New World Vistas

The Air Force Scientific Advisory Board explores what the future may hold. The expected changes will be on an epic scale.

By Peter Grier

As THE Air Force prepares for the next century, it must be ready to adapt to technological changes as profound as those the Army experienced in moving from horse to tank and those the Navy faced switching from sail to steam.

The "domain of conflict" may shift from Earth's atmosphere into space—and perhaps into cyberspace. The nation's commercial communications and information systems will become intimately intertwined with military counterparts. Advanced sensors and data processing capabilities will provide commanders unprecedented detail on global conditions.

Stealthy, "uninhabited" combat aircraft could well become significant weapons in the Air Force arsenal.

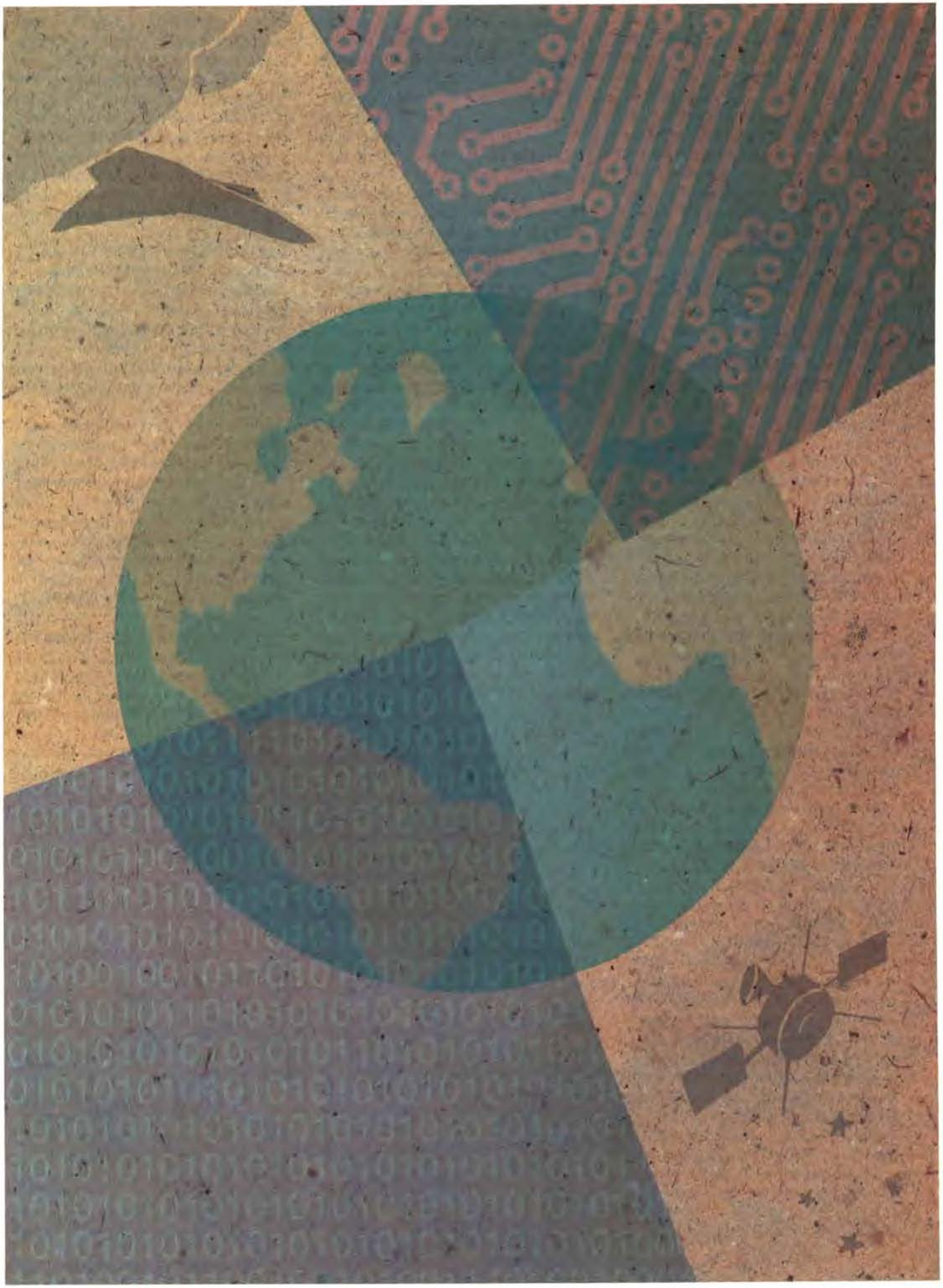
These are among the principal findings of "New World Vistas: Air and Space Power for the 21st Century," a major new study issued by the USAF

