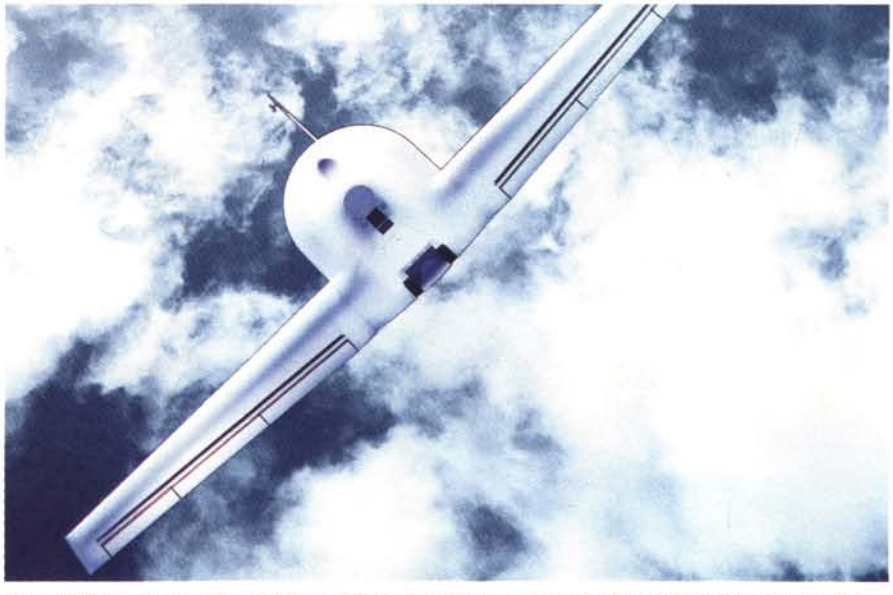
Unmanned aerial vehicles are looming large in the future of the Air Force.

DarkStar and Its Friends

By Peter Grier



The Defense Department intends to develop a range of relatively inexpensive UAVs and put them in the air quickly. This artist's rendering shows the DarkStar Tier III Minus UAV, which is to be a low-observable, "silver bullet" platform for use over heavily defended areas. Opposite is the DarkStar at its rollout at the Lockheed Martin Skunk Works on June 1, 1995.

DECADES after their first use by American military forces, unmanned aerial vehicles (UAVs) may finally be on the edge of becoming full-fledged contributors to US combat capability, with the Air Force playing a leading role in the transformation.

Plans call for the Defense Department to make a significant investment in an array of UAV programs in the latter years of the 1990s. UAVs under development range from small systems intended to give front-line commanders instant information on the state of the battlefield to huge "endurance airframes" capable of mapping an area the size of Indiana in a single day.

UAVs have never been a top priority for the Air Force. However, the march of unmanned vehicle technology—combined with the solid and positive performance of these air vehicles in the 1991 Persian Gulf War—has convinced many of today's Air Force leaders of their future utility.

Most manned reconnaissance aircraft are being phased out of the Air Force inventory. By the turn of the century, the US arsenal of penetrat-

