New aerospace technologies promise dramatic change in air combat operations, a noted RAND analyst argues.

Technology and Air War

By Benjamin S. Lambeth

AIRPOWER, coupled with information power, has arguably become the dominant force element in most circumstances of war. Ever since World War II, it has provided US and allied ground forces with the freedom to operate unmolested from above. Now, through a combination of technology development and astute concepts of operations, it could become an even more pivotal element of national power, if the possibilities before it are wisely cultivated.

The past decade has seen many airpower instruments evolve from advanced development to operational use. These systems have aggregated mainly in the areas of stealth, precision standoff attack, and enhanced information availability. Such capabilities were brought together for the first time in combat in the 1991 Persian Gulf War. In an unprecedented convergence of technology, doctrine, concepts of operations, and leadership, the coalition promptly attained an unquestioned dominance of the air.

Today, new aerospace technologies either in hand or on the horizon promise to generate even more dramatic changes, further widening the gap between states that possess them and those that do not. When it comes to the technical nature of systems, these developments are likely to cause changes in degree rather than in kind. Even so, from an operational perspective, they foreshadow a qualitative change. These fall into four categories:

■ **Advanced Platforms.** The F-22 fighter is the first next-generation combat aircraft nearing production. An engineering and manufacturing development model will fly next year, with initial operational capability planned for 2004. USAF intends to procure 442 to replace the F-15. Later, the US will field a Joint Strike Fighter to replace USAF's F-16, the Navy's A-6E, and USMC's AV-8B.

Successor generations of combat aircraft are likely to be quite different. Leading the pack may be what the USAF Scientific Advisory Board's "New World Vistas" study called uninhabited combat aerial vehicles (UCAVs). Now in concept development, these would feature pilots who sit in an execution center in the US and fly the aircraft as far as half a globe away through high-speed fiber-optic and satellite links.

UCAVs promise levels of performance unattainable from manned aircraft because they won't have to operate within limits of human tolerance. UCAVs with plus-or-minus twenty-G capability will be able to defeat nearly all opposing antiaircraft missiles.

Vehicles can be made smaller by eliminating displays, ejection seats, controls, life-support gear, and other aspects of manned aircraft, increasing stealth. Stealthy UCAVs with low-observable, long-range missiles will lessen the need for manned aircraft to penetrate defenses. They can extend aerodynamic performance to hypersonic range, permitting a direct attack of high-value targets from US soil anywhere in the world in less than an hour.

Such vehicles are in their infancy. In particular, it may take decades for unmanned aircraft to be used in the strike role.

■ **Precision Weapons.** Precision guided munitions (PGMs) largely swung the outcome of the Gulf War by quickly shutting down Iraq's air defenses. Such munitions already have provided a thousandfold increase in destructive power, compared to unguided bombs. As the US

Lockheed electronic artist's concept by Steve Moore

An artist's concept of the F-22 in the markings of the 3d Wing flies past Mount McKinley, Alaska. The F-22 and the Joint Strike Fighter will change the existing rules of combat and help the US achieve air dominance in any future conflict.

approaches near-zero-miss-distance accuracies, it can design and build smaller munitions and perhaps maintain fewer stocks.

Near-term systems include PGM upgrades and the Joint Direct Attack Munition. Next-generation sensor-fuzed smart weapons will be able recognize, identify, and sort targets even as their sensors guide them, achieving accuracies measured in centimeters rather than meters.

The march of technology is taking the United States away from primary reliance on the time-tested means of attack—putting iron on a target. US forces also will use disruptive measures, such as energy (lasers and high-power microwave bursts), electrons (directed radio-frequency energy), and deception.

Also in development are "information munitions" to attack, destroy, confuse, or fool information systems. This portends capabilities for entering a command's computers and destroying or distorting files. Information warfare techniques could enable a warfighter to sift through an enemy's e-mail, discover locations of his weapons, and scramble his air defense computers.

