THREE NEW WEAPONS

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(U) The United States Air Force's arsenal of weapons that performed so well during the Gulf War improved dramatically during the decade that followed. Many important systems entered the service's inventory during the 1990s. First, the GBU–31 joint direct attack munitions (JDAM) emerged as the largest precision munitions program of the period. Second, the General Atomic MQ–1 Predator was the first of a family of unmanned aerial vehicles (UAVs) destined to play a significant role in future conflicts and, possibly, to revolutionize the nature of aerial support for the foreseeable future. Finally, the fifth-generation, stealth-capable Lockheed Martin/Boeing F–22 Raptor fighter promised air superiority as well as increased performance in other roles well into the twenty-first century.

(U) The JDAM program began during the Gulf War, and, although the Air Force conducted a stunningly successful air campaign in that conflict, it found the performance of its air-to-surface ordnance lacking especially under certain climatic conditions prevalent in the Middle East. Poor weather during Operation Desert Storm sharply limited the use of optically-dependent precision guided munitions. During the first three days of the campaign, F–117A Nighthawks missed 48 percent of their targets due to low overcast or other poor visibility conditions. Commanders also found that gravity weapons, so-called "dumb bombs," delivered from medium and high altitudes sometimes were even less accurate than expected. "When you're up there and you're in your airplane and trying to drop your bombs and all that [air defense] stuff is coming up at you, and you have a 100-knot crosswind, the probability of hitting your target is

pretty low,"[1] one frustrated fighter pilot tersely summarized after the war. A team of consultants from the Fighter Weapons Center at Nellis Air Force Base (AFB), Nevada, visited the theater during the hostilities and on February 14, 1991, reported: "The biggest lesson learned so far for the F–16 community is the need to incorporate the capability of delivering precision guided munitions (PGMs) beyond the AGM–65 [Maverick]."[2] The JDAM program resulted directly from that experience.

(U) Impetus for change came from the top. On May 1, two months after the conflict, Air Force Chief of Staff (CSAF) General Merrill A. (Tony) McPeak sent a terse, hand-written memorandum to Maj. Gen. R. Minter Alexander, his Deputy Chief of Staff for Plans and Operations. "We need to lay down a requirement for an all-wx [all-weather] PGM," McPeak directed. "Work with TAC [Tactical Air Command]. Keep me up to speed."[3]

Image 1

MQ–1 Predator

(U) The Air Force pursued an all-weather precision weapon system through the JDAM Systems Program Office established in 1992. The program office originally contracted with the McDonnell Douglas Corporation of Saint Louis, Missouri, but the Boeing Company of Chicago, Illinois, assumed responsibility for the program in 1997 when it bought McDonnell Douglas. Other defense subcontractors supported JDAM production, including Honeywell Incorporated of Morristown, New Jersey; Rockwell Collins of Cedar Rapids, Iowa; and HR Textron of Santa Clarita, California.[4]

(U) These corporations resolved the Gulf War weather and delivery problems by developing a JDAM guidance tail kit that converted free-fall bombs into smart munitions that

provided accuracy under all flying conditions. Technicians could simply add a new tail section containing an inertial navigation system and a global positioning system (GPS) to an unguided general-purpose bomb in order to improve its accuracy. The GPS directed the converted weapon to within 39 feet of its intended target, a capability approaching the performance of a more expensive laser-guided bomb. The system required neither overflying the target nor waiting for good weather. The JDAM tail kits could be applied to two different payloads: the 1,000-pound BLU–110/Mark 83 warhead and the 2,000-pound BLU–109/Mark 84 warhead.[5]

(U) Air Force planners originally expected to pay roughly $40,000 for each JDAM kit, but streamlined contracting methods and advances in technology during the 1990s reduced this figure. At the time of the Gulf War, GPS-guided munitions were relatively new and, consequently, tended to be expensive to procure, but a revolution in micro-electronics during the 1990s caused both the size and cost of GPS receivers to drop, benefiting JDAM and many other Air Force programs and the U.S. economy in general. By the end of the 1990s, consumers could buy handheld GPS units in their local electronics stores and the Air Force was purchasing the JDAM kits for less than 50 percent of what it originally anticipated.[6]