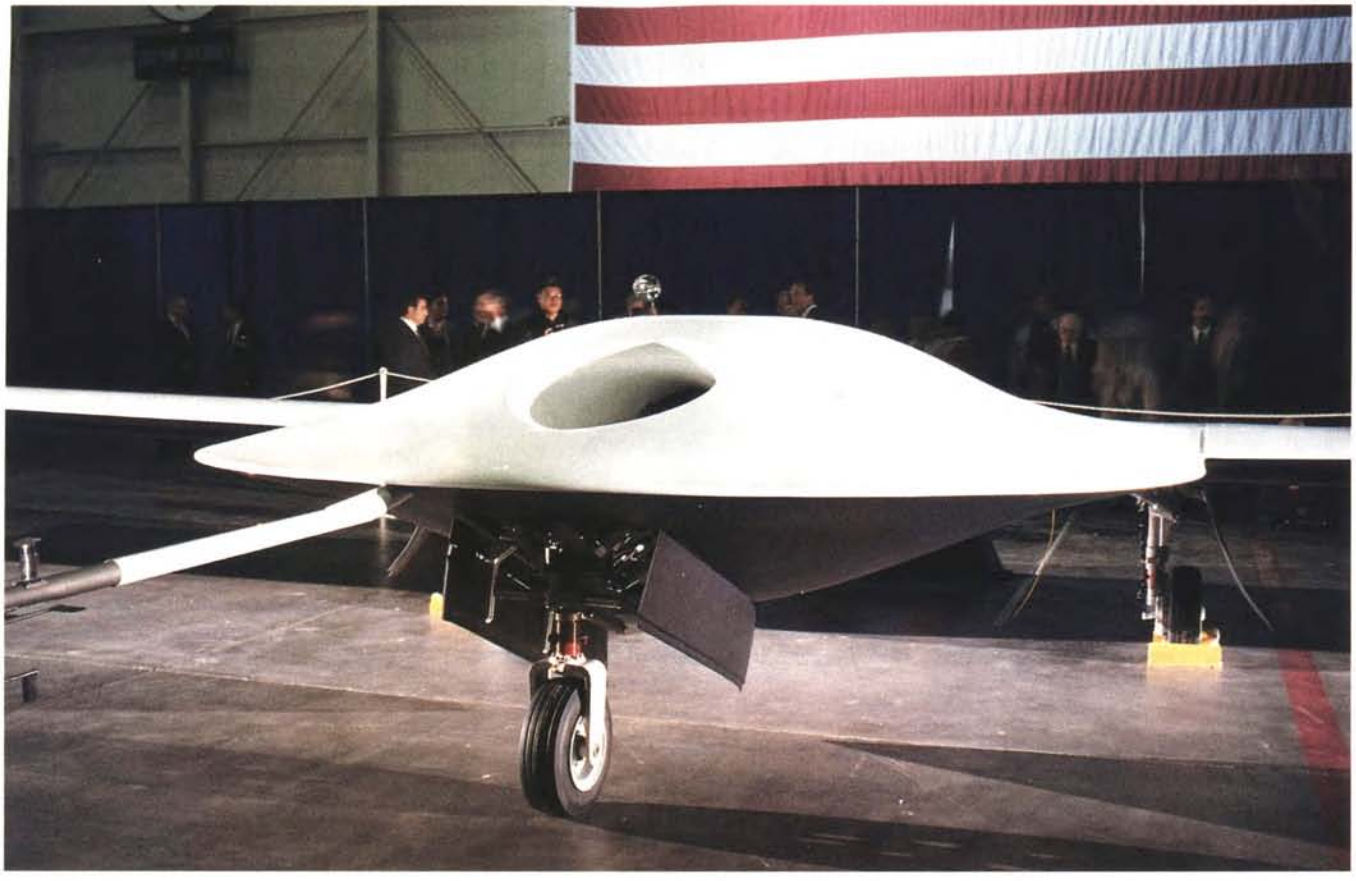


Photo by Erik Simonsen

ing reconnaissance systems will consist primarily of UAVs.

"UAVs hold great promise to perform many theater reconnaissance operations—from surveillance to targeting and bomb-damage assessment," wrote Air Force Chief of Staff Gen. Ronald R. Fogleman in a major policy letter. "Beyond these, we are contemplating their use in a variety of other operations, from peacekeeping or peace enforcement to counterdrug, counterterrorism, [and] peacetime surveillance."

The Chief of Staff concluded, "The bottom line is that, on my watch, the Air Force will embrace UAVs and work to fully exploit their potential."

Air Force use of UAVs certainly is not unprecedented. US forces have long used unmanned aircraft as target drones, and remotely piloted aircraft were used for reconnaissance as early as the Korean War. During the Vietnam War, Teledyne Ryan's Model 147 UAV flew more than 3,000 top-secret reconnaissance and surveillance missions over areas deemed too hazardous for manned airplanes. Launched from C-130s, Model 147s provided photographic images and TV signals beamed to their mother ships in real time.

The Desert Storm Difference

Even so, UAV development languished in the lean years of the 1970s. According to Air Force officials, a general appreciation for the value of UAVs did not reemerge in the US until the 1990–91 Desert Shield and Desert Storm operations.

When Iraqi forces invaded Kuwait, the Pentagon's UAV force consisted largely of one model—the Pioneer remotely piloted vehicle, which the Navy had bought off the shelf in the late 1980s to support Marine operations on land. Six Pioneer systems eventually took part in the Persian Gulf War. With virtually all of the Pentagon's manned reconnaissance assets committed to the area, the Pioneers provided valuable flexibility, spending long hours staring down at the theater's vast desert surface.