Twelve Vistas Behind "Vistas"

In its New World Vistas study, the USAF Scientific Advisory Board made twelve assumptions. They are:

- The Air Force will have to fight at long distances from the United States. Some operations may be staged directly from the continental United States. Operations may persist for weeks or months, and they must be executed day and night in all weather.
- The site of the next conflict is unknown. The Air Force must be prepared to fight or to conduct mobility or special operations anywhere in the world on short notice.
- Weapons must be highly accurate, must minimize collateral damage, must minimize delivery and acquisition costs, and must enhance—and be enhanced by—aircraft capabilities.
- Platforms that deliver weapons must be lethal and survivable. They must establish air superiority in areas heavily populated with surface-to-air missiles (SAMs), and they must carry the attack to all enemy targets, fixed and mobile.
- Adversaries may be organized national forces or terrorist groups.
- Targets may be fixed or mobile and may be well concealed. Target classes will span the range from personnel to armored vehicles and protected command centers and information systems. Operational geography will range from classical battlefields to cities and jungles.
- Adversary capabilities will steadily improve and will be difficult to anticipate. For example, the Air Force must be prepared to defend against improved SAMs, low-observable aircraft, cruise missiles, directed-energy weapons, and information attack.
- The Air Force must detect and destroy nuclear, biological, and chemical weapons and their production facilities.
- There will be peacetime missions in areas of local conflict. Aircraft must be protected against SAMs and ground fire by means other than offensive attack.
- Increasing the pace of operations increases the effectiveness of all operations.
- Cost will be equal in importance to capability.
- The number of people in the Air Force will decrease. Individual performance must be optimized.

Illustration by Randy Lyhus



Scientific Advisory Board. Commissioned in November 1994 by Sheila E. Widnall, Secretary of the Air Force, and Gen. Ronald R. Fogleman, USAF Chief of Staff, the New World Vistas study strives to identify technologies that could guarantee US air and space superiority for decades to come.

It also attempts to forecast potential force directions at a time of ultrarapid innovation.

"There has never been a period in our country's history when 'swift adaptation to new developments' was more important," wrote Secretary Widnall in a directive launching the study.

The 2,000-page, fifteen-volume report, an executive summary of which was released January 31, was consciously modeled on "Toward New Horizons," a seminal, 1945 technology study produced by the legendary Dr. Theodore von Kármán in response to a request from Gen. of the Army H. H. "Hap" Arnold. The von Kármán work predicted many of the systems and technologies that have appeared in the Air Force in the past fifty years and served as a founding document of the independent Air Force. Air Force officials hope the new paper will prove to be of similar worth.

"Broad, Superior Capabilities"

In a seventy-page summary of their work, the report's authors conclude, "It is appropriate to return to the idea that development of broad superior capabilities through application of new technology will maintain the United States Air Force as the most powerful and effective aerospace force in the world."

One reason to do this is the pace of research into microelectronics and stealth technologies, says the report. That, however, is not the only factor making today a good time to restudy the focus of USAF science and technology efforts, say the authors. They assert that, given the demise of the Soviet Union, the emphasis of USAF technology efforts must change.

Today the US has no single well-defined enemy, and the global situation makes it difficult to predict threats. Military technology, then, must in the future be able to respond to diverse and rapidly shifting situations—and it must be more cost-effective than it was in the 1970s, 1980s, and 1990s.

The New World Vistas analysts assumed that, in the future, the Air Force will fight far from bases in the continental United States. Furthermore, they assumed that combat aircraft will need highly accurate weapons that minimize collateral damage yet destroy targets that may be mobile or well concealed.