(U) The JDAM program made good progress during that decade. McDonnell Douglas initiated the effort and, by the time of Operation Deliberate Force over Bosnia in 1995, the USAF had the tail kits under operational test and evaluation. However, they were not yet ready for use. Two years later, following Boeing's purchase of McDonnell Douglas, the new primary contractor delivered the first JDAMs to the Air Force. The JDAM program also reflected another major trend of the 1990s, the Department of Defense's increased emphasis on "jointness," or more effective cooperation among the military services. The "joint" in joint direct attack munitions referred to the fact that the ordnance would be developed and used by both the U.S.

Navy and the Air Force. Technicians applied the conversion kits to weapons used by a wide variety of aircraft including the Navy's F/A–18 Hornet and the Air Force's B–1B Lancer, B–2A Spirit, B–52H Stratofortress, and F–16 Fighting Falcon. The Air Force also intended that all its attack aircraft except the F–117 would eventually use JDAM-type weapons. In 1998 the Air Force planned to buy 87,000 JDAM tail kits, while the Navy wanted 25,500 for its use.[7]

(U) The munitions were nearing the end of their operational testing on March 24, 1999, when Operation Allied Force, the Kosovo air campaign, began.[8] Boeing rushed some of its first tail kit production batches to the Air Force. The JDAM and B–2 Spirit long-range bomber made their combat debuts on the campaign's opening night when two of the stealthy flying-wing aircraft dropped 32 of the new munitions on selected targets. The Spirit, carrying JDAMs, became the first manned aircraft to penetrate Serbian air defenses.[9]

(U) Remarkably, the B–2s of Brig. Gen. Leroy Barnidge's 509th Bomb Wing mounted round-trip missions from Whiteman AFB, Missouri. General John P. Jumper, commander of United States Air Forces in Europe, flew there from Ramstein Air Base (AB), Germany, to talk with the bomber aircrews about the need for rapid adaptability. The B–2s carried their JDAMs on 28- to 32-hour round trip missions, with two in-flight refuelings during each leg.[10] A reclining chair behind the pilots' seats and hot food sustained the two-member crews on their long flights. Two Spirits launched on 15 nights of the air campaign and a single aircraft on 19 other nights, delivering a total of 652 JDAMs, and 4 GBU–37s.[11]

(U) The B–2 and JDAMs made a stellar team. The B–2s struck 80 percent of their assigned targets on a single pass, and, in one dramatic example of accuracy, a single Spirit scored six hits on six individual runway-taxiway intersections at Serbia's Obvra military airfield. Doubtlessly, Brigadier General Barnidge had the Spirit-JDAM combination in mind when he

declared the aircraft “flies like a Cadillac and bombs like a rifle.”[12] Lt. Gen. Michael Short, who commanded NATO air forces committed to Serbia, pronounced the pairing of the B–2 and JDAM “the No. 1 success story” of the Kosovo air campaign.[13]

(U) The JDAM proved so valuable during Operation Allied Force that Boeing accelerated its production. The Air Force had about 300 JDAMs when the air campaign began and almost immediately tasked the contractor to ramp up production. Boeing increased the workload at its Saint Charles, Missouri, plant and expanded production from about 200 tail kits per month to roughly 300. The September 11 terrorist attacks and beginning of Operation Enduring Freedom in Afghanistan would demand even more JDAMs and greatly accelerate production.[14]