Pioneers were often used in conjunction with the Air Force's E-8 Joint Surveillance and Target Attack Radar System standoff aircraft. First, the powerful Joint STARS radar would detect a potential high-priority mobile target. Then, a UAV would be flown into the area to confirm the sighting.

One major lesson the Air Force learned from its experience in the Gulf was that the US needs a diverse family of UAVs, not one all-purpose model. Smaller, target-spotting, tactical UAVs would be easier to operate near the front lines, under the control of corps or division commanders. Larger, long-endurance unmanned vehicles could take off far from the battlefield yet patrol broad swaths of strategic area, in service to joint task force or theater chiefs. Small numbers of low-observable UAVs could fulfill the hard-target reconnaissance mission, just as stealth fighters are used to attack high-value targets.

Such a range of capabilities would mesh perfectly with the Pentagon's emerging "information dominance" doctrine. It could help provide the detailed location data necessary for the best use of many types of precision guided munitions.

Furthermore, it was apparent by the early 1990s that technological advances had taken UAVs far beyond the Model 147 stage. New air-

The Pioneer needs no airstrip, and it has seen extensive use already, including reconnaissance missions over the Persian Gulf, Haiti, Somalia, and Bosnia-Hercegovina. It has an action radius of 115 miles and can stay aloft for five hours.

foils and lightweight materials made possible the construction of large airframes that could loiter aloft for hours. Leaps in signal processing and communications enabled the UAVs to download imagery much more quickly than was possible in the past. This technological advance included the real-time transmission of digital video.

Perhaps most important, the science of robotics advanced to the point that UAVs could be much more autonomous than the autopilot-equipped remotely piloted vehicles of the past. No longer did unmanned air vehicles depend on groundbased "pilots" staring at a TV screen, joystick in hand. Now they could be preprogrammed to fly to wait points, change altitude, and continue to their next target, all on their own. Ground operators with mouse and keyboard could check their progress via computers and alter course as needed.

Going Up

"With all these technologies coming into play, the value of a UAV has gone way, way up," said Lt. Col. Thomas J. Di Nino, director of the Joint Endurance Unmanned Aerial Vehicle System Program Office at Wright-Patterson AFB, Ohio.

This does not mean that the course of UAV development will always run smoothly. The Hunter tactical UAV (TUAV) program was recently canceled after racking up an embarrassing string of test crashes, among other things.

Still, the Defense Department intends to spend some $200 million per year indefinitely for UAV research and development—real money by unmanned vehicle standards. Here are the main programs that will make up the next-generation UAV family:

Tactical UAV. This as-yet unnamed air vehicle is the smallest and newest of the Pentagon's coming generation of UAVs. It supplants a number of previous tactical development programs, including Hunter.

With a projected range of 200 kilometers (124 miles) and an endurance time of four hours, it is meant to provide electro-optical and infrared intelligence for front-line units, such as Army brigades or Marine task forces.

With a bi-wing design, the UAV—formerly known as "Vixen"—can take off and land from unimproved airstrips or from the decks of ships, without aid of parachutes or arresting wires. Alliant Techsystems will deliver six complete TUAV systems, each consisting of three or four air vehicles and a ground station, to the Defense Department for testing, with a decision on possible full-rate production looming in about two years.

The TUAV program could eventually total $1 billion, with a projected requirement of some sixty systems.

Pioneer. The Pentagon intends to continue purchase of Pioneer air vehicles through at least 1997 to provide an interim tactical UAV capability until new models come on line. Plans call for an eventual force of nine Pioneer systems—five for the Navy and three for the Marines, plus one for training.

Pioneers have already flown in service over Bosnia-Hercegovina, Haiti, and Somalia, as well as the Persian Gulf. Powered by a twenty-six-horsepower, two-stroke engine,

Formerly, remotely piloted vehicles like this one had to be controlled by "pilots" staring at a TV screen. The new generation of UAVs is much more autonomous, needing only the occasional progress check via mouse and keyboard.

they have an action radius of about 185 kilometers (115 miles) and can stay aloft for about five hours. Their 100-pound payload consists of either infrared (IR) or electro-optical (EO) imaging equipment.

