phase III reports on fixed strategic targets to determine the extent to which the functional capabilities of the target had been eliminated. To correlate outcomes on targets with the input to them, we matched phase III data with data in the Missions database. For strategic targets where both BDA and WOE/TOE data existed, we sought to assess the relationship between the WOE and TOE data representing campaign inputs with phase III BDA data representing campaign outcomes, at the target level.[10] While this methodology has limitations, no other study of Desert Storm has produced the target-specific input-outcome database that can be derived from merging these sources.

Study Strengths and Limitations

This analysis of the campaign and aircraft and munitions use and effectiveness benefited from our use of the most comprehensive strike and BDA data produced from the Persian Gulf war, a previously untried methodology to match inputs and outputs on targets; additional qualitative and quantitative data obtained from Desert Storm veterans and after-action reports to corroborate information in the primary databases; and our utilization of the results of other Desert Storm analyses, such as the Gulf War Air Power Survey.

This study is the first to match available Desert Storm strike and BDA data by target and to attempt to assess the effectiveness of multiple weapon systems across target categories. Despite the data limitations discussed below, our methodology provided systematic information on how weapon systems were employed, what level and types of weapons were required to achieve success, and the relative cost-effectiveness of multiple platforms. The reliability and validity of these findings are strengthened by our use of interviews, after-action reports, and other Desert Storm analyses to better

[9]Variables that comprise the WOE measure include (1) the quantity of BE numbers to which platforms were tasked, (2) the quantity of strikes that platforms conducted, (3) the quantity of bombs that platforms delivered, and (4) the quantity of bomb tonnage that platforms delivered. Variables that comprise the TOE measure include (1) the quantity of bombs that were guided bombs, (2) the quantity of bombs that were unguided bombs, (3) the quantity of bomb tonnage that was guided, and (4) the quantity of bomb tonnage that was unguided.

[10]This methodology was discussed with DIA analysts who were familiar with both the Missions database and the phase III reports. They identified no reason why this methodology would not result in valid comparisons of inputs and outcomes. In addition, they believed that the utilization of WOE and TOE variables would alleviate data problems previously encountered by analysts conducting strike BDA.

understand platform performance variables and place the results of our effectiveness analyses in the appropriate context.

Our analyses of campaign inputs (from the Missions database) and outcomes (from the phase III reports) against ground targets have limitations of both scope and reliability imposed by constraints in the primary Desert Storm databases. Systematically correlating munition inputs against targets to outcomes was made highly problematic by the fact that the phase III BDA reports did not provide a comprehensive compilation of BDA for all strategic targets and could not differentiate the effects of one system from another on the same target.[11]

We sought to work around data limitations through qualitative analysis of systems, based on diverse sources. Claims made for system performance were assessed in light of the most rigorous evaluation that could be made with the available data. We have explicitly noted data insufficiencies and uncertainties. Overall, data gaps and inconsistencies made an across-the-board cost-effectiveness evaluation difficult. However, there were sufficient data either to assess all the major claims made by DOD for the performance of the major systems studied or to indicate where the data are lacking to support certain claims.

We conducted our work between July 1992 and December 1995 in accordance with generally accepted government auditing standards.

Conclusions

We reached the following conclusions from our review of the air campaign:

- DOD's future ability to conduct an efficient, effective, and comprehensive air campaign will depend partly on its ability to enhance sensor capabilities, particularly at medium altitudes and in adverse weather, in order to identify valid targets and collect, analyze, and disseminate timely BDA.
- A key parameter in future weapon systems design, operational testing and evaluation, training, and doctrine will be pilot and aircraft survivability.
- The scheduled retirement of strike and attack aircraft such as the A-6E, F-111F, and most A-10s will make Desert Storm's variety and number of aircraft unavailable by the year 2000.

[11]Such assessments, system by system, were not the objective of these reports. Since targets were generally assessed only episodically and, in most cases, after being hit by numerous diverse aircraft and munitions over a period of time, it was impossible to know which munition from which aircraft had caused what amount of damage.

- The cost of guided munitions (now estimated to be over $58 billion), their intelligence requirements, and the limitations on their effectiveness demonstrated in Desert Storm need to be considered by DOD and the services as they determine the optimal future mix of guided and unguided munitions.

DOD and associated agencies have undertaken initiatives since the war to address many, but not all, of the limitations of the air campaign that we identified in our summary (see pp. 3-4) and conclusions. We have not analyzed each of these initiatives in this report; however, we briefly describe those that apply to one or more of our conclusions below.