It is likely that the military capability of potential adversaries will improve steadily and be difficult to predict, according to study planners. It is also likely that the Air Force will continue to shrink—meaning more military productivity will have to be squeezed out of every man and woman in the Air Force.

Against this background, the planners anticipate that efficiency will be improved by dramatically picking up the pace of combat operations. The study points out that striking faster and "cycling" the attacks more rapidly will make the force appear larger to an adversary. So, too, will an increase in weapon accuracy, allowing more targets to be struck in a given period of time.

"Because of budget limitations, it is unlikely that we can justify large increases in numbers of aircraft, weapons, or people. Therefore, we will concentrate on technologies [that] increase the apparent force size through increased tempo of operations," write the Vistas' authors.

The future Air Force depicted in Vistas' scenarios shapes up to be far more than a mere evolutionary improvement in today's aircraft and missiles. It is based, instead, on what the authors call "discontinuous change"—quantum leaps in combat power over that provided by current technology.

Evolution, Revolution

The authors maintain, for example, that the Air Force's forthcoming F-22 advanced fighter, while undoubtedly superior to the rest of the world's fighters, will nevertheless provide an evolutionary, not revolutionary, improvement over the current F-15 fighter.

What, in fact, does the study mean by "discontinuous change"? In its view, firearms provided discontinuous improvement over weapons propelled by human power, such as spears and bow-launched arrows. The motorized tank provided a discontinuous change for armies that long had relied on foot power, horse cavalry, and horse-drawn artillery. The arrival of the airplane over the battlefield counts as a discontinuous change.

The Scientific Advisory Board predicts the Air Force could make similar leaps in technology in the near future. These include:

Uninhabited Aircraft. Current unmanned aircraft have limited capabilities, serving either as cruise missiles or as relatively expendable reconnaissance probes. New information technologies, however, are likely to soon allow the creation of uninhabited combat aerial vehicles (UCAVs) flown by pilots who never leave the ground.

The future force is thus likely to be a mix of manned aircraft and UCAVs, according to the advisory board. Unconstrained by the need to accommodate a human body and an ejection seat, UCAVs could provide superior capability for many high-value missions.

Uninhabited aircraft could maneuver beyond the physical limits of human endurance, for instance. Their radar cross section, when compared to that of stealthy manned aircraft, could reduce the effective range of enemy aircraft by a factor of two and area coverage by a factor of four.

"There is the possibility of extending UCAV performance into the hypersonic range to enable strikes from the [continental US] on high-value targets in minutes," according to the Vistas study.

Weapons Projected From Large Airframes. Today, big aircraft serve as bombers, tankers, airlifters, "eyes-in-the-sky" systems, or cruise-missile platforms. In the near future, such airplanes are also likely to play a greater role in tactical engagements.

They will be the first airframes to be outfitted with directed-energy weapons, for instance—something that promises a revolution in air-to-air combat. They may also serve as launch platforms for UCAVs, providing intercontinental standoff capability.

According to advisory board participants, these large aircraft will likely be outfitted with weapon types ranging from inexpensive enhanced weapons without sensors to Global Positioning System–directed weapons with better than one-foot accuracy to microsensor-directed microexplosive systems that kill moving targets using only "grams of explosives."

Extended Airlift Capabilities. While the addition of the C-17 will certainly improve the mobility situation for decades to come, evolutionary improvement in lift capability will not be enough to address US military needs. "Even the addition of the Civil Reserve Air Fleet (CRAF) cannot provide enough airlift capacity for the future," says the Vistas study.

One way to solve the problem might be the development and production of a huge airlifter with a gross takeoff weight of one million pounds. Precision airdrop should also become a routine method of delivering US military equipment and troops. A full airdrop capability could reduce the need for theater infrastructure for both the Air Force and the Army and greatly increase their potential operations tempo.

According to the study, "Worldwide coverage will require aircraft that can fly 12,000 miles, deliver cargo, and return without refueling at the terminal point. . . . Cargo capacity for airlifters of the [next] century should be 150,000 pounds."