Predator. The bulbous-nosed Predator medium-altitude endurance UAV (Tier II) will be the workhorse US long-range system over at least the next two years, although it is still an Advanced Concept Technology Demonstration program.

With an action radius of 926 kilometers (574 miles) and a 25,000-foot maximum altitude, Predator can loiter on station for twenty-four hours and has a maximum endurance of forty hours. It can carry a synthetic aperture radar (SAR), as well as EO or IR sensors, as part of its 450-pound payload.

The Predator has seen extensive action over Bosnia, with more than 2,500 missions as of mid-May. At 450 pounds, its payload is more than quadruple that of the Pioneer. It also has a longer loiter time and higher maximum altitude.

Much as the E-8 Joint STARS aircraft cut its teeth during Operation Desert Storm, the Predator UAV has already seen action over Bosnia. By May, the Predator fleet had logged 2,620 mission hours staring down at Bosnian territory and had amply proved the UAV's worth, according to Air Force Maj. Gen. Kenneth R. Israel, director of the Defense Airborne Reconnaissance Office (DARO).

For one thing, Predator's ability to loiter and stare at particular areas confounded the efforts of various combatants to camouflage their equipment or conceal their actions. At one point, said General Israel, a particular faction insisted that its M46 tanks were not firing into a town. The Predator buzzed them high overhead to see if this was so, drawing fire for hours as the faction tried to make it go away.

"They didn't believe it could just stay there," said General Israel. "Finally they got frustrated and fired into the town anyway."

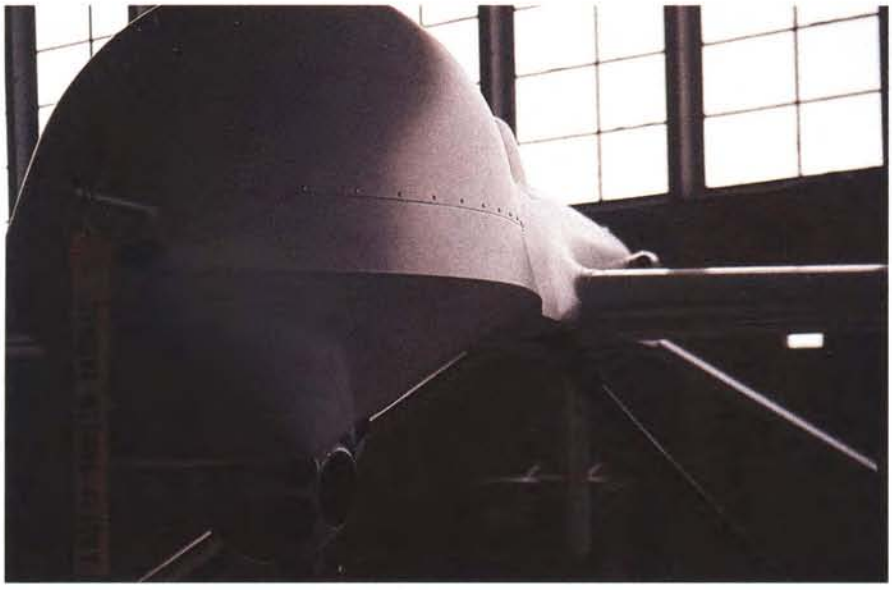
Predators were also used extensively to watch suspected mass grave sites and to document any attempt to tamper with bodies.

Global Hawk. The newly named Global Hawk, once known as "Tier II Plus," is intended to be the backbone of the nation's long-range UAV fleet of the early twenty-first

Vital Statistics

Specification	Pioneer	Tactical UAV	Predator	Global Hawk	DarkStar
Altitude, max.	15,000 ft.	15,000 ft.	25,000 ft.	65,000 ft.	45,000 ft.
Endurance, max.	5 hrs.	12 hrs.	40 hrs.	40 hrs.	8 hrs.
Speed, max.	110 knots	106 knots	129 knots	345 knots	250 knots
Radius	100 nm	108 nm	500 nm	3,000 nm	500 nm
Propulsion/thrust	26 hp	60 hp	85 hp	7,050 lbs.	1,900 lbs.
Length	14 ft.	23 ft.	26.7 ft.	44.4 ft.	15 ft.
Width	1.3 ft.	1.7 ft.	3.7 ft.	4.8 ft.	12 ft.
Weight (empty)	264 lb.	1,204 lb.	773 lb.	7,650 lb.	4,487 lb.
Span	17 ft.	29.2 ft.	48.7 ft.	116.2 ft.	69 ft.
Payload	100 lb.	196 lb.	450 lb.	2,140 lb.	1,287 lb.
Navigation system	GPS	GPS	GPS/INS	GPS/INS	GPS/INS
Sensors	EO or IR	EO, IR	SAR, EO, IR	SAR, EO, IR	SAR or EO

Source: DARO



Predator (above) can pinpoint concealed targets, such as a Bosnian Serb ammunition depot (top photo, below), and then assess the damage to them once they've been hit (bottom photo, below).

