Here are the weapon systems that the Air Force envisions for the twenty-first century.

The Shape of Things to Come

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AIR Force technologists, the wizards in charge of conjuring up weapons for the next century, are coming under pressure to work their magic.

Leaders of the Air Force's 8,000 scientists and engineers working at fourteen major laboratories are marshaling forces to take on a massive array of projects that will shape the service well beyond the year 2000.

They say that a drive to develop "revolutionary enabling technologies" within the next several years will undergird the Air Force's apparent plans for generating new military weaponry on an awesome scale.

The scope of the ambitions embraced by the Air Force is evident to those familiar with USAF's "Science & Technology and Development Planning Program," a thirty-two-page list of arms concepts produced by Air Force Systems Command (AFSC) officers.

Their concepts for the far future—that is, beyond the turn of the century—include robotic air vehicles, automated attack systems, advanced air-superiority missiles, autonomous antiarmor weapons, hypervelocity munitions, high-altitude long-endurance vehicles, and automatic image interpreters.

In addition, planners envision multimedia radios, laser communication systems, high-power microwave weapons, stealthy transport airplanes, long-range conventional cruise missiles, laser satellite links, and hypersonic aircraft.

Even the weapons envisioned for deployment within the next decade pose formidable challenges. Examples of such "next-generation" concepts include the Advanced Tactical Fighter, multimission drones, noncooperative aircraft identification systems, millimeter-wave ground-attack missiles, long-range optical sensors, automatic target recognizers, and space-based radars.

Overall, AFSC's list of prospective twenty-first-century systems to meet the Air Force's stated operational requirements contains no fewer than 224 high-technology concepts in mission areas ranging from armament to space.

AFSC leaders, aware that every weapon concept entails development of many costly technologies at a time of harsh budgetary pressures, are concentrating on those that promise a high payoff. Says Gen. Bernard Randolph, AFSC's commander: "The challenge is to focus valuable science and technology resources into areas that can achieve the greatest increase in combat capability."

Across thirteen general areas such as air vehicles, avionics, and the like, officers have selected ninety-one key "major technology thrusts" for emphasis, each containing a number of individual technologies. Specific examples of these technologies include:

• Photonics technologies that would permit a massive increase in capacity of military computers and reduce vulnerability to electronic warfare.

• High-temperature materials capable of retaining strength in temperatures as high as 4,000 degrees Fahrenheit.

• Nonlinear optics technologies in which light could be used in radically new ways for automatic tracking or elimination of atmospheric interference.

• High energy density propellants, chemically bound materials that might greatly increase fuel powers while reducing weight.

• Smart skins, surfaces whose embedded transmitting and receiving functions would eliminate today's need for pods and domes, which increase radar signatures.

• Knowledge-based systems that would use artificial intelligence to perform human-type logic exercises in avionics and weapons.

Notwithstanding the promise of these and many other technologies, Air Force officers acknowledge the magnitude of the weapons challenge ahead. What follows is a full picture of the task, based on AFSC's analysis of possible ways to meet Air Force needs in ten key mission areas.

Tactical Fighter Forces

THE MOST clear-cut ambition focuses on improvements to the tactical fighter forces that form the bedrock of Air Force combat power.

The service's technological establishment envisions new air supremacy and attack vehicles of unparalleled strength—stealthy, agile, far-seeing, and resilient, yet possessing an abundance of power. All these attributes and more, it is thought, will be needed to meet, in what promises to be a harsh twenty-first-century environment, requirements set by Tactical Air Command officers.

These requirements do not only include the capability to fight at night and in foul weather, locate and destroy mobile tactical targets, conduct airfield attack, survive in aerial combat, go after the hardest of hard targets, and carry out long-range interdiction. In addition, the systems must be reliable and easy to support.

At present, those needs are filled, with a greater or lesser degree of success, by such aircraft as the F-15, F-16, F-4, F-111, A-10, and A-7, based on earlier technologies that have led to improved reliability, secure communications, tactical decision aids, and integrated information processing. A need is foreseen for aircraft of greatly increased powers.

Some are expected to emerge in the "next generation" of weapons to be in service around the turn of the century. For the air-superiority role, the Advanced Tactical Fighter receives top billing. The Agile Falcon makeover of the F-16 fighter, along with an all-weather version of that versatile General Dynamics aircraft, are foreseen as the most likely multimission complements to the ATF itself.

AFSC is also working toward new aircraft for the close-air support, long-range attack, and defense suppression missions. Proposals include the possible development of a multimission, remotely piloted drone for various uses.

These air vehicles are expected to boast major advances in avionics. One example: so-called "noncooperative" aircraft identification systems able to perform the vital identification task by passive means. Next-generation aircraft could have links for instantaneous transmission of strike data, avionics suites capable of reconfiguring while in flight, and integration of sensors and other functions on a grand scale.

