Chapter Seven: Offensive Air Power, Strategic Bombing and Preparation for the Ground Offensive

The offensive air campaign during the Gulf War was so successful that it raises important questions about the role that offensive air power can play in determining the outcome of future wars. The Gulf War was the first war where that air power was able to play a critical role in defeating a well-positioned ground force before supporting ground attacks began. It was also the first war in which aircraft had sufficiently advanced avionics and weapons to destroy large numbers of dug-in armor and artillery weapons

Air power played a critical role before the ground war began. From January 24 until February 24, 1991, Coalition air forces were able to focus on destroying theater and military targets like the Iraqi ground forces in the Kuwaiti Theater of Operations (KTO), Iraq's elite Republican Guards units, its air bases and sheltered aircraft, and its hardened command and control facilities. At the same time they struck repeatedly at strategic targets like military supply depots and biological, chemical, and nuclear warfare facilities. Iraq's only ability to retaliate consisted of launching modified Scud missiles against targets in Saudi Arabia and Israel.

By the time the ground war began, Iraqi ground forces had been hit by more than 40,000 attack sorties. While studies since the war indicate that these strikes were substantially less lethal than USCENTCOM estimated at the time of the war, the corrected US estimates still indicate that Coalition air power caused the desertion of as many as 84,000 Iraqi personnel, and destroyed 1,385 Iraqi tanks, 930 other armored vehicles, and 1,155 artillery pieces. They also indicate that air strikes severely damaged Iraq's nuclear reactor facilities, three chemical and biological weapons production facilities, and 11 storage facilities, 60% of Iraq's major command centers, 70% of its military communications, 125 ammunition storage revetments, 48 Iraqi naval vessels, and 75% of Iraq's electric power generating capability. It had cut Iraq's flow of supplies to the theater by up to 90%.

As has been discussed in Chapters Four and Five, this achievement is particularly striking because the Gulf War exposed serious -- but correctable -- problems in the way that the US had trained for the AirLand battle and in many aspects of its C^4I/BM capabilities. It is also striking because of the transitional nature of much of the technology used in the air offensive, and because of problems in the strategic bombing effort and attacks on Iraqi ground forces that also are not likely to be repeated in future wars.

It is important to preface any examination of the lessons of the air war, however, with several caveats. First, future wars may not involve a scenario in which air superiority can be achieved in a matter of days, and where air forces can conduct a battle of attrition throughout the battlefield and the enemy's homeland virtually without challenge. Second, the air war was fought over an open desert, although under difficult weather conditions. This makes the analysis of the individual trends and lessons in the offensive air campaign particularly important. While history does repeat itself with alarming frequency, such repetition is scarcely a basis for planning military forces and action.

The Overall Structure of Coalition Offensive Air Power

Experts on air power and different air forces within the Coalition have used a number of different terms to describe the ways in which air attacks were structured and offensive missions were categorized and executed. In broad terms, however, the Coalition's offensive air strikes fell into five major groups: (1) the air attacks designed to win air supremacy described in the previous chapter, (2) attacks on Iraq's Scud missiles and weapons of mass destruction which are described in Chapter Eleven, (3) air attacks on strategic civilian targets and military targets in the rear, (4) attacks on the forces in the KTO which were designed to prepare for the land battle, and (4) air strikes in support of the land battle.[1]

The overall structure of the Coalition's offensive air effort is summarized in Table 7.1, although such figures should be approached with caution. While percentages of sorties give a rough measure of the weight of effort, they say little about the quality of that effort. Hardened targets and targets deep inside Iraq were much harder to attack. Similarly, there is no real separation between civilian and military in modern war. Many C^4 targets were military, as were many lines of communication (LOC) targets.

The Coalition had considerable success in attacking all of these target categories during the Gulf War, and more success than air power achieved in previous wars. In each case, however, studies since the Gulf War have shown that air power did not reach the level of performance claimed during and immediately after the war, and that the Coalition experienced operational problems and complications. Some of the reasons for these problems have been covered in the previous discussion of intelligence, targeting, and battle damage assessment. This analysis focuses on lessons in terms of the effectiveness impact of the strategic bombing effort, the effort to attack Iraqi ground forces before the war, and air attacks on Iraqi ground forces during the conflict.

Table 7.1

UN Coalition Air Strikes by Mission During Desert Storm

Type of Mission or Target	Number of Strikes Flown	Percent of Total
Strategic - Largely Civilian		
Leadership	260	0.6
Electric Power	280	0.6
Oil/Refinery/Fuel	540	1.3
Telecoms/C^4	580	1.4
LOCs	1,170	2.8
Total	2,830	6.7
Strategic - Largely Military		
Military Industry	970	2.3
Nuc/Chem/Bio	990	2.3
Scuds	1,460	3.5
Naval Targets	370	0.9
Total	3,790	9.0
Counter-Air		
Airfields	2,990	7.0
Air Defense (KARI)	630	1.5
Surface-to-Air Missiles	1,370	3.2
Total	4,990	11.8
Against Iraqi Ground Forces	23,430	55.5
Total Categorized by Mission	35,040	82.3
Uncategorized (Largely against ground forces)	7,200	17.1
Total	42,240	100%

Note: Some statistics ignore the unallocated sorties, and produce different figures. There are unexplained errors in the source material, which talk about a total of 35,018 allocate sorties, and 5,660 which could not be categorized.
Source: Adapted by the author from data in Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, p. 148.

Airpower in Transition: The Role of Key Weapons and Technologies

Technology played a critical role in shaping the effectiveness of offensive air power during the Gulf War, although it is difficult to put the impact of given technologies in perspective. The Gulf War involved the most advanced mix of technologies ever used in air warfare, but much of this technology was "transitional" in the sense that the US planned to acquire much more effective aircraft, avionics, and weapons in the future. While television coverage of the war often gave the impression that all of the air systems the Coalition employed were actually part of a high technology force, most Coalition offensive missions were flown by aircraft with avionics that had important limitations, and most mission dropped unguided or "dumb" bombs. Even many of the aircraft that delivered precision munitions did not have the all of the highly sophisticated attack avionics or survivability necessary to achieve consistently accurate delivery of their weapons.

As a result, any lessons drawn from the use of offensive air power during the Gulf War must be viewed from the perspective that the Gulf War occurred at time when offensive air technology was evolving towards much more sophisticated and capable forces. This was particularly true in the case of the US. Many of the C^4I/BM systems, aircraft, and munitions that US air units used during the war were in the process of change when it occurred, and the war has since led the US to accelerate many of these changes.

US air forces are already very different from the forces employed during the Gulf War. Other air forces -- including those of Britain and France are also making important changes in their offensive technology. In fact, the impact of the Gulf War in accelerating the transition to new offensive air technologies are equally important lessons of the war as the impact of any of the technologies actually employed during the conflict.

No Aircraft is Smarter than its C^4/BM system

This transition is particularly important in terms of battle management capability. As Chapters Four and Five have shown, the Coalition had to use a C^4I/BM system with many limitations. The US provided advanced capability to characterize and target radar and other emitters, but the C^4I/BM systems available were not capable of transmitting much of this information with anything like the efficiency of systems under development. Imagery and SIGINT data rarely reached the combat unit in a useful form. Even the most advanced strike aircraft operated under the constraints imposed by the system's limits in "netting" and "connectivity".

While the C^4I/BM system used in the Gulf War was the most modern and effective system ever used in air warfare, critical gaps existed in theater communications and reconnaissance capability. Systems like the JSTARS were only employed on an experimental basis with uncertain "netting" into the overall battle management system, and went into action with only part of their planned capabilities operational. Aircraft could not benefit from a realistic battle damage assessment system, and much of the intelligence used for targeting was wrong.

These problems have already led the US to begin extensive changes in many aspects of the C^4I/BM system used in the Gulf War. Virtually every aspect of joint doctrine has been revised, and a major effort is underway to make all aspects of the USAF, US Navy, and US Marine Corps air C^4I/BM system fully interoperable. The basic structure of the JFACC and ATO are being preserved, but the ATO process is being automated and reorganized to provide far more speed, integration, and adaptability, to provide more capability in joint and coalition warfare, and to provide more sophisticated, interoperable, and quick-reacting communications, computer, and intelligence support.

Systems like the JSTARS are being improved in computing capability, software, satellite communications, and real-time data link interface with ground stations and aircraft like the E-3A and ABCCC.[2] New all-weather and night sensors, and digitized electronic dissemination capabilities, are being added to reconnaissance aircraft like the U2-R and RC-135 Rivet Joint. A new Contingency Airborne Reconnaissance System (CARS) was established in October, 1994, to improve the timeliness and quality of tactical reconnaissance products, and to give field commanders and aircrews the same target information and battle damage assessment data for mission planning and execution. This will involve a major shift in the distribution of imagery data and intelligence information to what is called a "5D architecture" or demand-driven direct digital dissemination.

While improvements in battle damage assessment capability are proceeding more slowly, the US has established a unified Defense Airborne Reconnaissance Office that will develop a unified airborne reconnaissance architecture, and DIA and the Joint Staff are attempting to develop a common doctrine for BDA and a contingency capability to project effective BDA capability for major regional contingencies. The US has also established a battle damage assessment cell in the National Military Joint Intelligence Center (NMIC) to provide a single, fused, all-source, national level assessment to the supported command. Regular exercises of this system will be made part of US joint warfare exercises, and subordinate command specific capabilities are being developed by the US Central Command, Atlantic Command, Pacific Command, and Southern Command.[3]

The Strike/Attack Aircraft in the Gulf War: Mission Packages and "High-Low" Capabilities

Coalition strike/attack aircraft used a mix of new and old technologies. The Coalition introduced a wide range of new technologies to air warfare during the Gulf War. The UK made the first combat use of its Tornado strike aircraft and JP233 airfield suppression munition. The US used the F-117 stealth fighter and Tomahawk cruise missiles to strike against heavily defended targets. US bombers launched Conventional Air-Launched Cruise Missiles (CALCMs). At shorter ranges, the US Army fired the Army Tactical Missile System (ATACMS) missile.[4] The US also used air power to "own the night". Key aircraft like the F-117, F-111E/F, A-6, and F-15E flew almost entirely at night, and the US adjusted the launch schedule for its TLAMs to fire them during the day to keep up constant pressure on Baghdad. The US used the E-3A AWACS and airborne refueling to achieve extremely high sorties rates and concentrate up to 600 aircraft in the air at the same time.[5]

At the same time, Coalition air power employed many less sophisticated systems. As Tables 7.2 and 7.3 show, the Coalition employed a "high-low" mix of aircraft. These included attack aircraft like the Jaguar, F-5, AV-8B, F-18, F-18A/B, A-10, and AH-1W. In many, however, simpler platforms had special capabilities that gave them exceptional effectiveness in given missions. The Coalition used smart aircraft to drop "dumb" bombs, and relatively old aircraft with modern avionics to deliver smart strikes. Aircraft like the Tornado and F-15E used radar bombing to drop "dumb" bombs. Aircraft like the F-111 had their origins in the 1960s, but had been upgraded to the point where they were among the most advanced strike aircraft available.

Table 7.2

The Role of Key Strike/Attack Aircraft During Desert Storm

Type of Aircraft	Number of Aircraft in Theater	Total Sorties Flown	Percent of Total Sorties Flown
USAF			
A-10	132	8,034	14.8%
B-52	66	1,741	3.2
F-15E	48	2,172	4.0
F-16	244	13,087	24.2
F-111E	18	458	0.8
F-111F	64	2,423	4.5
F-117	42	1,299	2.4
Total	614	29,214	53.9
USN			
A-6	95	4,824	8.9
A-7	24	737	1.4
F/A-18	89	4,449	8.2
Total	208	10,010	18.5
USMC			
A-6	20	795	1.5
AV-8B	86	3,359	6.2
F/A-18A/C/D	84	4,939	9.1
AH-1W	(50)	-	-
AH-64	(274)	- -	
Total Fixed Wing	190	9,093	16.8
US Special Operations Command			
AC-130	4	104	0.2
Total US.	1,016	48,421	89.3
Saudi Arabia			
Tornado	24	667	1.2
F-5	87	1,129	2.1
	111	1,796	3.3
Britain (RAF)			
Tornado	39	1,644	3.0
Jaguar	12	600	1.1
Buccaneer	12	226	0.4
	63	2,470	4.6
Kuwait			
A-4	20	651	1.2
Mirage F-1	15	129	0.2
	35	780	1.4
France - Jaguar	24	571	1.1
Bahrain - F-5	12	122	0.2
Italy - Tornado	10	224	0.4
Total Allied	155	5,963	11.0
Total Coalition	1,595	54,176	100%

Note: Only includes aircraft that flew at least 100 sorties, and aircraft in theater, or Incirlik, Moron, Fairford, and Diego Garcia. Some sorties in other missions and sorties where aircraft aborted are counted. The AH-64 totals include US Army AH-64s. The aircraft totals shown are the peak deployed strength. The reader should be aware that a careful review of the data bases currently available indicates that calculating accurate percentages of total attack sorties flown is not possible without additional data. The percentages shown are only for fixed wing aircraft flying over 100 sorties.
Source: Adapted by the author from Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 184-185, 199.

Precision and Non-Precision Offensive Aircraft

These "high-low" capabilities also affected the precision with which Coalition aircraft could strike. The USAF concluded after the war that only about 200 of the aircraft in the theater could attack with precision guided munitions, and only 7% of all the munitions used were precision weapons.[6]

This still, however, gave the Coalition a mix of aircraft with considerable precision strike capability. The F-117 flew 2.4% of the Coalition's attack sorties, the F-111 flew 5.3%, the F-15E flew 4.0%, the Tornado flew 4.6%, and the A-6 flew 10.4%. As a result, Coalition aircraft with advanced precision strike capability flew 27% of all offensive sorties -- although these aircraft did not always deliver precision guided weapons. A number of other aircraft had considerable precision strike and all-weather/night capability, and any effort to make clear distinctions between aircraft quality is complicated by the fact that the level of accuracy that could be achieved with or without smart weapons varied according to the equipment on individual aircraft.

For example, Table 7.3 show that a wide mix of different types of new and old aircraft could deliver laser-guided bombs. The key aircraft that could use such bombs were the F-117, F-111F, A-6, F-15E, French Jaguars, Saudi F-5s, and some British Tornadoes. The F-15E only acquired laser designation capability after the aircraft had been deployed to the theater, and the Buccaneers, French Jaguars, and Saudi F-5s could only use laser guided bombs in daylight. British Buccaneer aircraft were used to laser designate targets for accompanying Tornado aircraft. At the same time, some newer types of aircraft could not deliver laser guided weapons. The aircraft which could not designate laser bombs included the F-16, F/A-18, B-52, A-10, AV-8B, A-7, F-111E (flown from Turkey), A-4, British Jaguar, and most British Tornadoes.[7]

Coalition aircraft differed sharply in their ability to use "smart" avionics to accurately deliver unguided or "dumb" ordnance. Improvements in avionics since the time of the Vietnam War had provided some Coalition aircraft with greatly improved all-weather and night attack capability -- as did similar steady improvements in the capability of ground mapping, terrain avoidance, and night viewing devices since the 1960s. Although the A-6A first demonstrated the ability to use such aids for low altitude penetrations in late 1965, and the F-111A made its first penetrations in 1972, the avionics and sensors on UN Coalition aircraft were far more sophisticated, reliable, and accurate by the time of the Gulf War than they had been in the past.

The Coalition still, however, encountered problems in using "dumb" ordnance which varied sharply by aircraft -- particularly when it used radar bombing. The Tornado, F-111, F-15E, B-52, A-6 -- and to some extent the F-16 and F/A-18 -- had all-weather radar delivery capability. Depending on the aircraft, they could use radar to look through night or cloud cover and to provide an image of the target area. The accuracy of this mode of delivery varied sharply, however, depending on the specific avionics on each aircraft, and radar bombing did not prove to be as accurate as infra-red assisted bombing.

Table 7.3

Bomb Capabilities of Key Coalition Aircraft By Type

Aircraft	Visual Bombing Day	Visual Bombing Infrared	Radar Bombing	LGB Self Designation	Air-to-Air Swing Role	Comments
TLAM/CALCM						Day/night precision pre-programmed strike capability
B-52			X			High bomb load, for area targets
F-117		FLIR/ DLIR	X			Night/AWX capability; 2 X 2,000 lb. bombs. Very accurate
F-111F	X	Pave Tack	X	X		Night/AWX capability; Large bomb load
F-111F	X		X			Night/AWX capability; analog avionics
Tornado	X		X	TLIAM		Only some had LGB pods
F-15E	X	LANTIRN	X	X	X	FLIR designator pods
A-6E	X	TRAM	X	X		SEAD role with HARM; Only limited LGBs deployed on ships
F/A-18	X		X		X	Dual role fighter
F-16C	X	LANTIRN	X		X	LANTIRN for two squadrons
A-10	X	X				Limited night capability with Maverick

Note: The F-111F and F-111E can use IR-guided air-to-air missiles in the self-defense mode.
Source: Adapted from Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, p. 270.

The Value of Mixed Packages of Aircraft

Yet, the Coalition's offensive air capabilities cannot be analyzed simply in terms of the performance characteristics of individual aircraft. The Coalition found tactical and technical ways to compensate for some of these problems by mixing different types of aircraft. The Coalition created "packages" of different aircraft in mission-oriented packages where one type of aircraft could support another, or where the limits of a given type of aircraft's capability were offset by specialized missions and mission support. It sent out flights of air defense, air offensive, electronic warfare, and special purpose aircraft that varied according to the nature of the target and the difficulty of attacking it, often drawing on aircraft from different countries and services. In fact, one of the lessons that the US learned from its offensive operations during the Gulf War was the need to organize and train its forces in such mission packages as part of their normal peacetime activity.

The Coalition also steadily improved its ability to match the capabilities of a given aircraft to given targets or sectors of the battlefield, and to use scout aircraft to compensate for limitations in avionics and precision strike capability. As the following discussion shows, such tactics could not compensate for important limitations in aircraft performance capability. They also often meant that much larger numbers of sorties had to be flown to support less sophisticated or stealthy aircraft in attacking given targets because of the need for more escort and supporting aircraft. Nevertheless, the Coalition exploited the fact that aircraft do not fight wars, air forces do. It demonstrated the fact that its ability to exploit the full "force on force" capability of a given air force that determines its success in offensive operations. In fact, one of the lessons of the Gulf War is that the effectiveness of weapons is not simply a matter of the technical sophistication of individual weapons, but the ability of a given side to mix different weapons and technologies to best achieve a meaningful strategic or tactical purpose.

Simultaneous, Constant, and Cumulative Pressure

The range of "high-low" capabilities shown in Tables 7.2 and 7.3 also gave the Coalition the ability to use a wide range of different aircraft to maintain simultaneous offensive pressure over the KTO and much of Iraq. There is no way to quantify the impact of this pressure on Iraqi forces and war fighting capability, any more than there is a way to quantify the shock effects of air strikes as distinguished from their damage effects. It is clear, however, that Iraq never was free of pressure from offensive air power from the beginning of Desert Storm to its end. Night did not halt Coalition operations. Weather gave only brief respites. Iraqi forces in the rear came under the same intense pressure as Iraqi forces in the forward area, and dispersed Iraqi forces came under attack as well as rear area facilities and the Iraqi economic infrastructure that supported military operations.

Quantifiable or not, it is obvious that day after day of 24 hour-a-day air attacks had to have a powerful cumulative impact on Iraqi forces. This point must also be kept in mind in evaluating the impact of air power during the air campaign, in preparing the battlefield, and during the Coalition land offensive. The impact of air power cannot simply be measured in terms of the sortie totals shown in Table 7.1 or the damage estimates discussed in Tables 7.9 and 7.11 It must be measured in terms of the understanding Coalition air power succeeded in keeping up simultaneous, constant, and cumulative pressure on Iraqi forces.

The Role of Bombers: The B-52

The B-52 is a good example of the strengths and weaknesses given aircraft had in using smart avionics to deliver "dumb" weapons. The new US B-2 stealth bomber was not operational at the time of the Gulf War, and the B-1 had severe operational problems. These problems included training, serious mechanical reliability problems, the inability to use cruise missiles because of arms control agreements, and electronic warfare problems that meant the fact its minimum radar cross section was at least that of a small fighter. The B-1 was also limited to the delivery of dumb bombs. It could only deliver of 84 Mark 84 500 pound air inflatable retard bombs under conditions that spread the bombs over a narrow oval with a maximum area in excess of 1,700 feet.[8]

In contrast, the older B-52G was capable of delivering high volumes of munitions delivery in day, night, and poor weather. It could lay down a dense cell of cluster bombs over a square area. It had an upgraded electronic countermeasures suite, low light level TV and FLIR, and an advanced offensive avionics system and integrated conventional stores management system. The B-52 could use radar, navigational aids like the Global Positioning System, and improved bomb delivery avionics to strike at area targets with something approaching an order of magnitude with more accuracy than in Vietnam. They could also carry up to 70,000 pounds of mixed ordnance: Each B-52 could carry 51 500 pound bombs, 51 750 pound bombs, or 18 2,000 pound bombs.[9] These improvements made the B-52 much more effective in striking at area targets when they were concentrated and sent on repeated missions than during Vietnam.

The USAF used 68 B-52Gs in the Gulf War, and they flew 1,741 missions and dropped 27,000 tons of munitions -- about 29% of the total Gulf War tonnage.[10] They flew 79 sorties against airfields, aircraft on the ground, and airfield support structures. They flew 954 sorties against chemical and nuclear sites, railroad yards, logistics sites, barracks, airfields, weapons sites, scud missile sites, power plants, military industrial sites, Republican Guards forces, and Iraq's air defense system. They also flew 527 sorties against Iraqi C^4, armor, infantry and mechanized infantry, minefields, logistics, tactical vehicles, ammunition supply points, and in psychological warfare missions. These missions were often directed against Iraq's forward defenses, and about 70% of all B-52 missions were directed against some aspect of Iraqi ground forces.[11]

The B-52G's ability to keep up a constant volume of attacks in poor weather and at night helped to ensure that Iraqi forces were kept under pressure 24 hours a day. B-52s dropped more than 72,000 weapons, and only one aircraft was damaged. At the start of the air campaign, seven B-52s flew 14,000 miles, on 35 hour missions, to deliver 35 AGM-86C conventional air-launched cruise missiles (CALCMs). These missiles were specially modified versions of the AGM-86C, which replaced the nuclear warhead with conventional high explosives, although they were the only CALCMs to be used in the war. The B-52s did, however, use Vietnam-era "dumb" bombs and cluster bombs in all missions after the first day of the war.

The B-52s also shifted their methods of attack in ways that reduced their effectiveness after the first days of combat. B-52 crews flew low altitude night penetration missions for the first three days of the war -- using GPS and night vision goggles. From the fourth day on, however, they normally flew high altitude mission packages. They bombed from over 30,000 feet, sometimes supported by electronic warfare and HARM equipped aircraft.

Using higher altitude deliveries and HARM aircraft allowed the bomber to penetrate far more easily into Iraqi airspace.[12] However, the resulting shift to high altitude bombing later proved to have created serious problems in terms of accuracy. B-52 crews were trained almost exclusively for low altitude delivery and sometimes had problems in bombing effectively or in flying in formation. Most bombs proved to have missed their targets by greater than expected distances, and jammers suited for high altitude missions had to be improvised and deployed. The B-52s required massive munitions stocks and extensive refueling support.[13]

USAF studies after the Gulf War could not make meaningful assessments of the damage done by B-52 sorties. A senior analyst leading one USAF study described the quality of BDA as "so awful that there simply is no way of reconstructing what happened." It is clear, however, that the B-52s flew 37% of all their sorties against the Republican Guards using dual-fused Mark 82 bombs or CBU-87s. Interviews and post-war battle damage assessment reviews indicate, however, that they had surprisingly little killing effect on targets like the Republican Guards armor, artillery, and rear area positions which had shelters or small dispersed facilities.

It is less clear how effective B-52s were in attacking the Iraqi barriers, berms, and wire in the forward area, or in attacking the Iraqi forces fleeing north out of Kuwait. Interviews do not indicate, however, that the B-52Gs a high rate of destructiveness or lethality. The B-52 also had problems in quickly destroying area targets. It took 68 sorties and 3,000 bombs between February 10-27, 1991, to reduce the single large Iraqi weapons manufacturing center at Taji north of Baghdad to the point where it required near total reconstruction.

The USAF claimed after the war that, "B-52 support must be measured not just in terms of direct hits or physical damage, but in terms of the psychological effects it produced."[14] There is considerable truth to this claim, and the B-52s also affected morale by delivering large numbers of psychological warfare leaflets. It is unclear from some of the evidence, however, as to whether the USAF actually found the B-52 strikes had a major psychological impact on Iraqi POWs, or concluded that the B-52 strikes had a major psychological impact on Iraqi POWs on the basis of limited interview data.[15]

At the same time, future strategic bombing efforts may be considerably more lethal than the B-52G strikes during the Gulf War. The USAF developed a bomber "road map" after the Gulf War that called for equipping its bombers with greatly improved sensors, navigation and targeting capabilities, smart stand-off ordnance and more lethal area munitions. It has advocated restructuring its bomber force to give it area munitions with smart submunitions, and advanced air-to-surface conventional weapons with stand-off ranges against any Third World target. It is considering equipping the B-52H with weapons like the AGM-137 Triservice Standoff Attack Missile, and with a GPS capability to deliver the Joint Direct Attack Munition guided bomb.[16] The USAF is also seeking to give the B-52 and B-2 greatly improved near-real time target acquisition capability against a variety of land targets, stand-off weapons, smarter and more lethal area munitions, and improved penetrator, hard target, and smart point target munitions.[17] While such developments are encountering growing funding problems, they still seem likely to improve the effectiveness of US bombers.[18]

There is much to be said for improving the lethality and effectiveness of bombers in regional conflicts, but it also is not clear that the USAF has always responded properly to the lessons of the Gulf War. Some of the rationale presented to date depends heavily on major advances in C^4I/BM and targeting capabilities against land forces which do not seem to be programmed in US defense plans, and even more significant advances in a number of classified air-to-surface munitions. While this rationale is sometimes related to the lessons of the Gulf War in USAF literature, the supporting analysis sometimes seems to be little more than the product of the USAF's "bomber bureaucracy's" search for a new mission in the post-Cold War era than a realistic effort to learn from the conflict.[19]

Quasi-Precision: Radar and Infrared Assisted Bombing

Part of the problems that the B-52 encountered during the Gulf War were common to all aircraft that used radar bombing. It became clear after the war that high altitude radar bombing often proved too inaccurate to be lethal. Wind, navigation problems, and a variety of avionics problems increased delivery errors. These navigation problems in approaching the target with the precision required for radar bombing were serious enough so that even the F-15E and F-111F are being upgraded with GPS and/or improved inertial navigation systems. The inherent problems in radar bombing were also compounded by the decision to bomb from medium altitudes after the third day of the war. This decision occurred after several aircraft were lost in low altitude penetration mission, but it meant that most

Coalition aircraft had to fly missions for which they were not trained, and where minor navigation errors could become serious.[20]

Radar bombing did have considerable success against some area targets, but was rarely effective in destroying targets when a few aircraft made a single raid on an area target, and had little capability to attack point targets. Radar bombing could not be used at all against small targets like dispersed ground forces, air defense units and bridges. While experts disagree on their detailed assessment of the damage effects inflicted from radar bombing, many of those interviewed felt that bomb damage assessment data indicated limited effectiveness in many attacks.

Infrared-assisted delivery of unguided weapons seems to have proved more effective than radar-guided bombing when advanced IR avionics were used, when the pilot used IR guided weapons or did not need to locate a small point target, and when the aircraft could fly profiles that allowed accurate target acquisition and weapons release. IR delivery, however, was most effective in delivering laser guided bombs.[21] Improved FLIR and laser-designator systems made night and all-weather target acquisition and tracking much easier for aircraft like the F-117, F-111F, and A-6E.

All of the F-15s in the theater, and two squadrons of F-16s used the new AN/AAQ-14 low-altitude navigation and targeting infrared for night (LANTIRN) system, although only six F-15Es could be equipped with the full LANTIRN system, which included the AN/AAQ-14 targeting and designator pod. F-15s often dropped dumb bombs.

The LANTIRN proved to be extremely successful, although only a comparatively few targeting pods were available during the war, and training and doctrine for making effective use of the full LANTIRN system was still evolving. The F-15E, for example, could use LANTIRN to achieve an 80% hit rate under ideal navigation and weather conditions -- although the limited number of designator pods sharply reduced the number of missions that could be flown with precision strike capability.

Modern Strike Fighters: The Role of the F-15E[22]

The 48 F-15E multirole fighters that the USAF deployed to the Gulf illustrate a different level of strike/attack capability. They were the most advanced strike fighters in US inventory, and the squadrons sent to the Gulf had just reached operational readiness when they were deployed to the Gulf.[23] They provided a combination of highly sophisticated APG-70 radar that could pick out many land targets while a LANTIRN infrared night navigation system gave the F-15E some of the most advanced night attack capabilities of any fighter in the Coalition, and a two man crew -- where one officer could concentrate full time on attacking the target.[24]

Most F-15E missions were conducted at night.[25] During these missions, the F-15Es were sometimes assisted by JSTARS, and radar mapping allowed them to locate their target within 50-100 feet at ranges of 10 miles. The limited number of F-15Es equipped with the targeting pod for LANTIRN could then acquire targets with considerable precision. They could destroy point targets with great effectiveness on clear nights using laser guided bombs. These avionics also made the F-15E one of the few systems capable of providing useful damage assessment data at the tactical level.[26]

F-15Es could carry a wide range of munitions. They could carry four GBU-10 2,000 pound laser guided bombs, eight GBU-12 500 pound laser-guided bombs, six CBY-87 cluster bombs, or 12 Mark 82 bombs on a single deep strike mission. In practice, laser-guided bombs proved to be the most effective munitions, and the F-15E demonstrated that it could release the GBU-10 at altitudes of over 15,000 feet, and at ranges of over 4 miles and still achieve considerable accuracy.

F-15Es flew 2,172 sorties during Desert Storm for only two losses. They delivered a total of 1,700 GBU-10 and GBU-12 500 pound and 2,000 pound laser-guided bombs. On several occasions, two F-15Es configured with the full LANTIRN system destroyed a confirmed total of 16 armored vehicles, using eight laser-guided bombs, each on a single mission. F-15Es with LANTIRN sometimes hit targets within a 10-foot area, and even destroyed one Iraqi helicopter using a laser guided bomb. The superior all-weather capabilities of the F-15E also made them the key fighter attacking the Iraqi forces fleeing towards Basra on the so-called "road of death."

Some senior USAF commanders in the Gulf War felt that the F-15E was far more effective than either the F-16 or F/A-18 because of its high range-payload capability, sophisticated electronics, and the ability of a two-man crew to handle the work load of demanding attack missions. They remarked that official analyses of the lessons of the war sharply understated the value of a second crew member, as well as the value of giving fighters the capability to strike deep, and operate in the target area for long periods of time without refueling. One senior USAF officer involved in planning and managing the air campaign described the Air Force's decision to limit procurement of the F-15E, and rely on upgrades of the F-16C as a critical mistake that would, "cripple key aspects of our force posture for decades to come."[27]

The F-15E would almost certainly have had even more impact on the war if more F-15Es had the full LANTIRN system, and so many F-15E missions had not been reallocated to the Scud hunt. They would also have been more effective if they had been given adequate time and intelligence support for mission planning. Further, sudden changes to the ATO seriously degraded the effectiveness of F-15E missions. One F-15E analyst stated,[28] "Time needed to plan air interdiction operations is critical. Aircrews need to have ATO changes at least six hours prior to take-off in order to plan interdiction missions properly. On several occasions ATO changes were received with little or no time to plan, brief, and upload the appropriate munitions. Aircrews became less effective...."

This need for better support for mission planning and briefings, better intelligence support, and better command-level understanding of the real-world needs of aircrews at the tactical level is a major lesson of the Gulf War, and applies to F-111 and F-117A operations, as well. Officers flying F-117As noted that, the amount of daily changes that the were made in the ATO became almost overwhelming." [29]

Old Platforms: Modern Avionics: The F-111F

The F-111F another key strike aircraft, capable of precision, radar, and infra-red assisted bombing. The US used a total of 84 F-111s, with 66 F-111Fs in Saudi Arabia and 18 F-111Es in Turkey. All of the F-111s were supersonic variable wing strike aircraft with terrain-following radars, inertial navigation systems, and radar bombing capabilities that could attack at low altitudes at night and in all weathers. They had two-man crews with a separate weapons officer, a high range-payload, speeds up to Mach 2.5, and an excellent low-altitude dash capability at up to Mach 1.2 -- although most missions in Desert Storm were flown above 10,000 feet. The terrain following radar on the F-111 was triple redundant, and automatically put the plane into a 2.4G climb if it failed.[30]

Each F-111 could carry two AIM-9 air-to-air missiles plus 8-12 500 pound bombs, 2-4 2,000 pound bombs, 2-4 500 pound laser-guided GBU-12s, 2-4 2,000 pound laser-guided GBU-10s, 2-4 2,000 pound laser-guided GBU-24s, one 4,700 pound laser-guided GBU-24, eight CBU 97 cluster bombs, eight CBU-89 Gators, 8-12 CBU-52s, 8-12 CBU/58/71s, 8-12 Rockeyes or 1-2 2,000 pound GBU-15s.

F-111s flew more than 4,000 sorties, with only one aircraft damaged. Many of these sorties delivered GBU-15 TV-guided bombs and GBU-28 laser guided bombs. Like the F-15E, the F-111F's long range gave it the ability to stay in the target area, and it was able to use the Pave Tack to locate and strike at dug-in Iraqi armor. F-111s proved able to hit high contrast targets with great accuracy, with electro-optical, and infrared-guided surface weapons at night, when it had minimum vulnerability to Iraq's shorter range air defenses. F-111s were also tasked to bomb aircraft and facilities on airfields, hardened aircraft shelters, C^4I facilities, bunkers, nuclear, chemical, and biological warfare facilities, and air defense

The F-111Fs were particularly effective in using these laser guided weapons. They were equipped with the Pave Tack forward looking infrared (FLIR) target acquisition and laser designation pod, which fits into the aircraft's weapons bay. The effectiveness of Pave Tack was more dependent on good weather than on some other IR equipment, which

degraded sharply if clouds or smoke was present, but allowed the F-111 to attack target points at night in clear weather with laser- guided weapons. When the Coalition shifted to the kill box system, F-111s often cycled through the night carrying four laser-guided bombs; after taking the time to find targets and designate them precisely, they struck them with great accuracy.
targets.

There are problems in the quality of the data base on some aspects of F-111 operations, including the categorization of sorties, to estimates of the probable effects, and number of bombs used in attacking targets like aircraft shelters. It is clear, however, that about 75% of F-111 strikes were directed against airfields and Iraqi ground forces, although they attacked a wide range of other targets. F-111Es flew at least 423 strikes, and F-111Fs flew at least 2,802 strikes. This leaves over 1,000 targets unaccounted for by type, but it is clear that F-111s of both types flew a total of 4,242 sorties.

The USAF estimates that 18 strikes were made against leadership targets (.4% of total), 58 were against C^4 targets (0.4%), 750 were against airfields (17.7%), 74 were against strategic air defenses (1.7%), 7 were against surface-to-air-missiles (.2%), 140 were against nuclear-chemical-biological targets (3.3%), 76 were against Scud targets (1.8%), 287 were against military support and production targets (6.8%), 2,440 were against Republican Guard targets and other Iraqi ground forces (57.5%), 267 strikes railroads and bridges (6.3%), 33 strikes against electric facilities (0.8%), and 83 strikes against oil facilities (2%).[31]

Like the F-15E and F-117A, the F-111 demonstrated that a mix of radar bombing and infra-red delivery capability, combined with precision weapons, could be extremely lethal in a wide range of missions. The F-111 proved to be the most effective aircraft in attacking the Iraqi Air Force, and while it is impossible to estimate the damage it did to Iraqi ground forces with any accuracy, it seems to have performed very effective when it used laser guided bombs against armor.

Like most aircraft that flew during Desert Storm, however, the F-111 may be upgraded -- although the USAF has sought to eliminate it from the US force structure because of the impact of recent defense cuts. The Congress has kept the aircraft active, however, and if the "Pacer Strike" upgrade program is funded, it will keep 84 F-111Fs flying until at least 2010. The improved F-111 aircraft will have their analog electronics converted to digital, ring laser gyro inertial navigation systems, GPS, new software, and integrated cockpit displays. Its engine controls are being improved to reduce maintenance problems, and the afterburner is likely to be improved to provide more thrust. The F-111 wing is also being reorganized to create a wing that will combine the EF-111 and F-111 force into a unified strike force organized and trained to fly offensive packages.