(U) Like the JDAM, the General Atomic MQ–1 Predator UAV was destined to play a major role in the conflicts of the 1990s and beyond. The advantages of using UAVs over a battlefield or enemy territory to gain intelligence or targeting information were obvious in terms of preserving human life. The unmanned vehicles did not expose a pilot or crewman to danger. As one proponent declared: “Our motto is: No widows, no POWs with UAVs.”[15] Eliminating the risk to Air Force personnel was the critical advantage of the advent of effective UAVs, but there was also a cost advantage. The UAVs were significantly less expensive to buy and operate than manned aircraft. Further, at the time of the Gulf War, one student of UAVs estimated that the Air Force spent more than $1,000,000 to train a pilot for a manned aircraft. Ground-based UAV operators were much less expensive to train.[16]

(U) Air Force planners became convinced of the value of UAVs well before Operation Desert Storm. The Israelis used them successfully during the 1973 Yom Kippur War and the 1982 Bekaa Valley campaign against Syria.[17] During the latter operation, Syrian air defense radar operators mistook UAVs for enemy aircraft; air defense batteries expended most of their

missiles against the bogus targets, thereby allowing manned Israeli fighters to roll in while the Syrians were reloading. Since the Syrians had tracked the UAVs, the attacking pilots knew where the emitting radars were located. With this advantage—and others—the Israelis gained air superiority in one afternoon.[18]

(U) By the 1991 Gulf War, UAVs proved themselves well suited to missions that were dull, dirty, and dangerous: long-endurance flights fatigued aircrews; UAVs were valued for their ability to detect chemical and other hazards without threat to a pilot; and they also conducted dangerous reconnaissance deep behind enemy lines and suppressed enemy air defenses.[19]

(U) The U.S. military had not been far behind the Israelis in the development of UAVs. Although the Air Force had been experimenting for many years with such aircraft as the Teledyne Ryan Firebee I and the Navy had developed the Beechcraft Model 1001, these remained little more than remote-controlled model airplanes until after the Israeli successes. Two UAVs made a successful appearance during Operation Desert Storm. The AeroVironment FQM–151A/Pointer, a hand-launched UAV, first flew in 1986 and entered operations in June 1988 with the U.S. Marine Corps. The Marines deployed three Pointer systems during the Gulf War which greatly impressed the ground troops. Veterans came back with a saying: having Pointers was like having 500-foot tall soldiers with binoculars.[20] The RQ–2 Pioneer was an upgrade of an Israeli-developed UAV system, re-designed by the AAI Corporation of Hunt Valley, Maryland, to accommodate a greater payload at the Navy's request. The Pioneer proved larger and even more capable than the Pointer with greater range and endurance. The Army, Navy, and Marines deployed Pioneers during the Gulf War, controlling them from either ground-based or shipboard stations. A study done immediately after the conflict by U.S. Army Brig. Gen. Robert H. Scales, Jr., spoke highly of UAVs[21] and expressed dismay that more Pioneers had not been available.[22]

(U) Air Force interest in UAVs increased exponentially following the Gulf War. The service reviewed its own combat experience and that of others with the vehicles and concluded that a diverse family of systems—rather a single all-purpose model—was needed. During the early 1990s the UAV Joint Program Office (JPO) continually revised the UAV Master Plan that dated to 1988, eventually arriving at a strategy of acquiring three "tiers" of vehicles, grouped by duration on station and by altitude of operation. The Predator fell within the middle of the three tiers, having a range of 500 nautical miles, endurance close to 20 hours, and an altitude of about 25,000 feet.[23]

(U) In 1993 senior Department of Defense leaders determined to accelerate the formal acquisition process that normally took ten years or longer to field new technologies by creating a category of Advanced Concept Technology Demonstration (ACTD) projects. General Atomics of San Diego, California, built the Predator as an ACTD program with the Navy supervising the effort and funding.[24] Secretary of Defense William J. Perry gave the Air Force operational control of the UAV in April 1996.[25]

(U) Originally designated the RQ–1 Predator,[26] the fully operational system consisted of four aircraft, each with a sensor; a ground control station; a Predator Primary Satellite Link; and 55 personnel. The UAV came in two versions, the initial "A" and the later "B," the latter a larger, faster variant with an increased payload capacity. This second iteration also had an improved targeting system and the potential to be armed with missiles. Moreover, Predator B eventually served in a hunter-killer role and in intelligence, surveillance, and reconnaissance roles with another unmanned vehicle, the Global Hawk.[27]