Success in these areas is contingent on a number of key technologies now emerging in AFSC labs. Chief among them are stealth properties that help to reduce aircraft signatures across the board. Technologists are striving to develop and perfect head-steerable target systems, multispectral and multimode sensors, sensors hardened against radiation, self-repairing flight controls, lightweight structures, and internetting of various communications systems. Also in prospect are faster and greatly simplified cockpit displays and night-vision devices.

For beyond the turn of the century, tactical aircraft concepts pose greater technological challenges. Among those concepts are robotic air vehicles for varied combat functions. Ultrasophisticated interdiction aircraft and a new multirole fighter are also being studied. Backing these up are such concepts as high-altitude/high-Mach protective equipment for crews, the Super Cockpit of multiple, integrated functions, and a fully automated attack system based on futuristic computer systems.

Making these concepts come to life will not be easy. The Air Force will have to master technologies now in the earliest stages of development. They include acoustic signature reduction, "few vs. many" air-to-air automated engagement systems, and flight decision aids based on artificial intelligence—systems that permit computers to conduct exercises in human-type logic.

The tactical force of the future also would benefit from successful development of the High-Performance Turbine Engine, a powerplant envisioned as having twice the thrust of, and far less weight than, today's most advanced engines, as well as short- and vertical-takeoff and landing technologies, in-flight thrust reversers, and robotic servicing of aircraft. An all-aspect head-up display and new systems that provide finely honed target discrimination will also be required.

Aircraft Armament

—Photo courtesy of Lockheed Corp.

To arm new fighters, USAF is developing advanced weapons, particularly for ground attack. Under review are powerful hard-target warheads, "stealthy" motors, lightweight structures, multirole warheads, and "brilliant" guidance.

TO COMPLEMENT what promises to be a greatly strengthened aircraft force in the future, the Air Force is mapping improvements in armament over the full range of combat missions.

The weapons now under study address requirements of extraordinary magnitude. Air Force users, for example, want the capability to employ weapons confidently at night and in poor weather. They want extreme standoff range, resistance to electronic countermeasures, capability to destroy heavily fortified targets, and greater ease of maintenance and handling. They want to be able to "launch and leave," achieve multiple kills with a single pass over a target, and yet be able to reduce the pilot's work load.

In addition, the new weapons will have to be stealthier, approach near-perfect accuracies, and have utility across a wider spectrum of engagement conditions.

Today's weapons fall short of these requirements. Based on older technologies of laser guidance, electronic fuzing, imaging infrared seekers, and the like, they include such air-to-air weapons as the AIM-9 Sidewinder and new AIM-120 Advanced Medium-Range Air-to-Air Missile, as well as a host of air-to-ground systems. While such weapons are effective today and for the near term, the future will pose problems for them.

As a result, technologists are focusing on highly advanced concepts, particularly for ground attack. Possibilities for relatively near-term usage include a version of the Maverick missile that incorporates millimeter-wave guidance. Also listed is an "autonomously guided weapon" able to carry out its mission with no instructions from a pilot after launch.

Planners are also investigating new forms of conventional cruise missiles, hard-target weapons, modular standoff weapons, munitions containing advanced inertial guidances, and hypervelocity missiles capable of traveling at least five times the speed of sound.

For air-to-air combat, the next generation of weapons is expected to include the AIM-132 Advanced Short-Range Air-to-Air Missile and an upgraded version of the AMRAAM weapon.

With respect to these next-generation arms concepts, technology development has become particularly active. Work is proceeding on autonomous guidance systems, powerful hard-target warheads, "stealthy" rocket motors, lightweight and stealthy structures, and multirole warheads. Also being pressed are new advances in algorithms that would permit microcomputers to "recognize" targets within a mass of data, as well as "smart" fuzing and low-cost components. Computational fluid dynamics, a computer-aided means of optimizing aerodynamic shapes *(see "The Electronic Wind Tunnel," p. 62),* is expected to play a major part in weapons design.

Then come weapons for the distant future. For the time period beyond the turn of the century, the Air Force is pursuing a different set of technologies in hopes of achieving a big payoff in combat power. Now getting major attention within the laboratories are technologies of "brilliant guidance," which include such techniques as laser radar sensors and exploitation of infrared and millimeter-wave signatures of targets to enhance recognition.

Other key technologies pertain to development of materials and design of hard-target penetrators and high-energy "insensitive" high explosives—materials that resist accidental detonation due to fire or blast. A family of technologies—hypersonic separation aerodynamics, high-temperature materials, and hypersonic guidance integration—is obviously germane to development of ultrahigh-speed missiles.

Based on the expectation that these and other technologies will mature reasonably well, USAF has postulated some remarkable weapons for the inventory of the early twenty-first century. It envisions development of an "Advanced Air Superiority Missile" far superior to even the AMRAAMs of tomorrow. For the air-to-ground mission, future forces might well be able to call on fully autonomous antiarmor weapons, autonomous "high-value target" missiles, hypervelocity submunitions, and advanced mines dispersible over a wide area after release from an aircraft.