First, DOD officials told us that the most sophisticated targeting sensors used in Desert Storm (which were available only in limited quantities) have now been deployed on many more fighter aircraft, thereby giving them a capability to deliver guided munitions. However, the same limitations exhibited by these advanced sensor and targeting systems in Desert Storm—limited fields-of-view, insufficient resolution for target discrimination at medium altitudes, vulnerabilities to adverse weather, and limited traverse movement—remain today.

Second, DOD officials told us that to address the Desert Storm BDA analysis and dissemination shortcomings, they have created an organization to work out issues, consolidate national reporting, and provide leadership; developed DOD-wide doctrine, tactics, techniques, and procedures; established more rigorous and realistic BDA training and realistic exercises; and developed and deployed better means to disseminate BDA. However, DOD officials acknowledge that additional problems remain with improving BDA timeliness and accuracy, developing nonlethal BDA functional damage indicators (particularly for new weapons that produce nontraditional effects), and cultivating intelligence sources to identify and validate strategic targets. Moreover, as our analyses of the air campaign revealed, timely and accurate BDA is crucial for the efficient employment of high-cost guided munitions (that is, for avoiding unnecessary restrikes). Therefore, acquisition plans for guided munitions must take fully into account actual BDA collection and dissemination capabilities before a final determination can be made on how much to acquire.

Third, DOD officials told us that survivability is now being emphasized in pilot training, service and joint doctrine, and weapon system development. Pilot training was modified immediately after the air campaign to meet challenges such as medium-altitude deliveries in a high antiaircraft

artillery and infrared surface-to-air missile threat environment. Service and joint doctrine now reflect the lessons learned from Desert Storm's asymmetrical conflict. Several fighter aircraft employment manuals specifically incorporate the tactics that emphasized survivability in the campaign. DOD and service procurement plans include new munitions with global positioning system guidance systems, justified in part by their abilities to minimize the medium-altitude shortcomings and adverse weather limitations of Desert Storm while maximizing pilot and aircraft survivability.

Fourth, DOD officials told us that although Desert Storm's successful aircraft mix will not be available for the next contingency, DOD and the services have made plans to maintain an inventory of aircraft that they believe will be more flexible and effective in the future. Flexibility will be anticipated partly from the modernization of existing multirole fighters to enable them to deliver guided munitions (the aircraft systems being retired are single-role platforms), and their effectiveness is expected to increase as new and more accurate guided munitions are put in the field. However, we believe that strike aircraft modernization and munition procurement plans that include increasing the number and variety of guided munitions and the number of platforms capable of delivering them require additional justification.[12]

Recommendations

Desert Storm established a paradigm for asymmetrical post-cold war conflicts. The coalition possessed quantitative and qualitative superiority in aircraft, munitions, intelligence, personnel, support, and doctrine. It dictated when the conflict should start, where operations should be conducted, when the conflict should end, and how terms of the peace should read. This paradigm—conflict where the relative technological advantages for the U.S. forces are high and the acceptable level of risk or attrition for the U.S. forces is low—underlies the service modernization plans for strike aircraft and munitions. Actions on the following recommendations will help ensure that high-cost munitions can be

[12]In Desert Storm, 229 U.S. aircraft were capable of delivering laser-guided munitions; in 1996, the expanded installation of low-altitude navigation and targeting infrared for night (LANTIRN) pods on F-15Es and block 40 F-16s will increase this capability within the Air Force to approximately 500 platforms. The services have bought or are investing over $58 billion (then-year dollars) to acquire 33 different types of guided munitions totaling over 300,000 units. (See U.S. General Accounting Office, Weapons Acquisition: Precision Guided Munitions in Inventory, Production, and Development, GAO/NSIAD-95-95 (Washington, D.C.: June 1995).) Air Force plans reveal that nearly 62 percent of all interdiction target types in a major regional conflict in Iraq could be tasked to either guided or unguided munitions today (1995) but that will fall to approximately 40 percent in 2002. Concurrently, the percentage of targets to be tasked to only guided munitions will increase from 19 percent in 1995 to nearly 43 percent in 2002.

employed more efficiently at lower risk to pilots and aircraft and that the future mix of guided and unguided munitions is appropriate and cost-effective given the threats, exigencies, and objectives of potential contingencies.