Information Technologies. While today's information networks provide an unprecedented picture of operations to Air Force commanders, similar systems of tomorrow promise a giant leap forward in communications ability. Surveillance and reconnaissance will be done worldwide, from commercially owned platforms, while a new ultraprecise Global Positioning System (GPS) will provide improved position and timing information to forces in the field.

"Communication of information and instructions throughout the force will be instantaneous over fiber and satellite networks," predicts the new Scientific Advisory Board report.

The use of "information munitions" against adversaries may also become an essential feature of war. At its most basic, so-called information warfare (IW) actions might use computers and software to fool and destroy enemy data networks. Attacks might occur over the Internet or special communications systems or even through surreptitious action by individuals.

Defensive IW is also likely to become an issue, at least for US corporations, "because of the obvious effects that malicious mischief can have on commerce," say Vistas' authors.

Space Munitions, Brilliant Sensors. The future force will include a mix of weapons, both space- and groundbased, able to shoot photon- and kinetic-energy munitions against enemy space and ground assets. Protection of US space assets and denial of this high ground to an enemy will become essential to military success.

No longer will a fighter aircraft's on-board sensors be its main source of information for combat operations. The future force will likely see a massive proliferation of information sources—from small, distributed satellite constellations to uninhabited reconnaissance aerial vehicles (URAVs) to weapon sensors and groundbased sensors delivered by URAVs.

The power of these new systems will lie in their ability to work together to correlate data automatically and rapidly. One sensor alone gives a necessarily limited view of the battlefield. In the future, many sensors together may provide operators with a complete and instantaneously updated picture of an operational area.

When assembling these building blocks in the Air Force of the next century, service planners will have to keep in mind their affordability as well as their potential performance. The cost of precision guided munitions (PGMs), for instance, might be kept in check by buying reusable close-approach delivery platforms—two UCAVs, perhaps—equipped with on-board electronics to aim relatively inexpensive bombs or missiles.

Operational planning and procurement management may also need to advance along with Air Force hardware. If high-rate operations are to be sustained, military plans must be made and executed in parallel, rather than in series, note Vistas' authors. The rate of commercial development means that for space, communications, and information systems, the time from concept to deployment cannot exceed two years.

"We must demand reduced cycle time in procurement just as we will demand it in execution," says the advisory report.

Technologies produce capabilities. To spark discussion between scientists and warfighters, the New World Vistas study group drew up a short list of capability categories it thought could be logical results of the study's technology vision. The categories are broad for a reason, say Vistas' authors: They are intended not as replacements for today's mission areas but as a means to encourage broad thinking about important problems.

■ **Global Awareness.** To the Scientific Advisory Board, this first capability category means, in essence, that everyone in the Air Force can get whatever operational information they need fast enough for it to be of use, but the technology to acquire it must not be too expensive.

This sounds simple enough, but its implications are enormous. One Air Force goal, according to Vistas' authors, should be to equip every aircraft and planning system with a map of the entire world, accurate to one meter. Using data-compression techniques, this "on-board world" will take up about ten to twenty terabytes of computer memory.

"The 'on-board world' will enable the ultimate in moving-map navigation and self-contained, undetectable, terrain avoidance," says the report.

The foundation of global aware-

ness would be a distributed constellation of 100 to 300 small satellites, linked to ground and airborne sensors.

When planning such a system, says the report, Air Force officials should not use spatial resolution as their sole criterion for judging satellite performance. To keep the constellation affordable, Vistas' authors recommend that the space system provide a less than state-of-the-art continuous ten-meter multispectral resolution.

Satellites should also be able to target radio frequency emitters to within ten meters at all times and carry a synthetic aperture radar (SAR) that provides a one-meter-resolution picture, once per hour. Finally, the global awareness satellites should be able to provide both SAR and multispectral data in submeter resolution, once per day.

The global awareness effort might also include standoff URAVs that loiter some 200 to 300 miles away from an area of interest, snapping its picture with high-resolution staring sensors and SARs. If allowed to overfly enemy territory, URAVs might provide images to within a few centimeters' resolution and sniff for telltale signs of biological or chemical agents. They might also drop tiny ground sensors capable of monitoring the local weather.