Reconnaissance/Intelligence

In the area of reconnaissance and intelligence gathering, the level of sophistication that the Air Force seeks in its future systems is evident in the performance goals that the service is setting for itself.

Stated Air Force requirements, although few in number, are extremely challenging. Operational commands say they must greatly expand the visual and electronic spectrum within which they are able to work, with particular emphasis on passive detection measures. They seek highly advanced, computerized correlation and fusion of reconnaissance data to provide, among other things, instant, automatic recognition of targets.

In addition, USAF's operational users are asking technologists to provide means for decentralizing full intelligence stations to the unit level and for setting up robust, secure communications with a low probability of enemy intercept.

This, the Air Force makes plain, will require systems considerably more advanced than those deployed in its current generation of reconnaissance and intelligence forces, which are based on earlier technologies of digital data links, electro-optical sensors, digital recorders, multisensor fusion, clutter rejection, and rapid software prototyping. Today's collection platforms such as the RF-4C, TR-1, and SR-71, sensors such as the Joint Surveillance and Target Attack Radar System (Joint STARS) multimode radar, and associated processing and dissemination systems will have to give way to more advanced concepts.

For the next generation, Air Force planners foresee development of an advanced and possibly "stealthy" platform, known as the FX-R, to take up the tactical recce duties of the RF-4C. To meet near-term requirements, attention is also being given to a vast array of new, highly sensitive sensors. Among them: a very-long-range optical sensor, advanced electronic-intelligence-gathering systems, systems to provide time-correlation of signal intelligence, advanced radar locators, and laser-detection systems.

At the same time, systems used to both process and pass along vital intelligence data are due for upgrading over the next several years. Processing concepts being studied include systems that manipulate images in three dimensions, devices for mass storage and recording in wide bands, correlators of cartographic images, and systems that perform as automatic target "recognizers." Distribution of the final product will be enhanced by antijam, high-frequency communications and integrated voice/data switches.

The technologies that will form the basis of these systems are among the most highly classified anywhere—parallel computer processing, pattern recognition, photonics, low observables, and laser communications, to name only the most obvious. Perfecting them is viewed as a major challenge.

Even more challenging will be the development of technologies required for those reconnaissance systems that come later.

In the twenty-first century, the intelligence-gatherers may well be deploying fleets of hypervelocity vehicles, capable of tremendous speed and range. Other concepts include use of low-cost tactical drones and high-altitude, long-endurance aircraft as collection platforms. Sensors are expected to move into advanced-frequency domains and even become expendable.

On the ground, collected data may be analyzed by automatic, expert image-interpreters and language translation and transcription machines. Wideband, high-frequency radios, radios that convey data in multiple media, and advanced, secure laser communications would be the means of transmitting the product to combat commanders.

These devices would be the offspring of technologies now glimmering in the distance. The laboratories will have to come up with the keys to not only hypersonic and high-altitude aerodynamics, but also hypersonic and high-altitude engines, instantaneous target recognition, and machines that think like humans. Also required, in the view of AFSC planners, will be so-called "smart" aircraft skins capable of precise sensing in all directions and communications that are impervious to compromise and jamming.

In the future, reconnaissance units may deploy high-altitude, long-endurance aircraft as collection platforms, as well as low-cost tactical drones. USAF seeks to develop highly advanced, secure communications to transmit data.

Electronic Combat

IF THE proposals of Air Force technologists give an accurate glimpse of what the future holds, USAF's multifaceted electronic combat forces are due for a major strengthening.

Already, scientists and engineers are proposing concepts that promise great advances over such systems as the F-4G Wild Weasel aircraft, High-Speed Antiradiation Missiles (HARM), jammers, and a plethora of other systems that make up the EC force of today. The concepts are intended to meet expanding requirements of tactical users across a broad front, from self-protection of combat aircraft to realistic simulation and training, from destruction of enemy electronic combat forces to disruption and suppression of these threats.

Within the next decade, for example, new concepts in self-protection systems are likely to be introduced. Proposals include warning and assessment systems such as millimeter-wave devices, infrared search and track systems, and laser scanners capable of giving precise range and bearing of enemy aircraft. Such missile-thwarting systems as automatic chaff dispensers and towed decoys are in the works, as are internal jammers capable of going against all enemy signals.

In the same time period, the Air Force wants to begin introducing new systems for demolishing enemy electronic threats. Planners see a need for new aircraft to perform the "Wild Weasel" radar-killing mission now carried out by an aging fleet of F-4G aircraft. The HARM would be updated and strengthened with a new dual-mode antiradiation seeker suited to missions against the most sophisticated Soviet radars. Destructive drones are being studied for missions against enemy electronic warfare, ground-control-intercept, and target acquisition systems as well as Soviet communications jammers.