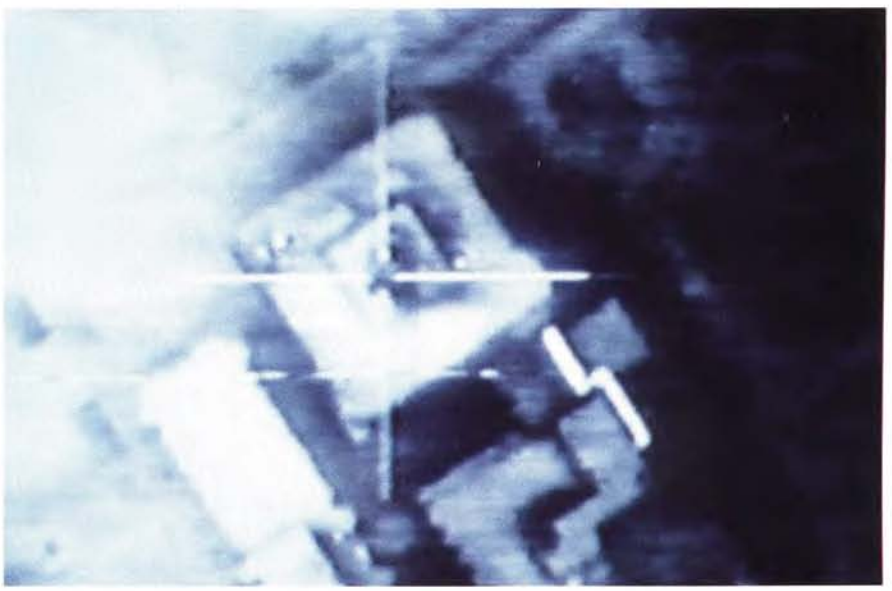
High-power microwave and laser weapons may work in tandem with or replace many traditional explosive weapons. They may, for example, penetrate an enemy fighter cockpit, illuminate the fire warning light, shut down digital engine controls, or make other surreptitious inputs like penetrating flight controls and forcing an uncommanded break turn. At the least, this will destroy formation integrity and make the enemy predictable. It will also surprise his socks off the first time it happens.

■ **Sensors and awareness aids.** "Situational awareness" is a term much in vogue, but fighter pilots have seen it for decades as the vital difference between winning and losing in combat. It determines combat outcomes more than all other factors combined, including previous combat experience.

Now in store are major upgrades for the E-3 Airborne Warning and Control System and E-8 Joint Surveillance and Target Attack Radar System aircraft. The E-3 will gain a doubled radar range against fighter-sized targets and an improved ability to detect and track cruise missile–sized targets. Technology promises high-speed processors exceeding today's capability by a factor of 10,000 for AWACS and 1,000 for Joint STARS. Synthetic aperture radar will be incorporated in sensors on distributed satellite constellations, unmanned aerial vehicles, munitions, and ground stations. Eventually, satellites will be able to locate an emitter with enough accuracy to permit delivery of Global Positioning System–guided weapons even if emissions cease.

Global awareness will include not only threat-related information but also information on one's own and allied forces—individual aircraft maintenance status, location, availability, mission status, and so on. It may include information from an enemy's databases. In fact, it may be more useful to preserve an enemy's command, control, communications, computer, and intelligence net than to destroy it, because US forces can take advantage of knowing what the enemy knows about his own assets.

■ **Information processing.** The Joint Tactical Information Distribution System (JTIDS) now offers an F-15 flight lead a god's-eye view of his tactical situation. This has greatly driven up kill ratios in peacetime air combat training. It permits real-time data exchange between aircraft and, accordingly, new tactics. It shows



Precision guided weapons, such as the one used in this attack against Iraq, provide a thousandfold increase in destructive power compared to unguided bombs. Future accuracy will be measured in centimeters rather than meters.

Staff photo by Guy Aceto

The Joint Tactical Information Distribution System is already offering F-15 pilots vastly improved awareness of the tactical situation, enabling prompt and precise application of force.

the position of all aircraft in a formation or strike package, as well as the location of enemy aircraft, ground forces, and other threats.

JTIDS allows an exchange of digital information on relative positions, weapons availability, and fuel status, among other things, reducing the need for intraflight voice communications. It indicates when other friendly fighters are being illuminated by radars. Its "buddy lock" feature notes when other fighters have radar locks on hostile aircraft.

Other systems include advanced data-fusion software, interlinked but physically dispersed databases, and high-speed, large-capacity communications nets, all of which will enable prompt and precise application of force.

Operational Implications

What do these trends mean for the operator? What are the advantages?

The first and most important payoff area entails the capability for maximizing US situational awareness while denying it to the enemy. If pursued to fruition, the new systems and capabilities outlined above will provide users at all levels with virtually complete and current knowledge of an operational situation: information dominance.

A second big payoff area is the synergism that will come from the greater efficiencies of seamless joint operations aimed at using the right assets in the right place at the right time. Technology is forcing movement toward true combined-arms and multinational operations.

This does not mean that the individual services or force elements will no longer perform as soloists in a combined-arms orchestra (to use retired USAF Col. John Warden's apt metaphor), with the soloist of the moment varying with the tactical and operational situation. However, traditional service lines more and more are breaking down under the pressure of the continuing integration of systems and capabilities.

In future wars—in which air activity will be a precursor to any land operation and naval weapons can engage a wider range of land targets—the interests of mission effectiveness will require cross-service communication as a matter of routine.

The US is approaching a time when an Air Force sensor operator and coordinator could assign a Navy platform to launch an Army weapon in support of Marines.

A third payoff area concerns the broadening of airpower's ability to accomplish tasks previously beyond its powers to address. Better information availability and directability mean reduced cycle time—a force-multiplier that creates a larger apparent force from small numbers by permitting a higher operations tempo. The next generation of aircraft will embody significant improvements in reliability, maintainability, and sustainability, making possible even greater leverage from fewer numbers.