Specifically,

- In light of the shortcomings of the sensors in Desert Storm, we recommend that the Secretary of Defense analyze and identify DOD's need to enhance the capabilities of existing and planned sensors to effectively locate, discriminate, and acquire targets in varying weather conditions and at different altitudes. Furthermore, the Secretary should ensure that any new sensors or enhancements of existing ones are tested under fully realistic operational conditions that are at least as stressful as the conditions that impeded capabilities in Desert Storm.
- In light of the shortcomings in BDA exhibited during Desert Storm and BDA's importance to strike planning, the BDA problems that DOD officials acknowledge continue today despite DOD postwar initiatives need to be addressed. These problems include timeliness, accuracy, capacity, assessment of functional damage, and cultivating intelligence sources to identify and validate strategic targets. We recommend that the Secretary of Defense expand DOD's current efforts to include such activities so that BDA problems can be fully resolved.
- In light of the quantities and mix of guided and unguided munitions that proved successful in Desert Storm, the services' increasing reliance on guided munitions to conduct asymmetrical warfare may not be appropriate. The Secretary should reconsider DOD's proposed mix of guided and unguided munitions. A reevaluation is warranted based on Desert Storm experiences that demonstrated limitations in the effectiveness of guided munitions; survivability concerns for aircraft delivering these munitions; and circumstances where less complex, less constrained unguided munitions proved equally or more effective.

Agency Comments

The Department of Defense partially concurred with each of our three recommendations. In their response to a draft of our report, DOD did not dispute our conclusions; rather, they reported that several initiatives were underway that will rectify the shortcomings and limitations demonstrated in Desert Storm. Specifically, they cited (1) the acquisition of improved and new precision-guided munitions, (2) two studies in process—Deep Attack/Weapons Mix Study (DAWMS) and Precision Strike Architecture study, and (3) several proposed fiscal year 1997 Advanced Concept

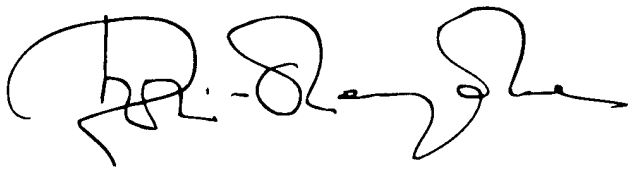
Technology Demonstrations (ACTDs) as programs capable of correcting Desert Storm shortcomings. In addition, DOD emphasized the importance of providing funds to retain the operational test and evaluation function to ensure the rigorous testing of our weapons and weapon systems. (See appendix V for the full text of DOD's comments.)

We agree that the actions cited by DOD address the shortcomings in sensors, guided munitions, and battle damage assessment we report here. However, the degree to which these initiatives are effective can be determined only after rigorous operational test and evaluation of both new and existing munitions and after the recommendations resulting from the Deep Attack/Weapons Mix and Precision Strike Architecture studies have been implemented and evaluated. Moreover, we concur with the continuing need for operational test and evaluation and underscore the role of this function in rectifying the shortcomings cited in this report.

DOD also provided us with a list of recommended technical corrections. Where appropriate, we have addressed these comments in our report.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after its date of issue. We will then send copies to other congressional committees and the Secretary of Defense. We will also make copies available to others upon request.

If you have any questions or would like additional information, please do not hesitate to call me at (202) 512-3092. Major contributors to this report are listed in appendix VI.



Kwai-Cheung Chan
Director of Program Evaluation
in Physical Systems Areas

Contents

Abbreviations

ACTD	Advanced Concept Technology Demonstration
BDA	Battle damage assessment
BE	Basic encyclopedia
BUR	Bottom-up review
C^3	Command, control, and communications
DAWMS	Deep Attack/Weapons Mix Study
DIA	Defense Intelligence Agency
DOD	Department of Defense
ELE	Electrical facilities
GOB	Ground order of battle
GVC	Government centers
GWAPS	Gulf War Air Power Survey
LANTIRN	Low-altitude navigation and targeting infrared for night
LGB	Laser-guided bomb
LOC	Lines of communication
MIB	Military industrial base
NAV	Naval facilities
NBC	Nuclear, biological, and chemical
OCA	Offensive counterair
OIL	Oil refining, storage, and distribution
SAM	Surface-to-air missile
SCU	Scud missile facilities
TLAM	Tomahawk land-attack missile
TOE	Type of effort
WOE	Weight of effort