Finally, plans call for stiffening the electronic-disruption powers of US forces by expanding the frequency coverage of the EF-111A electronic warfare aircraft, providing self-defense for the EC-130H Compass Call aircraft, and deploying jamming drones in abundance.

Making such systems possible are a number of key technologies now in various stages of development. Scientists are working hard, for example, on new millimeter-wave, electro-optical, and laser-sensing technologies. They are also working on parallel processors that expand the speed and capacity of computers used for processing threat signals.

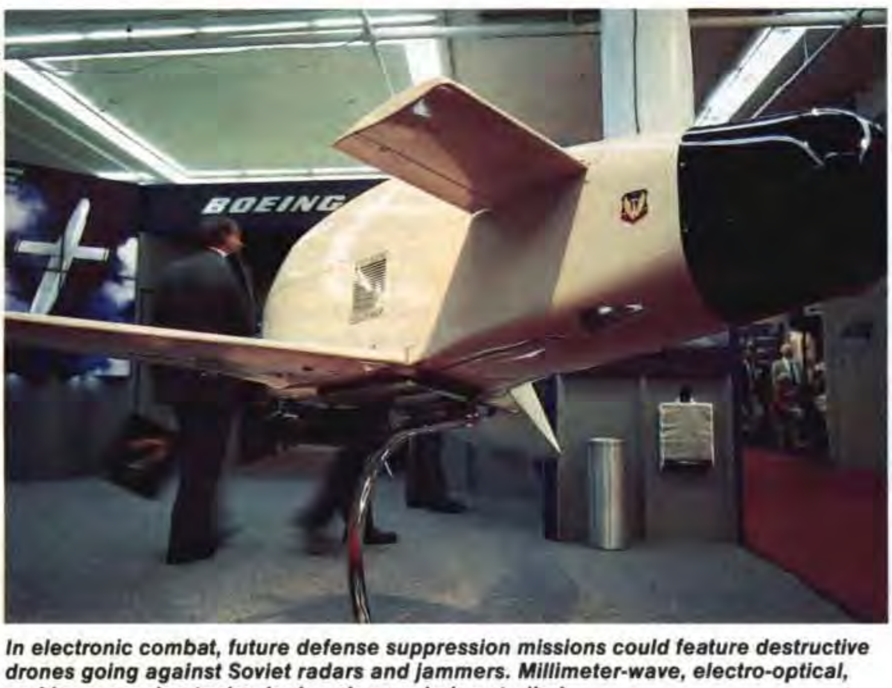
Development of antennas that conform to the shape of aircraft, thereby reducing radar signatures, is of key importance. The so-called "fail-soft, fault-tolerant" generation of electronics—layered systems that continue to work even if a single component breaks—is critical. So is the technology of integrating various electronic warfare functions into a single, robust system.

Technologists are working equally hard on the key technologies for systems now on the far horizon. Those the Air Force considers vital are means to detect stealthy or low-signature airborne threats, high-power microwave technologies, and artificial intelligence for monitoring and keeping track of vast amounts of data emanating from enemy aircraft and emitters. These and other technologies will be used to feed an entirely new generation of electronic combat hardware after the year 2000.

Among such futuristic concepts are totally integrated situational displays for friendly aircraft, multispectrum expendables, directional automatic dispensers, protection from lasers and high-power microwaves, full-spectrum jammers, and radio-frequency weapons—all for aircraft self-protection.

US capability to destroy enemy systems would be expanded by concepts such as highly advanced signal processors and drones able to locate, home in on, and destroy enemy sensors, whether they be microwave, millimeter-wave, electro-optical, or laser in nature. For disruptive activity, USAF may choose to pursue development of low-band advanced jammers, unmanned air vehicles against all types of signals, and high-power countermeasures to enemy electronic systems. Advanced communications deceptions also are being conceptualized.

—Staff photo by Guy Aceto



In electronic combat, future defense suppression missions could feature destructive drones going against Soviet radars and jammers. Millimeter-wave, electro-optical, and laser-sensing technologies also are being studied.

Mobility Forces

Special operations forces will benefit from advanced airlifters. Air Force technologists are working on providing the means for better intertheater and intratheater transports, better and more numerous combat rescue aircraft, and improved transports and gunships for small-scale SOF activities.

STRENGTHENING the military air transport arm, too, is emerging as a preoccupation of Air Force planners. In fact, airlifters and associated support equipment that provide high mobility for conventional and special operations forces (SOF) could undergo striking change.

What Air Force operators require seems clear enough: a fifty percent increase in intertheater airlift, up to a minimum capacity of some 66,000,000 ton-miles per day; intratheater transports capable of hauling heavy, outsize cargoes; better and more numerous combat rescue aircraft; improved long-range transports and gunships for small-scale SOF activities; and greatly expanded meteorological capabilities.