These advances even now permit the Air Force to maintain air dominance over hostile territory and enforce no-fly and no-drive zones.

These are new concepts. On the first count, allied control of the air over Iraq after the first week of Operation Desert Storm was so secure that in-flight refueling operations inside enemy airspace were possible. As for the second count, even if USAF had had the ability ten years ago to look deep with such platforms as AWACS and Joint STARS, it could have done little with the resulting information because it lacked the needed reach, standoff capability, and precision.

Without displays, life-support gear, or other necessities of piloted aircraft, Predator UAVs and future UCAVs can be much smaller than fighters. They can also ignore human tolerances and achieve plus-or-minus twenty-G capability.

Middle and Upper Air

Airpower can now make effective use of the middle and upper air to avoid enemy infrared surface-to-air missiles and antiaircraft artillery. Ironically, just as it has reached near-perfection, the low-altitude capability afforded by Low-Altitude Navigation and Targeting Infrared for Night may have been overtaken for most scenarios by the new attack options provided by long-range standoff capability and precision guidance, which now allow combat aircraft to work effectively from the safer medium-altitude environment. This new operating window also permits easier target acquisition. With the reduced risk of attrition it affords, numbers of aircraft needed in attack packages can be commensurately smaller.

The F-117's stealthiness was a key factor in enabling the coalition to achieve air dominance early in Desert Storm. Stealth in the F-22 and Joint Strike Fighter will further change the existing rules of aerial combat. It is already forcing a complete change in tactics, both in air-to-air and in surface attack, for the possessor as well as for the side that lacks it.

Stealth will allow airpower to operate virtually at will. The stealthy F-22 can use bistatic radar without revealing its location; the active transmitter can be on an off-board platform like AWACS, and the fighter can receive intercept vectors with its radar operating in a standby mode, so as not to emit radiation that would reveal its location.

Closely related in importance are the emerging advantages in reach in air-to-air combat (more commonly called "first shot with impunity") and survivability to kill heavily defended ground targets, which low observability offers.

A fourth payoff area is situation control from the outset of fighting. Thanks to this breakthrough, the initial blow can now achieve strategic goals in the first moments of combat and thus determine the subsequent course and outcome of a war.

Before long, the initial attack may even be surreptitious—for example, into computer systems, to pave the way for fire and steel to follow.

Photo © Randy Jolly/Arms Communications

Emerging technologies can be used to protect such high-value targets as KC-135 tankers and E-3 AWACS aircraft and allow them to operate with impunity, as they did during the Persian Gulf War.

As Desert Storm showed, the ability of independently applied airpower to control airspace and shape the battlefield eliminated any urgent need to commit ground forces. Virtually the only factor driving a demand to wrap things up quickly was the certainty of approaching summer heat, which would have made operations by all forces difficult, if not impossible.

Changed Essence of Air War

These payoffs will keep an enemy at arm's length indefinitely by providing the wherewithal to conduct deep battle as a rule rather than as the exception.

This change foreshadows a decline in the need for armies to prepare for close-maneuver ground combat and a similar decline in the need for air forces to plan and train for close air support—other than as an emergency mission of last resort.

All of this means a reduced incidence of casualties for friend and foe alike. Indeed, possibly the single greatest impact of the technology revolution on airpower and its effectiveness relative to other force components is its capacity to save lives. It saves enemy lives through the use of precision attack to minimize noncombatant fatalities and friendly lives by the substitution of technology for manpower and the creation of battlefield conditions in which land elements, once unleashed, can more readily do their jobs because of the degraded capabilities of enemy forces. This can prevent casualties on a scale that could undermine popular support for the use of US ground forces.

After the fact, Desert Storm was hailed as an exemplary demonstration of the technology revolution. Yet there was nothing foreordained about its outcome. It is certain that the coming revolution in aerospace technology will spur have-nots to produce countermeasures—quite possibly asymmetric countermeasures.

A determined rogue state could do much on the cheap to negate US technological superiority. Options include dedicated attacks on high-value targets, such as Joint STARS, AWACS, and tankers. Attacks on airlifters moving materiel into a theater and denial operations against rear-area terminals and other bases offer additional near-term options. Ever-present is the possibility of a desperate resort to a counterdeterrent based on nuclear and other weapons of mass destruction.

In short, as capable as they may be, these emerging aerospace technologies promise only a period of advantage but no "end of history" with respect to the enduring dialectic between offense and defense in military affairs. ■

Benjamin S. Lambeth is a senior staff member at RAND Corp., specializing in international security affairs and airpower. This article was condensed from a longer paper delivered at a conference on "New Era Security" held in Australia. His most recent article for Air Force *Magazine, "Hard Times for the Russian Air Force," appeared in the July 1995 issue.*