URAVs are strong candidates to replace the E-3 Airborne Warning and Control System (AWACS) and E-8 Joint Surveillance and Target Attack Radar System (Joint STARS) aircraft as Air Force surveillance systems of the future, claim Vistas' authors. High-speed processors should enable next-generation systems to exceed current Joint STARS capability by a factor of 1,000 and current AWACS performance by a factor of 10,000.

The Scientific Advisory Board strongly urges the Air Force to develop a new GPS system that has thirty-centimeter spatial accuracy and one-nanosecond timing ability. "Almost all of the processes related to global awareness need precise and absolute positioning and timing," the study notes. They also need a means of data dissemination. Direct-broadcast television will be an important interim technology, say Vistas' authors, but groundbased fiber networks may provide the ultimate answer.

■ **Dynamic Planning and Execution Control.** This second capability entails exploiting information gained through global awareness. Operations tempo cannot be increased unless planning is speeded up. The goal, according to the advisory board, should be to reduce planning time from days to hours or even minutes.

Vistas' authors chose the phrase "execution control" over "battle management" to emphasize that commanders should integrate mobility and attack planning in both war and peace. Speeding up this whole process might require such developments as automatic interpretation of voice commands and automatic translation from one language to another.

"Many situations use highly stylized language, which should be amenable to machine interpretation and translation," says the report.

High-speed parallel computing systems will be needed to make the dynamic planning and execution control system work. Likewise, two-way digital communications for aircraft will be an important part of future warfighting. Improvements over current systems, such as the Joint Tactical Information Distribution System, present a challenge. The Scientific Advisory Board suggests the exploration of digital "gateways" on URAVs or large AWACS-like aircraft.

"We recommend that technologies appropriate for direct satellite links to fighters be explored, but the Air Force should continuously evaluate the cost and utility of direct satellite links compared to links through aircraft," says the study.

■ **Global Mobility.** Whatever the attack capability of the force, mobility can be the limiting factor in many military operations, and mobility remains a problem for the Air Force. Even if CRAF is counted in, system capacity remains short of requirements.

The Scientific Advisory Board's answer: search for improvements independent of the number of mobility carriers. "We seek technologies that reduce the time en route by other methods and that reduce the amount of materiel needed," say Vistas' authors.

That does not mean they do not have a new kind of airlifter to recommend. Future needs will call for an aircraft that can fly 12,000 miles, deliver cargo, and return—without refueling, either in the air or at the terminal point. With a cargo capacity of 150,000 lbs., this behemoth would tip the scales at a million pounds in gross takeoff weight. A big jump in the lift-to-drag ratio of wings, coupled with evolutionary engine improvement and fast-response controls, among other things, could make this giant airlifter possible.

But the Vistas report further points out that major mobility gains can be had through such things as all-weather operation made possible by autolanding systems. In the end, says the report, the Air Force should aim for revolutionary "point-of-use delivery," which combines all-weather operations, improvements in handling equipment, and precision airdrop capability, to produce a true on-demand delivery system for the Army.

Airdrop is now basically an emergency procedure. In the future, Air Force crews should be able to deliver cargo, without landing, to an accuracy of ten to twenty meters, from altitudes up to at least 20,000 feet. A combination of GPS electronics with some kind of steerable parachute system might make this possible.

"The problem of airdrop should be treated as seriously as the problem of bomb drop," insists the Scientific Advisory Board report.

■ **Projection of Lethal and Sublethal Power.** PGMs have already wrought revolutionary change in the projection of airpower—but the Air Force still needs to consider ways to build on that revolution and make PGMs more effective. One such method whose time might be approaching is the UCAV, according to the Vistas report. Improvements in sensors, processors, and information networks may soon make UCAVs possible. The issue may then become one of economics: Which option is more cost-effective, transmitting large amounts of information needed for precision missions to an overworked pilot in a crowded cockpit or simply sending low-bandwidth control information from groundbased pilots to uninhabited aircraft scooting toward targets?