While the requirements are prosaic, some concepts for meeting them are not. New, high-technology equipment seems destined to replace or supplement the mobility force of today, which is built around C-5, C-141, and KC-10 long-range lifters, C-130 intratheater lifters, and the various fixed-wing and helicopter craft assigned to special operations duty.

At the heart of the "next generation" of transport systems lies the proposed C-17 lifter, capable of performing both long-haul and short-distance missions with equal effectiveness. Air Force plans now call for producing 210 of these aircraft by 1998, although the outlook is clouded somewhat by budget pressures.

Like the huge C-5 Galaxy, the C-17 will be able to carry outsize cargo such as M1 Abrams tanks. Unlike the Galaxy, the new lifter will also be able to deliver such cargo directly to small, austere airfields. C-17 plans call for a capability to land on a runway 3,000 feet long and ninety feet wide. Thrust reversers will give it the ability to back up on the runway. About fifteen percent of the C-17 will be made of lightweight composite materials.

Another new transport, the CV-22 Osprey tilt-rotor aircraft, is aimed at improving the Air Force's ability to support special operations. Able to hover like a helicopter and cruise with the speed of a fixed-wing aircraft, it is designed to ease clandestine insertion and extraction of forces behind enemy lines.

The next generation of meteorological systems—critical to effective worldwide flying operations—is expected to bring major advances over those of today. Concepts include an automated weather-data distribution system, highly advanced radars, and a new, block upgrade to the existing Defense Meteorological Satellite Program structure.

All these systems will draw heavily on key technologies that have been, and still are, under development in numerous Air Force laboratories. Artificial-intelligence systems, lightweight materials, multispectrum sensors, parallel processors, reduction of infrared signatures, and high-power engines are but a few of the technologies that will find their way into mobility forces of tomorrow.

Beyond the next generation of aircraft will come systems based on even more advanced technologies. Entirely passive means for reliable, low-level navigation, techniques for autonomous landing, passive self-protection devices, and ultralightweight materials are all being pursued. High-performance turbine engines of greatly increased thrust, short and vertical takeoff and landing capabilities, and, especially, advanced low-observable technologies will come into play.

These types of technologies and others now in their infancy are expected to permit the Air Force to develop and deploy, in the early twenty-first century, what it calls the "Advanced Strategic Airlifter" and the "Advanced Tactical Transport." Additional concepts include new, high-technology versions of transports and gunships for SOF missions. The latter could carry highly advanced forms of weaponry. These aircraft are expected to inherit virtually everything Air Force technologists have achieved in applying STOL and even stealth technologies to other planes.

Strategic Offense

—USAF photo by Bob Simons

Northrop's B-2, a stealthy, radar-foiling flying wing, heads the list of USAF "next-generation" strategic weapon systems. Other future concepts include ICBM upgrades, hypersonic aircraft, and advanced bomber-borne weapons.

NOWHERE IS THE magnitude of long-range Air Force ambitions—and the difficulty USAF will encounter trying to achieve them—more evident than in the realm of strategic nuclear weaponry.

What service leaders want to accomplish over the next decade or so seems challenging indeed. They hope to overcome present deficiencies and achieve true capability to rapidly find and strike strategic relocatable targets such as Soviet mobile ICBMs and to strike deeply buried targets such as hardened Soviet command bunkers.

In addition, they say they want to strengthen the survivability of USAF's penetrating bomber fleet, deploy new ICBMs in ways that make them relatively secure against surprise attack, and increase the refueling capacity of the USAF tanker force. They are calling for ICBM warheads able to penetrate layered defenses, should Moscow choose to deploy them. They assert a need to integrate conventional munitions into strategic forces in a big way.

But the premier weapons for achieving the goals—new manned bombers and superaccurate, mobile ICBMs—are expensive, politically controversial, or both, especially in an arms-control era marked by calls for deep reductions of superpower arsenals. Congressional approval is far from certain.

Even so, planners believe they have the proper systems concepts to strengthen a strategic armory now reliant on silo-based Minuteman and Peacekeeper missiles, B-1 and B-52 bombers, KC-135 and KC-10 tankers, and first-generation air-launched cruise missiles and gravity bombs.

Heading the list of "next-generation" nuclear systems: Northrop's B-2 Advanced Technology Bomber, the stealthy, radar-foiling flying wing rolled out last November in Palmdale, Calif. USAF wants to buy 132 B-2s, at an average cost of $516 million per copy, to confront future Soviet air defenses. The B-2 currently remains in the development stage.

Concepts for strengthening the ICBM leg of the strategic triad include Peacekeepers deployed in rail-garrison basing, single-warhead Midgetmen based on mobile launchers, and movable Minuteman IV/V intercontinental weapons. Also to be made available are new, earth-penetrating warheads to dig out heavily defended bunkers.