These potential upgrades illustrate two broad lessons of the Gulf War. First, the need to improve the navigation capabilities, software, and weapons control facilities of virtually every aircraft in service, to improve the accuracy of radar and day bombing, and the ability to navigate to points where IR systems can acquire targets. Second, the value of organizing and training air units to fly as packages, rather than by type of aircraft, so that the resulting force is ready to fly integrated strike/attack missions in wartime. For example, combining the EF-111 and F-111 in to mission packages offered the advantage that all aircraft can fly at the same speed. In contrast, F-111s had to slow down during a number of missions during the Gulf War to match the 540 knot speed of the EA-6.[32]

Old Platforms: Modern Avionics: The A-6E

The A-6E Intruder was a US Navy strike/attack aircraft flying off US carriers. It could not be used as flexibly during the Gulf War as the F-15E and F-117 because of its uncertain survivability and the command and control problems affecting the transfer of ATO data from the Air Force to the Navy described in Chapter Four.[33] However, the A-6E had excellent range-payload capability, and advanced precision strike capabilities, and the ability to attack at low altitudes at night, and in all weathers.[34]

Although the A-6 was developed three decades before Desert Storm, it had been steadily modified in the years that followed. After losses over Lebanon, the A-6's cockpit was modified for better night lighting and pilots were trained to use night vision goggles to penetrate at altitudes as low as 200 feet in good weather. The A-6Es used in the Gulf War had a terrain-following radar, inertial navigation system, an all-weather radar-mapping capability that provided radar bombing capabilities, and a forward looking infrared (FLIR) target acquisition, and a laser designation system with zoom capability. They carried a target recognition, and attack multi-sensor (TRAM) system in a precision-stabilized turret, which was mounted in the nose of the aircraft, and had a forward-looking infrared sensor, a laser designator/ranger, and a laser receiver. As a result, they could operate extensively at night, in poor weather, and even in areas where oil smoke presented serious visibility problems, and could attack target points at night in clear weather with laser-guided weapons. It had good radar and excellent infrared capabilities.[35]

The US Navy had 95 A-6Es in theater, and they flew a total of 4,825 sorties. These included missions against Scuds, suppression of surface-to-air missies and anti-aircraft systems, and a variety of other targets.[36] Two of the US Navy A-6E squadrons had been upgraded to provide improved avionics, and could make full use of SLAM, Maverick, HARM, and Harpoon. These units were the first to fire the SLAM missile, but they normally used a mix of laser guided bombs and conventional munitions. The A-6Es were employed in "packages" of fighter escorts, EW aircraft, and HARM aircraft in close air support missions, in attacking Iraqi naval units, and in suppressing Iraqi air defenses. The 20 US Marine Corps A-6Es flew 795 sorties -- over 98% of these sorties at night.[37] The Marine A-6Es normally used conventional bombs, although they used some laser-guided bombs.

A typical A-6E sortie carried 11 Mark 82s or Mark 20s, and one laser-guided bomb, usually a GBU-16. The A-6Es would have carried far more laser-guided bombs in these had been available in larger numbers. However, the US Navy and USMC had sharply underestimated the value of such weapons and their needs for a large inventory. The A-6Es normally operated as single aircraft targeted on specific targets or targets within a given kill box. Navy and USMC A-6Es normally used radar to cue the FLIR, but one-third of their missions required radar bombing only because smoke, haze, or weather obscured the target. Such radar bombing efforts seemed to have been significantly less accurate than FLIR assisted missions.

While the A-6E was successful in attacking many targets, and had a high rate of effectiveness, it also encountered a number of problems. It needed a substantial escort force, and had a relatively high maintenance burden. It was found to have insufficient chaff and flares to provide full coverage in penetrating the target, and its mission data recorder was too limited to provide battle damage assessment data against a number of targets, and five aircraft were lost or damaged in combat -- two in low altitude attacks. As a result, the A-6 delivered all of its ordnance from altitudes above 10,000 feet after the first four strikes. These losses raise the same questions about vulnerability in low altitude missions as the Tornado losses are discussed in the previous chapter, but it should again be noted that a loss of two aircraft is a dangerous basis for generalizing about the relative risk of low and medium/high altitude missions.[38]

Stealth Technology With Limited Attack Capability: The F-117A

The F-117A Nighthawk represented the most dramatic shift in technology of any strike aircraft employed in Desert Storm. Developed in the mid-1980s, the F-117A is a low observable or "stealth" strike aircraft that could fly a 540-720 mile combat radius and deliver two 2,000 pound GBU-10 or GBU-27 laser-guided bombs with great precision.[39] Unlike the other Coalition aircraft, the F-117A could use its stealth capabilities to penetrate deeply into Iraq, and attack even the most heavily defended targets. Its forward looking, down-ward looking infrared (FLIR/DLIR) system was also one of the most effective attack systems used in the war, and the F-117A and F-111 were the only aircraft whose FLIR systems had a wide enough angle of view to significantly reduce target acquisition problems.[40]

The 42 F-117As deployed during Desert Storm flew 1,296 sorties and strikes against 1,777 targets, during the war. The F-117 was the only Coalition aircraft to penetrate over downtown Baghdad, and hit all categories of targets. It struck about 40% of the strategic targets attacked, although it flew less than 3% of all sorties.

F-117s attacked 35% of the strategic targets hit on the first night, and played a key role in strike Iraqi air defense and C^2 targets.[41] However, they attacked a wide range of other targets and the F-117 proved to be a highly flexible aircraft. F-117s flew 187 strikes against leadership targets (11% of total), 205 strikes against C^4 targets (12%), 234 strikes against airfields (13%), 115 strikes against strategic air defenses (6.5%), 40 strikes against surface-to air-missiles (2%), 376 strikes against nuclear-chemical-biological targets (21%), 173 strikes against Scud targets (10%), 238 strikes against military support targets (13%), 15 strikes against Republican Guard targets (1%), 23 strikes during the breaching operation, 4 strikes against naval targets (0.2%), 2 strikes against electric facilities (0.1%), and 2 strikes against oil facilities (0.2%). On D+30 the F-117As delivered 32 strikes at the oil pumping stations used to flood the "fire trenches" in front of the Iraqi forward positions facing the 1 Marine Division with oil, and were a key reason Iraq was not able to use such defenses.[42]

No F-117As were damaged or lost in combat during the war, but it is important to note that the aircraft's "stealth" was relative. The F-117A does have a low radar cross section. At its optimal angle of approach to a radar, this cross section can be less than one-twentieth as visible to most surface-to-air missile radars as an F-15. The F-117 is not designed to be invisible to radar.[43] Instead, it is designed to take advantage of its low-radar cross section, to reduce the enemy's capability to detect and track it when it flies carefully planned missions at very low levels, through an enemy radar net.

This difference between invisibility and low observability has led to a great deal of confusion, and many reports that given radars somehow offer special advantages in detecting the F-117A. Virtually all of these reports are wrong to the extent they are based on the idea that the F-117A cannot be detected by radar under a variety of different conditions.[44] This difference between low observability and invisibility also explains why the F-117A sometimes used help from jammer aircraft -- although such assistance was not vital and no strikes were canceled when such support was not available.[45] The fact that the F-117A was sometimes detected by Iraqi radars from certain angles did not prevent the F-117A from successfully attacking targets in Baghdad long before the Coalition attacks degraded the effectiveness of Iraqi air defenses.[46]

The F-117A repeatedly demonstrated that it could attack deep into Iraq against the best defended targets without escort from other aircraft -- a major savings in the cost of strike missions. After the Gulf War, one senior USAF officer claimed that, "Eight F-117s with eight pilots could achieve the same results as 75 non-stealth aircraft with 100 crew members...though the F-117s represented only 2.5% of the asset, on Day 1, they flew against over 30% of the targets...the F-117s flew only about 1% of the sorties, (but they) covered about 40% of the strategic air campaign's target base."[47]

On the other hand, two Iraqi fighters did come close to intercepting an F-117A during the early days of the war, and the aircraft required an extremely complex and time consuming mission planning process to ensure that it would approach targets in ways that minimized the risk of detection and vulnerability to Iraqi surface-to-air missiles. As a lesson of the Gulf War, this mission planning system is being totally revised, and made fully interoperable with other US mission planning systems. Like other US strike aircraft, it is also being given an increased on-board navigation capability to improve the on-target accuracy of its penetration profiles. The most likely improvement is the GPS system.[48]

The F-117s had other operational limitations. It was demanding and difficult to fly and in terms of pilot burden. F-117A pilots had to be extensively retrained to attack targets in a desert environment, and changes had to be made in tactics. The F-117A's payload was limited to two 2,000 pound regular or penetrating laser-guided bombs, and none of the advanced stand-off air-to-surface missiles the F-117A may carry in the future were available during the Gulf War.

The F-117A was far more accurate than bombers in hitting its targets, using unguided weapons. It could theoretically hit 80% of its aim points on a clear night, versus CEPs in excess of 1,100 feet for most other aircraft. The stabilized infrared laser illuminator in the F-117A also covered a spot only 15" to 18" wide, which made it substantially more precise than most laser-guided bomb devices.[49] The F-117A did, however, rely heavily on extremely precise navigation and flying to bring it to the point where its infrared systems could acquire its target. It then had to rely on laser illumination to hit its target, and this often limited its mission and poor weather capabilities -- or meant it could not be used in bad weather or against obscured targets. Sensitivity to weather limited the F-117A's ability to strike targets like bridges, and 18.9% of the bombs it was scheduled to drop either missed or were not dropped for weather reasons.[50]

The effectiveness of the F-117A's air strikes is difficult to measure. The Gulf War Air Power Survey notes that,[51]

> "By far, the F-117A wing kept the best data on its own operations of any Coalition air unit that flew in the war...it soon became apparent that this level of clarity

> and data was the rare exception. Even the F-111 data base was less detailed...There appeared to be great uncertainty in the F-111 data over the target categories actually bombed, as well as the number of bombs dropped per aim point on many targets prior to the commencement of the 'tank plinking'...With other platforms, especially those that were heavily involved in either chasing Iraqi mobile missiles or delivering non-precision weapons into KTO 'kill boxes', information such as the precise target attacked, the weapons utilized, or even whether the planned sortie had been flown at all, was not only uncertain, but was often impossible to clarify or refine. Hence, beyond aggregate data on the numbers of sorties flown and total munitions expenditures,... details may never be known."

Even in the case of the F-117A, however, reliable battle damage assessment data are often uncertain or lacking. There is no doubt that many F-117A strikes actually hit high numbers of their targets, some estimates of hits are misleading. The USAF has issued estimates that show that the F-111A dropped 1,652 bombs that hit their targets, and 413 that missed, for an 80% hit rate. These figures, however, exclude 442 strikes where no drop occurred or where the strike missed because of weather. If these figures were included in the total, the total number of strikes would be 2,094 and there would be 855 missions where the aircraft failed to hit a target.[52]

As has been discussed in depth in Chapter Five, one of the key lessons of the Gulf War is that there is a major problem with most BDA data on the Gulf War. A great deal of the data do not actually measure battle damage at all. They simply detect the presence of a hit or near hit and then make estimates of the probable damage that a given munitions inflicted based on past tests of the weapon. Even many of those who produced such estimates, or who attempted to revise them after the Gulf War, had little faith in such data or on any statistics based upon them. They believed that such approaches provided broad indications of effectiveness, but often exaggerated factors of kill capability by a factor of three or more, and some felt they were force to use such data for quantified estimates for internal service or program-related political reasons. Further, such data emphasize physical destruction over disruption, although disruption and the shock power of air power are a critical aspect of its military effectiveness.

As a result, an figures on "hits" during the Gulf War both ignore the role of airpower in disrupting Iraqi operations and raise serious questions about the extent to which hits were real hits, versus near hits, and about the relationship between "hitting" a target and inflicting the required level of damage to the target. Even when the F-117A delivered both of the weapons it could carry against a single target, it lacked the payload necessary to destroy many targets, and analysis after the war indicated that strike planning often failed to allocate enough laser-guided bombs to effectively attack given targets. It seems doubtful that the F-117A produced the required damage or "kill" rate much in excess of 15-25% per strike -- although this still is a high rate of effectiveness and is extraordinary, given the fact that no other type of Coalition aircraft could strike many of the same targets and survive.[53]

Interviews also indicate that planners over-reacted to instructions to minimize collateral damage, a shortage of long range precision strike aircraft, and early BDA reports that exaggerated damage. They often tasked F-117s with attacking targets using only 50% or less of the munitions that pre-war studies had indicated were needed to destroy given targets. This was a common problem affecting USAF mission planning for many aircraft -- although it sometimes was part of a deliberate effort to emphasize disruption over destruction -- and one that needs to be firmly addressed as a lesson of the Gulf War. Effective battle management is absolutely dependent on realistic estimates of damage effects and the amount of munitions needed to accomplish a given mission.[54]

These problems in estimating the effectiveness of the F-117A are compounded by other factors which limited the effectiveness of all Coalition aircraft -- particularly precision aircraft like the F-15E, F-111, and F-117A. These factors included the failure to provide proper strike mission intelligence support at the national and theater levels, excessive sudden changes to the ATO that could not be supported with proper mission planning and briefings, and "friction" in selecting targets and aim points where the mission planning could only speculate about the probable value of the target.

In some cases, like leadership and C^4 sites -- where F-117A strikes delivered most of the precision strikes -- Coalition strike planners could only make vague guesses about the value of given targets and which targets to strike. In other cases, planners guessed wrong about weapons effects. For example, in the case of F-117A or F-111 attacks on conventional buildings or the Al Firdos shelter, analysts underestimated the damage done by penetrating bombs. In other cases, like the Iraqi Sector Operating Centers or aircraft shelters, they overestimated damage because bombs were deflected away from their targets as they penetrated the soil and rubble above the shelter.[55]

This experience illustrates a broader lesson of the Gulf War. BDA must be fully integrated into the C^4I/BM process. It is easy to talk about decision-making cycles and creating decision-reaction loops that are faster than the enemy. However, such efforts can never be efficient without accurate near-real time battle damage assessment data.

The F-117A is currently undergoing a number of upgrades as a result of this experience during the war. Some of the details of these upgrades are classified and most are subject to funding changes, but unclassified reporting indicates they may include the addition of a more accurate and reliable ring laser gyro and GPS navigation system. This improvement is critical because F-117 missions before Desert Storm were estimated to average about two hours -- allowing for one set of navigational tolerance -- but actually lasted 5-6 hours which required far more accurate equipment.

The improvement program seems to include color multi-function displays that incorporate a moving map capability, on screen call-up of target photos or identification diagrams, changes to the cockpit to reduce pilot disorientation, auto throttle control to ensure precise arrival time over target, replacement of metallic tail fins with composite ones, a modified engine exhaust system, secure low probability of intercept radios, an upgrade mission computer with four times the input, better tires and brakes, and a major upgrade of the IR acquisition and sensor suite that will effectively double its range. These is a chance that the US may add radar bombing capability and a slight change it may eventually stretch the F-117A to add more payload and add a new engine -- which would give the F-117A 28% more range, reduce take-off distance by 13%, and substantially increase maneuver capability and flyability.[56]

These upgrades of the F-117A in Desert Storm are likely to set the standard for "stealth" fighters for some years to come. At the time of the Gulf War, both the USAF and US Navy planned to procure advanced stealth strike fighters. Since that time, both programs have been canceled for technical and financial reasons. While the Air Force now plans to give its F-22 air superiority fighter a stealth bombing capability similar to that of the F-117A, and the new F-18E/F will have substantial stealth features, the F-117A is likely to be the only low observable strike aircraft in service until well after the year 2000. The US is procuring limited numbers of B-2 bombers, but the number that will be deployed and actively sustained in the force structure is likely to be very limited and will not exceed 20.

This experience raises the question of whether the US has reacted properly to the lessons of the Gulf War. The USAF has chosen a next generation air superiority aircraft over an advanced attack aircraft, although it is unclear where a threat exists to US air combat capabilities and their are many potential needs for advanced strike aircraft. The US Navy has chosen to fund a new multirole carrier aircraft largely because it so thoroughly mismanaged every aspect of its strike modernization program that it has no funds to do anything else.

Multi-Mission Fighters with Moderate Strike/attack Technology: The F/A-18

The principal multi-mission fighters that the US deployed were the F/A-18, F-18D, and the F-16. The F-18C/D is of particular interest because it had strike/attack capabilities that were superior to most of the world's deployed strike-capable fighters at the time of the

Gulf War. It was equipped with the AN/APG-65 multi-mode radar to locate ground targets as well as aircraft, carried a Thermal Imaging Navigation System (TINS) and a AAS-38 FLIR targeting pod.[57]At the same time, the F-18C/Ds deployed during the Gulf War lacked a laser- designation capability, target acquisition capability, and all-weather and night warfare capability of aircraft like the F-15E with LANTIRN. As a result, the F/A-18 and the F-16 used of unguided or "dumb" ordnance in most sorties, and the F/A-18 serves as a good illustration of the problems that most aircraft in the Coalition had in accurately dropping unguided bombs under many mission conditions.[58]

Approximately 90 US Navy F/A-18 Hornets flew from carriers, and 36 USMC F/A-18As and 36 F/A-18s flew from Sheikh Issa in Bahrain. These F-18 aircraft flew many counter-air missions, but also used FLIR, laser trackers, Walleye, Maverick air-to-service missiles, laser-guided bombs, and conventional ordnance in offensive missions. The F/A-18s delivered some 17,500 tons worth of ordnance. Typical F/A-18 attacks used unguided ordnance in areas covered by Iraqi air defenses and involved a 30 degree angle dives, beginning at 30,000-35,000 feet at speeds of 480-540 knots, and releasing at 10,000-20,000 feet. These attacks used head up display (HUD) assisted high-angle dive deliveries, which had a major impact on the effectiveness of such offensive sorties. So did the fact that Marine supply problems led a substantial number of sorties to be loaded with less effective munitions.[59]

HUD assisted high-angle dive deliveries presented special problems, because the dives from high altitudes had to be so steep, and speed increased very quickly while altitude dropped at rates that placed a high workload on the pilot. The "G" force at the moment of release often exceeded the 1 G limit that is optimal in such approaches, and aircraft often put addition lateral G on the munition as they maneuvered to avoid enemy air defenses.

There was considerable evidence that F-18 pilots -- like the pilots of other single man fighters without a separate weapons officer -- had serious problems in handling the result workload and "wasted" about 30-50% of the sorties flown using "dumb" bombs by missing the target.[60] Many pilots had severe targets acquisition problems, often acquiring the target too late to be effective. Many pilots could not both fly the plane and keep tracking the release point (pipper) against the target. As a USAF study noted,[61]

> "...pilots had to cross check ... information while maneuvering the aircraft to position the piper on target while maintaining predetermined release conditions necessary to put the bombs on target. Although this sounds easy, it was not. Flying parameters are up to the individual skill of the pilot. Pilots try to be wings level in approximately 1 G flight at release so that the weapon comes off a stabilized platform. Any added G forces negatively bias the weapon in the

direction of force. For example, releasing a weapon with the aircraft in a left bank will cause the weapon to land short and left of the aim point. Other factors affect visual releases: enemy threats disturbing pilot concentration; pilots attention focusing on the pipper rather than on flying the aircraft in relation to the target; acquiring the target late, so that aiming corrections cannot be accomplished; system altitude errors causing bombs to hit long or short of targets...."

The USMC dealt with some aspects of this problem by deploying 12 F-18Ds. The F-18D was a two-seat USMC strike fighter with multi-sensor imagery capability and which could be used to coordinate attacks by other aircraft. The Marine Corps used the F-18Ds largely as tactical air coordinators and in the airborne forward air controller roles.

The F-18Ds flew ahead of strike aircraft to locate targets and identify high value targets in tactical attack and close air support missions. They flew 557 sorties and controlled up to 20 other aircraft during 30 minute intervals. The F-18Ds generally only fired cannon or rockets to mark a target, but were a critical source of reconnaissance and intelligence data on Iraqi actions in the forward area. The Marine Corps' slow-flying OV-10s were also useful as spotters and target aircraft in the forward area, but were too vulnerable to be flown ahead of Marine ground forces. The F-18Ds could range freely over the KTO, marking targets in the kill boxes with white phosphorous rockets. Like the F-16s used in a similar role, the F-18Ds demonstrated that a high-performance fighter could linger in the battle area, and survive while finding targets for other aircraft. This is an important lesson for both low intensity conflicts, and for air forces that cannot afford the kind of "packages" of sophisticated specialized aircraft used by US air forces.[62]

Multi-Mission Fighters with Moderate Strike/attack Technology: The F-16

The USAF deployed 251 F-16 Falcons during Desert Storm, more than any other type of aircraft. These F-16s were used in a wide range of missions and packages. They flew more that 13,480 missions, struck more than 11,698 targets, flew more sorties than any other type of aircraft, and had the highest use rate of any aircraft in theater -- 1.35 sorties per day. F-16s flew 2,912 sorties in day visual attacks with unguided bombs against point and area targets in support of the strategic bombing campaign. They flew 421 strikes in the "Scud hunt", normally using GPS/LANTIRN equipped aircraft and cluster bombs; 8,258 strikes against Iraqi land forces, and large numbers of armed reconnaissance strikes in the killer scout role.[63] In spite of this high exposure to combat, only eight F-16s were lost during the war: Three in combat and four in accidents.

The F-16s could deliver unguided ordnance and air-to-surface missiles, but did not have a laser-designator. Two squadrons did, however, have the AN/AQQ-13 LANTIRN navigation pods needed for night operations and all 12 F-16s in Turkey were equipped to fire HARMs. In most sorties, the F-16s were equipped with two AIM-9 missiles, 500 rounds of 20mm armor piercing ammunitions, and with a package of 4-6 Mark-82 500 pound bombs, two Mark 84 2,000 pound bombs, four CBU-52/58/71s, four CBU-87s, four CBU-89 Gators, or 2-4 AGM-65s.

These sorties had mixed results. Like many of the world's attack and multi-role aircraft, the F-16 was designed primarily for low altitude deliveries -- where the optimal accuracy of a perfectly targeted bomb was 160-200 feet.[64] In Desert Storm, however, F-16 pilots normally had to fly medium-to-high altitude attack profiles similar to those of the F/A-18, and this presented similar problems in terms of accuracy and pilot work load.

The F-=16 pilot was given a continuously computed impact point by the fire control computer, which used both navigational data and the ballistic characteristics of the weapon being delivered to predict the impact point. A pipper, displaying the predicted impact point appeared in his HUD, but the pilot then had to maneuver the aircraft to superimpose the pipper on the target. In practice, the pilot was confronted with having to acquire and track the target, control and fly the airplane, and manipulate his attack avionics at the same time. This often did not prove practical, given the very fast reaction times required in most approaches, and the level of assistance from the F-16's avionics excluded many important variables.[65]

As a result, the F-16 often was not effective in delivering unguided ordnance -- although those F-16s that had LANTIRN navigation pods (No targeting pods were available for the F-16) and GPS proved to have roughly the same level of effectiveness at night as during the day when they used off-board sensors to help direct the aircraft.[66] USAF studies after the war indicated that most F-16 sorties that used unguided bombs or area munitions had comparatively low lethality, and the Gulf War Air Power study noted that,[67]

> "Initial mission effectiveness, in terms of 'bombs off on first pass,' was less than desired. There are multiple reasons why this happened, to include the confusion in the first days of combat, and the defensive maneuvers required for survival. However, another reason was the low knowledge level of medium and high altitude delivery constraints. Due to the previous low altitude training emphasis or lack of medium altitude releases, few pilots were exposed to some of the associated problems, such as extremely high crosswinds and high G releases due to delay cues. It should be noted that even though there was a training deficiency, the learning curve was steep."

The F-16s did occasionally deliver AGM-65 Maverick air-to-surface missiles and AGM-69/88 Shrike anti-radiation missiles. In theory, the infrared Maverick (AGM-65D/G) provided the F-16 with a precision weapon with near stand-off ranges. The pilot should also have been able to use the missile in conjunction with his radar to acquire some targets at beyond visual range. However, the F-16s experienced problems in acquiring and tracking targets using Maverick while flying outside the range of Iraqi short- ranged air defenses. As a result, the F-16s made comparatively limited used of guided weapons.[68]

The F-16s became more effective when the Coalition shifted to the use of the 30 by 30 mile kill boxes described later in this chapter, and when F-16s were sent out as "killer scouts" in the armed reconnaissance mode. Like the F-18Ds, these F-16 aircraft lingered over the battlefield and found targets for the other F-16s. The scouts flew in two aircraft formations during daylight hours, and provided target type and location data, and threat status and position data on other friendly aircraft for the attacking F-16s. This use of kill boxes and killer scouts reduced the problems that individual F-16 pilots had in acquiring and track the target and release bombs while flying the airplane.

The value of this technique is an important lesson of the war, as is the need to assist pilots with high technology targeting systems. As will be discussed shortly, the USAF had reacted to the lessons of the Gulf War by upgrading its F-16 force with the avionics and LANTIRN navigation and targeting pods needed for accurate night and precision bombing. It has also concluded that the value of killer scouts will be greatly increased if they are given an automatic target hand-off capability, and an integrated data modem to allow direct transfers of data from aircraft like the JSTARS.[69]

Pilots still, however, often missed their targets. Under some conditions, the F-16 hit the target only about one time in 12.[70] This is an important lesson for many of the world's air forces. USAF F-16 pilots were better trained than the pilots in most other air forces, and the USAF F-16C/D, and even its F-16A/Bs were generally better equipped than most of the dual-capable and attack aircraft in other NATO air forces. Nevertheless, they lacked the range-payload to deliver large "volleys" of unguided ordnance in a single pass, and the mix of avionics and range-payload capabilities to loiter over the target area and acquire and attack targets with high effectiveness.

Close Air Support Aircraft With Specialized Technology: The A-10

Several other US aircraft are of special interest. The A-10 was the only dedicated close air support aircraft that saw extensive service during Desert Storm. The USAF deployed a peak strength of 144 A-10s, and employed them in a number of missions, including escorting helicopters, Scud hunting, and combat air search and rescue. A-10s flew 49 strikes to suppress air defenses, 135 strikes to suppress Scuds, and 175 strikes to attack Iraqi electronic warfare and GCI sites early in the war. The aircraft's primary mission was killing armor and artillery, and it flew 3,367 strikes against these targets.

The A-10 Warthog, and the OA-10 observer version of the A-10 were originally designed to kill tanks and other armor in a European environment. As a result, the A-10 offered the Coalition a number of advantages in performing the close air support role and attacking Iraqi armor. The A-10 is a very stable firing platform, has a long loiter time, and flies slowly enough to allow better target acquisition. It has very high firepower, and a relatively low vulnerable area: The pilot is protected by a titanium tank, the aircraft's controls revert to manual operation if damaged, its engines are mounted high and protected, and the wings and tail can take exceptional damage.

The A-10 is equipped with a special internal GAU-8 30mm eight barreled Gatling gun that can fire up to 1,350 rounds of high explosive or depleted uranium armor piercing ammunition at a rate of 2,100 or 4,200 shots per minute at a velocity of 3,747 feet per second. At a slant range of 4,000 feet, the 30mm round has 14 times the kinetic energy of a 20mm round from a M-61 Vulcan, and the gun's depleted uranium armor penetrating round can not only penetrate all but heavy tank armor, but it burns as it penetrates, sending a stream of flame into the armored vehicle.

Use of the GAU-8 gun during Desert Storm had mixed results. The A-10 often had to dive from around 10,000 feet at a 45-60 degree angle, after which the aircraft closed on the target and firing a burst of 150-200 rounds.[71] Even with such dives, A-10s were not always able to close within gun range of armored vehicles because of Iraqi air defenses. Nevertheless, A-10s fired nearly 1,000,000 rounds of 30 mm shells from their GAU-8 Gatling guns, and OA-10s fired 16,000 more rounds of high explosive incendiary shells to mark targets.

The A-10 has 11 hard points for carrying conventional munitions, and can deliver smart weapons. The A-10s in the Gulf were all equipped with the AN/ASS-35(V) Pave Penny laser receiver/tracker which is a day/night target detection set that can be used to detect the energy from a ground based or buddy aircraft laser designator, and deliver unguided or laser-guided bombs. The A-10 was particularly effective in using Maverick to attack armor. A-10s fired 4,801 Mavericks, which was more than 90% of all the Mavericks fired during the war. About half of these Mavericks were electro-optical, and half had infrared imaging.[72] A typical A-10 attack profile using the AGM-65B electro-optical Maverick started with a 30 degree dive from 10,000-15,000 feet, and the A-10 then fired a single missile at a 2-3 nautical miles slant-range from the target. A typical A-10 attack profile using the AGM-65D infrared imaging Maverick started with a 20-30 degree dive from 15,000-20,000 feet, and the A-10 then fired a single missile at a 2-5 nautical miles slant-range from the target.[73]

The A-10 also used the M-20 Rockeye in dives from medium altitudes, but the weapon often missed its target and the Rockeye's submunitions did not prove reliable. A-10 pilots were able to compensate for some of these problems with steep dives and by simultaneously releasing a full load -- or "ripple" -- of Rockeyes on one target. A-10s also used conventional bombs like the Mark-82 -- fused for airbursts -- in "ripples" against artillery and soft vehicle targets, and cluster bombs against soft targets, personnel in the open, artillery, and soft-skinned vehicles, and these deliveries of unguided weapons were moderately effective. Interviews with USAF analysts indicated that the A-10 was far more accurate in delivering unguided and area ordnance than the F-16 and F/A-18 -- largely because A-10 pilots had more time to acquire targets, align avionics, and conduct attack operations.[74]

When the war ended, the A-10 was credited with using cannon, Maverick, and bombs to destroy 987 tanks, 926 artillery weapons, 1,355 combat vehicles, ten fighters on the ground, and two helicopters in air-to-air combat.[75] While many of these wartime kill claims later proved to have been discounted by USCENTCOM BDA analysts during the war, and could not be supported by after-action analysis. There is no doubt that the A-10 was often highly effective in areas where there was a reduced radar-guided SAM threat.[76] Even discounted kill claims indicate that the A-10 inflicted high levels of damage on Iraqi forces, and it was repeatedly able to engage four or five targets a sortie.

At the same time, the A-10s had significant operational limitations. The A-10 only had limited night-attack capability, although one of the six A-10 squadrons deployed had trained specially for night attacks and was used in that role.

The addition of the low-altitude safety and targeting enhancement (LASTE) system before the Gulf War had given A-10 pilots an integrated computer and software package that showed a continuously computed impact point on the pilot's heads up display, (HUD) and warned the pilot if the aircraft got too close to the ground. This system greatly improved the A-10's accuracy, but the A-10 is a one man aircraft, and still imposed a high work load on the pilot in a highly demanding combat environment. [77]

As a result, the A-10 required steep dive angles for maximum accuracy in delivering unguided weapons, but such dives could only be used in relatively good weather, and pilots were often forced to use shallower dives. While A-10 pilots often claimed considerable effectiveness in using unguided weapons in both steep and shallow dives, later analysis indicated that they often failed to destroy the target -- particularly when Rockeye was used against armored targets.[78]

The A-10 had to fly relatively near to its target to use Pave Penny or Maverick effectively. As was the case with the F-16, there were few occasions during the Gulf War when remote laser designation was available , and most of the Mavericks that the A-10s fired during the Gulf War had to be fired at ranges of 3.5 miles or less -- although the missile has a maximum range of 15 miles.[79] At this point, however, the pilot often had to chose between reducing his exposure to air defenses and setting up a Maverick strike as effectively as possible.

As the Defense Department study of the lessons of the war noted, "Maverick use requires comprehensive training because of the cockpit workload in the battlefield environment. This can cause aircrews to become unduly preoccupied and predictable targets for enemy anti-aircraft fire while attempting delivery."[80] The fact Maverick did not approach its potential 85 to 90 percent hit or kill rate does not, however, mean that Maverick attacks did not kill many Iraqi tanks and armored vehicles. Such kills were apparent in many areas in Kuwait and Iraq in walkthroughs of the battlefield.

The A-10 and OA-10 also presented problems because they were vulnerable in heavily defended areas -- particularly when operating deep into the KTO, in areas where pilots were unfamiliar with the Iraqi air defense, or under conditions where poor weather forced them into low altitude and vulnerable attack profiles. Six A-10s were lost in combat and 15 were seriously damaged. According to unofficial sources, some 70 out of 144 aircraft had some form of damage, although most problems were minor.[81] USCENTCOM concluded that the A-10 could not be employed safely in deep strike missions after these losses, and this presented problems in using it as a close support aircraft once Coalition ground troops penetrated deeply into the KTO and air attacks centered on the Republican Guards and forces escaping the Basra.

At the same time, the A-10's vulnerability should not be exaggerated. The A-10 was constantly put into harm's way, and its loss rate was still substantially below 0.1% per combat sortie.[82] Its peak rate of attrition was more than acceptable by the standard of previous wars, and the A-10s would almost certainly have been employed in deep strike and poor weather missions if the Coalition had not been decisively winning the war without such missions. Ten of the damaged A-10 aircraft could be repaired and returned to service within a day, and a total of 14 were returned to service before the end of the war.

This mix of strengths and weaknesses led to considerable debate over the A-10, and dedicated close air support aircraft, after the war. The A-10 was strongly praised by its advocates and damned with faint praise by many in the USAF. The USAF concluded after the war that, "Future aircraft should be designed with higher performance to reduce susceptibility to damage while maintaining low vulnerability" -- almost exactly the conclusion it had reached in trying to prevent procurement of the A-10 nearly a quarter of a century earlier.[83] At the same time, the A-10 did prove to be one of the few quick deploying tank killing systems available to US forces during the Gulf War, and was a valuable enough power projection asset for the USAF to keep in its force structure at a time when it was making major force cuts.

The A-10 has already been a controversial aircraft and it is unclear whether its critics in the USAF were drawing valid lessons in seeking a higher performance close air support plane, or is simply rejecting an aircraft that does not look or fly like a "proper" fighter plane. The A-10 has always been a controversial aircraft. The A-10 was forced upon the USAF by civilian planners during the McNamara era, who saw a slow flying specialized tank killer using cannon as a cost-effective force multiplier that the US could use to offset the Warsaw Pact's advantage in armor. The aircraft was designed, however, at a time when the Warsaw Pact had few self-propelled anti-aircraft weapons deployed with its armored units. By the time it went into initial service in 1977, the Warsaw Pact had begun to acquire excellent overlapping defenses of radar-guided guns and short range air-to-surface missiles. As a result, the A-10 deployed without the maneuverability it needed to survive in its new threat environment, as well as adequate attack weapons and avionics.[84]

In the years that followed, the A-10 was upgraded to use improved Mavericks, but was never given a new engine. This left it with insufficient engine thrust, which limited its rate of climb, acceleration, maneuver, and cruising speed, and increased its vulnerability to anti-aircraft fire during the Gulf War. The USAF to treated the close air support mission and the A-10 as something of a step-child. Long before the Gulf War, it pushed for the A-10's replacement by a specialized F-16 or some other aircraft closer to a conventional fighter plane.

The A-10 might have been far more effective and survivable during the Gulf War if it had been given an improved engine and other relatively low cost improvements. A-10 pilots had long recognized the need to provide the aircraft with night vision capability, and improved avionics. The A-10's night attack capability was so limited that it was difficult to employ it in free fall munitions at night except in strikes parallel to the front lines. The spotter aircraft version of the A-10, the OA-10, could not operate at night, and were forced to use the infrared Maverick seeker or flares to find targets. This deprived the A-10 of one of its best operating environments since Iraqi air defenses were far less effective at night.[85]

Since the war, a number of improvements have been suggested that indicate the A-10 could play a useful role well beyond the year 2000. These improvements include radar absorbing coatings, efforts to reduce the infrared signature of its engine, better missile warning and active defenses, adding GPS and a better data modem, adding night vision goggles and compatible lighting, providing low altitude terrain avoidance and targeting enhancement, adding FLIR for night combat, using smaller fuel tanks to improve maneuverability, and up-engining the aircraft to provide a 6 G rather than a 3 G maneuver capability and a speed increase from 320 to 450 knots.[86]

Further, the A-10's problems with target acquisition and BDA during the Gulf War were scarcely unique, and could have been corrected. It was clear long before the Gulf War that the A-10 needed the technology to provide better target acquisition and damage assessment capability. Even so, A-10 pilots were inadequately trained and briefed in the problems of target recognition and damage assessment before the war, and many were trained primarily to work with a mix of scout and attack helicopters in a European environment.[87] This may have helped lead to the situation where many A-10 kill claims later had to be discounted.