(U) In July 1995, while still an ACTD program and not a fielded system, Predator performed surveillance, reconnaissance, and image-gathering missions in the Balkans. During

the brief August–September 1995 Operation Deliberate Force air campaign over Bosnia, the UAV proved particularly valuable. Predators flew reconnaissance missions to determine if Serbian forces were complying with NATO/UN mandates. On the morning of September 5, Predators and other UAVs collected imagery that showed the Serbs skirting NATO/UN ultimatums. Serbian tanks and large artillery pieces remained defiantly in place and commanders made a show of moving around—but not withdrawing—other, lighter weapons. Acting on the Predator-collected intelligence, NATO and UN leaders ordered midday air attacks against ammunition dumps and vehicle staging and repair areas. The strikes continued for two more days, driving the Serbian units onto roads where they could be watched by UAVs and manned reconnaissance aircraft. On September 16, NATO aircraft reported Bosnian Serb army tanks and vehicles moving away from Sarajevo. Four days later, NATO and UN leaders declared further air strikes unnecessary.[28]

(U) Four years after Operation Deliberate Force, Predators contributed to another operation in the Balkans: Operation Allied Force conducted from March through June 1999, and perhaps better known as the Kosovo air campaign. “The Predator reflected the state of the art in UAV ground control and mission planning capabilities, airworthiness, and mission payloads. . . . During the air campaign, airmen watched Predator video in real-time for visual and other cues to mobile Serb target locations, which they could quickly provide to pilots.”[29]

(U) Predators and other UAVs sometimes operated at low altitudes during the Kosovo air campaign, gathering imagery of Yugoslavian army troop positions that A–10 Thunderbolt IIs and F–16 Fighting Falcons then attacked. Sometimes allied commanders asked for closer looks at enemy dispositions and the reconnaissance missions brought UAVs within the lethal envelopes of Serbian antiaircraft artillery and man-portable air defense systems. During the

campaign the Allies lost 4 Predators and 21 other UAVs.[30] Operation Allied Force commanders considered these numbers acceptable for the obvious reason that the UAVs, rather than manned aircraft, intentionally were sent on missions known to be hazardous.[31]

(U) One Predator innovation during the Kosovo campaign cleverly blended UAV sensor and command and control procedures. Two RQ–1s, operating at 5,000 feet, provided electro-optical and infrared identification of mobile targets, while a third Predator used its laser designator and mapping software to give geographic locations. Armed with this data, A–10s or F–16s were then able to identify and strike the detected target accurately. This technique produced several confirmed hits on enemy tanks.[32]

Image 2

RQ–1 Predator

(U) Despite its success during Operation Allied Force, some observers inside and outside the Air Force questioned how UAVs fit into the service's pilot-oriented culture. Should the airmen who operated Predators and similar systems, for example, be called "pilots," or was this term reserved for those who physically flew aircraft? In the case of Predator, the question was complicated to some extent by the fact that it, among all UAVs, required manual control for

takeoffs and landings. Beyond the semantics lay another question. Could non-rated officers or NCOs with civilian pilot licenses operate UAVs? In April 1996, Lt. Gen. Brett M. Dula, Air Combat Command's (ACC's) vice commander, answered the first question. "Air Vehicle Operator" (AVO) would be the duty title of those who flew Predator.[33] Two months later General Richard E. Hawley, the ACC commander, addressed the second question, stating that AVOs should be experienced rated officers, at least for the time being. The possibility that enlisted airmen could serve in this role remained under consideration during the late 1990s.[34]