Plans call for a new generation of bomber-borne weapons, such as an upgraded short-range attack missile—SRAM II—and the radar-deceiving Advanced Cruise Missile, both of them nuclear. New conventional cruise missiles and "hard target munitions" also are in sight.

Underpinning these systems is a host of key technologies brought into being in recent years—low observables, radiation-hardened devices, enhanced chemical propellants, advanced materials, multimode sensors, automatic target cuing, multisource data processing, and technologies that reduce telltale signatures of nuclear reentry vehicles. None has reached full maturity, though many are nearing that stage.

Beyond the next-generation systems, the ICBM leg of the triad begins to seem problematic. Systems Command planners forecast no new ballistic missile concept, only "enhancements" of the existing force, presumably some combination of Peacekeeper, Midgetman, and Minuteman.

The future looks very different when it comes to manned bomber aircraft. The lineal descendent of the B-2, in the Air Force's conceptual view, may well be some form of hypersonic air vehicle capable of traversing long distances and zooming from an airstrip into space and back again.

Supporting such a breathtaking aircraft would be a new aerial tanker now known as the KC-X. Superseding the bomber missiles and munitions of the next generation: hypersonic attack weapons.

To make these a reality, Air Force technologists will have to score breakthroughs in hypersonics, combined cycle propulsion, ultrahigh-speed computer processing, high energy density propellants, Super Cockpit technologies, superconductors, high-temperature and high-strength materials, fast-burning propellants, and active cooling techniques.

Strategic Defense

As it surveys the military requirements for effective strategic defenses—that is, protection of US territory from nuclear attack or coercion—the Air Force perceives a broad array of needs.

In its view, large-scale improvements are in order for some capabilities such as the ability to gain tactical warning of ballistic missile attack, rapid assessment of the scope and nature of an attack, and the like. Other needs—to conduct atmospheric and space surveillance and tracking, to protect US space vehicles from attack, to intercept threatening aircraft at long ranges and to intercept small air vehicles—are new.

At present, the Air Force bases its strategic defense effort on a narrow array of systems whose utility is limited almost exclusively to warning. The Satellite Early Warning System, Ballistic Missile Early Warning System (BMEWS), Pave Paws radars, and the Nuclear Detonation Detection System would provide notice of an ICBM attack and some assessment of its scale. The North Warning System, Over-the-Horizon Backscatter Radar network, and Distant Early Warning Line would alert Washington to a bomber or cruise missile assault. Ground-based deep space surveillance systems and space surveillance radars would keep track of US and Soviet space assets. With the exception of a few air defense fighters, no active means for resisting attack currently exist.

A large number of emerging technologies is cited as the basis for altering what is deemed an inadequate posture. Primary among them are means to detect stealthy air vehicles, lightweight structures, sophisticated multispectral sensors, radiation-hardened microelectronics, survivable solar panels, parallel processors, adaptive optics, improved atmospheric transmission codes, and clutter rejection techniques.

What kind of systems could emerge from these technologies? For the next generation, concepts for ballistic missile defense systems include a new system to replace the Satellite Early Warning network and major modifications designed to improve the BMEWS network and Pave Paws radars.

For defense against air-breathing threats, the Air Force foresees deployment of space-based radars, upgrades to the OTH radars, upgrades to the air defense fighter fleet, upgrades of E-3C AWACS aircraft, and use of an advanced aerial platform to monitor air corridors.

Space defense activities are focusing on concepts such as Deep Space Surveillance Radar, a Satellite On-Board Attack Reporting System for warning, and an air-launched antisatellite weapon to help deter the Soviet Union from initiating use of its own "satellite killer" weapons.

The real leaps in strategic defense capability, however, would not come until some time after the next generation of systems had been deployed.

In the conceptual view of Air Force planners, new technologies would enable the US in the far future to confront missile attacks in a more effective fashion. They envision advanced directed-energy weapons—lasers, neutral particle beams—taking on waves of missiles and warheads. It might also be possible to build highly accurate and effective kinetic-energy weapons able to hurl projectiles great distances at high speeds. Feeding in

To achieve effective strategic defenses, USAF would have to exploit the "high ground" of space. Possibilities include directed-energy weapons—lasers, neutral particle beams—and effective kinetic-energy weapons, able to hurl projectiles great distances. Key to this effort are technologies such as "brilliant" guidance, precision pointing and tracking, hypersonics, and artificial ionospheric mirrors.

target data would be the Space Surveillance and Tracking System, a network of satellites envisioned as having unprecedented abilities to detect and pinpoint small objects in space. The Boost Surveillance and Tracking System would serve a similar purpose with respect to missiles in the first minutes after launch.

Other concepts are advanced as possible answers to the long-term threat of attack through the atmosphere. Long-range hypersonic arms, able to close rapidly on attacking aircraft, are one possibility, as are interceptor missiles that could cruise at supersonic speeds. Another option for the future: an advanced interceptor fighter.