This need to train pilots in the real world problems of damage assessment, using exercises to emphasize the problems of target recognition and tracking in complex air defense environments is not a new lesson that emerges out of the Gulf War, any more than it is a lesson that only applies to the A-10. It is, however, a lesson that many air forces seem determined not to learn. Ever since World War I, combat experience and exercise tests have repeatedly shown that real world combat world load environments confront attack with a combined workload in flying the airplane, finding the target, and operating the weapons system that is too demanding for many pilots to accurately find and then characterize a target and judge whether they actually "kill" that target.

The A-10s were supported by OA-10 and OV-10 spotter aircraft, but such low technology spotter aircraft normally can only assess whether an approximate hit took place against a target, but cannot accurately assess the type of weapons being struck when it is sheltered or revetted, and finds it difficult to determine whether targets have previously been hit by other targets.[88] Similar experiences were common in World War II and Korea, when pilots flew more slowly against much less lethal air defenses. The fact that most aircrews cannot accurately assess air-to-ground kills and air-to-air kills without substantial technical assistance is not simply a lesson of the Gulf War, it is a lesson of every air war that has ever been fought.

Close Air Support Aircraft With Specialized Technology: The AV-8B

Unlike the USAF, the US Marine Corps entered the Gulf War with a firm commitment to the close air support role. The USMC is an integrated force which combines air and land power into integrated expeditionary forces, and uses a high-low mix of F/A-18s and AV-8Bs. The AV-8B is a one-man, short takeoff and vertical landing (STOVL) aircraft based on the British Harrier. It is subsonic and has a nominal combat radius of 506 miles. It is used for deep and close air support missions, as well as for armed reconnaissance, helicopter escort, and air defense missions. It does not have the high survivability of the A-10, but it does have a 25mm Gatling gun, and can be armed with AGM-65E Maverick missiles, the Mark 80 series of unguided bombs, laser-guided bombs, 2.75" and 5" rockets, CBU-72 fuel-air explosives, and Mark-20 Rockeye cluster bombs.[89]

The USMC deployed a peak of 86 AV-8Bs during Desert Storm. The aircraft can take off vertically from ships, vertically from land facilities, or in short take-off distances from short runways. During the Gulf War, they were operated from amphibious assault ships, from Saudi air bases, and from forward areas. The AV-8B often compensated for runway quality problems, or dense operating environments that crowded runways by operating in the STOVL mode (Vertical or short takeoffs and landings of less than 3,000 feet).

The AV-8B was used in a wide range of support missions during the Gulf War -- although it was kept south of 29 degrees, 45 minutes latitude during most of the war to reduce the risk presented by Iraqi air defense weapons.[90]

Like the A-10, the AV-8B proved to be a work horse during the war, although it rarely made use of precision munitions, and was less accurate and effective in using its ordnance than the F-16 and F-18. The AV-8B flew 3,342 sorties against artillery, tanks, armored vehicles, ammunition storage bunkers, convoys, logistic sites, troop locations, airfields, and preplanned anti-aircraft and surface-to-air missile sites. It delivered 83,373 rounds of 20mm ammunition, 4,167 Mark-82 bombs, 233 Mark 83 bombs, and 7,175 Mark-20 Rockeyes. Unlike most other Coalition aircraft, the AV-8B normally operated below the 10,000-15,000 foot altitudes that gave near immunity to Iraqi short-range air defenses.[91]

One interesting use of the AV-8B was to provide rapid response capability against Iraqi artillery, which helped the USMC compensate for its limited long-range artillery strength and targeting capability. AV-8Bs also rapidly shifted basing and moved north to Tanajib, about 42 miles south of the Kuwaiti border on February 18, 1991. This allowed the aircraft to minimize its limitations in range-payload, reduce its need for refueling, and increase its sortie rate: The AV-8Bs flew 236 sorties from this forward position in the last ten days of the war, and delivered 1,288 Rockeyes, and 1,609 Mark-82s against Iraqi targets in the KTO.

The Marine Corps found that the AV-8B both met its mission needs and was survivable enough to retain in its force structure. What is less clear, is the effectiveness of the AV-8B in killing given types of targets. The AV-8B had moderately capable attack avionics and used unguided weapons. This seems to have allowed it to destroy fixed targets like towed artillery units and air defense units with some success, but even using low altitude deliveries, many sorties against point targets like armor and infantry targets seem to have succeeded only to the extent that they paralyzed Iraqi operations, affected morale, or increased desertions. While the AV-8B provided ground commanders with responsive support, the reports the Marine Corps published after the war provide little information to indicate the AV-8B produced extensive kills that can be confirmed through battle damage assessment.

The Lesson of Precision and Sophistication: Change Since the Gulf War

It must be stressed that there is a very real difference between saying that some of the Coalition aircraft used during the Gulf War were not as sophisticated or as effective as was reported immediately after the war, and saying that such aircraft were not effective. Neither the limitations of the Tornado described in the previous chapter, nor the limitations of the US aircraft described in this chapter, prevented any of the types discussed from making a significant contribution to one of the most decisive victories in military history. Further, the effectiveness of aircraft is not measured by whether they achieve one or more "kills" per sortie, but rather by the ability to accumulate a significant number of kills over time while inflicting shock and disruption on the enemy. It should also be clear from the previous analysis that it is difficult to reconstruct just how serious the various limitations were to given Coalition aircraft, and the exact extent to which they degraded mission effectiveness against specific targets.[92] The problems in battle damage assessment capability alone make it almost impossible to accurately assess the capability of individual platforms.

At the same time, the problems the Gulf War revealed in US strike/attack aircraft were serious enough to lead the US to make major upgrades in the capabilities of many of its aircraft, and plan a much more sophisticated set of upgrades for the future. The US is putting particularly heavy emphasis on improved poor visibility night-warfare target-acquisition capability.[93]

The F-16 is a good case in point. In one of its analyses of the lessons of the war, the USAF noted that, "In the Gulf War, our density (of all-weather precision strike capability) was only about one per three aircraft, whereas we would have been better served with a density of one per aircraft employed in the theater..."[94] As a result, the USAF is replacing its F-16A/Bs with F-16C/Ds. It has substantially upgraded the F-16C since the war, and has provided many with the LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) and all F-15Es. It also is seeking to make major upgrades in its smart munitions as a substitute for its inability to procure an advanced strike aircraft, or a new design that grows out of the Joint Advanced Strike Technology (JAST) program until well after the year 2010.[95]

The USAF also has made other upgrades to deal with the problems revealed during the Gulf War. The F-16A has not been fully upgraded, but it has received a data transfer unit, improvements to its APG-66 radar, an expanded fire control computer, a radar altimeter, the AMRAAM beyond-visual-range air-to-air missile, and the ability to use the F-100-220E engine as an upgrade over its current F-100-200 engine. All F-16C aircraft can now use the AMRAAM and LANTIRN targeting pods. The F-16C Block 40/42 is being upgraded with the ALR-56M radar warning receiver and an ALE-47 chaff and flare dispensing system. The F-16 Block 50/52 has (a) a more powerful engine, (b) a Mil-STD-1760 Bus for fully integrated weapons delivery capability including HARM and grow to the Joint Stand Off Weapon (JSOW) and Joint Direct Attack Munition (JDAM), (c) an upgraded and expanded cockpit display to improve the pilot's situational awareness and target acquisition and attack capability, (d) an improved data modem to pass HARM targeting data and air-to-ground targeting information, and (e) the ALR-56M advanced radar warning receiver to provide greatly improved sensitivity and processing capability for detection of advanced threat systems.[96]

USAF experts feel such upgrades are critical for the effective operation of the F-16, and that the pre-Gulf War F-16A/B is too limited in capability to keep in the USAF force structure. They feel that the Gulf War shows that even the F-16C/D was under-equipped with modern navigation, targeting, all-weather night navigation and targeting systems and advanced strike munitions, and has the potential to be a far more effective aircraft. Many feel, however, that test and evaluation of the F-16C Block 50/52 with the full LANTIRN navigation/targeting system indicates that many of its problems have already been solved with this upgrade.[97]

Upgrades to the F-15E are more limited, but they include equipping all F-15Es with the LANTIRN navigation and targeting pods, AMRAAM, and the ALR-56C radar warning receiver to provide improved sensitivity and processing capability for the detection of advanced threat systems. The F-15E is also being modified to improve the APG-70 radar and the isolation between the APG-70 radar, ALQ-135 jammer, and the ALR-56C to remove interference problems revealed during the Gulf War. While it does not directly affect strike/attack capabilities, the F-15C is being improved to include the AMRAAM, ALR-56C, AN/ALE chaff/flare dispenser, an improved version of the Joint Tactical Information Distribution System (JTIDS), and the capability to use a higher performance engine. These improvements will increase the beyond-visual-range capabilities of the F-15C in CAP and escort missions, and its survivability against surface-to-air defenses.[98]

The USAF is upgrading the mission planning systems, avionics, and attack munitions for its F-117 stealth strike aircraft. It is also planning to give its new F-22 air superiority fighter the same kind of stealth strike capabilities that exist on its F-117s. This strike capability would be limited to the equivalent of two 2,000 pound weapons, but the F-22 is a low observable aircraft with considerable range payload capability, and would carry smart air-to-surface missiles internally as well as enhance laser-guided ordnance.

Whether these upgrades will meet the all of the USAF's future needs is uncertain. Senior USAF officers who participated in the Gulf War feel that the USAF badly needs more F-15Es and that no upgrade of the F-16 can fully overcome the problems that stem from placing so heavy a work burden on a one-man aircraft, or from trying to use a multi-role fighter as an advanced strike/attack fighter. The USAF procured a total of 109 F-15Es to support two wings of the aircraft in combat formation. About 60 of the planes have to be used in a training, testing, and back-up role, and the USAF would like to purchase at least 30-50 more F-15Es.[99] Some USAF officers in senior command roles during the Gulf War believe that the USAF needs one-two more wings of F-15Es, even at the cost of cuts in F-16C/D or F-22 strength.

The US Marine Corps has drawn conclusions about the need to upgrade its F/A-18s that are similar to the conclusions that the USAF has drawn about its F-16C/Ds. A senior USMC officer described the need to upgrade the F/A-18CD as follows,[100]

> "One of the key lessons learned during the Gulf War was that we need increased density of our NAVFLIR and TGTFLIR pods. The NAVFLIR pod can be employed aboard our F/A-18Ds and later-model F/A-18C aircraft. The TGTFLIR can be employed even by our earlier model F/A-18A aircraft. When equipped with FLIR pods, all Marine Corps F/A-18 Squadrons have a capability to engage ground targets at night. This capability includes the ability to designate targets for laser-guided bombs...In the Gulf War, our density was only about one per three aircraft, whereas we would have been better served with a density about one per aircraft employed in the theater. Accordingly, our procurement plan objective for TGTFLIR is to put a TGTFLIR on each warfighting aircraft."

As a result, the USMC is providing its F/A-18C/Ds with much more advanced night and all-weather attack capability, retrofitting the APG-73 radar to provide growth for stand-off reconnaissance, and is providing better all-weather strike capability, the ability to laser designate targets for laser-guided bombs, targeting FLIR pods, navigation FLIR pods, cockpit lighting and displays for employing night vision goggles, and digital moving map systems.[101] It is also providing its F/A-18s with upgrades to the APG-65 radars on its F/A-

18s that will provide an all-weather stand-off imaging capability, and a strip mode radar coverage for reconnaissance purposes, as well as hardware and software changes that increase synthetic aperture radar capability, provide an inverse SAR capability for ship classification, and a fixed target track mode.[102]

The US Navy is also modifying its F/A-18s. In a statement on the lessons of the war, a senior naval officer noted that,[103]

> "In the area of strike warfare, the Navy is investing heavily in a family of precision guided munitions to provide us additional standoff capability and increased accuracy and lethality. That, coupled with modifications of our F/A-18 aircraft, has significantly increased our ability to influence the land war generally and our precision air-to-ground capability in particular. For example, when the *USS Theodore Roosevelt* deployed last year, her air wing could deliver three times the number of PGMs when compared during her capability during the Gulf War. Armed helicopters are another example of our intent to adjust naval capabilities."

Further, the US Navy is procuring a much more advanced version of the F/A-18 called the F-18E/F with greater range-payload, low observability or stealth features, more maneuverability and speed, and much more advanced avionics. The aircraft would come into service shortly after the year 2000, and will have a long-range strike mission capability of 1,050 kilometers without buddy refueling and 1,350 kilometers with it. It will have a 33% increase in internal fuel over the F-18C/D, a 25% larger wing, 35% higher thrust engines, and a 34" fuselage extension. It will incorporate provisions for the Airborne Self Protection Jammer (ASPJ) to reduce its dependence on mission packages of EW aircraft, and carry 4-6 chaff/flare dispensers versus 2 for the F-18C/D. It will also deploy the ALE-50 towed decoy. It will attempt to ease the pilot's workload by using a larger central liquid crystal display, and the control panel on the F-18C/Ds HUD will be replaced with a touch panel liquid display.[104]

The US Navy is also seeking to upgrade its F-14A fighters to improve both their air defense capabilities and to give them full capability as long-range strike fighters. It is unclear what level of capability will actually be funded, but this program is the result of the Navy's conclusion that even a much more advanced version of the F/A-18 may not have the range/payload to meet the demanding requirements of long range strike/attack missions for power projection. An upgraded F-14 would potentially provide a two man aircraft that could have very advanced attack avionics, a weapons officer to reduce pilot work load, and the range-payload to select low vulnerability penetration corridors, reduce refueling needs and any problems because of carrier distance from the target, and improve the number of aircraft on US carriers with offensive capability. The F-14 is, however, a relatively large aircraft and one that will require advanced EW protection. It is not clear that it and/or the F-18E/F can fully replace the A-6s being phased out of the US Navy.

The Marine Corps has concluded that all of its AV-8B Harriers needed FLIR, a digital moving map display, and radar/night attack upgrades, although it can only afford to upgrade part of its force.[105] It will remanufacture 73 aircraft to carry advanced APG-65 radars, NAVFLIR night vision goggles, an upgraded cockpit to reduce work-load and improved all weather/night capabilities, an upgraded Rolls-Royce F-402-RR-408 engine, and new wiring and avionics provisions for advanced air weapons like the Joint Stand-Off Munition (JSOW) and JDAM.[106]

A senior USMC officer described the lessons of the Gulf War relating to the AV-8B as follows,[107]

> "The AV-8B was originally designed to be a daylight only light attack aircraft. It employed an angle rate bombing system coupled with a laser spot tracker. Fifty-six of the later model aircraft are equipped for night attack with the capability to employ NAVFLIR, cockpit night vision lighting, and a digital moving map display. The more recent models, including those in production now -- were upgraded into a radar/night attack aircraft employing the APG-65 radar from the F/A-18 platform....In order to transition the existing AV-8B aircraft into a radar/night attack capable asset, the Department of the Navy has initiated a remanufacture program which will incorporate several safety changes that otherwise would not have been retrofitted, in addition to the radar/night attack upgrades...The objective...is to field an operational AV-8B Harrier II fleet in the next century that will be all night attack capable with a majority also radar/night capable."

While the details of these different US upgrades and force improvement programs do not apply directly to other air forces and types of aircraft, they do have important implications for the future of air warfare and other air forces. The US programs have a common thrust. The US services have concluded that the aircraft that won Desert Storm still did not have sufficient effectiveness to support a modern air campaign or AirLand battle. They feel that major advances are needed in strike/attack lethality, all-weather/night strike, stand-off, and penetration capabilities, and that the trade-off between sophistication and force strength favors sophistication.

Given the fact that the vast majority of the aircraft now in service in NATO and Third World air forces are substantially less capable than the aircraft the US deployed at the time of Desert Storm, such conclusions imply that such air forces have major operational limitations that will sharply restrict their effectiveness in future wars. Other air forces can, of course, carry out similar upgrade programs or acquire more advanced aircraft. One potential lesson of the Gulf War is that upgrading the platform can provide most of the capabilities needed for the "military revolution" in regional conflicts. At the same time, few air forces can afford to act on the lessons of the Gulf War as the US has, and move towards a fully precision-capable, night/all-weather capable force.

Munitions and Less Than Surgical Bombing

The transitional nature of offensive air technology in the Gulf War applies just as much to munitions as it does to C^4I/BM and aircraft. While television coverage during the Gulf War focused almost exclusively on the use of smart munitions, the Gulf War was fought using relatively "dumb" munitions. The land and sea-based missiles used in the Gulf War were employed in comparatively small numbers. The US Navy launched a total of 282 Tactical Land Attack Missiles (TLAM), and the last one was fired on February 1, 1991. The USAF only fired 35 Conventional Air-Launched Cruise Missiles (CALCM), and all were fired on the first day of the war. The US Army fired 21 missions of Army Tactical Missile Systems (ATACMS), some with more than one missile, and the US Navy fired seven SLAMs, but this is still a small number of systems.[108]

Table 7.4 shows that nearly 70% of the air munitions that the US used in the Kuwaiti Theater of Operations were unguided or "dumb" bombs, and 26% were area munitions. Laser-guided bombs and precision-guided weapons only made up 7% of all munitions used, and about 25% of these were helicopter fired anti-tank guided weapons. While the data in Table 7.4 only apply to US forces, the US flew 90% of all the strike/attack missions in the KTO in Desert Storm (well over 90% if rotary wing attack aircraft are counted).

The US dominated the use of precision air ordnance. If all weapons are counted, including those used in strategic bombing inside Iraq, the US dropped 89% of the 10,468 guided bombs that the Coalition used during the war, 95% of the 2,151 anti-radiation missiles (principally HARMs), and 99% of the 5,508 air-to-surface missiles (principally Maverick and Walleye).

Only two other Coalition air forces conducted air attacks with precision guided missiles. The RAF Dropped 1,126 guided bombs of all types, used 112 air-launched anti-radiation missiles (ALARMs), and did not launch any air-to-surface missiles. The French Air Force fired approximately 60 AS-30 air-to-surface missiles. These totals do not, however, include the anti-radiation missiles used in the air superiority campaign. These missiles were fired by British Tornadoes and US F-4Gs, F-18s, F-16s, A-7s, and EA-6Es.

Further, many of the "smart" munitions listed in Table 7.4 were not particularly "smart." The laser-guided bomb had been used in the Vietnam War, although twice as many laser-guided bombs were dropped in the six weeks of the Gulf War as in nine months in Vietnam. Smarter and longer range versions of such weapons -- like the AGM-130 -- with stand off ranges and improved ability to operate in poor weather were not yet deployed.[109] Some "smart" munitions also were not sufficiently lethal, particularly in penetrating hard targets -- a costly problem, given the price of guided munitions. This is why the USAF is examining more lethal warheads for many systems and the possibility of find a deep penetration, hard target warhead to supplement or replace the standard BLU-109 warhead on its laser-guided bombs, the AGM-130, and the new Joint Direct Attack Munition (JDAM).[110]

The US had already used about 4,000 air-to-surface missiles in Vietnam. While the 5,400 Maverick missiles used in the Gulf War had been greatly improved in terms of their guided and warhead design, they were still basically short-range line-of-sight systems based on early 1980s technology and most were delivered by the A-10, which could not fully utilize the range and night vision capabilities of the IIR Maverick in most missions.[111]

With the exception of the HARM and ALARM anti-radiation weapons, none of the air delivered attack weapons used in the Gulf War had a "fire and forget" capability. As has been discussed in the previous chapter, the laser-guided bomb is not a particularly sophisticated munition, and glides to a target that must be kept constantly illuminated with a laser. Most of the missiles employed had limited range and relatively unsophisticated seekers. None of the missiles or area weapons were sensor fused, or had more than the most limited "through the weather" track and kill capability. Stand-off ranges were generally limited, and none of the area munitions used in the Gulf War used advanced systems to continually update their trajectory for wind errors or had more than limited accuracy and lethality when delivered at high altitudes.[112]

The problems is using "dumb" ordnance have been discussed earlier, and it is scarcely surprising that the US has reacted to the lessons of the Gulf War by concluding that it must emphasize precision guided weapons in future conflicts. The US has already made major improvements in its smart weapons capabilities and plans to make further improvements in the future. A USAF general has described these changes as follows:

> "Overall, the Air Force, Army, Navy, and Marine Corps now posses four times the precision weapons delivery capability they had at the end of Desert Storm. In the future, 100% of Air Force bomb droppers will be precision weapons capable...(Advanced) munitions combined with this fleet of precision capable

aircraft will bring about a revolution in the ability of air power to project force on the modern battlefield."[113]

Interviews indicate that the British and French air forces have drawn the same conclusions, but have not been able to get as much funding to react to these lessons. In broad terms, however, it is important to note that the US, and any Western or Coalition involving the US, will never fight another war using air power with the kind of aircraft, C^4/BM, or munitions used in the Gulf War.

Emphasizing smart weapons does not mean, however, that the US or any other air force is likely to abandon "dumb" bombs. Once again, "dumb" ordinance is often the most effective way of attacking area targets, and the purpose of air power is not necessarily killing. Presence -- knowing that aircraft are in the area or loitering near the battlefield or a target area -- can severely limit maneuver and movement and affect morale. The shock effect of exploding ordnance can disrupt operation, and affect morale and unit cohesion.

The cost trade-offs between ordnance can also be of critical importance. Many smart weapons are more expensive that the targets they are used against -- some USAF planners estimate than "smart weapons cost an average of ten times as much per pound as "dumb" weapons -- and Iraq often paid less for the weapons systems that the Coalition attacked than the Coalition paid for each of the precision weapons it used to try to destroy them. While only 7% of the Coalition strike/attack missions used precision weapons, this figure looks very different in dollar terms. The US estimated after the war that the offensive air munitions it used during the Gulf War, less anti-radiation missiles, cost a total of $1,290.3 billion. The 209,940 "dumb" bombs in this total cost $432 million or 33%. The 9,473 laser-guided bombs cost $307.6 million, or 24%. The 5,647 air-to-surface missiles cost $550.8 million, or 43%.[114]

Seen from this perspective, 67% of the investment in air ordnance went into delivering 7% of the weapons. Put differently, the average "dumb" weapon cost $2,057, while the average laser-guided bomb cost $32,470, and the average air-to-surface missile cost $97,538. If the Coalition had attempted to use nothing but precision weapons, with the same mix of laser-guided bombs and missiles, it would have cost an average of about $54,200 per weapon, and a total of $11.4 billion. While far fewer smart weapons would actually have been required to achieve the same effect, finding the right trade-off between very smart, smart, and "dumb" ordnance, and between very sophisticated, sophisticated, and moderate capability aircraft is an extremely complicated challenge. The Gulf War points towards more precision and more sophistication, but it does not provide a clear basis for determining the specific mix any given force needs or can afford. One in-house USAF study did indicate, however, that the optimal ratio of "smart" to "dumb" munitions would have been 30% to 70%.[115]

Table 7.4

Key Munitions Used by US Aircraft in the KTO

Munitions Type	Air Force	Navy	Marine Corps	Army Number	Total Percent	
Unguided General Purpose Bombs						
Mk-82 (500 pounds)	59,884	10,941	6,828	-	77,683	35%
Mark-83 (1,000 pounds)	-	10,125	8,893	-	19,081	9%
Mark-84 (2,000 pounds)	10,467	971	751	-	12,289	6%
Mark-117 (B-52)	43,435	-	-	-	43,435	20%
	113,786	22,037	16,472		152,488	69%
Unguided Special Purpose Bombs						
CBU-52 fragmentation bomb **	17,831	-	-	-	17,831	8%
CBU-87 combined effects munition	10,035	-	-	-	10,035	5%
CBU-89/78 Gator***	1,105	148	61	-	1,314	0.6%
Mk-20 Rockeye **	5,345	6,814	15,828	-	27,987	13%
	34,316	6,962	15,889		57,167	26%
Laser Guided Bombs						
GBU-12 (laser Mk-82)	4,086	-	-	-	4,086	2%
Air-to-Surface Missiles						
AGM-114 Hellfire	-	30	159	2,879	3,065	1.4%
AGM-65 Maverick	5,255	-	41	-	5,296	2.4%
BGM--71 TOW	-	-	283	-	283	0.01%
	5,255	30	483	2,879	8,644	4%
Total Munitions of All Types	125,999	28,673	32,404	2,879	222,385	100%
(% of Total)	57%	13%	15%	1%	100%	

*Does not include other types of laser-guided and special purpose bombs and air-to-surface missiles used largely outside of theater. Percentages are rounded and may not total 100%. Data for TOW include missiles used by both Navy and Marine Corps.
**Primarily targeted on artillery
***Primarily targeted on armor
Source: Adapted from Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 103.

The Bombs, Rockets and Guns Used in the Gulf War

Some of these issues become clearer when one examines the performance characteristics of the specific missiles and munitions used in the Gulf War, and what is known about their relative effectiveness. The performance characteristics of these weapons are summarized in Table 7.5. Like Coalition aircraft they represent a wide range of different levels of technological sophistication and mix of new and old technologies.

It is difficult to draw detailed lessons about the relative lethality of the weapons shown in Table 7.5. As has been discussed in Chapter Five, and earlier in this chapter, it is virtually impossible to find meaningful battle damage assessment data on any given type of missile or munition. Such data have been published -- some of it rushed into print right after the war and some it published to propagandize a given service, weapons system, or procurement concept. The fact is, however, that they cannot be validated in meaningful analytic terms.

In most cases, the data base is not adequate to make accurate judgments. For example, battlefield studies after the war had access to only 163 tanks, or 6% of the total of 2,633 estimated to be destroyed or abandoned in the KTO. Out of this sample, only 10-20% had been hit by air munitions, and 78 of the 183 had not been hit by any munition at all.[116] USAF studies, however, claim that about 41% were hit by air munitions.[117] At the same time, estimates of effectiveness that were made on the basis of pilot or operator reports, or using limited samples of recorded imagery, proved to have little statistical value upon close examination. In some cases, carefully selected samples are used where the data only refer to weapons operating under ideal or carefully selected conditions.

In other cases, effectiveness data do not mean what they appear to mean. Terms like "hit" are used in ways where they seem to imply a direct hit, although "hit" may actually be defined as a case where observation or recorded data simply indicates that the weapon went near the target. Even when "hits" could be physically shown to be real hits, which involved a small fraction of the cases for any weapons system used in Desert Storm, the term "hit" often had nothing to do with the term "kill". In many cases, there were no conclusive indications that a "hit" produced the desired damage effect. In many cases, it was often difficult to be certain that air strikes did not attack a target that had already been hit or "killed" by other means. In other cases, damage to a building or facility might or might not have achieved the intended or lasting damage, and "kills" of combat equipment could not be distinguished from damage that might be repairable.

The Department of the Defense summarizes these problems in assessing the impact of laser-guided bombs, and other precision guided ordnance, by stating that,[118]

> "Although there is a lack of comprehensive BDA data, LGBs appear to have performed well. After action reports indicate that LGBs were effective....However, while post war examination and analysis of Iraqi targets confirms the effectiveness of LGBs, battle damage assessment by reconnaissance assets...was difficult to determine. LGBs would often penetrate into the facility leaving only a small penetration hole. Although interiors were determined to have been destroyed or severely damaged, further data on precision guided ordnance is unavailable."

Interviews, and reviews of limited samples of data, also reveal problems in the analytic controls the US applied to validating the data, analyzing and resolving inconsistencies, and defining effectiveness. They also reveal many instances where a lack of observable activity led to the assumption of a "kill" when such evidence only indicates suppression and other cases where a lack of activity was assumed without validating reconnaissance data. One clear lesson of Desert Storm, which is discussed again in later chapters, is that far more demanding and standardized criteria need to be applied to estimates of weapons effectiveness. Further, a large set of data is simply missing. The Coalition deliberately rejected any effort to estimate Iraqi civilian and military killed and wounded, and to estimate the detailed impact of collateral damage.

These problems in measuring the effectiveness of individual air munitions do not, of course, mean that air power was ineffective, or that some munitions were not much more effective than others. Airpower clearly did tremendous damage to Iraq's military forces and capabilities, and one does not have to precisely measure a war to win it.

US planners have also drawn lessons from their experience in delivering air munitions during Desert Storm that are almost certainly valid in spite of such problems in effectiveness reporting. One such lessons is the need to develop methods of attack and delivery that are more accurate at altitudes about 10,000-15,000 feet. Another is the need to upgrade the guidance systems on laser-guided bombs to increased their range and a reliability -- a trend reflected in Table 7.5. A third is the need for conventional deep shelter killing munitions that can be linked to the use of unattended ground sonars to "map" the shelter or underground facility before it is attacked to ensure an effective level of destruction. A third is the need for more lethal and self-guiding submunitions. A fourth is the need to improve the fusing in many conventional bombs and submunitions, and finally, the need to develop lower cost glide bomb conversions to provide cheap stand-off capability.[119]

Table 7.5

Major Guided and Unguided Bombs Used in Desert Storm

Unguided or "Dumb " Bombs

o *Mark-82 General Purpose Free Fall 500 pound bomb:* Unguided bomb with a 192 pound explosive charge equipped with a mechanical nose and tail fuse, or the FMU-113 air-burst radar proximity fuse. The primary weapon used by the B-52, and also used by F-16s, F/A-18s, and AV-8Bs. A total of 77,653 were dropped during the war. The CEP of a Mark-84 using an optimal delivery profile and full computer assisted bombing is in excess of 160 feet. Operational CEPs usually exceed 300 feet. Area lethality is limited. Direct hit lethality against medium sized building is moderate. Reliability of denotation was high.

o *Mark-83 General Purpose Free Fall 1,000 pound bomb:* Unguided bomb with a 416 pound explosive charge equipped with a mechanical tail fuse, or radar proximity fuse. The CEP of a Mark-83 using an optimal delivery profile and full computer assisted bombing is in excess of 160 feet.

Operational CEPs usually exceed 300 feet. Area lethality is limited to moderate. Direct hit lethality against medium sized building is moderate to high. Reliability of denotation was high. Used largely by the Marine Corps to drop 19,018 weapons in close air support and battlefield air interdiction missions.

o *Mark-84 General Purpose Free Fall 2,000 pound bomb:* Unguided bomb with a 945 pound explosive charge equipped with a mechanical nose and tail fuse, or the FMU-113 air-burst radar proximity fuse. The CEP of a Mark-84 using an optimal delivery profile and full computer assisted bombing is in excess of 160 feet. Operational CEPs usually exceed 300 feet. Area lethality is limited to moderate. Direct hit lethality against medium sized building is high. Reliability of denotation was high. Some 12,189 were used by F-15Es, F-16s, and F-111Fs. About 1,000 were used by the Marine Corps in close air support and battlefield air interdiction missions.

o *Mark-117 General Purpose Free Fall 750 pound bomb:* Unguided bomb equipped with a mechanical nose and tail fuse. The CEP of a Mark-117 using an optimal delivery profile and full computer assisted bombing is in excess of 160 feet. Operational CEPs usually exceed 300 feet. Area lethality is limited. Direct hit lethality against medium sized building is high. Reliability of denotation was high. Some 43,345 were used, and virtually all were dropped by B-52s.

o *UK-1000*. A British 1,000 pound bomb that can be carried by the B-52, Tornado, Buccaneer or Jaguar. 4,372 were delivered as unguided weapons, principally by the Tornado.

Unguided Cluster Bombs

o *CBU-52 Cluster Bomb:* Uses the SUU-30 dispenser, a metal cylinder divided longitudinally. One-half have contains a strong back section that provides for forced ejection and sway bracing. The two halves lock together. Four cast aluminum fins are attached at a 90 degree angle to the aft end of the dispenser and are canted at 1.25 degrees to impart spin-stabilized flight. When released from the aircraft, the arming wire/lanyard initiates the fuse arming and unlocks the forward end of the dispenser. Ram air action on the dispenser forces the two halves apart, instantaneously dispensing the payload and allowing the bomblets to spin-arm and self dispense. The bomb has 220 anti-material and antipersonnel bomblets. It weighs 785 pounds and can be used with a variety of proximity fuses or a timed mechanical fuse. The submunition is a 3.5 spherical bomblet weighing 2.75 pounds with a 0.65 pound high explosive warhead. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. Area lethality is moderate. Direct hit lethality against armor is limited to moderate. Reliability of denotation was moderate to high. A total of 17,831 CBU-52/58/71 cluster bombs were used.

o *CBU-58 Cluster Bomb:* A larger version of the CBU-52 free fall bomb which also uses the SUU-30 dispenser The bomb has 650 bomblets with 5 gram incendiary titanium pellets. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. Area lethality is moderate but depends on flammability. Direct hit lethality against armor is very limited. Reliability of denotation was moderate to high.

o *CBU-71 Cluster Bomb:* A larger version of the CBU-52 free fall bomb which also uses the SUU-30 dispenser The bomb has 650 bomblets with both incendiary and fragmentation kill mechanisms. Both have a time delay fuse which detonates at random times after impact. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. Area lethality is moderate. Direct hit lethality against armor is very limited. Reliability of denotation was moderate.

o *CBU-78 Gator:* a tri-service 500 pound free fall bomb using 15 anti-personnel and 45 anti-armor land mines for delivery adjacent to Iraqi forces or to disrupt operations. The mines can be triggered by disturbance/anti-disturbance devices, by a magnetic field for the anti-tank mine, and by a trip line for anti-personnel mines. The is a self-destruct time set option. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. The Navy and Marine Corps dropped 209 weapons.

o *CBU-87 Combined Effects Munition (CEM):* A 202 bomblet free-fall weapon with a SUU-65 munitions dispenser an optional proximity sensor. The bomblet case uses scored steel designed to break into 300 fragments to attack personnel and armor. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. The USAF dropped 10,035 weapons.

o *CBU-89 Gator:* A free-fall bomb using a SUU-64 tactical munitions dispenser with 22 anti-personnel and 72 anti-armor land mines with an optional proximity sensor. Mine arming begins when the dispenser opens. Mine detonation is initiated by target detection, mine disturbance, low battery voltage, and a self-destruct time out. The anti-tank mine is magnetic sensing. The anti-personnel weapon uses trip wires. The mines can be triggered by disturbance/anti-disturbance devices, by a magnetic field for the anti-tank mine, and by a trip line for anti-personnel mines. The is a self-destruct time set option. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. The USAF dropped 1,105 weapons.

o *CBU-87 Combined Effects Munition (CEM):* A 202 bomblet free-fall weapon with a SUU-65 munitions dispenser an optional proximity sensor. The bomblet case uses scored steel designed to break into 300 fragments to attack personnel and armor. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. The USAF dropped 10,035 weapons.

o *Mark-20 Rockeye:* A free-fall weapon consisting of a clam shell dispenser, time mechanical fuse, and 247 dual purpose armor piercing shaped charge bomblets. Each bomblet weighs 1.32 pounds and has a 0,4 pound high explosive shaped charge which produces up to 250,000 psi at the point of impact, capable of penetrating 7.5 inches of armor. It is most efficient in attacking area targets with penetration is needed to kill. Rockeye is designed for low altitude delivery and must be preset for precise delivery altitudes and profiles. Dispensers often opened at the wrong altitude, affected bomb density, and greatly decreased the probability of a kill. The USMC used the weapon extensively against armor, artillery, and anti-personnel targets. It dropped 15,828 weapons, the USAF dropped 5,345, and the Navy dropped 6,814. Rockeye had an extraordinarily high dud rate during the Gulf War.

o *CBU-59 APAM:* An anti-personnel and anti material weapon developed as a successor to Rockeye. It uses the same dispenser but has 717 BLU-77 bomblets. It has anti-personnel and incendiary effects as well as anti-armor effects. CEP is normally in excess of 200 feet. Operational CEPs usually exceed 300-400 feet. 186 were used.

o *BL-755:* A medium weight British weapon with 147 anti-tank fragmentation bomblets. The dispenser opens after a preselected time delay, and the ejected bomblets have shaped charge warheads that can penetrate at least 9,84 inches of armor and explode on impact. They are retarded to increase their angle of attack on impact, and also scatter a cloud of at least 2,000 lethal fragments. Jaguars used eight BL-755s against Iraqi ground targets.

Fuel-Air Explosives

o CBU-72: A 550 pound cluster bomb containing three fuel-air explosive submunitions. Each weighs approximately 100 pounds, and contains 75 pounds of ethylene oxide with air burst fusing set for 30 feet. An aerosol close about 60 feet in diameter and 8 feet thick is created and laser ignited. The resulting explosion creates a high uniform overpressure useful for attacking soft targets. The USMC dropped all 254 CBU-72s used in the Gulf War, primarily against trenches and mine fields. While it produced some secondary mine explosions, its lethality was limited and its impact was largely psychological.