Contents of Classified Version of Report

Twelve Strategic Target Categories in the Desert Storm Air Campaign

Abbreviation	Target category
C^3	Command, control, and communication facilities
ELE	Electrical facilities
GOB	Ground order of battle (Iraqi ground forces in the Kuwait theater of operations, including the Republican Guard)
GVC	Government centers
LOC	Lines of communication
MIB	Military industrial base facilities
NAV	Naval facilities
NBC	Nuclear, biological, and chemical facilities
OCA	Offensive counterair installations
OIL	Oil refining, storage, and distribution facilities
SAM	Surface-to-air missile installations
SCU	Scud missile facilities

Organizations We Contacted

Organization	Location
Air Combat Command	Langley Air Force Base, Va.
Center for Air Force History	Washington, D.C.
Center for Naval Analyses	Alexandria, Va.
Central Intelligence Agency	Langley, Va.
Defense Intelligence Agency	Washington, D.C.
Department of Air Force, Headquarters	Washington, D.C.
Embassy of the United Kingdom	Washington, D.C.
Foreign Science and Technology Center	Charlottesville, Va.
Grumman Corporation	Bethpage, N.Y.
Gulf War Air Power Survey (research site)	Arlington, Va.
Institute for Defense Analyses	Alexandria, Va.
Lockheed Advanced Development Corporation	Burbank, Calif.
McDonnell Douglas Corporation	St. Louis, Mo.
Naval A-6E Unit	Oceana Naval Air Station, Va.
Naval F/A-18 Unit	Cecil Naval Air Station, Fla.
Navy Operational Intelligence Center, Strike Projection Evaluation and Anti-Air Research (SPEAR) Department	Suitland, Md.
Office of the Chief of Naval Operations	Washington, D.C.
Office of the Secretary of Defense	Washington, D.C.
Rand Corporation	Santa Monica, Calif.
Securities and Exchange Commission	Washington, D.C.
Survivability/Vulnerability Information Analysis Center	Wright-Patterson Air Force Base, Ohio
Texas Instruments	Dallas, Tex.
U.N. Information Center	Washington, D.C.
U.S. Atlantic Fleet, Headquarters	Norfolk, Va.
U.S. Central Air Forces, Headquarters	Shaw Air Force Base, N.C.
U.S. Central Command, Headquarters	MacDill Air Force Base, Fla.
U.S. Space Command	Cheyenne Mountain Air Force Base, Colo.
4th Tactical Fighter Wing	Seymour Johnson Air Force Base, N.C.
48th Tactical Fighter Wing	RAF Lakenheath, U.K.
49th Fighter Wing	Holloman Air Force Base, N.Mex.
57th Test Group	Nellis Air Force Base, Nev.
363rd Fighter Wing	Shaw Air Force Base, S.C.
926th Fighter Wing (reserve)	New Orleans Naval Air Station, La.

List of Consultants

Our draft report was reviewed by the following consultants. The final report incorporates appropriate changes based on their questions, comments, and suggestions.

Dr. John Ahearne, Sigma Xi, The Scientific Research Society

Dr. Eliot Cohen, Paul H. Nitze School of Advanced International Studies of the Johns Hopkins University

Vice Adm. Robert Dunn, U.S. Navy (ret.), independent consultant

Dr. Grant Hammond, Air War College

Brig. Gen. Edwin Simmons, U.S. Marine Corps (ret.), U.S. Marine Corps History and Museums

Col. Clinton Williams, U.S. Army (ret.), independent consultant

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

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STRATEGY
AND
REQUIREMENTS

MAR 2 8 1996

In Reply Refer to:
I-96/35381

Mr. Kwai-Cheung Chan
Director, Program Evaluation
in Physical Systems Area
Program Evaluation and
Methodology Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Chan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report "OPERATION DESERT STORM: The Air Campaign," February 12, 1996 (GAO Code 973364), OSD Case 1094-X. The Department partially concurs with the report.

The DoD continues to believe the coalition victory was impressive militarily and "our air strikes were the most effective, yet humane, in the history of warfare." (President George Bush, May 29, 1991). Similarly the DOD acknowledges (Title V Report) the shortcomings of PGMs, PGM capable aircraft, TLAM and TLAM strike-planning, and our combat strike assessment capabilities. The DoD is well along in its programs to correct these shortcomings:

See comment 1.

- The acquisition of improved and new PGMs (e.g., AGM-130, CALCM, TLAM, SLAM ER, JDAM, and JSOW) is on track.

See comment 2.

- Under ASD(S&R)/D,S&ST/D,PA&E/J-8 co-sponsorship, the DoD has undertaken the Deep Attack/Weapons Mix Study (DAWMS) which will give insight and answers into the proper mix of munitions, and insight into the value to force structure of adding different platforms (fighters, bombers, naval aviation).