Protection of satellite assets would get a boost. Maneuvering "defensive" satellites, ground-based lasers to shoot down hostile space vehicles, and space-based interceptor vehicles are but a few of the possible options.

These systems will require technologies such as "brilliant" guidance, noncooperative target recognition, precision pointing and tracking, hypersonics, artificial ionospheric mirrors, directed energy, and high-power microwaves.

Space Vehicles, Operations, and Services

FROM ALL appearances, the great advances that the Air Force foresees for its earthbound forces might be replicated in space. The service is signaling that improved space systems will be required if the US is to exploit the possibilities of this high frontier to the fullest extent.

The increasing US reliance on space-based technology for national security and civilian functions, USAF maintains, has upped the ante for developers of space systems. Both the immediate and far future will require more responsive operational launch processing, improvements in on-orbit control of space vehicles, better space services, strengthened space contributions to worldwide navigation, and more precise environmental monitoring capabilities.

Already at hand are a number of key technologies that hold the promise of providing the capabilities the Air Force maintains that it needs. Key among these are those that focus on control of large space structures, advanced orbit transfer propulsion, microelectronics hardened against radiation, lightweight structures, spacecraft charge control, and antennas for transmission of extremely-high-frequency signals. Also getting strong laboratory attention are high-efficiency solar power cells, autonomous guidance systems, and wideband communications links.

One projected result of the technological explosion: advanced vehicles for launching payloads into space. That function is now performed in large part by the fleet of space shuttles and various Titan, Centaur, and Delta rockets. The next generation of systems, however, will include projects such as the Advanced Launch Vehicle, a new and more effective orbital maneuvering vehicle, expendable orbital transfer vehicles, and reusable orbital transfer vehicles.

The next-generation technologies hold out hope for much-improved on-orbit control of space vehicles. The up-and-down communications and control links between earth-based facilities and operating satellites will become more survivable. Also possible are effective crosslinks between satellites.

In the area of space services, Air Force technologists foresee developing, within the next decade or so, new and survivable forms of solar panels for production of power as well as highly advanced nickel-hydrogen batteries. A sharply upgraded version of today's Global Position System, known as GPS IIR, will afford more precise and responsive navigation powers to military forces on earth around the turn of the century.

Beyond the year 2000, improvements in the Air Force's ability to conduct space operations will hinge on a variety of new technologies now attracting the attention of scientists and engineers in a big way. The object is to develop more effective technologies for spacecraft, space power, propulsion, microelectronics, and communications.

Key among these will be what is termed robotic telepresence, which is the use of dexterous manipulators such as mechanical hands controlled and directed from great distances by humans. High energy density propellants, which could yield up to sixteen times the energy density of existing propellant materials such as liquid and solid fuels, might bring about a twofold increase in launch vehicle lift capacity as well as a three- to fivefold increase in upperstage orbit transfer capability.

Also in store are so-called "fail-soft, fault-tolerant" computers, meaning that an individual failure within the system will not inhibit continued operations. Photonics—the use of basic particles of light as an agent of transmission—could dramatically increase the speed and capacity of information transfer in computers while reducing heat generated in the system.

The promise held by these and other futuristic technologies leads service scientists to postulate remarkable, far-future space system concepts. The current mixed launch force of manned space shuttles and unmanned rocket boosters, for example, might be supplemented by manned, single-stage-to-orbit vehicles that would be at home either in the atmosphere or in space. On-orbit control would be enhanced by fleets of autonomous, self-directing satellites and by survivable, jam-proof laser crosslinks tying together numerous independent satellites. Also foreseen are on-orbit repair and servicing of spacecraft and installation of microelectronics resistant to radiation damage.

Command and Control

THE FUTURE foreseen by the Air Force implies an obvious need for improvements to its command and control system—the nervous system of radios, computer stations, and communications satellites that enables civilian and military decision-makers to instruct the nation's strategic and general-purpose forces in a timely fashion.

The service projects a menu of clear-cut requirements for the decades ahead. It wants technologists to improve the Air Force battle management powers that are based on information processing and decision aids; reduce vulnerability of communications to electronic countermeasures, electromagnetic pulse, and physical attack; integrate tactical warning and assessment of missile, atmospheric, and space attack; and strengthen theater surveillance functions such as detection, tracking, and identification.

For the relatively near future, USAF will base its efforts on specific technologies already identified as critical. The laboratories will push to perfect new breeds of parallel computer processors that are secure from interference at multiple levels. They are at work on "smart," self-directing workstations involved in battle management. Laser communications, artificial intelligence processing techniques, photonic devices, processors for wideband extremely-high-frequency communications, and passive sensors capable of recognizing targets at great distances all are considered essential.