Air Force UCAVs might be flown from a centralized execution control center located in the US and connected to aircraft via massively redundant fiber and satellite commu-

nications routes. The absence of displays, controls, pilots, and support equipment would make UCAVs smaller and cheaper than manned counterparts, according to the Scientific Advisory Board. With the fragile human body removed, they could be made fast and maneuverable enough to simply outfly most air-to-air missiles. Keeping pilots at home would mean they would be well rested, and the number of personnel in-theater would be reduced.

Control technologies for UCAVs are not mature, admit Vistas' authors, but, they add, the Air Force should pursue the design of such vehicles. "It appears logical to begin with cruise missile parameters, such as those of the Advanced Cruise Missile, and then to increase capabilities by scaling," says the study.

For fixed targets, such as command centers and railyards, USAF might consider improving PGMs by reducing their complexity. Removing the sensors currently carried on some expensive bombs and improving aircraft sensors, release mechanisms, and weapon cases could produce accuracy comparable to a rifle bullet's, while saving money. Briefly exposed targets, such as mobile ballistic missile launchers, have long proved difficult to find and hit even with advanced PGMs; the advisory board believes that targeting information supplied by global awareness improvements, combined with the speed of dynamic planning and execution, might go a long way toward solving this problem.

■ **Space Operations.** In the next century, space operations will become increasingly important in military affairs, claim the study's authors. Commercial firms have been operating space communications systems for years, yet the Air Force has not really defined its relationship with the private space sector. Now, says the Scientific Advisory Board, is the time to start.

Currently, the military use of space is limited by the high cost of placing satellites in orbit—around $20,000 per kilogram. As a beginning toward lowering this price, the Air Force should undertake substantial research into the computational design of energetic materials, such as rocket fuel, says the study.

It should also look hard at ways to cut the cost of space vehicle preparation, which can be greater than the cost of the satellite itself. Automated control and monitoring systems should be designed to reduce the number of people in launch and mission control by a factor of ten; electric propulsion might reduce the cost of transfer from low-Earth orbit to geosynchronous orbit.

The US should also be prepared to project force into space, according to the Vistas study, both to protect US and allied space assets and to attack assets that threaten friendly forces. Kinetic antisatellite weapons are complex and expensive to keep ready, while lasers are difficult to direct at orbiting space vehicles. The Vistas' authors recommend development of groundbased directed-energy weapons to attack spacebased threats. They also judge that the benefits of developing low-observable technology to protect US satellites will not be worth the cost.

The authors acknowledge that projecting force from space toward Earth is a politically delicate subject. If it becomes reality, they predict, it will be in the form of groundbased lasers bounced off spacebased relay mirrors.

■ **Air Force Personnel.** Finally, the Scientific Advisory Board points out that increased tempo of operations and reduced force size will require Air Force people to work with their weapon systems more efficiently than ever before.

This advance means there must be improved and specialized training, more extensive use of flight simulators, and greater funding for technical degrees at the master's level. It also means more research into improving the efficiency of human-computer interaction.

Entertainment firms are among the leaders at developing new ways for people to interact with machines. "We urge the Air Force to establish continuing contact as closely as possible with entertainment organizations," says the study.

If the vision of New World Vistas is ever to become a reality, the Air Force will have to take concerted action on many fronts. Global awareness will require new active sensors and methods of signal processing. Global mobility will require new airlifter engine components and next-generation airframe design. UCAVs will not become a reality without greater understanding of the aerodynamics of tiny "micro-air vehicles," while the optics needed for high-power-laser directed-energy weapons are still not well enough understood.

Overall, the Scientific Advisory Board urges the Air Force to invest fifteen percent of its science and technology resources, over the next five years, in new-start projects directly related to New World Vistas' proposed technologies. Such an investment policy "will cause the Air Force to invest in long-term key technologies that are not under the current mandate of immediate short-term pay off," concludes the study. "Such activity will make possible the longer-term view needed to create the quantum leaps in capability in the next century." ■

Peter Grier, Washington bureau chief of the Christian Science Monitor, *is a longtime defense correspondent and regular contributor to* Air Force *Magazine. His most recent article, "ROTC's New Way," appeared in the January 1996 issue.*