Laser Guided or "Smart " Bombs

o *GBU-10:* All laser-guided weapons use guidance kits and regular bombs. The guidance kit consists of a computer control group, guidance canards to attach to the front of the warhead to provide steering commands, and a wing assembly attached to the rear to provide lift. LGBs are maneuverable free fall weapons with an internal semi-active guidance system that detects laser energy and guides the weapon towards a laser illuminated target. The range is determined by the speed and attitude of the delivering aircraft. The flight path is originally ballistic and relies on the aircraft to aim the bomb in the right direction. It transitions to a guided glide path as the bomb attempts to align its vector with the laser illuminated target. The GBU-10 adds a laser guidance package to a Mark-84 1,000 pound bomb. Optimal hit probability depended on whether the weapon had the Paveway I guidance with fixed wings or the Paveway II guidance with folding wings, improved detector optics and sensitivity, reduced thermal battery delay after release, a 30% greater field of view, and increased maximum canard deflection. An aircraft using the bomb and Paveway II under ideal delivery and weather conditions could achieve up to 80% hits within 10-30 feet of the illuminated spot. Operational average hit probability was probably 20% or less, but insufficient data are available to do more than guess. F-111Fs dropped over one-third of the 2,637 used, and F-117s, F-15Es and USMC and Navy aircraft dropped the rest.

o *GBU-10I or BLU-109/B (I-2000):* An improved 1,925 pound bomb with a 550 pound warhead that is designed as a penetrating weapon with a forward fuse well. It is relatively slim and its skin is a single-piece, forged warhead casing of 1 inch, high grade steel that much harder than the skin of a regular Mark-84. The BLU-109/B was always mated with a laser guidance kit to form a laser-guided bomb in Desert Storm. Its usual tail fuse is a mechanical electrical fuse. Optimal hit probability under ideal delivery and weather conditions was up to 80%. Operational average hit probability was probably 20% or less, but insufficient data are available to do more than guess. Area lethality is limited. Direct hit lethality against medium sized building is high. Reliability of denotation was high. F-111Fs and F-15Es used this weapon against bridges, Scud targets, C^4I targets, and bunkers.

o *GBU-12:* The GBU-12 adds a laser guidance package to a Mark-82 500 pound bomb. Optimal hit probability under ideal delivery and weather conditions was up to 80%. Operational average hit probability was probably 20% or less, but insufficient data are available to do more than guess. It was a key anti-tank weapon and F-111Fs dropped more than half of the 4,493 used. F-1-15Es and USMC and Navy A-6E aircraft dropped the rest, largely against tanks.

o *GBU-16:* The GBU-16 adds a laser guidance package to a Mark-83 1,000 pound bomb. Optimal hit probability under ideal delivery and weather conditions was up to 80%. Operational average hit probability was probably 20% or less, but insufficient data are available to do more than guess. All 219 GBU-16s were dropped by self-designating A-6Es.

o *GBU-24:* The GBU-24 adds a laser guidance package to either a Mark-84 or BLU-109 bomb modified with the Paveway III low-level laser-guided bomb kit, and uses proportional guidance rather than the guidance used in the Paveway II. It sharply improves the performance envelope over the Paveway II because of superior maneuverability, seeker sensitivity and field of view.. All 1,181 GBU-24s were dropped by F-111Fs. Operational hit probability (within 10-20 feet of illuminated spot) may have approached 30%.

o *GBU-27:* The GBU-27 adds a laser guidance package to a BLU-109 bomb modified with the Paveway III low-level laser-guided bomb kit, and the smaller GBU-10 tail assembly needed for internal carriage. All 739 were used by the F-117. Operational hit probability (within 10-20 feet of illuminated spot) may have approached 30%.

o *UK-1000*. A British 1,000 pound bomb that can be carried by the B-52, Tornado, Buccaneer or Jaguar. 1,079 were delivered as laser-guided weapons, principally by the Tornado.

Special Purpose Bombs

o *JP-233:* A heavy airfield attack weapon dispenser with 30 concrete penetrating and 215 area-denial bomblets. The concrete penetrating bomblets are parachute retarded and fall to the ground in a nearly vertical trajectory. A constant fuse sets of a charge to open a hole through which a second charge is fired to penetrate, detonate, and create a crater. The area denial weapon is fitted with disturbance fuses and variable self-destruct fuses to inhibit repair activity. Tornadoes delivered 106 during the war.

o *GBU-15:* An unpowered stand-off glide bomb with remote data link guidance and an electro-optical or infrared sensor in the nose. It allows automatic or manual delivery of the Mark 84 at ranges longer than those of the laser-guided bomb because the target does not have to be illuminated before it is released. The GBU-15 is controlled by a datalink system, and the operator locates the target area and aim point by observing the video transmitted by the weapon. A total of 71 weapons were dropped by F-111Fs, and this weapon was used to destroy the oil manifolds on storage tanks in Kuwait and keep oil from dripping into the Gulf.

o *BLU-82:* A 15,000 pound bomb originally designed to clear helicopter land zones in Vietnam. The warhead contains 12,600 pounds of GSX slurry and is detonated just above ground level, where it produces overpressures of 1,000 psi. It was initially used to try to clear mines, but no data are available to judge its effectiveness. It was later dropped for psychological effect.

o *GBU-82:* A special penetrating weapon designed to attack deep underground Iraqi command centers. It uses modified artillery tubes. It is 19 feet long, 14.5 inches in diameter, weighs 4,637 pounds, and contains 630 pounds of high explosive. It is fitted with GBU-27 laser-guided bomb kits. F-111Fs dropped two such bombs in Desert Storm. One bomb hit its target and the aircraft recorded an outpouring of smoke 6 seconds after impact.

o *Mark 77:* A napalm canister munition. The Marine Corps dropped a total of 500, primarily using AV-8Bs , which dropped the weapons at low altitude to ignite Iraq's oil filled trenches.

Source: Adapted by the author from interviews, and from Eliot A. Cohen, Gulf War Air Power Survey: Volume IV, Part I, pp. 66-84; Department of Defense, Conduct of the Persian Gulf War: Final Report, Annex T, pp. T-178 to T-102.

Table 7.5 does not describe the aircraft rockets and guns used during Desert Storm, but some data are available on their effectiveness. Only limited use was made of rockets. British Jaguar aircraft used 32 CRV-7 rocket pods with 19 rockets each, for a total of 608 rockets. These are special flat trajectory weapons and were used largely against the Iraqi Navy. Marine F/A-18 forward air controllers used 2.75 inch phosphorous rockets to mark targets, and USAF OA-10 aircraft used roughly 3,000 2.75" rockets to mark targets. The only extensive use of rockets against ground targets was by USMC AH-1s, which fired about 4,000 rockets, half to mark targets and half against Iraqi personnel and vehicles.

Guns were used more extensively to mark targets and attack vehicles and personnel. A-10s were not always able to close within gun range of armored vehicles because of Iraqi air defenses but they still fired nearly 1,000,000 rounds of 30 mm shells from their GAU-8 Gatling guns, and OA-10s fired 16,000 more rounds of high explosive incendiary shells to mark targets. AC-130 gunships used their 105mm guns, 40 mm gun, and twin 20 mm guns to attack a variety of targets within the KTO. AV-8Bs conducted strafing missions, AH-64 Apaches used their 30 mm guns against armored and other targets, and armed helicopters used guns in close support missions.

Only anecdotal claims are available on the effect of aircraft gunfire, but its importance should not be disregarded. Strafing has historically had a major impact on enemy morale and on killing soft targets. A number of the weapons left by the Iraqi Army on the battlefield also exhibited damage from aircraft cannon.[120]

The Guided Missiles Used in the Gulf War

Table 7.6 summarizes the performance characteristics and lethality of the guided missiles that the Coalition used in the strategic and air campaigns during Desert Storm, and it is interesting to note that nearly 30% of these missiles were launched by rotary-wing US Army and USMC aircraft. Like the laser-guided bombs discussed earlier, it is clear that many of these weapons proved to be highly lethal during Desert Storm. These weapons include the Tomahawk, Maverick, TOW, and Hellfire. Other weapons were little more than experimental test platforms with uncertain effectiveness and lethality: These weapons include the CALCM, SLAM, and the Skipper. One weapon, the Walleye, demonstrated the fact that clear weather high crew workload weapons have only limited value in modern mid to high intensity warfare.

It is not possible to quantify these levels of effectiveness. The same general problems apply to assessing the specific effectiveness of given guided missiles that apply to bombs. The data simply do not support detailed judgments about kill probabilities. For example, Maverick was said after the war to have a "success rate (successful launch and guidance to target) (of) approximately 85 to 90 percent."[121] Quite aside from the fact this statement says nothing about whether the weapon actually hit or killed the target, it has since become clear from examination of claimed versus actual ground kills that Maverick's combat effectiveness was a fraction of this figure.

US air planners found early in Desert Storm that aircraft like the F-16C/D and F/A-18 had problems in acquiring targets and operating precision weapons against many targets. The A-10 was the only aircraft capable of lingering over the battlefield and taking the time to use Maverick to acquire a target.[122] Even A-10 pilots, however, faced a difficult cockpit workload problem and were forced to fly within 2-4 miles of their target.

Analyzing the effectiveness of the Tomahawk or TLAM presents serious problems because it is so hard to relate any of the 85% hit rate claims that the US Navy made after the war to the system's actual effectiveness in hitting the target and the damage it did.[123] As Chapter Ten discusses in detail, the Navy successfully launched 282 out of 288 missiles, 64% of which were launched during the first 48 hours. This was a 92% successful launch rate. However, the Center for Naval Analysis later discovered a far lower success rate for the system than the Navy first claimed. This study, never been released by interviews, indicates that about 50% of the TLAMs fired during the Gulf War hit within 10 meters of their target, and about 7-15% probably inflicted meaningful damage on the target.[124]

The lesson to be drawn from these uncertainties is scarcely that weapons can only be effective if precise data are available on their performance. One lesson that is valid, however, is that the "Nintendo" and "Teflon"-like images of precision strikes that often dominated media coverage of the war were not representative of the real world performance of air power, and that exaggerated technical claims or "cheer leading" the US military services sometimes indulged in after the war painted an unrealistic picture of effectiveness, and ultimately failed to serve the interests of the American military.

Exaggerating weapons effectiveness has given the public and many political leaders a misleading picture of war, its human costs, and its real world risks. It has understated the value of combined arms and combined operations, and of highly trained, motivated, and combat ready military personnel -- lessons that are ultimately more valuable than the impact of "glamour" technologies.[125] It has partially discredited those who made exaggerated claims for what were real successes, it has confused the ability to learn valid technical lessons for the war, and it helped produce extensive negative publicity when only 67% of 24 improved Tomahawks hit an Iraqi intelligence facility in a June 26, 1991 strike on Baghdad.[126] It is a fact that truth can sometimes be the first casualty of war, but this is not a reasons for making it a casualty of peace.

A second lesson, and one the US had recognized before Desert Storm, is that precision is not enough. Weapons must increasingly have stand-off ranges, be smarter and more flexible, be usable in a wide range of light and weather conditions, and have more lethality. The Tomahawk, for example, is undergoing two sets of improvements. The revised Block III will provide quicker and more accurate theater mission planning, mapping, imagery; a variable fuse capability; a limited hard target kill capability with the WDU-36 warhead; increased accuracy and easier route planning with GPS targeting and constant navigational updates; a 700 pound titanium encased warhead with greater explosive power; and extended range by using a light warhead and new engine. A Block IV is in development which would allow the TLAM to achieve a CEP as accurate as three meters using aircraft or UAV control of the missile, new sensors and seekers that may be able to hit moving targets, a better hard target penetrator warhead, and additional range.[127]

More generally, the US is seeking to equip its air forces with systems like the Sensor Fused Weapon, and a dispenser-delivered guided wide-area weapon with smart or homing submunitions capable of destroying multiple armored vehicles. The Joint Stand-off Weapon (JSOW) will provide a precision stand-off, all-weather capability to attack known area locations from stand-off ranges. The BLU-108 variant will deliver the Skeet anti-armor submunition used in the Sensor Fused Weapon. The Joint Direct Attack Munition will provide high precise attack capabilities using data from the GPS without dependence on laser designating capability. The Tri-Service Standoff Attack Missile (TSSAM) will allow non-stealthy aircraft to attack highly defended targets from long range, and the Wind Corrected Munitions Dispenser (WCMD) -- which uses an inertial navigation system and continuously updates bomb trajectory to compensate for wind errors -- with allow fighters and bombers to attack ground forces from high altitude while avoiding vulnerability to short range surface-to-air missiles and anti-aircraft guns. The need for weapons with all these capabilities is a valid lesson of the war.[128]

Table 7.6

Major Guided Missiles Used in Desert Storm - Part One

Cruise Missiles

o *BGM-109 Tomahawk:* The Tomahawk or TLAM was carried and delivered by surface ships and submarines. It has a range of approximately 700 nautical miles, a weight of 3,200 pounds, an air breathing turbofan engine, an attached solid propellant booster. The booster launches the missile until the turbofan takes over for the cruise portion of flight when the weapon flies at altitudes of 100-300 feet.
The weapon use a guidance system that navigates by comparing stored digital ground images with actual ground points along its flight path. The overland route is mapped out before the mission by theater planners using data from the Defense Mapping Agency. Programming the missile's flight from ship to shore is done aboard ship. Initial guidance is provides a terrain-contour-matching system that compares a stored map reference with the actual terrain to determine the missile's position and then provides course corrections. The final guidance is provided a digitized scene matching area correlation (DSMAC) system. This system compares views of the ground below the missile with digitized pictures in its memory and directs course correction. The TLAM has a very small radar cross section and emits little infrared heat from its engine. If the missile functions perfectly and is properly programmed, it can function in most weather and any visibility conditions with little chance of detection or shoot down and low collateral damage.
Two types were used during Desert Storm. The C model had a unitary 1,000 pound high explosive blast and fragmentation warhead. The D model had a cluster warhead containing 166 bomblets in 24 packages which can be dispensed to attack multiple targets. The Navy fired 288-298 Tomahawks, and initially claimed that 85% of the missiles hit their targets. TLAMs were directed against chemical and nuclear weapons facilities, surface-to-air missile sites, command and control centers, and Saddam Hussein's presidential palace.

o *Conventional Air-Launched Cruise Missals (CALCM):* A wartime conversion of the nuclear armed ALCM developed to give the B-52 a stand-off capability. It is similar in some ways to the TLAM, and uses a turbofan engine, but uses GPS and INS guidance. It is 20 feet, 9 inches long, has a 12 foot wingspan, flies at 500 mph, and has a blast fragmentation warhead. It flies to its target using a GPS receiver, and is programmed to fly at a constant altitude. Seven B-52G bombers launched 35 missiles at targets in Iraq on the first night of the war, including power generation and transmission facilities and military communication nodes. All missiles transitioned successfully to cruise flight, but no BDA data are available on their effectiveness or indicate that they achieved unique damage affects against their targets.[129]

Fixed Wing Air-to-Ground Missiles

o *AGM-48E Stand-off Land Attack Missiles (SLAM):* US Navy A-6E and F/A-18s fired seven developmental SLAM missiles. The SLAM uses the airframe, turbojet power plant, and the 488 pound high explosive warhead and proximity or impact delay fuse of the Harpoon anti-ship missile, the imaging infrared (IIR) terminal guidance capability of the AGM-65D Maverick, and datalink capability of the AGM-62 Walleye glide bomb and a GPS receiver. The seeker video is transmitted to the system operator who recognizes, acquires, and selects the specific aim point on the target. The SLAMs are deployed from carrier-based aircraft and use targeting data loaded into the missile before take-off. They use GPS data, mid-course guidance assistance, and video aim point control to provide a precision strike capability that locks on the target so the missile is autonomous after lock-on and minimizes collateral damage. The SLAM's data link system allows the missile to be launched by one aircraft and to be guided by another aircraft, normally positioned out of danger more than 60 miles away from the target. The AAW-9 data link pod used in the war was unreliable and is being replaced by the AAQ-13 which is now entering the fleet. The continuing video tracking did aid in damage assessment.

Table 7.6

Major Guided Missiles Used in Desert Storm - Part Two

o *AGM-65 Maverick:* A 500 pound rocket propelled air-to-ground missile with a range of up to 15 miles, although most missiles were fired at ranges of 3.5 miles or less. The Maverick comes in four models. The A and B have electro-optical and the D and G have infrared guidance. All must acquire their targets within seeker range before launch. All are then guided autonomously, providing a launch and leave capability. The infrared seeker was added to provide clear night and degraded visibility attack range, and infrared missiles can also be slaved to on-board sensors. A dual field of view capability was added to the infrared versions to provide wide fields of view for target acquisition and arrow fields of view for improved target acquisition and increased launch range. The A/B/C versions have a 125 pound shaped charge warhead for use against armored vehicles, bunkers, boats, radar vans, and small hard targets.
The AGM-65G has a larger kinetic energy penetrator and a 300 pound blast fragmentation warhead designed to attack unusually shaped targets such as hangers, bridges, and ships and provide more lethality against tanks and bunkers. An additional force correlate mode allows this missile to strike a specific aim point that differs from the centroid of the target.
An aircraft can carry up to three AGM-65A/B/Ds on a LAU-88 launcher. Only one AGM-65F can be carried on a single-rail LAU-117 launcher. A total of 5,255 AGM-65A/B/C/Gs were fired, and over 4,000-4,800 by the A-10.[130] They were the primary tank plinking weapon used by aircraft without an self-designation LGB capability. Most targets were armor acquired by spotter aircraft operating in a given kill box and then attacked by A-10s.

o *AGM-65E Maverick:* A semi-active laser-guided solid rocket propelled standoff weapon similar to other Mavericks, but with a heavy warhead and laser seeker. It is a day night weapon designed for close support and to home in on ground designated targets. It has a 300 pound blast fragmentation warhead with a cockpit selectable fuse. The Marine Corps used 36. The weapon had serious problems, many were later traced back to the battery for the laser designator used on the ground.

Fixed Wing Long Range Guided Glide Bombs

o *AGM-62B Walleye:* A daytime clear-weather guided bomb used against large targets. It is an electro-optical pound weapon with a 2,015 pound warhead with a linearly shaped charge that uses proportional guidance to glide to the target. A two-way radio-frequency datalink allows the pilot in the release aircraft or another aircraft to control the weapon using a joystick. Wider fins can be fitted to extend range. A total of 133 were used by the US Navy.

o *AGM-123A Skipper:* A day or night medium range standoff glide bomb directed to the target by reflected laser energy. It uses an AGM-45 Shrike solid propellant rock motor, a Paveway II seeker and air foil group, and a Mark-83 bomb. It doubles the range of the present Paveway II series of munitions The Navy and Marine Corps used 12 on an experimental basis during Desert Storm.

Rotary Wing Air-to Surface Missiles

o *BGM-71 Tow (Tube-Launched, Optically Tracked, Wire Guided):* An anti-tank weapon using an a shaped charge anti-armor warhead with a 10 pound high explosive charge. Marine Corps and US Army helicopters operating from ships fired 293 during Desert Storm.

o *AGM-114 Hellfire (Heliborne-Launched Fire and Forget):* An anti-armor air-to-surface missile with a semi-active seeker which receives and homes in on reflected coded laser energy illuminated by a laser remote from the missile. It is not limited to direct line-of-sight attack, allowing launch without a seeker lock-on to reduce helicopter vulnerability. The AH-64 Apache fired all but 89 of 3,000 Hellfires expended during Desert Storm and it was the Army's singe largest tank killer.

Source: Adapted by the author from interviews, and from Eliot A. Cohen, Gulf War Air Power Survey: Volume IV, Part I, pp. 77-81; Office of the Chief of Naval Operations, The United States Navy in Desert Shield, Desert Storm, Department of the Navy, May 15, 1991, pp. 47-49; Aviation Week, January 28, 1991, p. 29; Christopher Gant, World Encyclopedia of Modern Air Weapons, 1988, p. 287; Department of Defense, Conduct of the Persian Gulf War: Final Report, Annex T, pp. T-178 to T-102.

Strategic Bombing

The strategic bombing campaign presents some of the most complex problems in assessing the lessons of the Gulf War.[131] Like the effort to win air superiority and air supremacy, a massive strategic bombing assault began on the first day of the war. The Coalition flew the first of what became a total of 46,000 fixed wing strike/attack sorties. British Tornadoes attacked Iraqi air fields with special JP233 munitions, that cratered and mined Iraqi runways. USAF F-16s and USMC F/A-18s attacked Iraqi air bases and surface-to-air missile sites in Kuwait and southern Iraq. Special RPVs and HARM (high speed anti-radiation missiles) attacked the radars needed to provide air warning and ground controlled intercept data, and a wide range of aircraft and helicopters struck at key sensors, command sites, and surface-to-air missile units. US aircraft based in Turkey began operations shortly after midnight on January 18, when four F-111Es successfully hit early warning radars in northern Iraq.[132]

The Coalition struck against eight main categories of strategic targets: (1) command, control, and communications facilities, (2) leadership facilities; (3) nuclear, chemical, and biological facilities and weapons, (4) military support facilities like ammunition, logistics, and repair sites, (5) ballistic missile launchers and support facilities, (6) electric power, (7) refineries, (8) key bridges and railways.[133] The total number of targets in these categories increased as the war went on, and rose from 295 strategic targets at the start to 535 on February 26, 1991.[134]

By the time the war ended, the Coalition had flown about 18% of its strikes against strategic targets. It had also used some of its best aircraft in these missions, and 30% of all the precision-guided munitions it delivered, were delivered against strategic targets. To put this effort in perspective, 14% of the remaining sorties supported the battle to achieve control of the air, 56% supported the battle against Iraqi ground forces, and another 15% were uncategorized.

These strategic attacks were often quite complex. The B-52s had to fly at least 700 miles for aircraft based in the theater in Egypt and Saudi Arabia, and more than 2,900 miles for aircraft based in Diego Garcia, Fairford Air Base in Britain, and Moron Air Force Base in Spain. Other attacking aircraft had to fly in "packages" of strike, air defense, and electronic warfare aircraft. These aircraft would assemble from all over the southern Gulf in areas on a parallel with King Khalid Military City. A package could include F-15C escorts from Tabuk (700 nautical miles away), EF-111s from Taif (550 nautical miles away), F-4Gs from Bahrain (120 nautical miles away), and KC-10 or KC-135 tankers from Seeb in Oman (650 nautical miles away). A typical package could involve 24-36 aircraft, and dozens of packages flew every day.

Why Air Forces Bomb: Accelerating Victory and Grand Strategy

The previous analysis has shown that the US entered the Gulf War with little prior planning to use air power to attack Iraq, with inadequate intelligence, without an updated targeting list, with a national and Air Force intelligence effort that the air planners and targeteers rejected as inadequate and unresponsive, and without the battle damage assessment tools to evaluate the impact of using airpower once war began. These are formidable obstacles to effective strategic bombing. However, the US and the Coalition also confronted a broader problem that has affected all previous efforts at strategic bombing. Even when the Coalition could accurately characterize and destroy a category of strategic targets, the question arose as to exactly what war fighting effect this bombing would have in accelerating victory.

This is a classic problem in strategic air power. The key issue in shaping and evaluating a strategic bombing campaign is not the size of the effort, nor its physical destructiveness, but rather, its affect on winning the war and on the resultant peace. Table 7.7 illustrates this point. It compares the number of bombs dropped in Desert Storm with the number dropped in previous wars, but such measurements have little practical value, and tell nothing about military effectiveness. Measurements of the types of targets hit, and the estimated level of destructiveness, are only marginally more important. They provide little indication of whether, and how much a given bombing effort did or did not speed the achievement of victory. Strategic bombing can also have negative effects. It can either stiffen resolve, or provide propaganda victories, and every sortie expended without military impact comes at the expensive of striking other valuable targets.[135]

Strategic bombing in World War II was scarcely ineffective, but the analysis of strategic bombing after the war had found cases where the air planners shaping the bombing effort had little real basis for estimating the effect of their actions on the political, economic, and military actions of the enemy, and where strategic bombing did not have its desired effect. Strategic bombing in Korea became a process of attrition decoupled from any effort to attack the primary enemy: the People's Republic of China. It has never been possible to accurately assess the impact strategic bombing effort had on the perceptions and actions of the PRC or of North Korea to the extent it was it assessing its effects on

Germany and Japan, but it is clear that the US bombing effort attacked many targets under conditions where air planners could do little more than guess at the resulting effect.

The strategic bombing effort in Vietnam initially involved a slow grinding process of escalation in which American political leaders attempted to influence the enemy on the basis of their own value systems and their perceptions that the enemy would react to escalation as they predicated. The result was a process of gradually escalation against targets that often did not have a major value to Vietnamese decision makers. In contrast, a sudden massive bombing against the capital of North Vietnam did force the North Vietnamese to the peace table, but only comparatively late in the war and where the North Vietnamese knew the US would probably withdraw from the conflict and they would face a weak and divided South Vietnamese regime.

US Air Force planners, and most US military planners, drew the lesson from Vietnam that future uses of air power must be quick, involve overwhelming force, and be designed to bring decisive results. They rejected the process of gradual escalation used in Vietnam. This shift in doctrine, however, shaped conceptual attitudes. It did not lead to the detailed war planning necessary to achieve such ends.

In the years that followed, US air planners gave only limited attention to conventional strategic bombing. At one level, the US planned with vast sophistication to execute a strategic nuclear war involving thousands of nuclear strikes on counterforce targets with the option of escalating to strikes to destroy the economy of the Soviet Union. It spent years developing a targeting list for such strikes and steadily expanding the number of targets to be struck. It spent years trying to estimate the political, economic, and war fighting impacts of a strategic nuclear war, but such an effort inevitably involved guesses of a kind which analysis could not resolve, and was shaped by the fact that the US could do nothing that would avoid such an attack on its soil by the Soviet Union. Some US senior planners tried to come to grips with the need to look beyond deterrence and destruction to the fact that wars would still have to end, but this effort was never transformed into an effective set of guidelines and practices for strategic nuclear bombing.

At another level, air planners viewed war with the Warsaw Pact in defensive terms where air power would be used almost exclusively to help defeat Warsaw Pact air forces, and deny the Warsaw Pact the ability to exploit its superior numbers of ground forces. It was assumed that the war would be a conventional or possibly theater nuclear battle of attrition, and that victory -- if achievable -- would consist of halting the Warsaw Pact in the forward area of West Germany and on the flanks of NATO. Neither the US nor NATO planned extensively for conventional strategic bombing in Europe, as distinguished from interdiction bombing designed to terminate the war by creating some stable line of engagement in Europe. There was little effort to address the very different problem of executing a complex large scale strategic bombing campaign against a major regional power like Iraq.

Important as the conceptual, doctrinal, and tactical advances made in planning the AirLand battle were, they did not lead the US to plan for a massive conventional strategic bombing campaign to support that battle. The US never seriously attempted to reshape its use of strategic air power for conventional war fighting. It never seriously planned for strategically bombing other regional contingencies in the Third World.

Table 7.7

Bomb Tonnage Statistics: Gulf War vs. Previous wars

War	Tonnage	Length months	Tonnage/ month	% of total in previous wars
WW-I	137.5	8	17.19	100%
WW-II	2,150,000	45	47,778	-
Germany	1,613,000	-	-	11%
Japan	537,000	-	-	-4%
Korea	454,000	37	12,270	-
Vietnam/SEA	6,162,000	140	44,014	-1%
Gulf War	60,624	1.5	40,416	100%

Source: USAF RgrpUSAFitgw-35

Improvising Strategic Bombing During the Gulf War

As has been discussed in the previous chapter, Iraq's invasion of Kuwait suddenly confronted US air planners with the need to develop detailed operational plans to act on the lessons of Vietnam. They had to determine what kind of strategic bombing effort that could quickly and decisively influence the Iraqi political elite while supporting the AirLand battle to liberate Kuwait. It also meant that US planners suddenly had to create lists of key target categories for strategic bombing -- some political, some economic, and some military, choose actual targets, decide on the means to attack them, and do it at a time when they faced many conflicting priorities, including the defeat of the Iraqi Air Force and ground forces.

It is not surprising that these sudden efforts to improvise a strategic bombing campaign had mixed success. As has been discussed earlier, the original air planning for the strategic bombing campaign in Instant Thunder was somewhat theoretical and "academic," but it is hard to see how this initial effort could possibly have been anything else, given the lack of prior planning and the short time available.[136] The revised versions of the plan quickly became more sophisticated, and USCENTAF's plans were always responsive to the needs of Coalition land forces -- although not without some resistance on the part of some USAF planners.

Table 7.8 shows how the steady improvement in the quality of planning increased the number of targets to be attacked. At the same time, there were limits to what could be accomplished in five and one-half months. Table 7.8 also reflects the extraordinary level of effort required to develop a targeting plan without adequate prior effort and intelligence, and the rapid changes in targeting that occurred once the war actually began. A small cell of US Air Force planners operating with inadequate intelligence was in no position to suddenly invent highly effective ways to carry out conventional strategic bombing, or solve targeting problems that required years of prior intelligence, and analytic effort.

Coalition air planners could focus on an air strategy that sought to use strategic air power to destroy and disrupt Iraq's leadership, C^4I/BM capabilities, lines of communication and supply, and military force. In order to implement this strategy, however, they had to develop the best target lists they could in the time available and with the intelligence available, attempt to guess at the value of given targets and their possible impact on enemy perceptions and capabilities, and try to destroy them by using data on weapons effectiveness that was often high theoretical and developed for other purposes. While it was possible to support the targeting effort by modeling some aspects of the Iraqi capabilities, it was not possible to model many others. More importantly, there was no way to accurately predict how any given level of damage would affect overall Iraqi war fighting capabilities, or the behavior of the Iraqi leadership. There was also no way to predict how the very real but intangible shock impact of strategic bombing and the impact of strikes that did not destroy a target but influenced Iraqi behavior.

Some aspects of the planning for the strategic bombing campaign also raise questions about the air planner's priorities. According to some sources, Coalition air planners assumed that the strategic bombing phase of the air campaign (Phase I) would last two weeks and that strategic bombing could take up to 1,000 sorties a day. These plans, however, seem to have gone forward at least in part because CINCENT did not actively involve himself in the details of the planning effort until the war began. There was little real rationale to give strategic bombing two weeks of priority for a total of around 14,000 sorties when the primary threat was Iraqi ground forces.[137]

In any case, General Schwarzkopf intervened by the fifth day of the air campaign, and 50% of the sorties planned for strategic bombing were diverted to battlefield preparation. Although Brigadier General Glosson protested this decision, the number of sorties allocated to strategic bombing dropped from a little over 500 on D+5 to a little over 300 on D+8. They dropped to well below 200 on D+12. During the rest of the war, the number of sorties allocated to strategic bombing never rose much beyond 250 a day, and only reached this level on D+25 and D+33. Even during the closing days of the war, strategic bombing sorties never reached 250 a day, and only rose substantially above 150 on D+44 (G+4).[138] It can be argued with some justification that the decision to shift to battlefield preparation at D+5 weakened the weight of effort devoted to strategic bombing. At the same time, it is far from clear that added weight of effort would really have solved any of the major problems in each major target area.

Limiting collateral damage imposed additional constraints. Attacking Coalition aircraft operated under rules that were intended to limited collateral damage to civilian facilities and allow Iraq to recover more quickly after the war. This led to tight limitations on the way in which targets like Iraq's electric power plants could be attacked, and to the creation of a long list of targets that could not be hit -- including historical, religious, cultural, archeological, economic, and politically sensitive installations in Iraq and Kuwait. The Coalition established demanding rules of engagement in terms of the visibility conditions required, the munitions that could be used, and the part of a target that could be attacked. While these rules were not perfect, munitions sometimes hit outside the authorized aim point, and civilians were killed, the Coalition operated under the tightest rules of engagement in military history, and civilian losses were generally very low.[139]

It may be that there is no way to make strategic bombing "efficient." It may be that many aspects of strategic bombing will always be as dependent on intuition and guesswork as they were in attacking Germany, Japan, Korea, Vietnam, and Iraq. One of the lessons of the Gulf War, however, is that the US must attempt to comprehensively rethink the entire issue of strategic bombing. It must attempt to develop better models of the impact of attacking key strategic targets, it must take the man-years necessary to develop effective targeting lists for key regional enemies and keep them up to date, it must rethink and reexamine its damage effect planning to consider such targets, and it must simulate and analyze such campaigns as part of an integrated effort by planners, operators, intelligence experts, and policy level decision-makers.

The USAF has recognized some aspects of this lesson of the Gulf War. Many senior officers in the Air Combat Command recognize the need for a fundamental reevaluation of US strategic targeting to focus on fighting major regional wars, to examine the extent to which strategic air power can supplement or substitute for the AirLand battle, and the ways in which strategic airpower can be made more effective in actually accelerating victory, in attacking the proper targets, and increasing effects on the course of a war while limiting collateral damage. They are creating new targeting lists in peacetime for major regional contingencies and conducting an ongoing review of the types of targets that should be attacked and how to mix strategic bombing with the destruction of the enemy's ground forces.

What is unclear is (a) whether US civilian and military leaders will support the level of attacks, and collateral damage, (b) whether US air power will get the kind of new targeting, C4I/BM, and smart stand-off weapons necessary to use heavy bombers and execute a strategic bombing campaign with effective economy of force and collateral damage that has any chance of winning political support, and (c) whether the US will maintain and upgrade the bombs and heavy strike aircraft needed for large scale strategic bombing. The USAF's current efforts to address these issues are also complicated by internal political efforts to defend and preserve parts of the USAF heavy bomber program. Ironically, the advocates of the B-1 and B-2 have often proved to be a major barrier to improving strategic bombing and even to sustaining support for a large and effective bomber force. Their efforts to "sell" particular weapons systems -- as distinguished from advocate real-world mission capabilities -- have limited objective planning and analysis within the USAF and their mix of "hard sell" and deliberately politicized analysis has done as much to alienate as persuade.

Table 7.8

The Growth of Target Sets During the Gulf War

Target Set	Instant Thunder Plan (21 Aug)	CENTAF Op Plan (2 Sep)	Briefing CJCS (13 Sep)	Briefing President (Oct 11)	Briefing Sec Def (20 Dec)	Start of Air Campaign (15 Jan)	Later Air Campaign (17 Feb)	Final Days of War (26 Feb)
Civil								
Leadership	5	15	15	15	27	33	37	44
C^4	19	27	26	27	30	56	84	146
Electric	10	17	14	18	16	17	22	29
Oil & Refining	6	9	8	10	8	12	12	28
Railroads and Bridges	3	12	12	12	21	33	40	89
Subtotal	43	80	75	82	102	151	195	336
Air								
Air Fields	7	19	13	27	25	31	38	46
Strategic Air Defense	10	39	21	40	27	56	73	85
Surface-to-Air Missile	-	-	-	-	-	45	45	45
Subtotal	17	58	34	67	52	132	156	176
Special Land								
Republican Guard	-	7	-	-	-	37	38	39
Breaching	-	-	-	-	-	0	6	6
Subtotal	-	7	-	-	-	37	44	45
Naval	1	0	4	6	4	17	20	20
Military Storage and Production	15	35	41	43	46	73	77	102
Scud Missile	0	0	5	5	13	48	52	59
NBC/WMD	8	15	15	15	20	23	23	34
TOTAL	84	195	174	218	237	481	567	772

Note that Republican Guard, Breaching, and Scud Target sets were added later in war.
Source: Adapted from Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 85-87.

Setting Grand Strategic Objectives for Strategic Bombing

It is clear that policy makers also need to reevaluate the role of conventional strategic bombing in achieving grand strategic ends. The military problems that the US encountered in using strategic air power for the Coalition were compounded by a conceptual failure at the policy level to understand the need to accept the high levels of damage and the resulting political problems that are the price of effective strategy bombing and a failure to set clear goals for conflict termination. Like all other elements of USCENTCOM and the Coalition high command, air planners lacked clear direction from the White House, the National Security Council, the State Department, the Secretary of State, and the Chairman of the Joint Chiefs as to the ultimate goal of the war and the desired outcome of conflict termination.

It is clear that the US had important war fighting goals: The liberation of Kuwait, the destruction of Iraq's offensive conventional capabilities, and the destruction of Iraq's missiles and weapons of mass destruction. Air planners did their best to use air power to achieve these goals, and it is clear that they targeted Iraq's leadership with the hope of influencing it to accept a Coalition and actually kill senior leaders like Saddam Hussein.
But, at no point in the data so far made available on the planning for strategic bombing is it clear that national command authorities in the US looked beyond these goals to define a grand strategic view of what they wanted Iraq to become after the war, how they wanted to influence Iraq's future role in the region, or what kind of post-war Iraqi regime would or would not be acceptable.