(U) Discussions of titles and qualifications suggested that at least some Air Force leaders had lingering uncertainties about UAVs. Issues involving resources highlighted even more strongly the service's reservations about unmanned vehicles. In 1996 one longtime defense correspondent bluntly acknowledged: "UAVs have never been a top priority for the Air Force."[35] In 1997 the Office of the Secretary of Defense (OSD) wanted to purchase 16 Predators; the Air Force only 13. The differences between OSD and Headquarters Air Force over this UAV's production rate and other issues continued into the new century. In 2004, Secretary of Defense Donald Rumsfeld indicated that he wanted Predator B's production accelerated; the Air Force complied, but had to overcome funding and program difficulties to do so.[36]

(U) No matter the Air Force's differences with OSD, leaders in the field significantly valued the capabilities of Predator and other UAVs. A major initiative the service undertook during the 1990s illustrated its commitment to the Predator: equipping the B version with Hellfire missiles, an anti-tank weapon that made an excellent complement to that UAV. The Hellfire was laser guided, and all Predators eventually carried a Multispectral Targeting System that integrated electro-optical, infrared, and laser designators with laser illuminators in a single sensor package. In 1996 Congress authorized $10,000,000 for arming the Predator B with the

Hellfire missile, and the combination reached full operational capability six years later. The idea proved so successful that the Air Force decided to convert all Predators to carry the missiles.[37]

(U) By the early twenty-first century the Air Force was expanding its UAV programs. But it was not alone in recognizing the combat value of unmanned vehicles, a reality that raised questions about who would exercise command and control over them. By the end of the 1990s, it was likely that the services would deploy UAVs more rapidly than they would arrive at agreement on executive agency for them.[38]

Image 3

F–22 Raptors

(U) The UAVs played an important role in the air operations of the 1990s and the early years of the twenty-first century, but another weapon, the F–22 Raptor, which made its first flight on September 7, 1997, loomed even larger in the history of the Air Force during this period. The highly-advanced fighter commanded more attention, if only because of the far greater resources that the Air Force invested in it. In February 1989, the system operational requirement document for the Advanced Tactical Fighter, the program's original designation, provided for an aircraft with a cost of $35 million in 1985 dollars. By the time of the President's budget for FY 1997, the F–22's total estimated production cost stood at about $48 billion.[39]

(U) The Air Force invested heavily in the F–22. The aircraft represented an exponential leap in fighter capabilities. Its unprecedented combination of stealth technology, supercruise operation, high maneuverability, and integrated avionics allowed it to project air dominance rapidly and at great distances. In 2000, military analyst Benjamin S. Lambert contended that no

other nation could afford to pursue the F–22 or any other aircraft with similar "high-end stealth applications."[40] He was proven correct: when the Raptor reached initial operating capability in December 2005, it was unmatched by any known or projected fighter.[41]

(U) This high technology aircraft program pre-dated the 1990s. It began in 1985 with a demonstration and validation phase for what was then called the Advanced Tactical Fighter. At that time, the Air Force planned to procure 750 of these aircraft at a rate of 72 annually through the year 2005. However, a DOD major aircraft review in 1990 reduced the production rate from 72 aircraft to 48 per year.

(U) In August 1991, the Air Force awarded a $9.55 billion contract for the engineering and manufacturing development (EMD) of a fighter then designated the F–22. A team of two firms received the contract: the Boeing Company of Seattle, Washington, and the Lockheed Martin Corporation of Bethesda, Maryland. During the 1980s, Lockheed personnel worked on the Advanced Tactical Fighter at facilities in Burbank, California. For the EMD and production phases of the effort, the corporation moved its program management and aircraft assembly operations to Marietta, Georgia. As EMD began, a Defense Acquisition Board reduced the F–22 procurement to 648 fighters and extended its production to 2012.