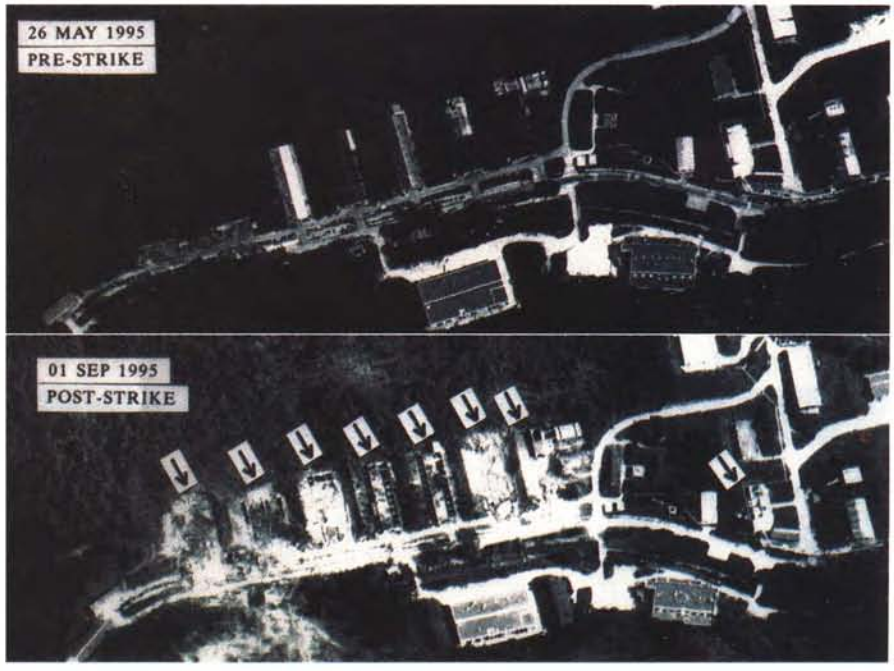
century. Unlike UAVs designed in the late 1970s and early 1980s, which to laymen's eyes resemble oversize model airplanes, Global Hawk will be a true unmanned air vehicle: Its wingspan is more than 116 feet long, and its turbofan engine will generate more than 7,000 pounds of thrust.

With a projected radius of 3,000 nautical miles, this UAV could take off in California, map a vast area on the East Coast, and then return to the West Coast. Its maximum endurance is projected to be forty hours, and its ceiling is planned to be 65,000 feet.

The Global Hawk will carry SAR, IR, and EO sensors, and its search-mode resolution will be three feet. A spotlight mode will provide one-foot resolution, according to contractor data.

The UAV's Hughes-built sensor package will allow ground commanders to switch among radar, infrared, and visible wavelength modes whenever they want. Thus, Global Hawk should be able to sweep wide areas, then zoom in on specific targets as they appear.

Global Hawk will have a relatively large communications "pipe," with the capability to send fifty megabits of data per second. That means it should be able to transmit video images back to ground stations in real time. It should also be able to send SAR data directly to front-line ground troops.



Global Hawk is intended for missions that require long range and a long "dwell time." Such missions could include constant scouring of a large area for mobile missile launchers. The vehicle will communicate with ground stations via satellite, enabling it to be controlled by headquarters far from the forward lines of operation.

First flight is currently scheduled for Fiscal 1997. Flyaway cost is projected at $10 million in Fiscal 1994 dollars.

DarkStar. The DarkStar Tier III Minus UAV is intended to be a "silver bullet" like the F-117 stealth fighter. Highly capable, built in small numbers, used to overfly only the most heavily defended areas, the stealthy DarkStar will have neither the performance specifications nor the payload capacity of Global Hawk, but it will have low-observable characteristics that should enable it to penetrate the best air defenses and survive.