The promise of these technologies leads the Air Force to propose new system concepts across the board. In the area of strategic command and control, USAF foresees the possibility of a sweeping strategic war planning system, a center for rapid processing and correlation of target data, an adaptive planning system for Strategic Air Command, and a mobile system capable of providing warning, processing, and display of attack information. In addition, USAF believes it will need to replace its present national emergency airborne command post aircraft, devise tactical data-processing stations, and come up with a command and control system for the mobile Midgetman missile, should Washington choose to build it.

For next-generation general-purpose forces, the Air Force has conceptualized an automated advanced planning system. The new Joint Tactical Information Distribution System would permit multifunction dissemination of target and other data across a wide range of forces. Adding to conventional command and control would be a new combat identification sensor, a network management processor, and a specialized mission support system.

A number of concepts are proposed to meet the needs of strategic and conventional forces on a common basis. These include an upgrade to the Defense Satellite Communications System, to the level known as DSCS IIIC, plus antijam high-frequency communications, integrated voice/data switches, and systems to provide multilevel security for communications and gateways to multiple command and control networks.

The technologies of artificial intelligence and photonics also will be vital in developing far-future systems. The Air Force sees high potential in other technologies such as high-rate burst radio transmission, "smart" aircraft skins, three-dimensional situation displays, and detection and tracking of advanced, stealthy platforms, all of which are now under review.

The systems concepts that these technologies would support include ultrasophisticated command centers for ballistic missile defense forces, command and control networks to manage the antimissile battle, and airborne centers to provide processing and display of warning information.

That's in the strategic weapons field. For general-purpose forces, what the Air Force is looking for are radios that can transmit in multiple media, advanced airborne surveillance radars, and advanced tactical surveillance radars. Conventional forces also would benefit from multisatellite networks, an advanced, secure satellite communications terminal, and wideband high-frequency radios.

In the area of C^3, USAF envisions upgrading the Defense Satellite Communications System to DSCS IIIC, antijam high-frequency communications, integrated voice/data switches, and multilevel security for communications.

Air Base Operability

—USAF photo by TSgt. Kit Thompson

Keeping USAF air bases operating in wartime will require new vehicles to assist in rapid runway repair and clearing unexploded ordnance. Also being developed are new substances to patch craters in runways, special munitions storage systems, and handheld data-burst systems for base communications.

As it charts its many future requirements and their associated systems, the Air Force has not neglected the critical need to keep its air bases operating in time of war. This "mission," like electronic combat, strategic offensive action, and other wartime business, carries with it a demand for specialized, top-flight "weapons."

In an age of expanding Soviet long-range airpower, American forward bases in Western Europe and Asia can no longer be viewed as sanctuaries from which the Air Force could operate free from interference. The upshot, in the view of Air Force planners, is a new requirement to prevent air base damage by actively defending against the Soviet air and ground threat, increasing the base's ability to survive an attack by providing passive defensive measures, enhancing the base's ability to recover from an attack and get back into action, strengthening its post-attack powers to generate combat sorties, and bolstering the infrastructure that supports base operations.

Helping the Air Force to relieve the danger in the next decade will be such technologies as survivable base communications systems, easy-to-handle polymer concretes, means of detecting the presence of plastic explosives, and systems to contain the effects of chemical and biological warfare agents.

These and other technologies underlie a number of new system concepts proposed for possible future use. They will enhance the defensive fighting positions from which US base-defense troops would try to ward off commandos seeking to disable a base. To help the base survive an attack, there would be infrared reflectors to confuse Soviet attack pilots, high-strength shelters to protect base personnel, and personal cooling systems to use in protective suits.

In addition, the Air Force is working on transparent patches to repair cockpit canopies damaged in an attack, new substances to patch craters in runways, and vehicles called Oracle, Flail, and MARV/SMUD that would be used to clear runways and taxiways. Revetted shelters and special munitions storage systems would help the base start operations quickly after an attack. Underlying the entire process are redundant utility cables and pipelines and precise, easy-to-use, handheld data-burst systems for base communications.

Even greater advances are sought in the far term, by which time technologists are expected to have mastered rapid repair of advanced aircraft materials, robotic operations in hostile environments, and other base repair techniques. Forthcoming advances in short takeoff and landing technologies will greatly ease the task of keeping an air base functioning after attack. Aircraft will simply need less to land on.

For the twenty-first century, concepts include advanced intrusion barriers that could supplement or replace manned fighting positions. New forms of deception, the ability to relocate high-value base targets, and a new, impermeable protective suit will all contribute to the survival of base systems and personnel. After an attack, the base and its aircraft might be brought back to life by using self-repairing avionics systems along with robotic and remotely controlled systems to disarm and dispose of unexploded ordnance. New treatments for biological agent contamination are in the works.

Other concepts to help base personnel weather an attack include collocation of fuel tanks within aircraft shelters, development of weapons containing "insensitive" high explosives, and other advances. Throughout the air base, currently vulnerable infrastructure would be replaced with hardened utilities, hardened vehicles, robotic fire-fighting systems, and fiber-optic communications cables armored for protection against blast. ■