(U) The Department of Defense's 1993 Bottom-Up Review again reduced the aircraft's procurement, this time from 648 to 442. By the time the Air Force approved the final design of the F–22 and approved the program to proceed to fabrication and assembly – an important milestone – the pattern of reducing the procurement rate and stretching the production time had continued to raise its cost. In June 1996, the Air Force chartered a joint cost estimate team (JET) to review the F–22's development and production costs. The JET recommended restructuring the fighter's production schedule to offset the costs introduced when the Air Force extended the

EMD phase by nine months. The production rate was reduced and four pre-production verification aircraft (PPV) were cut from the program, lowering the total procurement number to 438 F–22s. The PPV fighters had been intended to be used only for operational test and evaluation; the JET recommended cutting them and using two EMD aircraft and the first two production F–22s instead. While the JET's recommendations emerged in their final form, the 1997 Quadrennial Defense Review (QDR) made yet another reduction in the F–22's production, lowering total procurement from 438 to 339 and reducing the maximum yearly production rate from 48 to 36.[42]

(U) Taken collectively, all the changes made after 1985 in the F–22's production quantities grossly inflated the cost of bringing the fighter into the inventory. By 1999, the Raptor's development cost had increased by $3.5 billion. In 2003, Lt. Gen. John D. W. Corley, then the principal deputy to the Assistant Secretary of the Air Force for Acquisition, presented national lawmakers with a hard truth: "The reduced quantity has been the most dominant factor in increased F/A–22 production unit costs."[43]

(U) The F–22 Raptor, the JDAM, and UAVs were major Air Force weapons that emerged during the 1990s. Each of them, in different ways, shaped the history of the service during that decade—and into the new century. The JDAM arrived in time to be used in Operation Allied Force and also served the Air Force well after September 11, 2001. Emerging from Operation Desert Storm, Predator and other UAVs established themselves as weapons of the present and future. The Air Force's strong commitment to the F–22 manned fighter aircraft continued the service's traditions and would influence its operations for decades.

[1] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-17–VI-18 (info used is U).

[2] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-17–VI-18 (info used is U).

[3] (U) Web site (U), JDAM Warfighter Web site, https://jdam.eglin.af.mil/hist/2.html (accessed 13 May 10).

[4] (U) Web site (U), JDAM Warfighter Web site; John A. Tirpak, "Brilliant Weapons," *Air Force Magazine* 81:2 (Feb 1998), p 53; Report (U), Boeing Company Communications and Community Affairs, "Joint direct attack munitions (JDAM) Backgrounder," Apr 2007.

[5] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-17–VI-18 (info used is U); Tirpak, "Brilliant Weapons," *Air Force Magazine* 81:2, p 53.

[6] (U) John A. Tirpak, "The State of Precision Engagement," *Air Force Magazine* 83:3 (Mar 2000), p 29; Tirpak, "Brilliant Weapons," *Air Force Magazine* 81:2, p 53 [note: Tirpak's two articles give the same initial cost estimate, and show how the Air Force's estimated savings changed over time].

[7] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-17 (info used is U); Tirpak, "Brilliant Weapons," *Air Force Magazine* 81:2, p 53.

[8] (U) Richard L. Sargent, "Weapons Used in Deliberate Force," in Robert C. Owen, ed., *Deliberate Force: A Case Study in Effective Air Campaigning* (Maxwell AFB, Ala.: Air University Press, 2000), p 275; History of Headquarters USAF, 2002 (S//NF), vol 1: VI-18 (info used is U); Tirpak, "The State of Precision Engagement," *Air Force Magazine* 83:3, p 28.

[9] (U) Tirpak, "The State of Precision Engagement," *Air Force Magazine* 83:3, p 28; Peter Grier, "Aerospace World: USAF Accelerates JDAM Production," *Air Force Magazine* 82:7 (Jul 1999), p 9; Benjamin S. Lambeth, *NATO's Air War for Kosovo: A Strategic and Operational Assessment* (Santa Monica, Calif.: Rand Corporation, 2001), p 89.

[10] (U) Rebecca Grant, *The Kosovo Campaign: Aerospace Power Made It Work* (Arlington, Va.: The Air Force Association, 1999), p 19; Lambeth, *NATO's Air War for Kosovo*, p 90.