See comment 3.

- The Precision Strike Architecture study and several of the proposed FY1997 ACTDs (Counter CC&D, Integrated Sensor Tasking, Operator/ Intelligence, Precision Identification/ Engagement, Rapid Battlefield Visualization, Survivable Armed Reconnaissance on the Digital Battlefield, and Unattended Ground Sensor) will give insight into improvements to the DoD's ability to locate targets, discriminate among them in varying weather and environmental conditions, assess damage done by prior attacks and the need for re-attack, and rapidly provide targeting-quality data to weapons/delivery platforms.

See comment 4.

The DoD shares the GAO and Congressional interest in the effectiveness of the nation's aircraft and munitions. The aforementioned programs and the FY1996 authorizations and appropriations, providing funds to retain the Operational Test & Evaluation function at the OSD-level, will ensure rigorous testing of our weapons and weapon systems.

Technical corrections to the report were provided separately. The Department appreciates the opportunity to comment on the draft report.

Sincerely,

Frederick L. Frostic
Deputy Assistant Secretary of Defense
Requirements and Plans

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**GAO DRAFT REPORT - DATED FEBRUARY 12, 1996
(GAO CODE 973364) OSD CASE 1094-X**

"OPERATION DESERT STORM: THE AIR CAMPAIGN"

DEPARTMENT OF DEFENSE COMMENTS

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RECOMMENDATION

RECOMMENDATION: In light of the shortcomings of the sensors in Desert Storm, we recommend that the Secretary of Defense analyze and identify DOD's need to enhance the capabilities of existing and planned sensors to effectively locate, discriminate, and acquire targets in varying weather conditions and at different altitudes. Furthermore, the Secretary should ensure that any new sensors or enhancements of existing ones are tested under fully realistic operational conditions that are at least as stressful as the conditions that impeded capabilities in Desert Storm.

DOD RESPONSE: PARTIALLY CONCUR.

See comment 5.

The DoD is actively researching new or enhanced target search, acquisition, and discrimination sensors. The physical limitations of all sensors including Lasers and FLIRS were known prior to Desert Storm. The DoD continues to seek new and improved technology to overcome these limitations. Testing will continue over the entire range of operational conditions, to ensure that we understand the limitations of all current and future systems.

See comment 3.

The Precision Strike Architecture study and several of the proposed FY97 ACTDs (Counter CC&D, Integrated Sensor Tasking, Operator/ Intelligence, Precision Identification/Engagement, Rapid Battlefield Visualization, Survivable Armed Reconnaissance on the Digital Battlefield, and Unattended Ground Sensor) will give insight into solutions to the DOD's ability to locate targets, discriminate among them in varying weather and environmental conditions, assess damage done by prior attacks and the need for re-attack, and rapidly provide targeting-quality data to weapons/delivery platforms.

RECOMMENDATION: In light of the shortcomings in BDA exhibited during Desert Storm and BDA's importance to strike planning, the BDA problems that DoD officials acknowledge continue today despite DoD postwar initiatives, problems such as timeliness, accuracy, capacity, assessment of functional damage, and cultivating intelligence sources to identify and validate strategic targets, need to be dealt with. We recommend that the Secretary of Defense expand DoD's current efforts to include such activities so that BDA problems can be fully resolved.

DOD RESPONSE: PARTIALLY CONCUR.

See comment 2.

See comment 6.

See comment 7.

Under ASD(S&R)/D,S&ST/D/PA&E/J-8 co-sponsorship, the DoD has undertaken the Deep Attack/Weapons Mix Study (DAWMS). This study involves an end-to-end analysis that provides insight and answers on the proper mix of munitions; the value to force structure of adding different platforms (fighters, bombers, naval aviation) and munitions; and the C4ISR architecture necessary to underpin our future attack operations. The scope of this study is sufficient to fully address all facets of combat strike damage assessment.

The BDA problems will never be fully resolved. As long as hostilities exist, perfect BDA will not exist. Current investments in platform and munition improvements and new acquisitions reflect lessons learned from DESERT STORM and shortcomings addressed in the Title V report and this and previous GAO reports.

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See comment 2.

See comment 8.

RECOMMENDATION: In light of the quantities and mix of guided and unguided munitions that proved successful in Desert Storm, the Services' increasing reliance on guided munitions to conduct asymmetrical warfare may not be appropriate. The Secretary should reconsider DoD' s proposed mix of guided and unguided munitions. A reevaluation is warranted based on Desert Storm experiences that demonstrated limitations to the effectiveness of guided munitions, survivability concerns of aircraft delivering these munitions, and circumstances where less complex less constrained unguided munitions proved equally or more effective.