As was the case in the Korean and Vietnamese wars, strategic bombing lacked direction in terms of a meaningful grand strategy that projected a post-war period outcome that could achieve broader goals over a period of years. It may be argued that such an effort is illusory or impossible. There may be no way to use strategic bombing, or any other aspect of military force, to shape the future of a state that an attacker is not willing to conquer, occupy, and reshape from within.

The fact remains, however, that US national command authorities did not properly review the planning and execution of the strategic bombing effort at the policy level and failed to try to link strategic bombing to grand strategic objectives. By not trying they greatly compounded the problem of using military force effectively in any form, and strategic air power in particular. The need to search for better ways of deciding upon grand strategic goals and specific goals for conflict termination is a clear lesson of the war.

The Attacks on Iraq's Leadership and C4 Capabilities

The details of the strategic air attacks on Iraq's air forces have been discussed in Chapter Six and the details of the attacks on Iraq's nuclear, chemical, and biological facilities and weapons, and ballistic missile launchers and support facilities will be discussed in Chapter Eleven. This leaves six categories of attacks: (1) command, control, and communications facilities, (2) leadership facilities; (3) military support facilities like ammunition, logistics, and repair sites, (4) electric power, (5) against refineries, and (6) key bridges and railways.

The Scale and Nature of the Attacks

The Coalition carried out 260 attacks on Iraq's leadership and the 580 strikes on its command, control, and communications facilities. These attacks were closely related, and were part of what the US air planners in the "black hole" saw as attacks designed to disrupt and weaken Iraq's "central nervous system."[140] Leadership targets were defined in terms of key government facilities like official residences, government ministries, and command and control bunkers which planners saw as critical to the regime's ability to control the Iraqi people and Iraq's military forces. C^4 targets included radio and TV stations, the redundant coaxial and fiber land lines for voice, and data that Iraq used for internal and external communications, microwave radio relays, associated switching facilities and satellite communications.[141]

These were often difficult targets because many were hardened or sheltered, and others required considerable precision. As a result, 81% of the total of 840 precision and non-precision strikes on these targets were carried out by F-117s, 15.5% were carried out by TLAMs and CALCMs, and 3.5% were carried out by F-111Fs.[142] Most of the attacks on leadership facilities were carried out by F-117s using GBU-27s.

The Attack on the Al-Firdos Bunker

Attacks on leadership facilities were given high priority during the first three nights of the war, beginning with nearly 58 strikes on the first night. They then occurred at a level of about 5-10 strikes per day during January 20-February 4. The number of strikes rose again during the February 4 -5, but them diminished to very low levels until February 10. They surged to nearly 40 sorties on February 13.

February 13, however, was the night the Coalition hit a major bunker in the Al Firdos district in Baghdad with two GBU-27 bombs that killed a larger number of civilians. The exact numbers of Iraqis killed are unclear. Iraq made the incident into a major propaganda issue, and issued reports that 200-300 Iraqi civilians died, including 100 children, but the actual number has never been firmly established.[143]

The Al Firdos bunker was a legitimate target of war by any normal standards. It was one of ten leadership bunkers in the suburbs of Baghdad. These shelters were the most "luxurious" of the shelters and similar shelters had been bombed early in the campaign. US intelligence reports during early February indicated that the Al Firdos shelter had been activated as a leadership site and it was targeted, although it is still not clear exactly how the Iraqi leadership planned to use the bunker, if at all. Unfortunately, the bunker's upper level was being used as a bomb shelter at night, although suburban areas were not being bombed, the shelter was protected in ways that made it look like a military facility, and Iraq made no effort to declare it was using facilities as shelters.

The Coalition's propaganda efforts before the bombing, however, had repeatedly given the impression that the Coalition was carrying out a surgical bombing effort against Iraq. As a result, the negative publicity from CNN coverage of Iraqi civilian losses created a situation where General Schwarzkopf began to personally review all targets in Baghdad, which led to a virtual pause in attacks on leadership targets until February 20, 1991.

This experience illustrates the problems inherent in trying to limit collateral damage and civilian losses, and the problems in mixing politics with operational effectiveness. The Coalition did not have any easy time in defining its rules for limiting air strikes Some of the arguments over limiting collateral damage before Desert Storm had reached the point where USAF and US Army lawyers argued at length during the war that the Coalition should not even strike Saddam Hussein's grandiose statues of himself because they were cultural monuments.[144]

The resulting Iraqi propaganda victory is also a further argument against efforts to dehumanize the reality of war and portray it as a people-free or Nintendo-like conflict. It also, however, raises the issue of the extent to which efforts to limit collateral damage should be given priority over war fighting. The Al Firdos incident, like the US shoot-down of an Iranian airliner two years earlier, brought the war home to the Iraqi leadership in ways that attacks on its facilities and military forces did not. Brutal as it may seem, the civilian casualties may have reduced the total casualties and speeded up the termination of a conflict. It is also dangerous to fall into the trap of assuming that only uniforms define legitimate targets. The Ba'ath leadership and its families, and the civilian elite that benefited from the regime, were almost certainly more legitimate targets than 18 year old conscripts from poor farming villages.

The Hunt For Saddam Hussein

Another aspect of the Coalition strikes on leadership targets raises equally serious issues about the targets that should be attacked in wartime. While the US officially disclaimed any effort to assassinate Saddam Hussein, it is clear from interviews with senior officers shaping the targeting and other sources that the US deliberately tried to find and kill Saddam Hussein with bombing. It launched a new round of attacks just before the land war began, including attacks that became something of a Saddam Hussein hunt, attacking VIP bunkers and the "Winnebago" trailers used as dispersed command facilities.[145]

The Coalition also carried out last round of leadership attacks that took place on the last night of the war, when it rushed two special 4,700 pound GBU-28 penetrating bombs that had just arrived in the theater onto F-111Fs and attacked the leadership bunker at Taji, north of Baghdad.[146] This bunker was some 40 feet underground, and USCENTAF believed that it was one Saddam used at night. It had repeatedly attacked this bunker before, using F-117As that delivered 2,000 pound bombs, and these attacks had failed. As a result, USCENTCOM intelligence believed it was likely that Saddam might believe the shelter was invulnerable and would use it as the war was ending. One of the bombs succeeded in destroying much of the bunker, and this led to a brief celebration in the "Black Hole". Reports of Saddam's death, however, proved to be exaggerated. As a result, the issue of bombing is or is not different from assassination, and whether the word "assassination" is relevant in talking about the leader of a war effort in wartime, is an issue that will have to be left to future conflicts.[147]

The Overall Impact of the Strikes on Leadership Targets

The attacks on leadership targets did not have great effectiveness. They are known to have disrupted Iraqi ministries and command activities, and forced them to relocate. This may have had some impact on operations and probably had some impact on the willingness of Iraq's leadership to accept a cease-fire and its fear of the consequences of using chemical weapons.

It is doubtful, however, that the attacks on Iraq's ministries and facilities really had much impact on the conduct of the war. The Ba'ath regime does not rely for control of the state or armed forces on the regular branches of government, and four years after the war, it still is not clear that the leadership strikes killed or incapacitated any significant leader or figure that affected Iraq's war fighting capability.

It is also clear from interviews that many targets were chosen in an almost arbitrary manner simply because they might be leadership targets. In fact, only sheer luck could have transformed the strikes into effective military actions. The US simply did not have the intelligence and analytic base to create an effective targeting system or to use strategic air power effectively against Iraq's leadership.[148]

The Overall Impact of the Strikes on C^4 Targets

The Coalition attacks on Iraqi C^4 and telecommunications facilities had some success in disrupting Iraqi efforts, but it is difficult to determine how much they contributed to victory. Iraq's redundant land lines, microwave relay facilities, and fiber optic lines were highly survivable, and the Coalition attacks were limited in number and intensity. C^4 targets only received a limited number of precision sorties during each day of the first three weeks. They did received some additional sorties during the fourth week, but sortie levels then went back to their earlier level. Most of the Coalition strikes on C^4 targets were non-precision strikes, and had a limited effect.

The targeting problems described in Chapter Five also affected Coalition capabilities. Table 7.8 shows that the initial planning for Instant Thunder only selected five leadership targets, the total rose to 33 targets at the start of the air campaign and to 44 by its end. Similar problems occurred in targeting C^4 sites. The number of C^4 target sets grew from 19 in the first briefing on Instant Thunder, to 56 at the start of the war, and then to 146 at its end.

The initial intelligence analysis of Iraqi communications did not provide a realistic picture of the size and scale of the Iraqi system, and two factors limited the effectiveness of the Coalition effort. First, US planners had estimated that Iraq would shift to dependence on radio communications when the war began, but they actually kept relatively tight communications discipline. Second, the major bridges in downtown Baghdad held the major fiber-optic cables crossing the Tigris, but weather delayed attacks on the two key bridges until the second week in February, and General Powell decided not to destroy all of the bridges because of the risk of adverse publicity. Many senior USAF planners and analysts felt the bridges should have been totally destroyed and see this decision as an example of the over-caution that affected the strategic bombing effort.

Attacks on Iraq's C^4 capabilities, and the resulting disruption, might have had more impact if Iraq had not had five and one-half months to deploy its forces, or Iraq had depended on a fraction of the volume of the command traffic that the US took for granted. The attacks might have had more impact if the US had had the kind of intelligence to know what C^4 facilities were critical. In practice, however, the attacks seem to have done little more than reduce connectivity and impose some disruptive effects. They did not cut communications from Baghdad to the theater or key military activities like the Scud launch units. Neither US studies nor Iraqi writing after the war indicate that the C^4 strikes in the Gulf War had a major war fighting effect.[149]

In contrast, efforts to prepare the battlefield in the KTO, interdiction bombing, and the Iraqi fear of anti-radiation missiles and being targeted by US ELINT and ESM systems, did have a significant effect on Iraqi communications in the KTO and forward areas which unquestionably contributed to the rapid collapse of Iraqi ground forces during the ground battle. As the Gulf War Air Power survey notes,[150]

> "Prisoner of war reports often describe Iraqi measures to preserve their equipment. Measures included using messengers, prohibiting the use of radios

> after the start of air attacks, and even pronouncing death sentences for those who used two-way radios or telephones. Also, the Iraqis laid extensive wire, buried throughout the theater, to preserve emergency communications. Wire was strung between units, which were sometimes as far apart as 50 kilometers. Bombing cut the wire at times, but Iraqis often repaired these lines within a day.
>
> "Effective communications, however, required more than the ability to warn another unit of attack; if the warned unit could not undertake some sort of coordinated action in response, the warning was of little value. Here, the system collapses. Reports show that once the units tried to move, wire strung between units no longer sufficed and the lack of communications became debilitating -- units either tried to talk, unsuccessfully, on radios susceptible to jamming, or simply did not attempt to communicate with one another. Reports after the battle of Khafji provided examples of Iraqi units lost in the desert or unable to coordinate actions with jammed communications."

Attacks on Iraqi Electrical and Oil Facilities

The Coalition carried out 890 strikes against Iraqi electric and oil facilities. About 60% of the strikes on electric facilities, including 60 Tomahawk strikes, came in the first 11 days of combat. Oil facilities were struck more consistently throughout the war.

The Coalition did not deliberately attempt to destroy Iraq's economic infrastructure or inflict long-term damage. It deliberately structured its targeting on Iraqi electricity and oil facilities to concentrate on electric power transformer and switching yards, and control buildings -- rather than turbines, generator halls, and boilers. It restricted its attacks on oil to concentrate on refined product storage, and to only attack refining and distillation areas if they produced military fuels.[151]

This guidance was often ignored in the heat of combat, however, particularly during the first week of the war. Many generator buildings were hit. This was partly because they were the largest buildings in the 25 major power stations in Iraq and the most obvious target, and partly because the attacking units were sometimes given inadequate briefings on the need to try to exercise restraint. One generator building was repeatedly hit because it was a secondary target for aircraft that did not strike their primary target.[152]

Attacks on Electrical Facilities

Attacking Iraqi electrical facilities meant attacking a large target base. Iraq had an installed generating capacity of 9,500 megawatts, and normally used only 5,000 megawatts in peacetime. Its major power plants were well netted into the electrical grid, and there were 140 separate electric power stations. Iraq could refine more than 840,000 barrels of fuel a day and because of its export market, could refine more than twice what it needed for its domestic and military needs.

Nevertheless, strategic bombing was more effective in destroying Iraq's electric power capabilities than its planners intended. It did serious damage to 11 power generating plants, and shut down 88% of Iraq's electric grid. The remaining 12% was only available locally because the grid no longer could wheel the power. Power generating capability dropped to only about 3,000 megawatts of capacity in three days, 2,000 megawatts by January 24, and remained at around 1,000 megawatts after February 10.

These power cuts and damage to Iraq's generating facilities later led to estimates of collateral damage that estimated that power losses would could 70,000-90,000 post war deaths. In practice, Iraq's electric power grid recovered far more quickly than such studies anticipated. Iraq was able to restore electric power for water purification and sewage treatment without major medical problems.[153]

The military effect of this destruction was also limited. Iraqi units in the KTO had their own generating plants, as did most Iraqi forces in Iraq. The Coalition did not shut down all of the power in Kuwait City, and Iraq's forces were already deployed and dug in. The loss of electric power almost certainly had some impact on the attitudes of the Iraqi leadership and the perceptions of the Iraqi public, but it is difficult to translate them into a significant impact on direct Iraqi war fighting capability.[154]

Attacks on Oil and Refining Facilities

Strategic bombing effort was effective in eliminating much of Iraq's refining capability, although attacks on known Iraqi oil storage facilities were not as effective as Coalition planners hoped. The US estimated after the war that the Coalition had made nearly 90% of Iraq's refining capacity inoperative by striking distillation towers with a small number of precision weapons -- including two TLAMs and F-117s with GBU-10s. In contrast, the use of non-precision weapons against oil storage tanks produced "more visible but less damaging results." While there were often large clouds of smoke, attacks did not destroy entire storage areas and tank farms. [155]

These strikes also did not have a lasting impact on the Iraqi economy, in part because of a decision by the Joint Chiefs to prohibit repeated strikes on such facilities. Iraqi claimed that crude oil production had been restored to 800,000 barrels a day by October, 1992, and Iraq could not only meet its own needs for refined product, but was exporting it to Jordan. Once again, however, the military impact of the Coalition strikes on oil facilities was also limited. As the Gulf War Airpower Survey notes,[156]

> "For the most part, the Iraqi Air Force stayed in its shelters and sat out the war, hence it required little fuel. Iraqi ground forces in the Kuwaiti theater had access

> to Kuwaiti oil facilities and continued to operate the Kuwaiti refining facilities and use Kuwaiti stocks. Eventually, Coalition air forces began bombing selected Kuwaiti oil facilities to limit use of stocks. Even so, the amount of fuel available at the outset of what turned out to be a 100 hour ground campaign would probably have sufficed for weeks, if not months of combat. Before that time, most Iraqi forces in the theater were dug into static positions and had minimal....requirements. Individual units faced local shortages because of distribution problems to which the Coalition undoubtedly contributed by striking targets such as trucks and bridges. However, the limited difficulties caused by local shortages were not the result of Coalition attacks on Iraqi refineries and major petroleum depots."

The attacks on electric and oil facilities might have had more effect on Iraqi war fighting capability if Coalition planners had been correct in estimating that the ground war would last up to six weeks, including a four week consolidation phase. They did not, however, have a significant impact on Iraqi military operations under conditions where the Iraqi Air Force ceased to fly and where the land war lasted a few days. While they did have some shock and disruptive effects, it is doubtful that they were worth the sorties devoted to the mission or that they played a significant in accelerating victory. This experience does not mean that such targets should not be attacked in future wars, but it does illustrate the difficulty of defining priorities for strategic bombing.

Attacks on Iraqi Lines of Communication

The Coalition flew a total of 1,170 strikes against Iraqi lines of communication (LOCs) during the Gulf War. Coalition forces faced a complex mix of advantages and disadvantages in flying these missions. Iraq had had five and one-half months to build up massive stocks of supplies in theater, and shelter, camouflage, and disperse them, although Iraq failed to make equal preparations in terms of food, water, and medical supplies. This made it almost impossible to destroy enough munitions and military supplies to deprive Iraqi units of at least four days to a week of forward deployed munitions -- [157]

Bridges were key targets in these attacks. The Iraqi road and rail supply routes from the north into the KTO crossed a series of bridges over the Tigris or Euphrates, and the Iraqi road network was located along the along the two rivers, or to the west, in routes that crossed several water barriers and merged near Basra. There were a total of 126 highway bridges and nine railroad bridges south of Baghdad.

Coalition planners focused on attacking the bridges that had the most direct impact on military movements into and out of the KTO, and targeted roughly half of these bridges.

Coalition planners also targeted Iraq's seven main rail yards, but these were area targets that were relatively easy to repair and the attacks on the bridges were most critical to rail movements.[158] Coalition air units began intensive operations against Iraqi bridges on January 27, when eight bridges were dropped or substantially damaged. These attacks on bridges continued on February 1, 1991, and steadily increased to the point where 30 Iraqi bridges were unusable by February 17. By the time of the cease-fire, the DIA estimated that 37 highway bridges and all nine rail bridges were unusable for vehicle or rail traffic, and nine other highway bridges were severely damaged and had restricted capacity. [159]

Bridges in the area of Samawah, An Nasiryah, and Basra were hit the hardest. The area around Basra had a number of bridges and causeways, and a large marsh or lake called the Hawr al Hammar extended across the northern part of the KTO on a line from a position west of Basra to a position just to the east of An Nasiryah. Only one major causeway crossed the Hawr al Hammar between Iraq and the KTO.

The Coalition air attacks were particularly effective in destroying bridges in the areas around Samawah, An Nasiryah, and Basra. Coalition air planners felt that destroying the bridges and causeways around Basra was particularly important in limiting Iraq's ability to reinforce -- or retreat from -- the KTO. Attacking the causeway across the Hawr al Hammar was particularly important because there was only one major causeway across this large marsh or lake, and it extended from the west of Basra to the east of An Nasiryah.

During the war, Coalition planners estimated that Coalition air strikes on these LOC targets had cut resupply movements to the minimum of 75,000 metric tons per day necessary for Iraq to support offensive operations by D+5, and that they cut the follow of supplies below the 30,000-42,000 metric tons per day necessary to sustain defensive operations by D+18 (February 4). They estimated that resupply dropped below the 12,000-167,000 metric tons/day necessary to sustain Iraqi forces in place by D+25 (February 11).[160]

These estimates, however, almost certainly over-estimated the impact of the Coalition attacks. The Coalition was not attacking a "follow-on" force like the Soviet forces in Europe, and Iraq had fully deployed most of its combat effective forces before the war began, and provided them with enough supplies for at least seven days of combat. Cutting off the main roads from Baghdad into the theater along the Tigris and Euphrates had only a limited effect on Iraqi forces in the KTO.

Many of the Iraqi bridges and causeways were large multi-lane structures, many of which were very well engineered. Iraq had extensive engineering equipment and pontoon bridges, and many structures could be bypassed using less efficient cross-country routes, building temporary earthen causeways or using amphibious ferry vehicles. Coalition planners did not recognize how quickly such techniques could be used to improvise new lines of communication, and how well Iraq could use alternative routes, by moving at night, and by moving tracked vehicles by road rather than rail.

A substantial flow of supply continued until the ground campaign began, although the bombing certainly disrupted many aspects of the Iraqi effort.

General Horner, the commander of USCENTAF, later stated,[161]

> "Anybody that does a campaign against transportation systems had better beware! It looks deceivingly easy. It is a tough nut to crack. (The Iraqis) were very ingenious in repairing them or bypassing them.. I have never seen so many pontoon bridges. (When) the canals near Basra were bombed, they just filled them in with dirt and drove right across the dirt."

Coalition air strikes on Iraqi LOCs and supply activities seem to have had their most severe affect on Iraqi forces near the front lines. They do not seem to have had any major effect on supply to the Republic Guards, and only moderate to limited impact on Iraqi regular mechanized and armored divisions. It is also difficult, however, to distinguish the impact of these strategic attacks on LOCs from the impact of air strikes on forward deployed trucks and vehicles and from the organizational problems that occurred in Iraqi supply operations through sheer inefficiency -- problems that surfaced whenever major Iraqi redeployments occurred during the Iran-Iraq War.

As the Gulf War Air Power Survey notes,[162]

> "Prisoner of war reports from the front-line forces showed a general pattern of units low on food and water and lacking in resupply capability. at the same time, there were reports of units having plentiful supplies of war and hot meals. Prisoners captured at Khafji were described as being in wretched health and malnourished, but wearing new uniforms and boots. In the Republican Guards areas, on the other extreme, US VII Corps soldiers found trailers of quality foods such as canned mackerel and crackers...The pattern that emerges from the evidence is not of a starving army, but of an organization in which the distribution system had ceased to function: distributions appeared illogical and goods were generally absent, hoarded, or lying unused. The policy of the Iraqi army not to use radios or telephones, combined with a beleaguered transportation system, accentuate(d) this condition."

There are indications that battlefield interdiction bombing had considerably more impact on supply than the strategic bombing effort. Aircraft like the F-16 killed large numbers of Iraqi trucks moving in the theater during the day. Other aircraft killed trucks at night, and made Iraqi break up ins convoys and send out single or small numbers of vehicles. Iraqi POW reports indicate that the impact on food supplies at forward deployed

Iraqi tactical units was severe. Strikes on convoys and movements along Iraqi LOCs seem to have eliminated about 50% of the Iraqi military trucks in the KTO -- either through direct damage or because Iraqi could not efficiently provide spares and repair capability in the field.[163]

Strategic bombing also does not seem to have played a major role in preventing Iraq's forces from escaping after the Coalition victory than in affecting in-theater war fighting. A number of strikes than were made on Iraqi lines of communication (LOCs) to keep Iraqi forces from retreating out of the theater than to prevent further reinforcement. As Chapter Eight indicates, however, these strikes failed to have a decisive effect, but this may well have been because the Coalition chose not to directly bomb the Iraqi forces that had escaped from the KTO. The destruction of brigades and causeways might have had much more effect if the Coalition had authorized plans for an air assault to block the escape routes north of Basra or large scale air attacks on the Iraqi forces in the Basra pocket.

This experience is another indication of the need to both make clear decisions at the national command level about what degree of lethality is acceptable in making a strategic bombing effort effective, and the need to improve the intelligence, planning and analytic support for strategic bombing campaigns. As was the case with some of the previous categories of targets, the Gulf War involved enough unique operational conditions so that it is far from clear that similar attacks on lines of communication cannot be more effective in future wars. As the same time, attacks on North Vietnamese LOCs had only limited to moderate impact during the Vietnam War, attacks on Egyptian LOCs had limited impact during the 1973 conflict, and attacks on Chinese LOCs had limited impact during the Korean conflict. All of these wars also produced exaggerated estimates of effectiveness.

One possible lesson from the Gulf War about attacks on LOCs is that they cannot be successful if limiting collateral damage is given a higher priority than effectiveness. Other lessons may be that (a) bridges must be totally destroyed, including all supports and spans, regardless of collateral damage, (b) approaches and bypasses need to be mined and night attacks must be conducted on pontoon bridges, (c) impressive secondary explosions from attacks on supply depots rarely indicate a loss of war fighting capability in well-supplied forces, and (d) far more careful targeting and reconnaissance is needed to identify high value military targets. What is all too clear, however, is that the LOC models used during the Gulf War simply were not adequate for war fighting purposes.

Attacks on Iraqi Ground Forces Before the Ground Offensive

The Coalition was far more successful in attacking Iraqi ground forces in the KTO in preparation for the land battle than it was in conducting strategic bombing. It flew a total of 23,430 strikes against Iraqi ground targets. These strikes steadily degraded much of Iraq's ground battle capability in the KTO, although the USAF later found that they were far less effective than planned in attacking their key target -- Iraq's elite Republican Guards.[164]

The Coalition began these attacks on Iraqi ground forces long before it began the ground offensive. On the first day of the air campaign, USAF A-10s flew more than 150 sorties against Iraqi ground forces in the KTO, as well as radar sites in Iraq. USMC AV-8Bs attacked Iraqi armor and artillery targets in southern Kuwait, and flew 20 missions the first day, and 55 on the second. B-52s struck key elements of the Iraqi Republican Guards, including the Tawakalna Mechanized Division. This was part of an attack plan that called for strikes against all three heavy Republican Guard divisions in the KTO. The plan called for 146 F-16, 6 B-52, and 8 F/A-18 strikes on the Tawakalna Division by the end of D+2; 8 F-15E, 42 F-16, 22 F/A-18, and 15 B-52 strikes on the Hammurabi Division; and 26 F-16, 6 F/A-18, and 10 B-52 strikes on the Al-Madinah Division.[165]

The Coalition intensified its attacks on Iraqi ground forces after the Coalition achieved air supremacy on January 24, and again on the night of 6-7 February, when air resources were shifted away from strategic targets to attack the Iraqi ground forces. From this point on, until February 24, 1991, Coalition air forces focused on destroying Iraqi ground forces in the Kuwaiti Theater of Operations (KTO) -- particularly Iraq's elite Republican Guards units -- and reducing their effectiveness to 50% of their pre-war level. In addition to the earlier forms of air attack, MC-130s began to drop 15,000 pound BLU-82 bombs on Iraqi front line positions to demoralize Iraqi troops, and AC-130 gunships stepped up attacks on Iraqi troops in exposed positions.[166]

Lessons from the Battle of Khafji

The battle of Khafji showed how vulnerable Iraqi troops would be the moment that they attempted to maneuver and advanced. This battle, which is described in Chapter Three, actually involved elements of at least two Iraqi divisions that attempted to penetrate south into Saudi Arabia on January 29, 1991. Other Iraqi units also changed location to the north. In the process, Iraqi forces moved into the open and maneuvering Iraqi armored forces were exposed to air attack for the first time. As a result, the battle became a test ground for many aspects of Coalition air operations.[167]

The Coalition soon demonstrated the impact of its superior targeting and reconnaissance aircraft. It made its first major use of JSTARS to target Iraqi armor deep behind the forward line. It used spotter aircraft like the OA-10 to increase the effectiveness of its AV-8Bs, A-6s, and F/A-18s in finding armored targets. Special forces units on the ground proved the value of using radar beacons to designating targets like Iraqi artillery positions for A-6 strike aircraft. AC-130 gunships showed that they could use miniguns and cannon to provide close air support even in a high intensity conflict environment -- although one AC-130 was shot down. A-10s had the opportunity to use Maverick against exposed maneuvering targets, F-16s used the LANTIRN to drop CBU-87 combined effects munitions on armor and vehicles, and Coalition precision strike aircraft were employed in large numbers.

The Coalition quickly learned that Iraqi forces became extremely vulnerable when they tried to maneuver in the face of Coalition air supremacy. Iraqi forces suffered four times more equipment losses to air strikes per day during January 29-31 than they had up to that date. In addition to the JSTARS, the US also had the opportunity to test its RPVs and the new sensors on the TR-1 against maneuvering Iraqi forces both in the battle and to the rear. Coalition land forces learned lessons of their own. Saudi forces learned that they could achieve a significant edge over Iraqi forces with the M-60A1 tanks, and the USMC found that it could achieve considerable effectiveness with lightly armored LAVs by using the TOW anti-tank guided weapons at long ranges. While it was scarcely Iraq's intention, its attempt to win a propaganda victory provided the Coalition with an ideal opportunity to test the impact of its air power in the AirLand battle.[168]

One Iraqi prisoner of war stated later that his brigade suffered more losses under 30 minutes of air attack than it had during the entire Iran-Iraq War.[169] While any such judgment is speculative, the air attacks during Khafji may have convinced many Iraqi commanders that they could not maneuver effectively in the face of Coalition air power. In any case, Iraqi forces began to dig in even deeper, did not conduct any further maneuvers or major movements during the air war, and did not attempt counter-attacks during the ground war, except for scattered small unit actions by regular forces and the Republican Guards.

Making Attacks on Iraqi Ground Forces More Effective

In contrast, Coalition air attacks on dug-in Iraqi ground forces only had limited to moderate effectiveness until the first week in February. It took time to discover many of the operational problems in using Coalition aircraft and weapons discussed at the start of this chapter, and it took time to understand that many pilot claims of success were not supported by battle damage assessment. This was partly a result of the fact that Coalition air planners had so little hard data available. As has been discussed in Chapter Five, the Coalition had a serious shortage of theater reconnaissance assets and used them targeting rather than battle damage assessment. It only had 5 TR-1s, 6 U-2s, 24 RF-Cs, and a limited number of UAVs in theater. Many of these assets were devoted largely to strategic targeting during the first two weeks of the campaign, and did not support any aspect of the strikes on Iraqi ground forces.[170]

Much of the battle damage assessment analyses that were carried out were carried out by untrained or partially trained personnel. There were no truly experienced battle damage assessment personnel that had worked on previous wars or who had been subject to demanding training using actual test experience in the field. Battle damage assessment is inevitably something of an "art form", but it was an area where the USAF and US Army had done far too little to train the "artist" before the Gulf War began. Further, the imagery and data that were collected often did not support accurate battle damage assessment unless a weapon blew up the target and proved to be a clear catastrophic kill.

This mix of problems took time to become apparent. As a result, it was only two weeks after the air campaign began that enough data and analyses were available to show that many B-52, F-16, and F-18 sorties were a waste of effort, and that high quality imagery from the U-2 on heavily attacks targets like the Tawakalna Division of the Republican Guards "showed many of its combat systems to be untouched. [171] Once these discoveries were made, however, General Glosson and General Horner developed several major innovations in the air campaign that steadily increased the lethality of Coalition air strikes against static Iraqi forces after the third week of the air campaign. These innovations included introduction of "kill boxes" and "killer scout" aircraft, on February 4, and the introduction of "tank plinking" using laser-guided bombs on February 6, and the use of a "CAS flow" system during the land offensive.

"Kill Boxes"

The creation of "kill boxes" provided a way of allocating attack aircraft to areas, rather than specific targets, and giving spotter and attack aircraft freedom to operate within a given area without losing central control of the battle and sacrificing the battle management capability of the ATO. They allowed CENTAF to compensate for the fact that management of the air battle had proved to be over-centralized and too rigid early in the war. It also demonstrated that the proper tactics can help compensate for the problems that aircraft have in finding and characterizing revetted and camouflaged targets, and for the problems that single seat fighters with limited endurance and less sophisticated attack avionics experienced in successfully attacking Iraqi targets defended by short range air defenses.[172]

Coalition air planners divided the Kuwaiti Theater of Operations into squares about 30 miles on a side (about three times the area of New York City), with eight kill boxes in Kuwait, and 33 in the entire Kuwaiti Theater of Options.[173] Each box was subdivided into four quadrants to be assigned to a flight for a given period of time. These divisions "deconflicted" the Coalition aircraft flying over a given area so they could strike on a target of opportunity basis. Wherever possible, forward air controller (FAC) aircraft gave attack aircraft specific targets, and FACs and attack squadrons were repeatedly assigned to specific kill boxes to improve their familiarity with an area. The kill boxes near Kuwait's southern border, and the I MEF area of operations, were further subdivided into maneuver boxes and fire support boxes to simplify the coordination of aircraft and artillery, and preparation of the battlefield for the Coalition land offensive.

These kill boxes became steadily more effective once the US began to use imagery from the H-2 cameras on its U-2s to provide six digit coordinates for the targets in given kill boxes. These precise coordinates allowed the targeteers to provide precise target or kill arrays. FB-111 weapons officers used these arrays to program in each target before take off which greatly improved the discrimination and lethality of air attacks.[174]

Some US Army officers were not as happy with the kill box system as the US Air Force. A US Army history of the war notes,[175]

> "The kill box technique was not an unqualified success in the eyes of ground commanders. Although the technique generated lots of sorties, three problems emerged. First, the kill boxes were an Air Force control measure, meaning that selection of the target was the prerogative of squadron and aircraft commanders flying the missions, rather than the supported ground commanders. This situation, in turn, decentralized the targeting, making it difficult, if not impossible, for the ground commander to find out which targets had been hit. Finally, the Air Force selected kill boxes based more on geographical convenience than on the corps commander's scheme of maneuver. The boxes were not necessarily centered over the most menacing Iraqi defenses. The kill concept worked as well as it did in practice because during the air operation the battlefield was almost completely static and there was plenty of time to be methodical and deliberate."

At the same time, such criticism assume a degree of C^4I/BM flexibility and connectivity that Chapters Four and Five indicate did not exist. They ignore the careful limits that had to be placed on using some aircraft near ground troops because of the risk of fratricide, that available sorties were limited, and that General Schwarzkopf directed that the air planners emphasize strikes against the Republican Guards. The above quotation may be more a reflection of the continuing problems in the interface between the US Army and the USAF than a valid criticism of the "kill box" system.

"Killer Scouts"

The introduction of the "killer scouts" on February 4, was the second change that Brigadier General Glosson made to improve the effectiveness of Coalition air attacks on Iraqi ground forces. While it adapted a tactic from the Vietnam War, it is still a good example of the emphasis on "ideas and action" that helped win the Gulf War.[176] Once Coalition air planners recognized that many F-16 and F/A-18 strikes were not as effective as they initially had estimated, they sought a better way to use the aircraft.[177] As one USAF officer noted later, "The F-16 pilots knew that, on each anti-Republican Guard mission, they had been plagued by a common set of problems. Thick cloud decks kept pilots from seeing the target areas until they actually rolled down the chute. Primary targets looked exactly like other armored formations surrounding them. The sheer volume of sorties sent to the area meant that F-16 pilots could not loiter and positively identify their targets."[178]

As a result, Coalition planners began to examine the option of using fighters as killer scouts. This led planners to search for an aircraft that could operate in heavily defended kill boxes deep in the KTO, and they chose the Block 40 models of the F-16C. The F-16s aircraft carried GPS and had the most accurate navigation capability of any version of the aircraft, although they did not fire rockets and had to mark their targets with 500 pound bombs -- while led to their being called "killer" scouts. Further, a number of these F-16 pilots had experience as forward air controllers (FACs), A-10 pilots, or both. This training proved to greatly improve the pilot's ability to locate targets and plan realistic strike approaches for other aircraft.

Air planners worked out a system where A-10 FACs supported close air support operations behind the US Army's fire support coordination line while the F-16Cs would control all F-16 strikes above the line. They also developed procedures for the F-16C to work with the E-3As and EC-130s to obtain additional intelligence and IFF data. When the killer scouts began operation on February 4, they quickly discovered far more buried equipment than they had seen for flying quick missions assigned by the ATO, and found that the ATO was often out of date and that the Iraqi's had moved equipment leaving empty revetments.

The killer scouts also proved they could deal with a number of the problems that the Coalition was experiencing in air operations. For example, it was difficult for fighters flying into the area to orient themselves because the terrain was flat and open. While this exposed some Iraqi targets, it gave pilots a few cues to set up their attack approaches. It was also difficult for Coalition pilots to set up their attacks because the Iraqi ground based air defenses forced aircraft to fly relatively high. Pilots were forced to deliver munitions from higher altitudes than they trained for, and their deliveries were less accurate. The killer scouts greatly reduced the problem in orienting attack aircraft, and provided the data they need to fly more accurate delivery profiles.

The killer scouts found that pilots could often spot dug-in Iraqi armor -- even in revetments with partial shade -- if they used binoculars, and took time to search the area. They were able to locate new targets in the areas that they covered in spite of the fact that Iraqi ground forces often made good use of decoys, camouflage, and revetments, and they found that they could use the moving target indicator capabilities of their radars to target Iraqi armor during periods of bad weather and low cloud cover.

As the killer scouts became more experienced, they sometimes coordinated strikes by as many as 120 Coalition strike aircraft within a two hour period. The number of killer scout pilots also rapidly increased from 8 to 32, and killer scout aircraft began to work four to six kill boxes at a time -- covering an area of up to 5,400 square miles. They provided overlapping coverage by two aircraft formations from "sunrise to sunset."[179]

The killer scouts also quickly worked out ways to minimize their vulnerability. They usually flew at 15,000 to 30,000 feet, and the lead aircraft usually acted as the scout while the wing man searched for Iraqi air defense threats and surveyed a wider area. The lead aircraft carried six 500-pound bombs and would dive bomb at 25-40 degrees to mark, suppress, or attack targets. The wing man carried cluster munitions. These measures also aided in the air defense suppression mission since killer scout aircraft did not attempt to fly defensive tactics and aggressively attacked any Iraqi air defense threat on the ground.