[11] (U) Grant, *The Kosovo Campaign*, p 19; Lambeth, *NATO's Air War for Kosovo*, pp 90–91 [note: The 652 figure follows Lambeth, p 91; he may have used later information than Grant, p 19 (who gives 650), or, Tirpak, "The State of Precision Engagement," p 29 (656, which may represent the addition of the 4 GBU–47s to Lambeth's 652)].

[12] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-18 (info used is U).

[13] (U) Lambeth, *NATO's Air War for Kosovo*, p 91; Grant, *The Kosovo Campaign*, p 19; Tirpak, "The State of Precision Engagement," *Air Force Magazine* 83:3, p 28.

[14] (U) Tirpak, "The State of Precision Engagement," *Air Force Magazine* 83:3, p 29; Grier, "USAF Accelerates JDAM Production," *Air Force Magazine* 82:7, p 8; History of Headquarters USAF, 2002 (S//NF), vol 1: VI-18–VI-19 (info used is U).

[15] (U) Richard P. Hallion, *Storm over Iraq: Air Power and the Gulf War* (Washington: Smithsonian Institution Press, 1992), pp 311–12.

[16] (U) James W. Canan, "Steady Course for Unmanned Aircraft," *Air Force Magazine* 74:3 (Mar 1991), p 88; Brian P. Tice, "Unmanned Aerial Vehicles: The Force Multiplier of the 1990s," *Airpower Journal* 5:1 (Spring 1991), p 41.

[17] (U) Tice, "Unmanned Aerial Vehicles," *Airpower Journal* 5:1, pp 43–44; Hallion, *Storm over Iraq*, p 312.

[18] (U) Tice, "Unmanned Aerial Vehicles," *Airpower Journal* 5:1, pp 43–44.

[19] (U) Tice, "Unmanned Aerial Vehicles," *Airpower Journal* 5:1, p 53.

[20] (U) Hallion, *Storm over Iraq*, p 312; Canan, "Steady Course for Unmanned Aircraft," *Air Force Magazine* 74:3, p 87.

[21] (U) Hallion, *Storm over Iraq*, p 312; Web site (U), AAI Corporation website, https://www.aaicorp.com (accessed 13 May 10); Robert H. Scales, Jr., *Certain Victory: The U.S. Army In the Gulf War* (McLean, Va.: Potomac Books, 1994), pp 167, 229, 365, 371–372.

[22] (U) Scales, *Certain Victory*, pp 169, 179, 204.

[23] (U) Peter Grier, "DarkStar and Its Friends," *Air Force Magazine* 79:7 (Jul 1996), p 41; Report (S//NF), James George, "Predator Comes To Air Combat Command" (Langley AFB, Va.: Air Force History and Museums Program, 2006), p 1 (info used is U); John A. Tirpak, "The Robotic Air Force," *Air Force Magazine* 80:9 (Sep 1997), p 72.

[24] (U) Report (S//NF), George, "Predator Comes To Air Combat Command," p 1 (info used is U); Web site (U), General Atomics, http://www.ga.com (accessed 13 May 10); Tirpak, "The Robotic Air Force," *Air Force Magazine* 80:9, p 72.

[25] (U) Report (U), Headquarters Air Combat Command Office of Public Affairs, "MQ–1 Predator," May 2008; Tirpak, "The Robotic Air Force," *Air Force Magazine* 80:9, p 72.

[26] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-21 (info used is U); Report (U), Headquarters Air Combat Command Office of Public Affairs, "MQ–1 Predator," May 2008 [note: The Air Force changed this designation to MQ–1 in 2002, when Predator gained an armed reconnaissance role].

[27] (U) History of Headquarters USAF, 2002 (S//NF), vol 1: VI-21–VI-22 (info used is U).