DOD RESPONSE: PARTIALLY CONCUR:

The Department is currently conducting a comprehensive review of weapons and platforms required to perform assigned missions. The Deep Attack Weapons Mix Study (DAWMS) under ASD(S&R)/D,S&ST/D/PA&E/J-8 co-sponsorship has undertaken a study of the DoD's aircraft and weapons mix. This study's end-to-end analysis will provide insights and answers on the proper mix of munitions; the value to force structure of adding different platforms (fighters, bombers, naval aviation) and munitions; and the C4ISR architecture necessary to underpin our future attack concepts of operations.

Concurrently, the DoD is aware of the capabilities of our highly-trained pilots and smart aircraft to achieve effectiveness similar to smart and expensive weapons. Innovations in tactics and weapons fusing are allowing our aircraft today to use unguided munitions where guided munitions were previously required. Unguided munitions will always be an important part of our munitions inventory mix. The DoD will continue to evaluate and balance new, more accurate, and more survivable weapons for those targets where they are required.

The following are GAO's comments on the March 28, 1996, letter from the Department of Defense.

GAO Comments

1. The acquisition of new precision-guided munitions may well provide new capabilities that overcome the limitations observed in Operation Desert Storm. However, the degree to which these new munitions may overcome the limitations of existing munitions can only be determined after rigorous operational test and evaluation of both new and existing munitions.

2. The Deep Attack/Weapons Mix Study will not fully address the implications of our findings concerning the strengths and limitations of guided and unguided munitions. DAWMS is an analysis of the full range of precision-guided munitions in production and in research, development, test, and evaluation that will determine the number and types of precision-guided munitions that are needed to provide a complementary capability against each target class. By analyzing only precision-guided munitions, the study does not address the benefits realized from 92 percent of the munitions delivered in Operation Desert Storm. The premise of the DAWMS does not acknowledge the ambiguous results from Desert Storm regarding munitions effectiveness, the cost and operational trade-offs between guided and unguided munitions, and the demonstrated preference for unguided over guided munitions against several strategic target categories.

3. The Precision Strike Architecture study was designed to define a "system of systems" for precision strike by

- defining the mission,
- identifying the component systems,
- developing a concept of operations,
- facilitating opportunities for system evolution,
- creating criteria for establishing choices among alternatives, and
- determining costs.

The resulting architecture for precision strike is a plan that addresses the limitations in strike capabilities demonstrated in our report. However, the degree to which the sensor and other precision strike shortcomings are alleviated cannot be known until a new precision strike architecture is implemented and tested.

4. We strongly acknowledge the need to maintain a rigorous operational test and evaluation capability to ensure that commanders, planners, and operators are aware of both the strengths and weaknesses of existing and new weapon systems under a variety of combat conditions.

5. While the physical limitations of all sensors, including laser and forward-looking infrared, may have been known before Desert Storm, they were not necessarily fully acknowledged by DOD or its contractors either before the conflict or in reports to Congress after the coalition's victory.

6. Our recommendation addresses the demonstrated intelligence shortcomings in performing BDA and in identifying strategic targets in Operation Desert Storm. It is not apparent that the scope of the Deep Attack/Weapons Mix Study is sufficient to address DOD's need to cultivate intelligence sources that can identify and validate strategic targets in future scenarios.

7. Part of the significance of the munitions use data from Desert Storm is that it reveals patterns of use when perfect BDA does not exist. For example, we found in Desert Storm that multiple strikes and weapon systems were used against the same targets; more munitions were delivered than peacetime test capabilities would indicate as necessary; determinations of whether target objectives were met were frequently unknown; and when objectives were met, the specific system responsible could not be determined. These observations should temper one of the primary expectations of the DAWMS: that a growing inventory and increasing capabilities of weapons will reduce the sorties required for deep attack missions.

8. We recognize that where DOD concurs with the premises of our recommendations, it does so based on information other than the analyses we conducted of the Desert Storm air campaign. Owing to these differences, the solutions pursued by DOD may not fully address the needs perceived by GAO. Therefore, although the scope of the specific studies and ACTDs indisputably address our recommendations, the degree to which they result in solutions to Desert Storm shortcomings and limitations cannot be known until the resulting changes and innovations are operational.

Major Contributors to This Report

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