The US Marine Corps used F-18Ds in a similar role, and the "killer scout" system allowed aircraft like the F-16 and F/A-18 to become much more effective in attacking Iraqi ground targets, and they helped the Coalition to attack Iraqi ground forces with limited losses. The Coalition only lost three aircraft (an A-10, AC-130, and A-6E during the week of January 31-February 6. Further, the combination of both killer scouts and kill boxes worked synergistically to provide the Coalition with greatly improved capability to target sorties in support of rapidly moving Coalition ground forces during the land offensive.

"Tank Plinking" With Laser Guided Bombs

Using infra-red sensors to attack dug-in Iraqi armor with laser guided bombs. or "tank plinking, was a third major innovation which greatly increased the effectiveness of the air campaign in striking Iraqi ground forces. While air units had proved to be effective in killing armor when Iraqi forces left their sheltered revetments, they had far more problems in identifying and attacking Iraqi armor when it was static, camouflaged, and in shelters.

This situation changed drastically in early February. F-111 crews returning to base near sunset found that the FLIR equipment in their Pave Tack sensors could detect partially buried and camouflaged Iraqi armor because the Iraqi armored vehicles cooled more slowly than the ground. Brigadier General Glosson directed the F-111 wing to experiment with using laser guided bombs to attack tanks, and F-111's first attempted to use this discovery for targeting on February 8. An F-111 carrying four GBU-12 500 pound laser-guided bombs located and bombed an Iraqi tank. When this attack succeeded, F-15Es and A-6Es were also allocated to such missions with immediate success. Pilot claims were often confirmed by BDA, and reached the point where two F-15Es carrying 16 bombs seem to have killed 16 tanks in a single mission.[180] Attacking armored vehicles with laser-guided bombs came to be called "tank plinking", and proved to be the most lethal form of Coalition air attack on armor.[181]

These innovations were supported by the fact that the Coalition steadily improved the targeting cycle that it used to integrate reconnaissance, central analysis of targeting needs, the theater and tactical requirements of ground commanders, actual air targeting and strike operations, causing damage assessment to improve with time. As Chapter Five discussed, however, this cycle never became fully efficient. USCENTCOM simply lacked the sensors, C^4 assets, procedures, and trained targeteers and battle damage assessment analysts to make the process work with this level of effectiveness.[182] The job got done, and done better than ever before, but it is clear that further major improvements are possible with only limited investment, and that air power can be far more efficient in killing the *right* ground targets in the future than it was in the Gulf War.

The A-10, Maverick, and Battle Damage Assessment

Use of the kill boxes, improved use of Scouts, and better battle damage assessment also allowed Coalition aircraft to make more effective use of the Maverick air-to-surface missile. Improved targeting capability and ability to guide aircraft to the target reduced pilot workload and the risk of losses to ground-based air defenses. This was particularly important in the case of the A-10 As has been noted earlier, the A-10 alone fired 4,801 missiles out of the total of roughly 5,100 infrared and electro-optical Maverick missiles fired by A-10, F-16, AV-8B, and F/A-18 fighters. Some 90% of all the Maverick kills credited to the A-10 during the war were credited to the Maverick.[183]

In spite of these innovations, however, USCENTCOM was never able to solve its battle damage or be certain of just how effective air power really was.[184] There is no doubt that the A-10 was an effective killing platform. During the course of the air campaign, however, the battle damage assessment staffs in ARCENT increasingly discounted A-10 kill claims. They at first counted only 50% of A-10 pilot claim and all imagery reported kills. As time went on, A-10 kills were discounted to 33% of claims. The Department of

Defense lessons of the war study notes that, "an A-10 mission report of a tank kill was counted as one-third of a tank destroyed.[185]

The same report notes that an F-111 claim would be counted as one half of the reports claims."[186] The US Army history of the war notes that, "ARCENT G-2 modified the process to reduce the weight of A-10 claims from one-half to one-third and to accept only 50% of all F-111 and F-15E kills supported by gun video."[187]

The Impact of Weather on Air Attacks on Iraqi Ground Forces

Improvements in tactics and battle management also could not deal with another major problem in attack operations. As has been discussed earlier, air operations in Desert Storm encountered substantially worse January and February weather conditions than experts had predicted before the war, and cloud ceilings existed over Baghdad and Kuwait below 10,000 feet roughly twice as often as weather experts predicted. Weather was bad during the first seven days of the war, and then again during the three days of the ground campaign --when conditions were made even worse later in the war by the smoke from oil wells that Iraq had set on fire in Kuwait.

As a result, as many as 50% of the strike sorties had to be canceled, or missed their targets during the early days of the war. For example, 50% of the F-117 sorties over Baghdad had to be canceled or missed their target on the second and third days of the war, and A-10s could only fly 75 out of over 200 planned sorties over Kuwait on the third and fourth days of the war.

Such weather conditions may, however, be more the rule than the exception. Yet, the impact of bad weather should not be exaggerated. Low cloud ceilings would have been twice as frequent over northern Germany in the winter or Vietnam during the Monsoon season. Immediately after the war, analysts concluded that the weather was the worst in 14 years. Many experts have also concluded since the Gulf War that the weather was not as unusual as climatologists thought, and the problem lay in the statistics available and not in the unusually bad weather. This lack of adequate weather data in for regional conflicts may be a lesson for future wars.[188]

Levels of Damage to Iraqi Forces Before the Ground War Began: 50% or Not?

The number of air strikes called in on Iraqi front line divisions increased steadily as the time set for the beginning of the ground battle approached, and peaked just before February 24. USCENTAF also authorized lower attack altitudes for the A-10 and F-16. By the time the Coalition land forces attacked, Coalition air power had delivered a total of 6,717 strikes against targets in the main kill boxes occupied by Republican Guards units; 2,694 in the two southern kill boxes in the "heel" of Kuwait, 1,290 in the kill box opposite the I MEF, 931 in the kill box surrounding the Wadi Al Batin, and 996 in the two kill boxes along the Saudi-Iraqi Kuwait border west of the Wadi Al Batin. Coalition air units had flown 1,769 sorties against the Iraqi army reserves south of Kuwait City, and just west of the city, 1,018 sorties against targets north of Kuwait City and south of Iraq, and 1,553 sorties in the key kill box north of Kuwait and south of Basra.[189]

The Coalition's goal was to reduce the effectiveness of Iraqi ground forces by 50% before the land battle began. Part of this effort focused on the Republican Guards. Roughly 5,600 sorties, or 15% of the more than 35,000 attack sorties flown during the war, were targeted against Guard forces. This emphasis peaked during the period just before and after the beginning of the land offensive. The USAF alone flew 147 strikes against three heavy Guards divisions on D-1, and 112 on D+2.[190] The key goal set by USCENTCOM, however, was to reduced the overall effectiveness of Iraq's forces in the KTO by 50% before the ground offensive began, and the destruction of Iraq's major ground force weapons in the KTO became the key test of success. USCENTCOM's estimate of its progress in meeting this goal is shown in Table 7.9.

Table 7.9

USCENTCOM Estimate of Cumulative Air Damage to Iraqi Major Combat Equipment in the KTO

Date	Tanks		APCs		Artillery	
	No.	% Lost	No.	% Lost	No.	% Lost
Pre-war Total	4,280		2,880		3,100	
Losses By:						
January 22	-14	0.03	0	0	-77	2.0
January 27	-65	1.5	-50	1.7	-281	9.1
February 1	-476	11.1	-243	8.4	-356	11.5
February 6	-728	17.0	-552	19.2	-535	17.3
February 11	-862	20.0	-692	24.0	-771	24.9
February 16	-1,439	33.6	-879	30.5	-1,271	41.0
February 21	-1,563	36.5	-887	30.8	-1,428	46.1
February 23	-1,688	39.4	-929	32.3	-1,452	46.8
February 24	-1,772	41.4	-948	32.9	-1,474	47.5

Source: Adapted by the author from Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 1887-188, and Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, p. 211.

Even one accepts the claims reflected in Table 7.9, it is clear that the Coalition did destroy 50% of Iraqi major combat equipment before the beginning of the land battle. The decision to launch the ground attack was taken largely on the basis of the estimated impact of air power as on February 23, when USCENTCOM estimated that Iraq had lost 39% of its tanks, 32% of its APCs, and 47% of its artillery. As has been discussed in Chapter Five, the estimates that DIA and CIA were making estimates that were much lower. DIA estimated that Iraq had lost 16% of its tanks, 13% of its APCs, and 20% of its artillery. CIA estimated Iraq had lost 12% of its tanks, 9% of its APCs, and 8% of its artillery.[191]

USCENTCOM was almost certainly more correct in indicating that it had come close to 50% than DIA and CIA were at this time, since DIA and CIA estimated Iraqi losses that were only one-third to one-half as high.[192] While reports based on interviews with POWs were scarcely reliable sources of accurate numbers and information, they also seem to support the USCENTCOM view. Such reports have not been fully released, but one source indicates that Iraqi prisoner of war interviews indicated that by late February, the Hammurabi Republican Guard Division, with 10,000 deployed, had 5,000 deserters, 100 killed, and 300 wounded. This source reports that the 52nd Armored Division's 52nd Armored Brigade, with 1,125 personnel deployed, had 550 deserted, 35 killed, and 400 wounded and had lost 62 of 80 tanks; and that the 8th Mechanized Brigade of the 3rd Armored Division, with 2,300 deployed, had 520 deserted, 1000 killed, and 250 wounded and had lost six of 35 tanks. This same source indicates even greater problems in Iraqi infantry divisions: The 27th Division, with 8,000 men, had 3,000 deserted, 108 killed, and 233 wounded and had lost eight of 17 tanks; The 48th Division, with 5,000 men, had 1,000 deserted, 300 killed, and 800 wounded and had lost 18 of 25 tanks; the 30th Division, with 8,000 men, had 4,000 deserted, 100 killed, and 150 wounded and had lost all 14 tanks; and the 31st Division, with 8,000 men, had 4,000 deserted.[193]

In fact, if one used estimates based upon imagery and corrects for the fact that US intelligence over-estimated the Iraqi threat in the KTO by at least 800 tanks and 600 artillery weapons at the start of the war, USCENTCOM may actually have *underestimated* the percentage of damage done to the Iraqi forces actually in the field, even though it *over-estimated* the total number of Iraqi weapons destroyed. An analysis in the Gulf War Air Power Survey indicates that if one corrects the over-estimation of the Iraqi threat in the KTO at the beginning of the war, air power had actually destroyed 48% of Iraq's tanks, 30% of its APCs, and 59% of its artillery.[194]

It is clear, however, that air power was not always as effective in striking critical Iraqi forces as USCENTCOM estimated.[195] This discrepancy is particularly striking in the case of the Republican Guards. USCENTCOM not only devoted a high percentage of its attacks to striking Guard forces, it estimated that Guard forces were relatively vulnerable. The initial reports on the lessons of the war quoted Coalition pilots as claiming during the war that, "Flying in the area of the Republican Guard was a fighter pilot's dream come true.

There were revetments full of tanks, armored personnel carriers, ammunition, AAA, and artillery as far as the eye could see."[196]

Yet, although USCENTCOM estimated that it had destroyed 34% of the heavy Republican Guards forces at the time the ground war began, intelligence analysis later concluded that the Coalition attacks had only destroyed 24% of their armor in the KTO.[197] The damage done to forward deployed Iraqi regular divisions was often more severe, sometimes approaching 70-90% or more for forward deployed divisions like the 52nd Armored, and 25th, 30th, and 48th Infantry. On the other hand, some low grade Iraqi regular divisions suffered comparatively little damage: The 12th Armored Division suffered only 10% losses.[198]

These problems in estimating the precise impact of airpower before the ground battle are yet another a lesson in the potential value of improvements in battle damage assessment. At the same time, there is a point at which the argument as to how many bombs can explode on an Iraqi tank takes on the same meaninglessness as the debate during the Middle Ages over how many angles could dance on the head of a pin. Brigadier General Glosson had first established the 50% figure as an arbitrary goal for the air campaign, and had based it on overall unit effectiveness, not on equipment levels for planning use simply because some goal had to be set. There was no historical precedent or military reason for choosing 40% or 60% over 50%, and past wars had shown that units often lost most of their effectiveness when they took 25-30% losses of major combat equipment.

Even if accurate data had been available on Iraqi losses, there was still no reliable way to relate damage to different types of equipment to any analytic model for estimating a 50% loss of overall effectiveness. There also was no way in which General Schwarzkopf or other Coalition planners could possibly predict how the date at which the Coalition achieved a 50% cut in effectiveness would relate to the final build-up or readiness of Coalition land forces, to the level of deception achieved, or to any of the many other factors affecting a decision to initiate the land attack.

What is obvious in retrospect is that air power played a critical role in preparing for the land battle, and that equipment losses are only part of the story. Air power unquestionably helped to contribute to massive desertions in the Iraqi forces during the air campaign. According to revised estimates of Iraqi forces, the total manning of Iraqi units in the KTO dropped from 336,000 at the beginning of the air war to 200,000-220,000 by February 24. This 25-30% drop came largely through desertions, although some estimates indicate that up to 10% of the force suffered some kind of wound to air power, disease, or other incapacitation.

As has been noted earlier, the POW reports indicate that interdiction bombing helped to severely restrict communications and training; that some forward deployed units had severe food problems; that little maintenance took place and troops moved away from their equipment, and that many of the officers and enlisted men in units under heavy air attack that remained with their units decided not to resist and to surrender at the first opportunity.[199]

POW reports also indicate that the primary course of desertions was not the loss of combat equipment, or air inflicted casualties, but rather a growing sense of futility and problems with food and water. This feeling of futility was reinforced by a massive psychological warfare effort that was simple, but effective. B-52s, F-16As, and MC-130s, dropped millions of leaflets with warnings and messages calling for surrender. UH-1N helicopters used loudspeakers to send messages, and large bombs were used as part of the effort to increase the terror effect of bombing. While such propaganda efforts were not particularly sophisticated, POW reports do indicate they had some effect in inspiring Iraqi troops to surrender or flee, particularly in the forward area. Such reports are a further lesson in the fact that "unquantifiables" and intangibles are just as important in modern war as in the past, and that military judgment should not be based simply on what can be quantified.

Direct Air Support to the Ground Battle

The Coalition made further adjustments in its offensive air tactics just before the beginning of the land battle to improve its close support capabilities. It carried out major additional attacks on Iraqi land forces just before Coalition ground forces pushed through the Iraqi forward defenses, and it continued to support Coalition ground forces and attack Iraqi ground forces in the rear areas of the KTO until the cease-fire.

"Flow CAS" and "Demand Pull"

The approach of the land battle led to a number of important changes in the way the air war was fought. Ground forces were given USAF, US Navy, and US Marine Corps forward air controllers (FACs) and air-naval gunfire liaison teams. FACs were provided to all of the non-US Coalition major combat units in the attack, and tactical air control teams were provided to JFC-E and JFC-N. F-18Ds and F-16 killer scouts, and close air support FAC aircraft like the OA-10s and OV-10s, were assigned the role of spotting targets.

General Horner introduced another important innovation that improved the effectiveness of air power in affecting the ground battle. In response to his orders, the JFACC set up an operating system where fixed wing aircraft were launched according to a schedule, instead of against given targets, and flew to a series of "stacks" or holding points. Aircraft were then allocated according to "demand pull" in response to requests for air support from ground force commanders. It pushed forward sorties to support given ground force commanders at regular intervals based on the tactical situation. The aircraft were then controlled by USAF ABCCC aircraft. The air liaison officer in each ground Corps would check in regularly with the ground commander. If the ground commander had such targets, he would get air support. If not, the ABCCC aircraft could reassign the fighters to ATF-based targets without wasting sorties.

This system came to be called "flow CAS," and increased the responsiveness of air power to ground commanders although it could scarcely meet every request. US Army figures indicate that ARCENT submitted a total of 3,067 targets during the war for support of ground commanders.[200] About 1,240 of these target requests were included in the ATO, and over 1,580 were submitted directly to USAF targeteers or wings. It is not clear how these totals correlate to the total number of targets attacked in the "kill boxes" or "kill arrays," or to the somewhat different sortie figures used by the USAF, but the "flow CAS" system unquestionably made air support more flexible and quick reacting in meeting ground force needs.

Other changes occurred in the I MEF area. US Marine Corps air units had always taken a more independent view of the JFACC and the ATO during the air campaign than the US Navy and US Air Force -- often "adapting" the ATO to meet the needs of the Marine Corps with only limited coordination with the JFACC. Just before the land offensive, however, the I MEF coordinated a more formal degree of independence with CENTAF. A special high density air control zone (HIDACZ) was created to allow the Marine Corps to coordinate the large number of aircraft, artillery, and rockets that were to be used to support the I MEF in breaching Iraqi defenses. Combat aircraft entering the HIDACZ then worked with the I MEF command and control system to manage air traffic and the hand-off of attack aircraft to the FACs. The size and shape of the HIDACZ was constantly adjusted in coordinating with the JFACC to provide support to other users.[201]

This arrangement did not mean that Marine operations did not remain under were not part of the overall theater air control system. Aircraft like the AV-8B, for example, flew to a "stack" east of the battle zone and orbited for 20 minutes while awaiting targets for close air support missions that were tasked by the ground forces. If they were not requested, they then flew deeper into the KTO and were assigned a mission by one of the FAC fighters covering a kill box. These missions were weighted to emphasize close air support for the Coalition forces leading the breaching operation. During daytime, sections of two US Marine fighters entered the stack every seven and one-half minutes; at night aircraft like the A-6E entered the stack every 15 minutes. EA-6Bs provided jamming and EW protection.[202] The JFACC also instructed Coalition pilots to begin operating below the medium altitudes they had used to protect themselves from Iraqi air defenses once the ground war began, and to press their attacks home at lower altitudes.

This use of "CAS flow," "demand pull," and a special air control zone in the I MEF area, unquestionably played an important role in supporting the land battle -- this is clear from every description of the role of air support in the land fighting. While some competition did take took place for air space and for attack sorties, both the system developed by the JFACC, and the value of the HIDACZ system for providing special support to a key breaching operation while maintaining central control over the air campaign, are lessons of the war.[203]

Support of the Breaching Operation

Air power made four major contributions during the land battle: (1) A special operation to support the breaching of Iraq's two defensive belts near the border, (2) other efforts to prepare the battlefield, (3) close air support of ground forces, and (4) interdiction bombing throughout the KTO to attack Iraqi ground forces. The air effort in support of the breaching operation included the use of B-52s with Mark-117 750 pound and Mark-82 500 pound bombs. These attacks were targets against minefields, but do not seem to have been effective in suppressing mine fields. As has been touched on earlier, MC-130s dropped BLU-82 15,000 pound bombs to create an overpressure that would detonate minefields and demoralize Iraqi troops. The bombs had little impact on minefields, and it is not clear that they had any special psychological warfare impacts beyond the impact of other bombing.[204]

AV-8Bs and F-117s seem to have been have been more effective in attacking Iraq's oil trenches. The AV-8Bs dropped napalm on the oil in the trenches and Attacked pumping stations to burn off oil, while also dropping fuel air explosives to detonate the minefields. F-117As used laser-guided 500 pound bombs to attack oil pipes and distribution points. The AV-8B attacks on Iraqi minefields were no more successful than those of the B-52s and MC-130s, but the oil trenches and oil supply pipes and facilities did exhibit damage after the war. At the same time, close inspection on the battlefield indicates that a number of trenches were filled with oil, and that Iraq still had the ability to distribute oil in other areas.

In any case, Iraq's oil trenches were probably more important as psychological barriers than military barriers. Their construction was erratic, and they were not wide or deep enough to prevent engineering equipment from pushing in sand and creating a breach. Further, a brief experiment with one small section indicated that igniting it would have blinded the Iraqi defenders with oil smoke, although the Coalition forces would have been able to use aircraft and helicopters to provide continuing reconnaissance data. It is interesting to speculate on whether the trenches would really have helped the Iraqi troops in the forward area.[205]

There are two lessons to be drawn from this experience. One is that there is little point in using air power resources to attack targets without testing the lethality of given types of strikes. The second is the need for special purpose air munitions that are effective in mine clearing.

Air Support in Preparing for the Land Battle

The Coalition air support plan for the land offensive called for extensive air support of the land attack during the last few days before Coalition ground forces advanced, and then for a massive multi-sortie surge to support the land offensive, particularly by aircraft like the A-10 and AV-8B. The surge in close air support and interdiction attacks before the land battle helped the Coalition destroy or suppress much of Iraq's artillery in the forward area, and to further weaken Iraqi forces in the path of the Coalition advance.

Weather was relatively good during the week before the land war began, although it did force the cancellation of 500 sorties in support of preparation the land battle on February 20. The Coalition had favorable weather for concentrating air attacks on the Republican Guards on February 21 (the Guards received 89% of all air attacks on that day), and had excellent weather on February 22, when it flew a total of over 1,300 sorties against all targets in Iraq and the KTO. The Coalition also had excellent weather on February 23, when USCENTCOM estimated that air power destroyed 178 tanks, 97 APCs, 201 artillery/multiple rocket launchers, 202 trucks/vehicles, 66 revetments/buildings/bunkers, and two anti-aircraft/SAM fire units on this day alone.[206]

Two days before the land attack, F-111s were shifted from the Republican Guards to attack key artillery concentrations like the artillery component of the 467th Iraqi Infantry Division which had an estimated 204 weapons, rather than the usual 72, and which could have fired on either the Egyptian or VII Corps.[207] When the VII Corps breached the Iraqi defense lines about 36 hours after the F-111 attack on the artillery positions in front of it, Iraqi artillery fire was weak and had little impact on the advancing forces. USMC aircraft also stepped up their attacks on Iraqi artillery and began to support the breaching operation along the Kuwaiti border two days before the Coalition land forces advanced.

These pre-G-Day attacks struck at a key aspect of Iraqi military capability. Iraqi forces had been trained throughout the Iran-Iraq War to rely on massive artillery support when under attack. No advancing Coalition force encountered highly effective or sustained mass fire. This may partly have been the result of problems in the way that Iraq organized its forward defenses, which are discussed in the next chapter, but air power almost certainly had had a major impact in weakening a critical element of Iraq's land defenses.

Close Air Support During the Land Battle

Any analysis of the role of fixed wing air power in providing direct support to the land battle presents a problem in definition. The entire air campaign played a role in shaping the outcome of the four days -- or "100 hours" of land combat. The previous analysis has also shown that the air campaign began to focus on direct support of the land battle well before Coalition ground forces attacked into the KTO. The level of this support is illustrated in Table 7.10, which shows the size of the Coalition fixed wing close air support and interdiction efforts during the last two days before the beginning of the ground battle versus the four days of the ground battle.

It is striking that the Coalition flew 2,896 sorties in such missions during these two days -- February 22 (G minus 2) and February 23 (G minus 1) -- 5,809 such sorties during the entire ground war. If this table was expanded to include earlier missions in direct support of the preparation of the ground battle during the final week before G-Day, it would be clear that air power did as much to directly shape the outcome of the land battle before it began as it did during the "100 hour" campaign.

The data available on Coalition air power also focus on fixed wing aircraft and ignore the role of rotary wing aircraft in providing close air support and battlefield interdiction missions. This focus reflects a traditional split between the analysis of air (fixed wing) and land (rotary wing) forces, but makes no sense in an era of joint operations and the AirLand battle. It disguises the fact that air power actually played a far greater role than Table 7.10 can show -- a role discussed in Chapters Eight and Nine. This failure to link the analysis of fixed and rotary wing combat sorties also disguises the fact that air power played a larger role in providing close support to field commanders than an analysis of fixed wing sorties alone can show. The analysis of air power in future wars should integrate the study of fixed and rotary wing operations.

These consideration aside, it is clear that Coalition air power played a major role once the full Coalition land attack began on February 24 (G-Day). The speed of Iraq's collapse and weather prevented the Coalition from fully executing its air support plans. Weather began to deteriorate on G-Day. Low ceilings and rain showers over the KTO severely limited air strikes early in the day, and USCENTAF was forced to issue a warning that, "... it is better to return with bombs than to risk hitting friendlies" Weather forced the rescheduling of many missions, and a shift away from the use of precision munitions.[208] Nevertheless, the Coalition still flew a total of over 3,000 sorties of all types and approximately 1,200 sorties in direct support of the land battle -- although these sorties were flown against strategic targets as well as against armor, artillery, and infantry and only

400 were close air support missions. B-52s, however, also carried out 43 strikes against Iraq's forward positions.[209]

This same day, Iraq's infantry forces defending its forward positions began a process of collapse that occurred far more quickly than Coalition planners had estimated. As is discussed in the next Chapter, over 8,000 Iraqis surrendered during the first day, and most Iraqi ground defenses in the KTO had collapsed by the second day. This reduced Coalition air activity because missions were not flown against troops that surrendered or were static in bypassed positions, and C^4I/BM problems prevented the rapid reallocation of air support to meet Corps level requests for air support from outside the areas which aircraft were assigned in the ATO. While requests from other sectors -- particularly in the VII Corps area -- could not be met, forward air controllers in some sectors began to turn strike aircraft back to the Tactical Air Control Center because they did not need the support as early as the morning of G-Day.[210]

Coalition aircraft often had to return with their munitions unused. While close air support aircraft, like the A-10 and AV-8B did play a major role in the land battle, A-10s did not drop bombs in 316 of 909 sorties, and AV-8Bs canceled more missions or returned from more missions without meeting ground force requests (143) than they executed (131). Even B-52 strikes scheduled to bomb Iraqi forward defenses were canceled because Coalition troops had already penetrated through the Iraqi defenses.[211]

There were growing weather problems. February 25th (G+1) was the critical day of the land campaign in breaking the Iraqi defenses in the KTO, and the first day in which it was possible to fly extensive sorties in support of maneuvering Coalition armor. However, winds, weather and oil smoke presented problems over much of the battlefield. While the Coalition flew some 577 close support and FAC missions, weather made it difficult to identify close air support targets and distinguish them from friendly forces. USCENTCOM analysts estimated that many British, Canadian, and French sorties were ineffective, as were many US sorties using less sophisticated aircraft and "dumb" weapons. Aircraft that were radar bombing capable were forced to switch to this mode "as the weather deteriorated" and only the F-111s and F-15s were able to carry out extensive numbers of precision strikes which "again took a heavy toll on Iraqi armor and artillery."[212]

USCENTCOM did estimate that air power destroyed 170 tanks, 62 APCs, 155 artillery/multiple rocket launchers, and 103 trucks/vehicles on February 25, although later battle damage assessment indicated that this estimate was exaggerated.[213] Physical destruction, however, was no longer the issue. By the early evening, the Iraqi retreat became a rout. At this point near misses or even the presence of attack aircraft almost certainly had a major impact on morale, and on the willingness to stay in positions or military vehicles, regardless of the amount of equipment destroyed. Many Iraqis began to abandon their combat equipment even if they were not under direct pressure from Coalition ground troops and air strikes and the constant presence of aircraft in the battle area almost certainly contributed to this process.

The weather grew worse on February 26 (G+2), and heavy rains and morning fog restricted air movement and aerial supply missions. This did not prevent the USAF from flying 1,673 missions, the USN from flying 664, the USMC from flying 405, and allied forces from flying 904. The Coalition flew 581 close air support and FAC sorties, including a total of over 350 sorties against Iraqi armor and artillery in direct support of Coalition ground forces, although smoke and weather led many scheduled close air support sorties to be redirected by the CAS flow system to targets like the Republican Guards forces in locations south and west of Basra. The Coalition also flew 22 B-52 strikes and 52 packages against bridges, airfields, production and storage facilities, and command and control sites.

USCENTCOM estimated that these strikes destroyed 128 tanks, 38 APCs, 13 bridges, and 401 trucks/vehicles. Later battle damage assessment indicates that this estimate was probably more exaggerated than that of the day before, but air power clearly helped increase the rate of the disintegration of the Iraqi Army. It kept up constant pressure in rear areas, forced even more equipment to be abandoned, and helped prevent any effort to organize the Iraqi retreat of support organized counterattacks.[214]

Late on February 27 (G+3), President Bush declared that, "Kuwait is liberated (and) Iraq's Army is defeated," and ordered the suspension of hostilities as of 12:00 US Eastern Standard Time on February 28. By the end of February 27, the USAF had flown a total of 1,651 missions, the USN had flown 671, the USMC had flown 147, and allied forces had flown 471. Poor weather and oil smoke presented problems over much of the area of operations, and forced many strike/attack aircraft to rely on radar bombing. Nevertheless, the USAF flew 284 close air support and FAC sorties, the USMC flew 114 CAS and FAC sorties, and the US special forces flew four sorties. US aircraft flew over 400 sorties against Iraqi armor, artillery, and vehicles. USCENTCOM estimated that these strikes destroyed over 80 armored vehicles, and 54 transport vehicles. This low total was largely a product of weather, since the Iraqi rout would otherwise have exposed many vehicles in large open clusters to Coalition air attacks. This might well have led to catastrophic damage under other circumstances because Iraq's forward air defenses had largely collapsed and many units were extremely vulnerable.[215]

Night and weather forced the Coalition to concentrate heavily on radar bombing, and on trying to attack bridges and causeways to bottle-up Iraqi forces in the KTO and southern Iraq. These attacks, however, had considerable success, but they did not affect

Iraqi movement as much as was estimated at the time, and all attacks halted before the Coalition could either seal off the KTO or use the improving weather on March 1 to attack Iraqi ground forces in depth.[216]

The cease-fire was pushed forward by four hours and went into effect at 0800 hours local time on the 28th (G+4). The timing of the cease-fire sharply reduced the number of sorties the Coalition flew on the last day of the war. The USAF only flew 575 sorties of all types, the US Navy 187, and the USMC 30. Only 93 of these sorties were in interdiction and battlefield interdiction missions, however, and only 26 were close air support sorties. Allied forces flew 200 sorties, and virtually none were in support of the land battle.

The Role of Interdiction Attacks

The Coalition flew a total of 917 interdiction and battlefield interdiction missions on February 24 (G-day), 813 on February 25 (G+1), 1,102 on February 26 (G+2), 867 on February 27 (G+3), and 93 on February 28 (G+4). This is about twice as many sorties as the number of close air support and FAC sorties (3,702 versus 2,107), but such figures can be misleading. The difference between a close air support sortie and a battlefield interdiction sortie was often a matter of relatively arbitrary classification, particularly after G+1. Coalition land forces had already converted the AirLand battle to a battle of deep maneuver, and many "interdiction sorties" directly supported the maneuver efforts of the main thrusts against the Republican Guards and the maneuver efforts of Corps and division commanders.

A-10s and F-16s flew armed reconnaissance along the vehicle filled roads leading out of the theater. "Packages" of F-A/18s and A-6Es -- supported by EA-6Bs, E-2s, and KA-6Bs -- struck Iraqi forward air defense batteries in the KTO. Saudi F-5s, UAE Mirage M-2000s and Kuwaiti Mirage F-1s attacked Iraqi artillery batteries and other Iraqi land force targets. Italian Tornado GR1s, French Jaguars and Mirage F-1s struck at Iraqi troops, armor, and artillery. However, the Coalition took the decision not to launch massive attacks on Iraqi land forces in the area of Basra. This limited the impact of interdiction on rear area missions during the last days of the war.

The air interdiction missions also had two phases. From the start of the ground offensive to late February 25 (G-Day to G+1), they concentrated on attacking the Republican Guard and regular army armored and mechanized divisions in the reserves. These strikes were supported by the JSTARS, F-16C killer scouts, and F/A-18Ds. Once a general Iraqi retreat began late on February 25, however, the Coalition air interdiction effort shifted to pursuing and destroying the retreating Iraqi Army. It attacked the retreating columns of tanks, armored vehicles, trucks, and cars until 0800 local time on February 28, when the cease-fire went into effect.

These strikes had a decisive impact on the Iraqi columns fleeing north from al Jahra towards Basra and up the Mutla Pass to the Mutla Ridge. on the night of second day of the ground attack, Iraqi III Corps forces fleeing the oncoming I MEF and JFC-E joined the Iraqi forces in Kuwait City in fleeing north towards Basra. The narrow pass area at the ridge became a natural target, and aircraft quickly destroyed enough vehicles to make further movement impossible. At the same time, vehicles continued to pour onto the road out of al Jahra and Kuwait City, creating a massive traffic jam two miles long. The JSTARS detected and characterized these movements, assisting both air targeteers and the commanders of the ground campaign. F-15E aircraft were able to exploit their superior all-weather capabilities to attack in spite of weather that prevented attacks by most other types of Coalition aircraft, and to press home their attack during the night and then through the daylight hours.

The resulting damage to Iraqi forces led to press reports of an immense "highway of death" that did not have the slightest relation to reality. In fact, most Iraqi vehicles were abandoned undamaged, or only exhibited collision damage from the attempt to work their way through the routed vehicles. While more than 1,400 vehicles were trapped, only 14 were tanks and 14 more were armored vehicles. Even reports of 200-300 dead in a column that must have had over 10,000 people may be exaggerated. These figures include the dead from another road to the east around the shore towards Bubiyan. This road was taken by a number of tanks and armored vehicles, many of which suffered from catastrophic kills from the air.[217]

The Hawr al-Hammar causeway -- which crosses over the large lake or marsh south of the junction of the two rivers northeast of Basra and whose eastern end is just north of Az Zubayr -- was a different story. This lake extends west to an area about 30 miles east of An Nasriyah, and forms a natural chokepoint. By the time that Iraqi forces attempted to flee north across the causeway, it had already been repeatedly bombed and repaired, and could only sustain a limited flow of traffic. F-111Fs with laser-guided bombs hit enough Iraqi vehicles to block the causeway on the night of February 26, and air strikes and AH-64 strikes continued through February 27. Reconnaissance later showed about 550-600 abandoned vehicles. Only 10-20 of these vehicles were heavy armor.[218] It seems likely, however, that Iraq recovered at least some of the armored vehicles trapped along the causeway before these photos were taken.[219]

Air power also helped make the area around Basra became another chokepoint for fleeing Iraqi forces. Most of the roads and bridges north converged near the city, and most of the Iraqi military forces fleeing north moved into the area because the XVIII Corps had sealed off the routes to the West, and the VII Corps could not drive northeast fast enough to seal off the roads to Basra. While some movement was still possible north across the rivers, the main bridges over the canals and rivers had all been damaged or destroyed. As a result, a virtual flood of escaping Iraqi forces created a 20 mile long traffic jam on the western side of Basra. This concentration normally would have been an ideal target, but it was not exploited for several reasons: It was so near Iran that it created the risk of collateral damage across the border, the Iraqi military forces were an urban area and civilian buildings, there was a low weather ceiling, Coalition ground forces had begun to approach the area on February 27, and the cease-fire occurred at 0800 on February 28.[220]

Strategic strikes also continued during the ground campaign, including an attack on the Iraqi leadership bunker at At Taji that briefing led air analysts to believe they had hit Saddam Hussein. Tornado GR1s and Buccaneers, protected by F-Gs, attacked the hardened shelters at the Jalibah and Tallil airfields. B-52s bombed C^4 sites in southern Iraq. "Packages" of F-16s and F-4Es, escorted by F-15s, EF-111s, and F-4Gs attacked targets like military production and R&D facilities in northern Iraq, and a liquid fuel facility for missiles. The Coalition also lost eight aircraft during this last week of the war: Three AV-8Bs, one A-10, one OA-10, and two F-16s.[221]

The Role of Individual Coalition Air Forces and Aircraft During the Land Battle

The detailed patterns in the use of Coalition air power to support the land battle are also shown in Table 7.10. The data in this table present problems because different countries reported their support of the land battle in different ways, and because different counts exist for the number of sorties flown by different air forces on a given day. These data, however, are approximately correct in terms of sortie numbers and are almost certainly correct in showing the relative weight of effort.

A number of points emerge which support the preceding analysis. Many different figures can be used to portray any given aspect of Coalition air activity. It is possible to use a total like 110,000 sorties for the total of all sorties flown, or use a total only about half that amount for direct combat sorties. Regardless of what figure is chosen, it is striking that the Coalition flew only about 10% of its sorties during the land battle. The Coalition flew less than 5,800 interdiction and air support sorties during the entire land battle, and only a little over 2,100 of these sorties were close air support or forward air control sorties. Even if one only counts the entire 13,1881 sorties flown during the land battle, only 44% were flown in offensive missions and only 16% in close or battlefield air support.