[28] (U) Report (S//NF), George, "Predator Comes To Air Combat Command," p 1 (info used is U); John A. Tirpak, "Deliberate Force," *Air Force Magazine* 80:10 (Oct 1999), p 41 (caption), p 42; Mark J. Conversino, "Executing Deliberate Force, 30 August–14 September 1995," in Owen, ed., *Deliberate Force: A Case Study in Effective Air Campaigning*, p 158.

[29] (U) Report (U), HQ USAF, "The Air War Over Serbia: Aerospace Power in Operation Allied Force," 2000, p 44.

[30] (U) Lambeth, *NATO's Air War for Kosovo*, pp 94, 97 [note: "The Air War Over Serbia: Aerospace Power in Operation Allied Force," p 44, states the United States lost 15 UAVs during Operation Allied Force; Lambeth, p 97, accounts for 16].

[31] (U) Lambeth, *NATO's Air War for Kosovo*, p 94.

[32] (U) Lambeth, *NATO's Air War for Kosovo*, p 95.

[33] (U) Report (S//NF), George, "Predator Comes To Air Combat Command," pp 13–15 (info used is U).

[34] (U) Report (S//NF), George, "Predator Comes To Air Combat Command," pp 14, 29–32 (info used is U) [note: The issue of NCOs as air vehicle operators remained open at the end of the decade. Into the new century there were discussions of it and other, related subjects: the possibility of non-rated officers commanding UAV units was considered in May 2000]; Report (S//NF), George, "Predator Comes To Air Combat Command," pp 58, 83, 86-87 (info used is U).

[35] (U) Grier, "DarkStar and Its Friends," *Air Force Magazine* 79:7, p 40.

[36] (U) Report (S//NF), George, "Predator Comes To Air Combat Command," pp 21, 123–125 (info used is U).

[37] (U) Rebecca Grant, "The Drone War," *Air Force Magazine* 90:7 (Jul 2007), p 37; History of Headquarters USAF, 2002 (S//NF), vol 1: VI-22 (info used is U).

[38] (U) Grant, "The Drone War," *Air Force Magazine* 90:7, pp 37, 39 [note: This article ably details how the Air Force, as of the summer of 2007, saw the issue of executive agency for UAVs].

[39] (U) Susan H.H. Young, "USAF Almanac Gallery of USAF Weapons," *Air Force Magazine* 82:5 (May 1999), p 137; History of Headquarters USAF, 1989 (S//NF), vol 1: p 249 (info used is U); Report (U), United States General Accounting Office, "Tactical Aircraft: Restructuring of the Air Force F–22 Fighter Program (Letter Report, 06/04/97, GAO/NSIAD-97-156)," Jun 1997, p 1 [note: During its history this fighter carried more than one designation. It first was called the Advanced Technology Fighter, then the F–22. In Sep 2002 it was redesignated the F/A–22; in Dec 2005 it became the F–22A]; History of Headquarters USAF, 2002 (S//NF), vol 1: VI-12 and VI-14 (info used is U); Report (U), Headquarters Air Combat Command Office of Public Affairs, "F–22 Raptor," Apr 2008.

[40] (U) Report (U), Headquarters Air Combat Command Office of Public Affairs, "F–22 Raptor," Apr 2008; Benjamin S. Lambeth, *The Transformation of American Air Power* (London: 2000), p 8 [note: "Supercruise" referred to the F–22's ability to cruise at supersonic speed without using its afterburners]; Young, "Gallery of USAF Weapons," *Air Force Magazine* 82:5, p 137.

[41] (U) Report (U), Headquarters Air Combat Command Office of Public Affairs, "F–22 Raptor," Apr 2008.

[42] (U) Note: This section on the F–22 program represents a slight reworking of one the author contributed to the History of Headquarters USAF, 2002 (S//NF), vol 1: VI-12 and VI-14 (info used is U).

[43] (U) John T. Correll, "Editorial: One by One," *Air Force Magazine* 82:9 (Sep 1999), p 4; History of Headquarters USAF, 2002 (S//NF), vol 1: VI-14 (info used is U).