Resembling a plate equipped with long, narrow wings, DarkStar will have an action radius of 926 kilometers, an endurance time of eight hours, and a maximum altitude of 45,000 feet. Its turbofan engine, the Williams International FJ44, is the same one used in the Cessna Citation business jet.

DarkStar will carry either EO or SAR sensors, but, with communications limited to 1.5 megabits per second, it will transmit primarily fixed-frame images while in flight. Its Westinghouse radar, a legacy of the Navy's failed A-12 program, will be able to search for and capture data at a rate of 1,600 square nautical miles per hour.

Built by Lockheed Martin's famous Skunk Works, DarkStar made a successful twenty-minute first flight on March 29 of this year. A second flight attempt ended in a crash on

takeoff in April. The crash is still under investigation, its cause undetermined.

Some members of Congress have occasionally questioned the need for a family of next-generation UAVs. In particular, they wonder why the Pentagon needs two types of endurance unmanned vehicles. Why not build one, they said, and give it both the low-observability of DarkStar and the performance specs of Global Hawk?

The problem with that approach, say US UAV officials, is that loading so many capabilities into one program would end up costing more money. Individual UAVs would become prohibitively expensive.

"Two different endurance UAVs give us more bang for the buck," said Colonel Di Nino of the Joint UAV program office.

The Defense Department's overall UAV goal is to get a range of relatively inexpensive air vehicles with reasonable amounts of utility into the air quickly.

"By the time 1999 rolls around, we should be in a phase where we are demonstrating to the users what the capabilities are of these systems," said Colonel Di Nino.

Global Hawk, seen here in artist's concept, was designed as a huge "endurance airframe," capable of flying from California to Maine, mapping Maine, and flying back. Such UAVs will be invaluable to DoD as it seeks information dominance.

Who's in Control?

While UAV technology is generally in hand, operational concepts are not. The Air Force and its fellow services will be venturing into a new military world with an extensive UAV force, and such questions as who will control them, how will they be deployed, and how will their product be disseminated have yet to be answered.

The preprogrammed nature of their flight plans and the long range of the bigger, "endurance" models make consideration of UAVs and their control somewhat complicated, points out General Israel of DARO.

Basically, users will exert three types of control over next-generation unmanned vehicles, he said. The first will involve simply receiving information—front-line troops tapping into SAR images from DarkStar, say. The second will involve control of where the sensors are looking and where the vehicle is headed on station. This direction would be provided by higher-level force commanders. The third type of control would be actually controlling UAV landings and takeoffs. This is likely to fall to specialized teams who are relatively immobile.

Just because the targets of endurance UAVs change, said General Israel, "you're not going to be sending launch and recovery teams across the country."

Full-scale military assessments of how UAVs will be integrated into force planning should begin in late 1997, said Air Force officials. Planned procurement numbers are not yet set, either, though initial analysis shows that buying four conventional endurance Global Hawks for every one low-observable DarkStar should provide the most economical UAV force mix.

New sensor payloads now in development could make UAVs even more valuable in the future. Among the projects: a signals intelligence payload to give unmanned vehicles a state-of-the-art eavesdropping capability, foliage-penetrating radars, and miniature spectrometers and gas chromatographs to provide chemical analysis.

Vertical-takeoff UAV designs are also in the works, for possible use in urban reconnaissance.

"It's going to be more of a premise in the future that we understand what's on the battlefield before we get there," said General Israel.

The newfound success of UAVs does not mean that US forces will do away with manned penetrating reconnaissance air systems entirely, said the DARO chief. Such venerable aircraft as U-2s will remain in service. The development of more and more capable all-weather, multispectral sensors will benefit both manned and unmanned systems.

Still, in a country where the public appears to want military operations to be carried out with an absolute minimum of casualties, UAVs offer the US a distinct advantage: expendability. Two Predators have been lost during operations in Bosnia, for instance. One was shot down ("Not before taking some fairly exciting pictures," said General Israel), and another was flown into the side of a mountain on purpose after it developed a manifold pressure problem.

When Air Force Capt. Scott F. O'Grady and his F-16 were shot out of the sky over Bosnia, the nation held its breath. When the UAVs went down, "the President didn't call," said General Israel. "That's the difference." ■

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