The data against reflect the dominant role of US air power. Table 7.10 shows that the US flew 92% of the offensive sorties in support of the land battle. The only other air forces to fly a significant number of missions in support of the land battle were Saudi

Arabia with 3% of the total and Kuwait with 2%. Table 7.10 also shows the US also flew virtually all of the close air support sorties. The allied air forces that flew offensive missions in support of the land battle generally flew interdiction or battlefield interdiction missions further to the rear. This emphasis on US air power reflected the superior precision strike and close-air support mission-orientation of US aircraft, but it was also a matter of C^4I/BM capability. The US found it far easier to control its own aircraft in what became a far more complex air combat environment the moment that strike/attack aircraft had to engage in combined operations, and also found it easier to use this control to reduce the risk of fratricide.

Further, Table 7.10 shows that there was often a limited correlation between aircraft type and use in missions in support of the land battle. The US made use of almost all of its different strike/attack assets including heavy bombers. For reasons that have been touched upon earlier, dedicated close support and forward air control/spotter aircraft -- the A-10, AV-8B, OA-10, and OV-10 -- played an important role, but they did not dominate the use of air power during the land battle. They flew a total of 1,625 sorties: This is fewer sorties than were flown by multi-mission aircraft, and 31% of the total interdiction and attack sorties flown during the ground war. As has also been noted earlier, the use of air power during the land battle also generally did not involve the use of smart or highly sophisticated weapons. Many of the F-111 sorties during this period used radar bombing as did many of the F-15 and A-6 sorties. Only the A-10 made heavy use of air-to-surface missiles, and it was often forced to use cluster bombs or "dumb" bombs in the air burst mode.

Table 7.10

Coalition Sortie Rates in Close Air Support/Interdiction Missions By Aircraft Type During the Land War - Part One

Aircraft Type	Final Preparation of the Battlefield		Ground Combat						
	22nd	23rd	24th*	25th	26th	27th	28th*	Total	% of Total
Weather	Moderate	Moderate	Poor	Poor	Poor	Poor	Mixed		
A. Total Coalition Sorties	3,089	3,254	3,280	3,056	3,244	2,878	723	13,181	100
B. Total Offensive Sorties									
Interdiction & Battlefield Interdiction	995	1,036	917	813	1,012	867	93	3,702	28
Close Air Support & FAC	373	492	521	577	581	402	26	2,107	16
Sub-total	1,368	1,528	1,438	1,390	1,593	1269	119	5,809	44
C. US Air Force Offensive Sorties By Service									
USAF									
Interdiction & BAI	676	601	517	380	492	403	20	1,812	31
CAS & FAC	45	144	212	335	339	284	22	1,192	21
Sub-total	721	745	729	715	831	687	42	3,004	52
USN									
Interdiction & BAI	126	176	169	244	278	270	72	1,033	18
USMC									
Interdiction & BAI	46	166	91	93	150	59	1	394	7
CAS & FAC	326	345	306	239	239	114	4	902	16
Sub-total	372	511	397	332	389	173	5	1,296	23
USSOCCENT									
CAS & FAC	2	3	3	3	4	4	0	14	.3
Sub-total	1221	1,435	1,298	1,294	1,502	1,134	119	5,347	92

Table 7.10

Coalition Sortie Rates in Close Air Support/Interdiction Missions By Aircraft Type During the Land War - Part Two

Aircraft Type	Final Preparation of the Battlefield		Ground Combat						
	22nd	23rd	24th*	25th	26th	27th	28th*	Total	% of Total
Weather	Moderate	Moderate	Poor	Poor	Poor	Poor	Mixed		
D. US Offensive Sorties By Missions and Type of Aircraft									
Bombers									
B-52G (USAF)	51	43	47	47	37	29	0	160	4
F-111F (USAF)	71	62	69	64	59	59	0	251	6
Sub-total	122	105	116	111	96	88	0	411	10
Dedicated Strike									
F-15E (USAF)	52	51	60	56	80	56	4	256	6
A-6E (USMC/ USN)	2	32	35	38	35	26	2	1	102
EA-6B (USMC)	16	16	16	16	15	5	2	54	1
(A-7)	(NA)	(17)	(28)	(-)	(0)	(16)	(29)	(12)	(NA)
Sub-total	100	102	114	107	121	63	7	412	10
Multi-Role									
F-16A/C (USAF)	305	310	275	312	342	274	8	1,211	29
F/A-18 (USMC/USN)	192	204	175	135	166	102	4	582	14
Sub-total	497	514	450	447	508	376	12	1,793	42
Close Air Support									
OA-10 (USAF)	21	20	22	22	19	21	4	88	2
A-10 (USAF)	175	208	216	212	220	207	26	881	21
AV-8B (USMC)	136	211	174	152	186	63	0	575	14
OV-10 (USMC)	16	21	23	24	24	9	1	81	2
Sub-total	348	460	435	410	449	300	31	1,625	38
US Total	1,067	1,181	1,115	1,075	1,174	827	50	4,241	100

* Ground campaign begins at 2401 on the 24th and ceasefire occurs at 0800 on the 28th.
Source: Adapted by the author from data in Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 220, and Volume V, Part I, pp. 223-352. USN did not fly such missions. A-7 shown but not counted in totals

Table 7.10

Coalition Sortie Rates in Close Air Support/Interdiction Missions By Aircraft Type During the Land War - Part Three

Aircraft Type	Final Preparation of the Battlefield 22nd	23rd	Ground Combat 24th*	25th	26th	27th	28th*	Total	% of Total
Weather	Moderate	Moderate	Poor	Poor	Poor	Poor	Mixed		
E. Allied Air Forces									
Saudi Arabia									
F-5 46	48	48	12	24	36	0	120	2	
Tornado	19	20	20	18	11	16	0	65	1
Sub-total	65	68	68	30	35	52	0	185	3
Bahrain									
F-16	0	0	0	0	0	0	0	0	0
F-5	4	4	0	4	0	4	0	8	.1
Canada (CF-18)	0	0	8	8	12	20	0	48	1
France									
Jaguar,	20	21	18	0	0	0	0	0	0
Mirage F-1	4	0	2	0	0	0	0	0	0
Sub-total	24	21	20	0	0	0	0	20	.3
Italy (Tornado)	4	4	4	4	4	4	0	16	.3
Kuwait									
A-4	20	20	20	22	20	19	0	81	2
Mirage F-1	10	10	-	0	5	10	0	15	.1
Sub-total	30	30	20	22	25	29	0	96	2
Qatar (Mirage F-1)	0	0	0	4	0	0	0	4	.1
UAE (Mirage 2000)	4	4	4	8	8	10	0	30	.5
United Kingdom									
Buccaneer	0	0	0	0	0	0	0	0	0
Tornado ADS	0	0	0	0	0	0	0	0	0
Tornado IDS	0	00	0	0	0	0	0	0	0
Jaguar	16	16	15(16)	16	8	16	0	55	.9
F. Allied Sub-total for Offensive Sorties	147	147	139	96	92	135	0	462	8
G. Total Coalition Offensive Sorties	1,368	1,582	1,437	1,390	1,594	1,269	119	5,809	100

Note: Mission categorization varied among allied countries, and various data bases reported different sortie rates during this period. No allied country reported close air support sorties. Saudi Arabia and Kuwait reported both BAI and interdiction sorties, but only flew interdiction sorties during the land war. Bahrain, Canada, Italy, Qatar, UAE and United Kingdom only reported interdiction sorties. France only reported

battlefield interdiction sorties. The UK flew the Tornado and Buccaneer in interdiction missions during the war, but not during the period shown.
Source: Gulf War Air Power Survey, Volume V, Part I, pp. 234-309

The Impact of the Cease-Fire and the Overall Impact of Airpower on the Land Battle

There is no doubt that Coalition airpower played a major role in supporting the ground campaign, just as it had played a major role before the Coalition began the last phases of its effort to preparing the battlefield. Air power played an important role in breaching Iraqi forward defenses, in attacking forward Iraqi positions in preparation for the start of the land offensive, in close air support and battlefield interdiction sorties, and in attacking retreating Iraqi forces. At the same time, many uncertainties exist regarding the role air power played in destroying Iraqi forces.

Table 7.11 provides the most detailed estimate of the impact of air power in destroying Iraqi ground equipment that is currently available. The first part of Table 7.11 shows estimated Iraqi losses to air power during each day of the ground campaign. These estimates, however, present serious problems. They only include losses to fixed wing aircraft. At the same time, post-war review of these data indicate they include a substantial number of Iraqi systems killed by helicopters and land weapons, "double kills," and systems that have been abandoned or which were repairable.[222]

The second part of Table 7.11 shows USCENTCOM's estimate of the impact of fixed wing air power before and during the land offensive. These data indicate that 451 of the 2,159 tanks were destroyed by air (19%), 224 of the 521 APCs (43%) and 353 of the 1,465 artillery weapons (24%). These figures, however, are based upon the USCENTCOM claims that Coalition land and air forces destroyed at total of 2,159 tanks, 521 APCs, and 1,464 artillery weapons.

USAF experts sharply disagreed with the allocation of kills to air power in the USCENTCOM figures, but this particular debate is moot. As Chapter Five has already discussed, analysis after the war produced much lower estimates of Iraqi losses. These estimated, based largely on imagery, are also shown in Table 7.11, and total only 1,245 tanks (58% of the USCENTCOM estimate), 739 APCs (142% of the USCENTCOM estimate), and 1,044 artillery weapons (71% of the USCENTCOM estimate).

These imagery based data, however, are not separated into air and land kills, and have serious defects and uncertainties of their own. As Chapter Five documents, much of the information is not supported by detailed battle damage data. No survey was taken of the battlefield after the war was over that had enough detail or scope to determine what weapons produced different results during the conflict.[223] This makes it impossible to be certain of the correct numbers. It is unclear that any effort to estimate the relative size of air and land kills could be accurate that was not based on detailed inspection of individual Iraqi weapons on the ground. The land campaign moved extremely quickly at a time when weather limited the effectiveness of strike/attack aircraft, and most of the intense fighting involved joint operations by fixed and rotary wing aircraft, artillery, and armor. Excluding rotary wing air power from most figures on air power "kills" ignores the fact that AH-64s alone claimed to have destroyed more than 600 tanks, and Marine attack helicopters played a major role in the war.[224] As Chapter Nine shows, there were a number of encounters during the land battle when attack helicopters were the only aircraft that could operate because of oil fires, blowing sand, and weather.

Further, even if the data in Table 7.11 were correct, there would also be good reason to question how much they would say about both the overall effectiveness of airpower in the Gulf War and lessons for the future conflicts. Any effort to estimate the effectiveness of air power solely in terms of the amount of equipment destroyed is also inherently misleading. If sheer destruction had been the goal, the Coalition should have engaged Iraqi forces in populated areas around Basra, and systematically destroyed the retreating Iraqi columns. There were many opportunities on the 25th through the 28th for the Coalition to increase the destructive impact of air power on Iraqi forces that no longer contributed to the land battle if this had been a major goal. Regardless of the weather, there were also many unexploited "killing grounds" in the KTO.

The shock power of air attacks may be an intangible, but it certainly played a major role in the rout and disintegration of Iraqi forces, and there is no way to separate the shock impact of air power before the land battle, from the shock impact of air power during the AirLand battle. Further, armored maneuver and rapid combined arms advances have shock power of their own, and there is no way to separate their impact from the impact of the shock and lethality of air power.

Attacking with total air supremacy and carrying out a one-side air campaign for weeks, and then fighting an AirLand battle of only "100 hours" is scarcely likely to be typical of future wars. It is also difficult to generalize about the future role of many aspects of joint warfare and combined operations. For example, weather helped to ensure that attack helicopters would play a more decisive role during the ground battle that might otherwise be the case. The Coalition combined its advantages in air power with vastly superior artillery targeting and lethality, and the longer range firepower and thermal imaging sights of Coalition tanks. These advantages will not occur in wars where ground forces were more evenly matched, and this too will change the relative impact of air power.

At the same time, ongoing improvements in tactics and technology will make many aspects of air power more lethal in future wars. It is almost certain, for example, that if the Coalition had had more aircraft with advanced infrared navigation and targeting capability, this would have made air power much more lethal in both the close air support and interdiction roles. Air power would have been much more lethal with a major increase in support from systems like JSTARS and near-real time theater and tactical air reconnaissance assets. Better identification of friend and foe (IFF) would have allowed the use of air power closer to advancing Coalition ground troops. Smart submunitions and air-to-ground munitions would have compensated for a number of weather problems, and more precise navigation systems, and all-weather/night avionics would have greatly improved kill capability under these conditions.

It also is unlikely that air and land commanders will have similar problems in integrating requests for air support with the overall management of the air battle. Some of the problems that occurred in the AirLand interface during the ground campaign were the product of other causes. They were the result of the fact that CINCENT gave priority to air attacks on interdiction targets like the Republican Guards units in the rear, and this forced the JFACC to deny some of the requests by Corps commanders -- particularly by VII Corps. They were also the product of the fact that air planners were attacking all of the Iraqi forces in the KTO, and had legitimate reasons for denying some requests from Corps commanders.[225] Many of the problems, however, were the result of the fact the situation on the battlefield moved so quickly that Corps level requests did not reach the JFACC in time so air strikes could still be effective, and there was not way to fully integrate requests from land units into the overall management of the air battle. The state of the art in C^4I/BM systems simply did not permit time urgent integration of land force requests for close air support and battlefield interdiction missions into the overall management of the air battle -- any more than it permitted full flexibility in mixing fixed and rotary wing string assets -- and there were many cases after G-Day when FACs in one area were releasing aircraft assigned to close air support missions while the JFACC could not meet requests in other areas.[226]

Many improvements to deal with these C^4I/BM problems are already being made by the US military services and the forces of number of other countries. While there are still very real technical problems in fully integrating air power into the land battle, and some of the C^4I/BM problems may take more than a decade to fully solve, it is clear that military planners are already acting on the lessons of the both the air and land campaigns to improve the lethality of airpower against ground forces. As a result, air power is likely to be significantly more effective in supporting the ground battle in the future -- even under demanding weather conditions.

Table 7.11

The Impact of Coalition Air and Land Forces on Iraqi Equipment Strength

A. Bomb Damage From Fixed Wing Coalition Air Strikes

Date	Tanks	APCs	Artillery	Trucks
February 24	77	58	133	245
February 25	76	66	98	151
February 26	170	62	103	155
February 27	128	38	19	401
Total	451	224	353	952

B. Estimates of the Combined Impact of Air and Land Forces During the Entire War

	Tanks	APCs	Artillery	Trucks
Total Iraqi ground force equipment in KTO on January 16, 1991, at start of Air Campaign (Imagery)	3,475	3,080	2,474	-
Total Imagery Based estimate of equipment destroyed during the air campaign before the ground battle.(USCENTCOM estimate less the over-estimate of Iraqi tanks by 300, and over estimate of artillery.	1,388	929	1,152	-
Total Iraqi ground force equipment left at beginning of the land campaign	2,087	2,151	1,322	-
(Total Initial USCENTCOM Estimate of Iraqi ground force equipment in the KTO destroyed or abandoned during the during land campaign before Imagery Analysis	(2,159)	(521)	(1,465)	-
Destroyed by air	(451)	(224)	(353)	-
Destroyed by land or abandoned)	(1,708)	(297)	(1,112)	-
Total Corrected Imagery Based Estimate of Iraqi ground force equipment in the KTO destroyed or abandoned during the during land campaign	1,245	739	1,044	-
Total Iraqi ground force equipment in the KTO destroyed during both the air campaign and land offensive (Imagery Based)	2,633	1,668	2,196	-
Still in Iraqi Control on March 1, 1991 (Imagery)	842	1,412	279	-

Source: Adapted by the author from Eliot Cohen, ed., Gulf War Air Power Survey, Volume II, Section II, pp. 259-261.

The Other Side of Airpower: Readiness and Human Factors

There are additional lessons regarding the impact of air power in the Gulf War which are not uncertain or controversial, and which do not lend themselves to the analysis of either the counter-air or offensive air campaigns. Previous chapters have already stressed the critical importance of other aspects of air power: the value of superior leadership and doctrine, the value of Saudi and other Gulf bases and support, the value of training and highly skilled personnel, and the value of high levels of readiness. It would be unrealistic to close the discussion of airpower, however, without repeating these lessons and discussing several related aspects of airpower.

Readiness and Maintenance

Each of the US services military services has stressed the value of high levels of aircraft readiness during the Gulf War as one of the key factors that made the air campaign so successful. The USAF has repeatedly raised the high aircraft availability rates shown in Table 7.12 as a lesson of the war, and as a model of what can be achieved in the future. The USAF makes a valid point, although it uses readiness rates measure as of midnight and daytime operational rates were often significantly lower. High levels of air crew training and readiness were critical to making the Coalition's technical superiority meaningful. It would have had far less impact without the best possible "man in the loop." The same was true of the readiness of maintenance and support personnel.

Much of the most sophisticated combat equipment employed in the war was more reliable and easy to maintain than its less sophisticated and capable predecessors. The need to design in maintainability, availability, and reparability -- rather than focus on initial combat capability -- is a key lesson the US drew out of Vietnam. It is one the US clearly put into practice.[227]

Technology alone, however, played a far less important role in achieving the aircraft readiness rates shown in Table 7.12 than the hundreds of thousands of work hours by combat ready and highly trained men and women put into aircraft and weapons maintenance. The availability of US strategic airlift -- and of massive stocks of supplies, spare parts, and repair equipment -- allowed the rapid deployment of the equipment needed for aircraft and weapons maintenance. The five and one-half months that Iraq gave the US to deploy, allowed it to provide the needed support capabilities, to adapt to new maintenance cycles, to modify equipment and operating procedures, and to draw upon the highest worldwide pool of readiness assets the US had ever had in peacetime. So did the US ability to use advanced interoperable Saudi facilities -- which the USAF later estimated saved the equivalent of 1,800 airlift missions to the region.[228].

While combat aircrews and aircraft may have done the more visible part of the fighting, approximately 98% of all USAF personnel deployed to the region were in maintenance, ground-based C^4I/BM functions, engineering units, and various forms of support services. They were the personnel that made high sortie rates possible and ensured that weapons could be effective.

As was the case with the other US services, logistics were also of critical importance. The USAF had to organize a massive deployment and logistic effort to make Desert Storm possible. This task was eased somewhat by the fact that the USAF had invested in support systems for rapid deployment to bare bases without military facilities, had prepositioned munitions in the Gulf region, and had created War Readiness Spares Kits (WRSKs) to provide for the rapid deployment of 30 days worth of supplies, spares, and maintenance personnel.

Some of the key programs in preparing for deployment to the Gulf involved the "Harvest" programs; including Harvest Eagle, Harvest Bare, and Harvest Falcon. Harvest Eagle provided 1,100 persons and housekeeping sets for bare bases. Harvest Bare provided a 4,400 person package to support a wing of 72 aircraft, and Harvest Falcon was a 55,000 person package to support 750 aircraft at 14 different locations. At the time Desert Shield began, Harvest Falcon was about 82% complete, and 35% of the necessary equipment had been deployed to the region.[229] The ability to use this package and the 21 airfields in Saudi Arabia and other friendly Gulf states, eased some of the problems that the US faced in deploying air units during the Gulf War, and demonstrated the value of prepositioning, packaging forces for expeditionary missions, and preplanning rapid deployment.

The USAF still, however, had to adapt and improvise much of its logistic, basing, and support activity. It had to go through a major construction and engineering exercise which helps illustrate the importance of readiness and rapid deployment capability. During Desert Storm, USAF engineers and community support personnel erected over 5,000 tents, constructed over 300,000 square feet of hard-wall facilities, laid over 500,000 square meters of concrete and asphalt, and served over 20 million meals.

One air base had to be built from the ground up in forty days. As the wing commander noted, "the tallest thing on the base when we got here was the two inch high taxi way lights." USAF personnel and Saudi contractors worked around the clock to build the base areas -- 380 tents, four field kitchens, a 50-bed hospital, tactical field laundry, 19 latrine/shower units, and a tactical field exchange. They even had to bring electrical power to the base "without this support, aircrews at these bare bases could not have performed their mission."

Many logistic and maintenance problems had to be solved through sheer volume of effort. The WRSK system was supposed to rely on a mainframe computer and computerized combat supply. In practice, the system netting failed, and work arounds had to be developed using modems and couriers to carry floppy disks. An effective regional system did not begin operation until January 5, 1991.[230] This set of problems interacted with the fact that the US did not have enough initial locations to load strategic air lifters, faced very real limitations in the number of aircraft available, the fact that individual services grossly mismanaged their prioritization activities and sometimes gave top priority to over 50% of their requests, and the continuing changes in USCENTCOM's force requirements discussed in Chapter Two.

The build-up time available during Desert Shield was again of great importance. Deliveries of some critical parts and items of maintenance equipment experienced long delays, and a great deal of equipment was mis-prioritized. Massive backlogs occurred in the shipment of critical supplies, further compounding the problem of managing the flow of cargo and the overall problem of setting theater-wide priorities.[231] The records of much of the support effort during Desert Shield reveal that it had a man against system character that increased the burden on personnel and the overall work effort.[232]

The WRSK system was also heavily dependent on readiness which presented problems with some aircraft. The USAF had been able to fund about 92% of its WRSK requirements during FY1984 to FY 1987, but only 35% during FY1988 and FY1989. This created serious problems in terms of parts for new aircraft like the F-15E, and forced the USAF to cannibalize its global and regional inventory to keep aircraft in the Gulf operational.[233]

The in-theater maintenance effort was eased by the steady improvement of the reliability and maintenance design of US aircraft. A F-16, for example, needed only about 18% of the spare parts in dollar value of the F-111 and less than 50% of the parts needed by the F-16. This still, however, left a massive work burden. For example, logistic support of the maintenance effort involved the distribution of over 60,000 types of spare parts. It also rapidly became apparent that USAF maintenance cycles had to be changed in many ways, such as the cycles for changing air filters. Some aircraft had to be modified to move temperature sensitive voltage regulators, and power supplies, etc. away from engine hot spots.

As was the case for the US Army and US Navy, US bases in Europe had to be used for many tasks, including a major increase in engine repair and overhaul activity over predicted levels, and performed more than 500 engine and 4,500 major avionics repairs. Some repairs, like C-130 propeller repairs, were conducted in Europe to provide clean space free of sand and grit. Major increases also took place in US maintenance facilities in the US, which rebuilt 260 engines and major sections of 550 more. This use of European and US facilities also helped to reduce the drain on WRSK parts and spares.[234]

Medical support services are another example of the effort required. The first USAF squadron medical elements and air transportable clinics left for Saudi Arabia. This began the largest projection of medical personnel in American history. Over 6,200 active duty medical personnel and 5,500 from the Air Force reserve deployed to Europe or the Gulf. The first of 15 air transportable hospitals arrived in theater within the week and was ready to receive patients within 24 hours. These 50 bed hospitals, together with a 250 bed contingency hospital, were the primary air force medical support in the theater. During Desert Shield and Desert Storm, almost 130,000 outpatient visits and 3,500 admissions were made in the Gulf. In addition, four USAF contingency hospitals in Europe with 3,250 beds were prepared, staffed and made ready for casualties, while 2,175 beds were made read in the US. Reserve forces in the US by augmented USAF medical treatment facilities with over 6,600 personnel.[235]

The US military services have done an uncertain job of publicizing the importance of readiness, human factors, time, Saudi facilities, and the scale of this support effort since the Gulf War -- although this has scarcely been true of commanders who served in the theater. Any detailed review of unit logs, the logistic and support data in Volume III of the Gulf War Air Power Survey, or of the chronology in Part II of Volume V of the Gulf War Air Power Survey, shows, however, just how critical time, readiness, people, foreign support, and adaptation were to the real world war fighting capability of every element of US air power, as well as to every other weapon system employed. Technology alone is never the answer to any military problem; it is meaningful only to the extent it is supported by tactics, training, and human technical skills. Further, the US military services do themselves no favor by failing to analyze what is necessary to deploy forces with the same levels of combat readiness and effectively under surprise or sudden attack conditions.

Table 7.12

Aircraft Operational Availability and Readiness Rates in Desert Storm

Aircraft Type	Mission Capability During Desert Storm	
	Wartime Capability	Comparison with Peacetime
A-10	95.7	+5%
B-52	81%	+2%
F-117	85.8	+4%
F-15	94	+8%
F-15E	95.9	+8%
F-16	95.2%	+5%
F-111	85	+8%

Source: Adapted by the author from USAF Headquarters, "White Paper: Air Force Performance in Desert Storm," Department of the Air Force, April, 1991

Refueling and Sustained Operations[236]

Coalition aircraft had another great advantage in flying sustained missions over the battlefield. Iraq had limited refueling capability and could not use the capability it had without air superiority. In contrast, five of the Coalition countries provided refueling aircraft, and the US military services alone provided more than 300 tankers: 262 KC-135s and 46 KC-10s.[237] The Coalition flew an average of 360 tanker sorties per day, and USAF tankers alone refueled an average of 1,433 aircraft per day. Further, Coalition maintenance and repair standards were far higher than those of Iraq, and the Coalition was able to sustain sortie rates about three to five times higher per combat aircraft.

The USAF alone deployed 256 KC-135s and 46 KC-10 tankers in theater during the war. During the five and one-half months of Desert Shield, Tankers flew 4,967 sorties and 19,089 hours, refueled 14,588 aircraft, and off-loaded 68.2 million gallons of fuel in the air. During the six weeks of Desert Storm, tankers flew 15,434 sorties, logged 59,943 hours, refueled 45,955 aircraft, and off-loaded 110.2 million gallons of fuel. About 20% of the aircraft refueled were Navy and Marine Corps aircraft.[238]

The importance of refueling is also indicated by a comparison of the combat radius of key US aircraft against typical mission distances. The F/A-18 had a combat radius of up to 434 miles with external tanks, the F-15E had a combat radius of 525 nautical miles, and the F-117 had a nominal radius of 550 nautical miles. It was 680 nautical miles from F-15E bases in Saudi Arabia to the western Scud area, 695 miles from a carrier in the Red Sea to Kuwait city, and 905 nautical miles from an F-117 base to Baghdad.[239] One has only to contrast these Coalition capabilities to Iraq's primitive refueling capabilities and inability to move equipment securely by land to see another lesson of the Gulf War.

Training and Readiness[240]

Training was the final key component of superior readiness. The various Western Coalition air forces began the Gulf War with relatively high training standards. As has been shown in this chapter and Chapter Six, however, the various US air forces and the RAF were still forced to make many changes in tactics and operations for which they had never trained.

Much of the Coalition's mission capability during the fighting was the result of the fact that there was time for five and one-half months of specialized training experience during Desert Shield, and many air units were able to train for months in-theater before the war began. US aircrews averaged about 2.5 specialized training sorties per week and 10 per month. They also had time for desert acclimatization, preparing missions tailored to local conditions, and area orientation. They were able to gain experience in dealing with special regional problems like haze, shadow, and sand. They practiced flying in high temperature environments, escape and evasion in the desert, orientation and navigation over flat desert terrain, complex C^4I/BM activities, flying in integrate mission packages, and in joint exercises like Imminent Thunder. This exercise alone involved over 1,300 close air support sorties and a total of over 2,300 sorties.

This training had its weaknesses. The RAF encountered problems during the war because it continued to train solely for low altitude delivery, and some USAF, USN, and USMC aircrews suffered from such problems. A-10 and other pilots also found that reliance on simulation training for what seemed to be minor and routine activities inhibited their mission effectiveness because the actions necessary to deal with real-world problems were not constantly practiced and tested. One of the lessons of some training activity is that simulation can prepare crews to make full real-world exercises more efficient, but cannot act as a substitute for substantial practical activity.[241]

Most important, the Gulf War also showed that air forces cannot rapidly deploy and fight the massive offensive air campaigns needed in major regional contingencies in unfamiliar areas without specialized training. The USAF did succeed in some striking rapid deployments -- such as rushing F-15Cs and F-15Es into the theater, but it has tended to exaggerate the speed with which large forces of effective air power can be deployed since the Gulf War. Other Coalition military services -- both US and allied -- have followed the same course. The detailed records of orders and deployment times in the chronology in Volume V of the Gulf War Air Power Survey, however, provide a more realistic indication of the fact that moving planes and war fighting readiness are very different things.[242]

This is an important lesson for theater warfare and cooperative security. Air forces must train specifically for regional warfare in ways that make them capable of dealing with special regional conditions, that train them to fight specific regional enemies, and in ways that train them to fight effectively with regional allies of they are not combat ready. The generic peacetime training, and related ways of measuring combat readiness, are completely inadequate in achieving true combat readiness in war. train in peace time.

Strategic and Theater Airlift

Airlift does not fit into a discussion of either air supremacy or offensive air capabilities, but it was a critical aspect of air power and one whose importance is a major lesson of Desert Storm. Strategic lift activity was dominated by sea power, which carried 95% of the cargo moved to the theater. Similarly, theater lift was dominated by land movements. Nevertheless, airlift played a critical role during the early deployments in Desert Shield, and then was critical to moving time urgent cargo and personnel until the day of the cease-fire. Quality and time urgency of lift is often more important than volume of lift.

All of the Coalition forces in Desert Storm made extensive use of airlift, but the US faced a special problem because of its distance from the theater and the scale of the forces it was deploying. As a result, the US alone airlifted 544,000 tons of cargo, and 500,000 passengers into the theater during Desert Shield and Desert Storm, -- which required 94% of its 126 C-5s and 73% of its 265 C-141s at peak periods, plus extensive air charters, and the support of about 25 missions per day from its Civil Reserve Air Fleet.[243]

The US strategic airlift effort averaged 74 missions a day and flew a total of 15,402 missions by March 1, 1991. These missions included 8,060 C-141 missions, 3,622 C-5 missions, 3,142 commercial aircraft missions, 379 KC-10 missions, and 199 C-9 missions.[244] They delivered a peak of 17 million ton miles per day, which compares with a peak of 4.4 million ton miles per day during the previous peak lift in US history -- which provided resupply to Israel during the October, 1973 conflict. In October, 1990, the US also created the equivalent of a major passenger cargo airline from the US and Europe to the Gulf. C-141s began to fly the equivalent of a regular overnight delivery service. This service was called "Desert Express", and flew 1,840 short tons of cargo from the US to the Gulf between October, 1990 and February, 1991. It flew 636 short tons of cargo from Europe to the Gulf.[245]

Strategic airlift was critical in providing this capability. In spite of extensive Coalition use of charters and other Coalition airlift aircraft, the USAF C-141s and C-5s moved nearly 75% of all air cargo and 33% of all personnel moved by air. The US used peaks of 158 CRAF aircraft, which transported about 64% of the troops and 27% of the cargo airlifted to the Gulf.[246] By December, 1990, US strategic airlift was using up to 65 aircraft per day to deliver up to 8,000 troops per day. This lift effort used up to 16 airfields and meant the equivalent of a landing every 22 minutes. During Desert Storm, however, it rose to a peak of 127 aircraft per day, or a landing every 11 minutes.[247]

Many experts on airlift believe that this experience validated the need for an improved strategic airlift aircraft like the C-17. For example, the commander-in-chief of the US Transportation Command testified after the Gulf War that the C-17 would have increased the tonnage the US could have off loaded by 41% to 100% over a force of C-5s and aging C-141s in airfields with limited ramp space, and reduced the loading time for key armored vehicles like the M-2 Bradley from a total of 16.5 man hours, preparation, loading, off loading, and reassembly to a simple drive-on, drive off mission requirement.[248]

The US strategic airlift effort did, however, have other problems that may be important in future regional contingencies. USCENTCOM had never conducted detailed planning for an airlift effort, and every aspect of the lift effort had to be created from scratch. USCENTCOM then kept changing priorities, often with little notice to airlift planners until the time a change in lift was needed. As was the case with all strategic lift, the decision to reinforce the Gulf with another heavy Corps was not rapidly communicated to lift planners, and capacity was underutilized during the pre-notification period, and then inadequate as the full build-up for Desert Storm began.[249]

Reserve aircrews for strategic lift aircraft were not called up on a timely basis. Because of overall problems in managing the lift effort, far more cargo flowed into some key bases than they could handle or sufficient lift existed to move. The backlog in cargo awaiting lift sometimes reached five times daily lift capacity and some cargo had to be stored in parking lots. Similar off loading bottlenecks developed in Saudi Arabia early in the lift effort. The military services totally mismanaged their effort to prioritize cargo, reaching the point where 50-68% of all cargo had the highest possible priority during November, 1990 to February, 1991. As a result, the prioritization system collapsed and cargo was shipped on a first-in first out basis. No recovery base was established in theater which increased crew fatigue and equipment wear.[250]

Theater airlift was equally important. Helicopters and smaller fixed wing aircraft were used throughout Desert Shield and Desert Storm as a solution to a host of command, service, maintenance, and logistic problems. The US began what became a massive Coalition intratheater airlift effort with its first flights on August 11, 1990. The C-130 was the dominant theater lift aircraft used by the USAF, and by the end of 1990, the US regularly used 96 C-130s for such lift, and had already flown more than 8,000 sorties and 19,400 flying hours.[251] By the peak of Desert Storm, the USAF alone deployed 147 C-130s in support of Desert Storm. In addition to flying many special missions, it had created both a major scheduled mail and passenger traffic service (STAR), and a scheduled lift service (Camel).[252]

US C-130s flew a total of 46,500 sorties, logged more than 75,000 hours, carried over 209,000 people, and over 300,000 tons of cargo from August 10, 1990 to April 2, 1991. They played an important role in medical evacuations and in battlefield mobility though landings and air drops. They flew over 500 sorties a day during the ground battle.[253] These totals, however, understated the role of intratheater lift. The US Navy flew its own intratheater lift service, using five C-130s, seven C-2s, two US-3s, five C-12s and CH-53 and H-46 helicopters. The USMC flew 20 active and reserve C-130s, based largely at Bahrain and Al Jubayl. Britain, France, and Saudi Arabia also flew substantial numbers of intratheater airlift missions.

There is no way to quantify how many times strategic and intratheater airlift solved critical deployment and sustainment problems during Desert Shield, during the air campaign and preparation for the ground offensive, and during the ground offensive and its aftermath. The sheer volume of airlift activity during the Gulf War is, however, an important lesson in the fact that strategic and theater mobility are critical to power projection, are critical to supporting the increased tempo of modern military operations, and air critical to ensuring that sustainment can keep up with the enhancements in mobility and firepower.[254] They are a key lesson in why the US has since sought to upgrade its C-130s and C-141s, and procure advanced lift aircraft like the C-17.[255]

The Revolution or Non-Revolution in Offensive Air Warfare

Any analysis of the air war during Desert Storm is a demonstration of the fact that some problems have to be complicated before they can be simplified. It is clear from the preceding analysis that the offensive air war was not dominated by a few revolutionary technical changes, and was not the product of a smoothly executed strategy and set of force capabilities developed over the years before the war began. It instead was a game of four dimensional chess in which all of the pieces played an important role, and in which both the lay out of the board and many of the rules had to be improvised as time went on. The most striking aspect of the air war is not the role of some set of changes in tactics, training, and technology in dominating its outcome, but just how complex the air war really was and how many different dimensions were critical to its success.

At the same time, Chapter Six and Chapter Seven reveal a number of major lessons. One is the critical importance of improving battle damage assessment and being able to use such data in near real time to adapt an offensive air campaign to achieve realistic and purposeful results. There are, however, many other aspects of offensive air capability that need to be improved before a true revolution takes place in air combat. These areas include the need for:

- o Aircraft with more advanced "all-weather" -- or night and poor visibility -- navigation, targeting, and strike capability.
- o More use of active and passive "stealth" in both offensive and air combat aircraft.
- o Fuller exploitation of UAVs in intelligence, reconnaissance, and attack roles.
- o Improved smart and highly lethal stand-off weapons systems.
- o Better hard target and underground facility target, characterization, attack, and damage assessment capability.
- o Smarter or "brilliant" munitions and submunitions
- o Better anti-radiation missile and UAV capability and the means to shift from suppression of ground-based air defenses to killing such systems
- o Near real-time and interactive C^4I/BM systems avionics to allow an individual aircraft locate and strike at particular targets rather than rely on preplanned missions
- o A fully integrated and more flexible real-time ATO/JFACC system
- o Full exploitation of new deep strike targeting systems like JSTARS, and high endurance UAVs.
- o Superior close air support systems
- o Better targeting, intelligence, and reconnaissance systems at the tactical air and theater level
- o Aircraft with two-man crews aircraft or avionics that can solve the problem of target acquisition and kill in the brief interval allowed to pilots flying tactical missions over defended air space
- o Improved mission planning and weapons lethality for strategic bombers.

The Gulf War raises fundamental issues about the use of "dumb" versus "smart" weapons in AirLand battles. While the data base does not support detailed quantitative comparisons, it consistently suggests that most "dumb" ordnance had little real killing effect -- making its effectiveness dependent on intangible factors like shock effect, suppressive effect, and impact on morale. While such shock effects are real -- as are the cost differences between "dumb" and "smart" weapons -- the Gulf War suggests that an immediate large-scale conversion to either smarter weapons or more lethal area ordnance is another essential part of a true military revolution in offensive air warfare.

The Gulf War also suggests that some of the apparent cost issues discussed earlier do not portray the full story. Three additional factors must be considered in measuring the true cost of "smart" and "dumb" C^4I/BM systems, aircraft, and munitions. First, reliance on "smart" weapons would have been far more critical if Iraq had not been passive during

Desert Shield and passive during Desert Storm. Second, conventional "dumb" munitions involved a massive burden in terms of strategic lift, logistics, and support activities that must be considered in any cost trade-offs. And third, "dumb" munitions involved a massive penalty in terms of additional aircraft numbers, sortie numbers, and related support activity. These factors strongly suggest that the price of munitions is a minor factor not only in strategic and tactical terms, but in terms of true system cost.

This issue, in turn, illustrates broader lessons regarding the projection of offensive air power. The least important problem or limiting factor in power projection is flying combat aircraft from one location to another. The Gulf War shows that deploying effective offensive air combat capability requires a massive logistic and support effort, requires massive strategic lift, is heavily dependent on host nation support and facilities, and may be severely sortie limited for months by such factors. Conversion to "smart" or more lethal munitions is only part of the requirement to make air power more deployable.

Finally, there is one area where a revolution clearly did not take place. The strategic bombing effort in the Gulf War had some significant successes, but it still operated without effective guidance in terms of political direction and grand strategy that led to a major gap between the goals air planners were seeking in USCENTAF and the desire of the Chairman of the Joint Chiefs and some civilian policy makers to restrict collateral damage and the political impact of high levels of damage to Iraq. The choice between political constraints and military effectiveness is always a matter of judgment, but it was not made clearly and consistently during the Gulf War and serious gap developed between theater planning and higher levels of command.

Effective intelligence, peacetime analysis of the effect of conventional strategic bombing against different kinds of targets, and battle damage assessment were lacking. Many problems stemmed from a lack of peacetime preparation. While the AirLand battle attempted to come to grips with the need for change in terms of practical exercises and tests, strategic bombing failed to conduct realistic planning, test and evaluation, and realistic assessment of the state of the art in tactics and technology. If ideas and boldness gave interdiction bombing of critical value, policy level decisions and a lack of adequate peacetime planning within the USAF sharply limited the ability to decide what strategic bombing could accomplish.

It is unclear that the need for realism is a lesson that either US policy makers or the US Air Force has learned. Little of the political rhetoric about the uses of military force since the Gulf War have focused on the need to develop a major clearer picture of what political constraints will be placed on the use of strategic air power in future wars. Military planners may be addressing the problem of conventional and nuclear "extended deterrence" and warfighting in the post Cold War era, but there is little sign of such an effort at the senior civilian policy level.

As for the USAF, its "bomber" culture is still emphasizing new heavy bombers like the B-1B and B-2. These weapons have great potential, but the current focus on strategic bombers to the exclusion of new theater-level strike systems seems dangerous and USAF planners have decoupled much of the planning of their "bomber road map" from a realistic assessment of the effectiveness of the intelligence, targeting, C^4I/BM systems, and new "smart" and stand-off weapons needed to give the B-52, B-1, and B-2 the desired lethality. The USAF and USN are also now committed to modernization programs that mean that an advanced successor to strike/aircraft like the F-15E and F-111 will not be in service until well after the year 2010 -- a point at which every combat pilot now in service will no longer be flying. The cost of these decisions may well be a lesson of future wars.

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[1] The separation many US analysts make between strategic air attacks and interdiction attacks does not really describe the target base in the Gulf War. Similarly, it does not make sense to divide air strikes in the support of the land battle into interdiction strikes in the rear of the battlefield and close air support strikes in direct aid of the land battle because weather, speed of maneuver and the accelerating collapse of Iraq forces make such a distinction somewhat unrealistic.

[2] See Peter Grier, "Better Eyes in the Skies," Air Force, October, 1994, pp. 24-31.

[3] This discussion draws on Dr. Edward L. Warner, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," Office of the Assistant Secretary of Defense (Strategy and Requirements, April 18, 1994, p. 4; Major General Larry L. Henry, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Air Force, Staff for Plans and Operations, April 18, 1994; Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994.

[4] The ATACMS has a range of over 50 miles and is a "deep strike" weapon. Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 200.

[5] For a good description of poor weather operations during the Gulf War, see Peter Bacque, "When Weather is an Enemy," Air Force, April, 1992, pp. 68-71.

[6] Major General Larry L. Henry, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Air Force, Staff for Plans and Operations, April 18, 1994, p. 4.

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[7] See the two tables in this section, and Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 203, their discussion in pages 198-204, and Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 97-98.

[8] This discussion is based primarily on Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-24 to T-27; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 85, 121-122, 131, 218, 220, 230-231, 252-262, 269-270, 339-340; Washington Post, March 8, 1991, p. 23; Aviation Week, July 5, 1993, pp. 26-27; General Accounting Office, "Operation Desert Storm: Limits on the Role and Performance of B-52 Bombers in Conventional Conflicts," GAO/NSIAD-93-138, May, 1993; Defense Daily, January 17, 1992, p. 88; Jane's Defense Weekly, January 26, 1991, p. 114; Aviation Week, September 3, 1990, p. 35; Air Force Times, February 21, 1994, p. 10.

[9] B-52s had the ability to carry the AGM-142A Have Nap stand off missile with a 110 kilometer range and the AGM-84E stand-off land attack missile (SLAM), but these had not proved highly reliable and it was felt that area bombing would be more lethal. Jane's Defense Weekly, January 26, 1991, p. 114.

[10] There is a difference in USAF counts of missions. Some reports say 1,624 missions and over 25, 700 tons of munitions. See US Department of the Air Force, "Air Force Performance in Desert Storm," White Paper, Washington, USAF Office of Legislative Affairs, April, 1991, p. 5.

[11] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-24 to T-27; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 252-262, Volume II, Part II, pp. 99-102, 160 238, 246; General Accounting Office, "Operation Desert Storm: Limits on the Role and Performance of B-52 Bombers in Conventional Conflicts," GAO/NSIAD-93-138, May, 1993, p. 4.

[12] Captain Doug Fires, "The BUFF at War," Air Force, June, 1992, pp. 44-49.

[13] General Accounting Office, "Operation Desert Storm: Limits on the Role and Performance of B-52 Bombers in Conventional Conflicts," GAO/NSIAD-93-138, May, 1993, pp. 5-6.

[14] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 230-231.

[15] See Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 252-262.

[16] Air Force Times, October 11, 1993, p. 28; Aviation Week, July 5, 1993, p. 26.

[17] The US bomber program is in a complete state of flux at this writing (November, 1994), but is likely to shrink from a force goal of nearly 180 aircraft to below 100.

[18] Defense News, July 11, 1994, pp. 3 and 20.

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[19] The worst of these rationales was provided in a heavily politicized RAND study the USAF presented to Congress in 1992. In the study and supporting testimony, the USAF presented comparisons of the effectiveness of bombers based on impossible sortie rates sustained over impossible periods, using munitions that did not yet exist with highly suspect effectiveness, and in ways that ignored real world target profiles, refueling needs, crew endurance, and targeting factors.

[20] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 99-100.

[21] See the discussion in Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 134-141.

[22] For a good discussion of the F-15E's performance at the operator level see William L. Smallwood, Strike Eagle: Flying the F-15E in the Gulf War, McLean, Brassey's, 1994.

[23] The total USAF F-15E buy was completed in October, 1994, with a total of 204 aircraft.

[24] See Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-61 to T-63; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume I, pp. 21, 32-39; 229-231, 252-254, 261, 269, 375; Volume II, Part II, pp. 97-99 102, 186, 200, 243-244 322, 331, 333-335 336 341, 384; and Volume IV, Part I; Aviation Week, February 18, 1991, p. 60; Richard P. Hallion, Storm Over Iraq, pp. 291-292; Aviation Week, November 12, 1990, pp. 54-56, February 4, 1911, p. 59, April 22, 1991, pp. 54-55.

[25] Eliot A. Cohen, ed., Gulf War Air Power Survey; Volume II, Part II, pp. 97-99 102, 186, 200, 243-244 322, 331, 333-335 336 341, 384; and Volume IV, Part I.

[26] Aviation Week, April 22, 1991, pp. 54-55.

[27] Based on interviews.

[28] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume I, pp. 229-231.

[29] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume I, pp. 231-232.

[30] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-68 to T-71; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume I, pp. 25, 28,-30, 166, 173, 201, 231, 237-242; Volume II, Part II, and Volume IV, Part I; Air Force Magazine, April, 1993, pp. 40-48; AFA Advisory Group, Air Force Association, Long-Range Airpower, June 29, 1993, pp. 38-48; Stan Morse, ed., Gulf War Debrief, pp. 66-67.

[31] Like many aspects of the Gulf War data bases, different parts of the data bases on the war produce different figures. See Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 383-389 and Volume IV, Part I; pp. 39-41, 177-189, 209, 212.

[32] Air Force Magazine, April, 1993, pp. 40-48.

[33] Also see Inside the Navy, July 12, 1993, p. 6.

[34] Aviation Week, November 12, 1990, pp. 54-56; Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-4 to T-7; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, and Volume IV, Part I.

[35] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, and Volume IV, Part I, pp. 227-228; Aviation Week, February 4, 1991, p. 23, 64.

[36] Aviation Week, February 4, 1991, p. 23.

[37] Data differ on sortie rates. The Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-4 to T-7, indicates the Navy flew 4,045 sorties and the Marine Corps flew 854 sorties. Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, says the Marine Corps flew 850 sorties, 98.8% at night..

[38] The Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-4 to T-7.

[39] Other data state the F-111&A has a 600 NM combat radius which extends to 1,800 NM with a single refueling in each direction. Jane's Defense Weekly, October 26, 1991, p. 771.

[40] This section draws heavily on interviews with F-117A pilots; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, and Volume IV, Part I; General John M. Loh, "The Value of Stealth," presentation before the US Senate Armed Services Committee, June 4, 1991; Stan Morse, ed., Gulf War Debrief; International Defense Review, 5/1991, pp. 468-472; Washington Times, March 18, 1991, p. 6; Aviation Week, August 27 ,1990, pp. 24-25, February 4, 1991, pp. 30-31, February 18, 1991, pp. 40-41, April 22, 1991, pp. 51-53, July 1, 1991, pp. 66-67; Jane's Defense Weekly, January 26, 1991, p. 104, April 27, 1991, p. 699, October 23, 1991, p. 771; Air Force Magazine, April, 1991, pp. 36-38, 75; Inside the Air Force, November 8, 1991, p. 3; Aerospace Daily, October 31, 1991, p. 173; Washington Post, June 23, 1991, p. A-1; New York Times, February 14, 1991, p. A-18; Defense News, April 15, 1991, p.1.

[41] For a good description of an F-1117A mission during the war, see James P. Coyne, "A Strike By Stealth," Air Force, March, 1992, pp. 38-43.

[42] Like many aspects of the Gulf War data bases, different parts of the data bases on the war produce different figures. See Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 383-389 and Volume IV, Part I; pp. 39-41, 177-189, 209, 212.

[43] General John M. Loh, "The Value of Stealth," presentation before the US Senate Armed Services Committee, June 4, 1991. The F-22 will have only 10-20% of the "visibility" of the F-117A.

[44] See US News and World Report, November 18, 1991, p. 52; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I; pp. 241-245.

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[45] See Aviation Week, May 6, 1991, pp. 66-67; US News and World Report, November 18, 1991, p. 52; Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, p. 164;.

[46] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, p. 354. For detailed data on target types per day see pp. 383-389.

[47] General John M. Loh, "The Value of Stealth," presentation before the US Senate Armed Services Committee, June 4, 1991, pp. 4-5.

[48] Interviews with F-117A pilots and USAF personnel, and Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-72 to T-75; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, p. 350.

[49] Aviation Week, June 24, 1991, pp. 20-24.

[50] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 20, 287, 389, Volume IV, Part I, p. 137, 176-177, 273-274

[51] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, p. 21; Volume I, , pp. 173-174, 199, 231.

[52] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, p. 354. For detailed data on target types per day see p. 389.

[53] Based on interviews.

[54] Based on interviews.

[55] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 13-14, 34-35, 103, 280; Volume I, , pp. 173-174, 199, 231, 261, 269.

[56] Jane's Defense Weekly, October 26, 1991, p. 771, July 11, 1992, p. 24; Inside the Air Force, May 20, 1991, p. 7; Aviation Week, June 24, 1991, pp. 20-24, July 6, 1992, 58; Defense Week, April 13, 1992, p. 1; Flight International, February 25, 1992, p. 24.

[57] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, and Volume IV, Part I, pp. 227-228; Aviation Week, February 4, 1991, p. 23, 64.

[58] Based largely on discussions with F/A-18 pilots and senior naval officers, senior USAF officers, Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-76 to T-78; and Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, p. 130. Also see sources in Chapter 8.

[59] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-76 to T-78; Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

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[60] This range comes from a series of nine interviews with senior USAF, USMC, and USN air officers involved in the Gulf War.

[61] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, p. 130.

[62] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-79 to T-82; Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

[63] See Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 20, 47-49, 221-223; Volume II, pp. 96, 98-99, 143, 178, 244 249-251, 280-281; Aerospace Daily, May 16, 1991, p. 274; Air Force Magazine, April, 1991, pp. 76-79, November, 1991, pp. 60-61; Aviation Week, March 4, 1991, p. 66, April 22, 1991, pp. 62-63; Flight International, May 8-14, 1991, p. 12; International Defense Review, 7/1991, pp. 742-743; Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-64 to T-67.

[64] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 86, 131, 225, 349, 356

[65] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, p. 261-263, 275, 344.

[66] See Aviation Week, February 1, 1993, p. 27 for F-16 pilot claims.

[67] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, p. 356.

[68] Based on interviews with senior USAF officers serving in the Gulf and personnel working on the Gulf War Air Power Survey.

[69] Aerospace Daily, May 16, 1991, p. 274; Air Force Magazine, April, 1991, pp. 76-79, November, 1991, pp. 60-61.

[70] Based on interviews with senior USAF officers serving in the Gulf and personnel working on the Gulf War Air Power Survey. Also see Gulf War Air Power Survey, Volume IV, Part I, pp. 178, 271, 281.

[71] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 221-223.

[72] For an excellent discussion of the A-10s performance during the war, see William L. Smallwood, Warthog: Flying the A-10 in the Gulf War, Washington, Brassey's/RUSI, 1993.

[73] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 221-223.

[74] Based on interviews, and Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 221-223; Volume II, Section II, pp. 206, 209-210.

[75] This claim is made in Air Force Magazine, August, 1993, pp. 28-30.

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[76] See the discussion of BDA in Chapter Five. Interviews with USAF personnel indicate that efforts to discount A-10 and other claims were largely sophisticated guesswork, and that there is no way to establish an accurate figure. Actual kills were probably about 30-50% of the figures initially claimed, but this problem occurs with all aircraft in the Gulf War because a hit or near hit on a designated target is so often associated with a kill against a correctly identified target. This is a major problem in all the unclassified data bases on the Gulf War.

[77] Frank Oliveri, "The Warthog Round at Gunsmoke," Air Force, March, 1992, pp. 32-37.

[78] Based on interviews, and Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 221-223; Volume II, Section II, pp. 206, 209-210.

[79] For detailed discussion of the A-10 see Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-184 to T-185; Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 52-55, 221-223; Volume II, Section II, pp. 102-103, 144, 206, 209-210; Army Times, March 11, 1991, p. 11; Stan Morse, ed., Gulf Air War Debrief, p. 176-178; Aviation Week, September 3, 1990, pp. 77-78; February 11, 1991, p. 23, August 5, 1991, p. 40-43; Aviation Week, Persian Gulf War, Assessing the Victory, New York, Aviation Week, 1991; Air Force Times, March 11, 1991, p. 14; Periscope: Special Report, March 28, 1991; Washington Post, February 12, 1991, p. A-15; Boston Globe Magazine, July 21, 1991, pp. 12-16.

[80] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. T-186.

[81] Aviation Week, August 5, 1991, p. 40-43

[82] There is some difficulty in precisely counting combat sorties for the A-10 and other aircraft in terms of exposure to enemy fire, but the loss rate is probably around 0.07%.

[83] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, p. T-11.

[84] The author was in OASD(Systems Analysis) during much of the debate over the A-10, and has regularly visited A-10 units. Also see Army, July, 1991, pp. 36-39, and Boston Globe Magazine, July 21, 1991, pp. 12-16.

[85] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-8 to T-11.

[86] Aviation Week, June 7, 1993, pp. 135-138.

[87] It seems fair to state that the USAF did too little to train any pilots in the real world problems of damage assessment before the Gulf War, and allowed its Red Flag exercises to under emphasize the problems of target recognition and tracking in complex air defense environments.

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[88] Based on interviews, Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 221-223; Volume II, Section II, pp. 206, 209-210, Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; and Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

[89] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-20 to T-24.

[90] Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October ,1991, pp. 44-48; Lt. General Royal N. Moore, "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-69.

[91] Department of Defense, Conduct of the Persian Gulf War, Final Report, Annex T, pp. T-20 to T-24.

[92] This subject is discussed at length in Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I,. This volume provides a great deal of useful data and insights, but does not attempt to quantify the impact of given limitations in technology on lethality against given targets.

[93] For an interesting unclassified analysis of the kind of trade-offs involved, see William Stanley and Gary Liberson, "Measuring the Effects of Payload and Radius Differences of Fighter Aircraft," Santa Monica, RAND, November 1993, and Christopher Bowie, Fred Frostic, Kevin Lewis, John Lund, David Ochmark, and Philip Proper, "The New Calculus, Analyzing Air Power's Changing Role in Joint Theater Campaigns," Santa Monica, RAND, MR-149-AF, 1993.

[94] Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994, p. 7.

[95] Defense News, April 25, 1994, pp. 10 and 14.

[96] USAF Congressional Liaison Office, June 3, 1994.

[97] Interviews with USAF officers in Washington and at Luke Air Force Base.

[98] USAF Congressional Liaison Office, June 3, 1994.

[99] Air Force Times, April 11, 1994, p. 30.

[100] Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994, pp. 6-7.

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[101] Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994, p. 7.

[102] Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994, pp. 10-11.

[103] Rear Admiral John Scott Reid, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Navy, Staff for Plans, Policies, and Operations (N-3/5), April 18, 1994, pp. 7.

[104] Jane's Defense Weekly, April 16, 1994, p. 35.

[105] Major General Larry L. Henry, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Air Force, Staff for Plans and Operations, April 18, 1994, p. 4.

[106] Jane's Defense Weekly, April 2, 1994 p. 14; Aviation Week, August 5, 1991, pp. 44-45.

[107] Lt. General Norman E. Ehlert, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Marine Corps, Staff for Plans, Policies, and Operations, April 18, 1994, pp. 6-7.

[108] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 200.

[109] Clifford Beal, Mark Hewish, and Bill Sweetman, Bolt from the blue: making dumb bombs smart," International Defense Review, 12/1992, pp. 1173-1180, and Chicago Tribune, October 13, 1992, p. 9.

[110] The problems in penetrating deep targets used for weapons of mass destruction is another reason. See Defense News, June 27, 1994, p. 10.

[111] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume II, Part II, pp. 353-356.

[112] Major General Larry L. Henry, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Air Force, Staff for Plans and Operations, April 18, 1994, p. 4.

[113] Major General Larry L. Henry, "Statement Before the Subcommittee on Military Readiness and Defense Infrastructure of the Senate Armed Services Committee," US Air Force, Staff for Plans and Operations, April 18, 1994, p. 4.

[114] Eliot A. Cohen, ed., Gulf War Air Power Survey, Volume IV, Part I, pp. 252-253.

[115] Interviews.

[116] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 106.

[117] Comments by Lt. General Buster Glosson.

[118] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. T-182.

[119] Based on interviews.

[120] The author saw a number such weapons during his tour of the battlefield in March, 1991.

[121] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. T-185.

[122] Based on interviews. Also see the detailed description of Maverick delivery requirements see Aviation Week, February 11, 1991, pp. 24-25.

[123] For an example of the 85% hit rate claim see Office of the Chief of Naval Operations, The United States Navy in Desert Shield/Desert Storm, Washington, Department of the Navy, 00/1U500179, May 15, 1991, p. 47, which claims that 85% of 288 missiles fired hit their targets.

[124] Interviews and reports on the CNA study and other corrections to the initial data on the Tomahawk. See Defense News, January 24, 1994, p. 1; Washington Post, April 10, 1992, p. A-1 for typical reporting.

[125] See Jane's Defense Weekly, January 26, 1991; Aviation Week, January 21, 1991, p. 61; Norman Friedman's reference to Navy claims of 51 hits in 51 firings in "The Air Campaign," Proceedings, April, 1991, pp. 49-50, reference to Navy claim of 80% hit rate in New York Times, March 28, 1991, p. A-19; and Eric H. Arnett, "Awestruck Press Does Tomahawk PR," Bulletin of the Atomic Scientists, April, 1991, pp. 7-8.

[126] Aviation Week, July 5, 1993, p. 26. For backlash impacts of exaggerated claims on funding see Defense News, January 24, 1994, p. 1.

[127] Defense News, June 3, 1991, p. 4, July 5, 1993, p. 18; undated US Navy PEO(CU) information paper; Commander Steve Froggett, "Tomahawk in the Desert," Proceedings, January, 1992, pp. 71-76..

[128] Statement on Gulf War lessons learned by Dr. Edward L. Warner, Assistant Secretary of Defense (Strategy and Requirements) before the Subcommittee on Military Readiness and Defense Infrastructure and Coalition Defense and Reinforcing Forces of the Senate Armed Services Committee, April 18, 1994; Statement on Gulf War lessons learned by Major General Larry L. Henry, Chief of Staff for Plans and Operations, USAF, before the Subcommittee on Military Readiness and Defense Infrastructure and Coalition Defense and Reinforcing Forces of the Senate Armed Services Committee, April 18, 1994.

[129] Limited data are provided in Eliot A. Cohen, ed., Gulf War Air Power Survey: Volume IV, Part I, pp. 248--252.

[130] The GWAPS says over 4,000. The COW says over 4,800.

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[131] For an excellent history of the development of the strategic bombing campaign, see Dianne T. Putney, "From Instant Thunder to Desert Storm," Air Power History, Fall, 1994, pp. 39-50 and Eliot Cohen, ed., Gulf War Air Power Survey, Volume I, Part II, Washington, GPO, 1993. For a very different "insider" view of the personalities and inter-service debates affecting the planning and execution of the strategic bombing campaign, see Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, pp. 77-94, 307-309, 318-322.

[132] The structure and effectiveness of the strategic bombing campaign during the Gulf War is described in detail in Chapter 6 of Eliot A. Cohen, ed., Gulf War Air Power Survey: Volume II, Part II, pp. 265-345. The reader should be aware that the statistics presented in this chapter do not always agree in exact detail with the statistical data base in Volume V..

[133] There were a total of 12 target sets, but only 8 were strategic. Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 126-127.

[134] For details of the growth of target sets, see Eliot A. Cohen, ed., Gulf War Air Power Survey: Volume II, Part II, pp. 86-89.

[135] For an outstanding historical review of this issue, see Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 56-93.

[136] James P. Coyne, "Plan of Attack," Air Force, April, 1992, pp. 40-46; Michael Palmer, "The Storm in the Air: One Plan, Two Air Wars," Air Power History, Winter, 1992, pp. 24-31; Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, pp. 77-94.

[137] See the analysis in Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15. General Schwarzkopf says in It Doesn't Take a Hero that he shifted from strategic bombing to battlefield preparation after two weeks, but the allocation of sorties by target provides a different picture. The description of the CENTAF planning effort in Dianne T. Putney, "From Instant Thunder to Desert Storm," Air Power History, Fall, 1994, pp. 39-50 and Eliot Cohen, ed., Gulf War Air Power Survey, Volume I, Part II, Washington, GPO, 1993, also provides a picture of a much more balanced effort.

[138] Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, p. 6.

[139] See Chapter Six for more details.

[140] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 66, 70.

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[141] Interviews and Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, p. 276-277.

[142] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 68.

[143] For details, see Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 282-285. Also see pages 23, 86, 288, 363, 367-368, and 378-379.

[144] Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 244-246.

[145] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 68; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 284-285; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 240-247.

[146] For a summary history of the GBU-28, see Washington Post, July 6, 1991, p. A-14.

[147] Interviews, and Rick Atkinson, Crusade, p. 473.

[148] Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 289-290; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part I, pp. 205-208.

[149] Interviews; Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 70-71; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 277-282 and 285-290.

[150] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 98.

[151] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 209; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 291-292.

[152] Interviews, and Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 72-73. For an example of the resulting reports that the US deliberately shut down Iraqi power plants for long periods of time, see Washington Post, January 28, 1992, p. A-14.

[153] Harvard Study Team, Harvard Study Team Report: Public Health in Iraq After the Gulf War, May, 1991, pp. 12-13; Aviation Week, January 27, 1992, pp. 62-63; Interviews, and Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 73-74; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 295-296.

[154] For a somewhat different view, see Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 200.

[155] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 73-74; Eliot A. Cohen, Gulf War Air Power Survey: Volume II, Part II, pp. 298-305.

[156] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 77.

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[157] The author visited Iraqi positions in Kuwait and Iraq for a week after the war, and did not find positions with critical military supply shortages.

[158] The models Coalition air planners used to target Iraq's lines of communication has some of the over-simplification, and reliance on rigid route capacity measures and known targeting nodes, that restricted the impact of similar bombing efforts in Vietnam.

[159] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 92-93.

[160] These data are taken from Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 179. The text in the table on this page does not agree with the title of the left hand axis, and these supply requirements seem very high by Iraqi standards. There are indications that intelligence may have seen Iraqi supply needs in terms of the worst case demand during the Iran-Iraq War.

[161] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 95.

[162] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, , p. 98.

[163] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 64-90, (especially p. 65) and 92-97.

[164] Michael R. Gordon and General Bernard E. Trainor argue in The General's War: The Inside Story of the Conflict in the Gulf, (Boston, Little Brown, 1994, pp. 318-322) that the Air Force strongly opposed both shifting sorties away from strategic bombing and that at least some air planners felt they could achieve victory without a land campaign. The author's interviews encountered different views of the air campaign that indicate air planners and commanders did not make a serious effort to argue against the ground offensive, although it is clear some air planners did not want to reduce the number of sorties allocation to strategic bombing. The facts, however, are unclear and impossible to put into a clear historical context.

[165] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. 164-166.

[166] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 176.

[167] See Chapter Three and Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 174-176; Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, p. 90, 231-242.

[168] Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 174-176.

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[169] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 109.

[170] Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, p. 179.

[171] Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, pp. 187-189.

[172] Lt. Colonel Mark A. Welsh, "Day of the Killer Scouts," Air Force Magazine, April, 1993, pp. 66-68; Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, pp. 88-95, and 219-223.

[173] Interview with Lt. General Charles A. Horner, March 14, 1991; Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, p. 90.

[174] Interview with Lt. General Charles A. Horner, March 14, 1991; Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, p. 188.

[175] Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, p. 188.

[176] Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, pp. 323.

[177] Interview with Lt. General Charles A. Horner, March 14, 1991; Lt. Colonel Mark A. Welsh, "Day of the Killer Scouts," Air Force Magazine, April, 1993, p. 66; Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, pp. 102, 209, 237; ; Richard P. Hallion, Storm Over Iraq: Air Power and the Gulf War, p. 155.

[178] Lt. Colonel Mark A. Welsh, "Day of the Killer Scouts," Air Force Magazine, April, 1993, p. 66.

[179] Lt. Colonel Mark A. Welsh, "Day of the Killer Scouts," Air Force Magazine, April, 1993, pp. 66-68.

[180] Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 180-182, 184; Air Force Magazine, April, 1993, pp. 66-68.

[181] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 170-171.

[182] See the detailed discussion in Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, pp. 178-180 and 187-189.

[183] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 185.

[184] For a history of some of the major problems involved, see the detailed discussion in Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15

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185 Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 187.

186 Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 187.

187 Brigadier General Robert H. Scales, ed., Certain Victory: The US Army in the Gulf War, p. 188. This statement does not agree with the information provided in Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15.

188 Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 171-173; Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

189 Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 104.

190 Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 165, 178.

191 See Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, pp. 217-221; Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, p. 352.

192 See Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15

193 Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, p. 352.

194 Eliot A. Cohen, Gulf War Air Power Survey, Volume II, Part II, pp. 218-219; Michael R. Gordon and General Bernard E. Trainor, The General's War: The Inside Story of the Conflict in the Gulf, Boston, Little Brown, 1994, pp. 334-338.

195 Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 106.

196 Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 178.

197 Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 106. This estimate did not, however, reflect unity within USCENTCOM. For example, General Yeosock and ARCENT issued an estimate indicating that the Iraqi forces in the KTO were still at 93% of their strength, and the Republican Guards were still at 99% of their full strength, on January 31, 1991. See Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15.

198 The reader should be aware that these percentages are based on imagery and all-source analysis after the war, and that wartime estimates were much higher.

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[199] Based on interviews and Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 107-108

[200] Brigadier General Robert H. Scales, Certain Victory, p.188.

[201] Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

[202] Based largely on interviews and Department of Defense, Conduct of the Persian Gulf War: Final Report, pp. 194-195.

[203] Lt. General Royal N. Moore, Jr., "Marine Air: There When Needed," Proceedings, November, 1991, pp. 63-66; Colonel Norman G. Ewers, "A Conversation with Lt. General Royal N. Moore, Marine Corps Gazette, October, 1991, pp. 44-50.

[204] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 196.

[205] Based on inspection of the battlefield after the war and interviews.

[206] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Section II, pp. 226-230.

[207] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 193.

[208] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Section II, pp. 230-235.

[209] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Section II, pp. 230-235.

[210] Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15; Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 195; Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 108.

[211] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 195; Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 108.

[212] Eliot Cohen, Gulf War Air Power Survey, Volume V, Part II, p. 236.

[213] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Part II, pp. 234-237.

[214] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Part II, pp. 237-238.

[215] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Part II, pp. 238-241.

[216] Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Part II, pp. 241-243.

[217] The author spent a full day in the area with three other people examining the column, and combat damage in the surrounding area. The vehicles had no corpses, were largely undamaged in any way, and were so filled with loot that Kuwaitis were drive cars and trucks of goods away from the scene. See Washington Post, March 11, 1991, p. A-11; Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 112-113; Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 194.

[218] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 115.

[219] Interview.

[220] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 115.

[221] Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 197.

[222] Eliot Cohen, ed., Gulf War Air Power Survey, Volume II, Section II, pp. 259-261.

[223] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 108.

[224] Eliot Cohen, ed., Gulf War Air Power Survey, Volume II, Section II, p. 260.

[225] See the discussion in Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15

[226] Colonel Richard B. Lewis, "JFACC: Problems Associated with Battlefield Preparation in Desert Storm," Airpower, Spring, 1994, pp. 4-15; Department of Defense, Conduct of the Persian Gulf War: Final Report, p. 195; Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, p. 108. The problems in mixing fixed and rotary wing strike assets as discussed in more detail in Chapters Eight and Nine.

[227] For additional details on this lessons, see Annex F to the Department of Defense, Conduct of the Persian Gulf War: Final Report, . For example, see pages F-6 to F-9 and F-62 to F-64 for some of the issues relating to the maintenance of air equipment. The GAO report, "Operation Desert Storm: The Services' Efforts to Provide Logistics Support for Selected Weapon Systems, GAO/NSIAD-91-321, Washington, GAO, September 26, 1991 and following reports on the M-1/M-2 and AH-64 also illustrate the level of maintenance effort involved.

[228] USAF Headquarters, "White Paper: Air Force Performance in Desert Storm," Department of the Air Force, April, 1991, p. 9.

[229] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, p. F-7.

[230] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-7, F-57.

[231] For a good summary description of such problems, see GAO, "Desert Shield/Desert Storm: Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993.

[232] See the interview with Major General William Sistrunk, then commander of the Military Airlift Command, in Government Computer News, September 30, 1991, p. 38;

Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-7, F-57. Also see the detailed description in see Eliot Cohen, ed., Gulf War Air Power Survey, Volume III, and in the Desert Shield chronology in Part II, of Volume V.

[233] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, p. F-8.

[234] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-9, F-22, F-62.

[235] Response by USAF Public Affairs to questions by the author dated April, 1991.

[236] For a more technical description of lessons relating to refueling, see Eliot Cohen, ed., Gulf War Air Power Survey, Volume IV, Section I, pp. 311-318.

[237] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, p. F-29.

[238] USAF Headquarters, "White Paper: Air Force Performance in Desert Storm," Department of the Air Force, April, 1991, p. 9. Slightly different totals are provided in Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-28 to F-31.

[239] Thomas A. Keaney and Eliot A. Cohen, Gulf War Air Power Survey: Summary Report, pp. 171-173.

[240] The best description of air training activity during Desert Shield and Desert Storm is in Eliot Cohen, ed., Gulf War Air Power Survey, Volume IV, Section I, pp. 343-364.

[241] Eliot Cohen, ed., Gulf War Air Power Survey, Volume IV, Section I, pp. 355-356.

[242] See Eliot Cohen, ed., Gulf War Air Power Survey, Volume V, Section II, pp. 355-356. See the air order of battle, logistics, and air operations sections in pages 10, 12, 13, 16, 18, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 36, 37, 38, 39, 40, 42, 43 for a list of just some of the real world deployment problems affecting air power during August alone. There are few two day periods during Desert Shield where this chronology does not reveal a problem of some kind, although none are war stoppers or mean air power could not have played a useful role in combat.

[243] The best single summary of the strengths and weaknesses in the US airlift effort is contained in GAO, "Desert Shield/Storm, Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993.

[244] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, p. F-29. Slightly different figures are provided in GAO, "Desert

Shield/Storm, Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993.

[245] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-32 to F-33.

[246] "Desert Shield/Storm, Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993, pp. 15-16.

[247] These data are taken primarily from Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-26 to F-27. As is the case with virtually all Gulf War data, significant differences exist even within official US data bases. Other figures are taken from the slightly different summary in US Air Force, "Reaching Globally, Reaching Powerfully: The US Air Force in the Gulf War," Washington, USAF, September 1991. This report is not generally used in this study because it was superseded by the Gulf War Air Power Survey (which also has a number of internal statistical contradictions in describing the airlift effort). The figures used here, however, are typical of USAF reporting.

[248] General Ronald R. Fogleman, Commander in Chief, US Transportation Command, "Defense Transportation in a Changing World," Statement to the Senate Armed Services Committee, April 22, 1993, pp. 6-8. For a detailed description of the strengths and weaknesses of the C-141 in Desert Storm, see GAO, "Military Airlift: Structural Problems Did Not Hamper C-141 Success in Desert Shield/Desert Storm, Washington, GAO/NSIAD-93-75, December, 1992.

[249] "Desert Shield/Storm, Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993, pp. 23-24.

[250] "Desert Shield/Storm, Air Mobility Command's Achievements and Lessons for the Future," Washington, GAO/NSIAD-93-40, January, 1993, pp. 18, 20-21, 25-26, 29-37, 37-40.

[251] For an excellent overview of this issue, see Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-40 to F-44.

[252] Department of Defense, Conduct of the Persian Gulf War: Final Report, Department of Defense, April, 1992, pp. F-41 to F-42.

[253] USAF Headquarters, "White Paper: Air Force Performance in Desert Storm," Department of the Air Force, April, 1991, p. 10.

[254] For more detailed discussions of US airlift enhancements relating specifically to lessons of the Gulf War, see Secretary of Defense Les Aspin, "The Bottom Up Review: Forces for a New Era," Washington, OSD, September 1, 1993, pp. 9, 11-12; Chairman of the Joint

Chiefs of Staff, "Report on the Roles, Missions, and Functions of the Armed Forces of the United States," Washington, Office of the CJCS, February, 1993, pp. II-6 to II-7 and II-10 to II-11; General Ronald R. Fogleman, Commander in Chief, US Transportation Command, "Defense Transportation in a Changing World," Statement to the Senate Armed Services Committee, April 22, 1993, pp. 9-10. The future size of US strategic airlift, and the future of the C-17 were still the subject of great uncertainty in late 1994

[255] Also see the discussion in Aviation Week, February 22, 1993, p. 56, and Peter Grier, "The Ton-Mile Gap," Air Force, November, 1992, pp. 30-33