The lone Global Hawk flying above Iraq was one busy, busy bird.

Eyes Wide Open

By Rebecca Grant

THE US Air Force dispatched more than 600 fighters, bombers, tankers, airlifters, and intelligence-surveillance-reconnaissance aircraft to Operation Iraqi Freedom. In the pack was one loner: the RQ-4 Global Hawk unmanned aerial vehicle. The Air Force deployed to the theater just one Global Hawk and flew it 18 days in a row to provide unblinking coverage of the Republican Guard and other key targets.

The performance of this aircraft over Iraq drew praise from all quarters and marked a significant step forward for long-range, high-altitude unmanned reconnaissance.

The 1991 Gulf War dramatized the possibilities of real-time imagery. The Desert Storm coalition acquired tremendous situation awareness from new assets such as E-8 Joint STARS aircraft, but there were gaps in ISR coverage of the battlespace. Commanders wanted a platform that would provide 24-hour coverage to support the hunt for Scuds and help keep track of Iraqi forces. That new requirement in 1991 led directly to the presence of

What Global Hawk Did in the War

All told, the RQ-4 aircraft snapped 3,655 images using all sensors (radar, infrared, and electro-optical). These images helped locate and identify the following:

- 300+ tanks.
- 13 full SAM batteries.
- 50+ individual SAM launchers.
- 300+ SAM canisters.
- 70+ SAM transporters.

Global Hawk in the skies over Iraq in 2003.

The Defense Science Board's 1993 summer study called on the Pentagon to spur development of UAVs. This, it said, would help "fix the problems exposed in Desert Storm." The DSB said the use of reconnaissance UAVs would help US forces gain wide-area coverage, acquire all-weather access to the battlespace, and integrate combat information.

The challenge was to create a new type of craft, one that would build on the experience gained from decades of operating remotely piloted vehicles—or drones—and experimental high-altitude vehicles.

Drones had done yeoman's work in Vietnam. The Firebee drone was launched from a mothership such as a C-130 and guided by remote control. The Firebees streaked over targets at low altitude, snapping pictures of downtown Hanoi, pulsing electronic countermeasures, and dropping leaflets. On their return, helicopters would snag them with hooks. Although loss rates were fairly high, one drone, nicknamed Tom Cat, flew 68 missions.

In the late 1960s and early 1970s, experiments proved the feasibility of a "high-altitude, long-endurance" RPV, often referred to by the acronym HALE. In 1971, the Compass Arrow RPV flew four-hour surveillance missions to a height of 81,000 feet. However, DOD canceled the expensive program after producing 28 vehicles and never put them into operational service.

Requirements had changed. A program that was intended to produce a more sophisticated RPV, Compass Cope, featured a flyoff between Teledyne Ryan and Boeing. The concepts were to demonstrate autonomous flight from takeoff to landing. In 1974, Ryan's Compass Cope piloted itself to a series of preprogrammed way points and set an RPV endurance record with a 28-hour flight. However, when it came time to buy an operational system, the Air Force of the 1970s was not ready.

The development of the Global Positioning System and more-powerful computing power in the 1980s made the high-altitude, long-endurance unmanned aerial vehicle an attractive prospect.

In the early 1980s, the Defense Advanced Research Projects Agency began managing secret UAV programs. One was Amber, a CIA-directed project that became the father of today's Predator UAV. DARPA, however, was on the lookout for a "different, new, advanced technology that would revolutionize ISR," said John Entzminger, who was a director of DARPA's Tactical Technology Office in the 1980s.

"Long endurance, persistence—those kinds of things were in our mind at the time," said Entzminger, who added that the question was, "Why does the man have to be there in something which is going to stay up for 24 hours?"

DARPA organized its unmanned aerial vehicle research projects on the basis of planned performance. One such grouping—known as "Tier II"—contained two very different aircraft: medium-altitude (Tier II) and high-altitude (Tier II+). They were to be complementary, providing a low/high mix of forces.

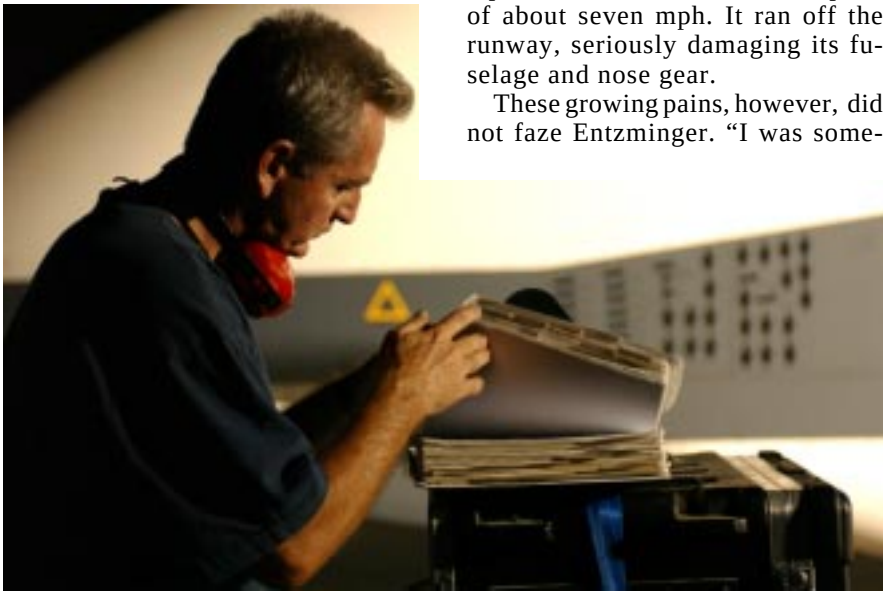
The high-altitude UAV was to merge responsive, long-duration tactical reconnaissance with the wide-area and highly survivable reconnaissance inherent in high-altitude operations. Given that demand, the Tier II+ UAV had to have endurance of at least 24 hours, carry high-resolution synthetic aperture radar and electro-optical-infrared sensors, and operate at 65,000 feet to stay above the threat from enemy surface-to-air missiles and fighters.

DARPA was the executive agent for the initial phases of the high-altitude UAV demonstration program, one of the first efforts in a new DOD plan to speed technology to the warfighter.

Fourteen companies submitted proposals. In May 1995, Ryan's Global Hawk was announced as the winner of Tier II+. Airframe designer Alfredo Ramirez had already sketched out the distinctive "swoopy curves" and long wingspan of Global Hawk. Now, engineers drew on proven technologies to build Global Hawk, shooting for effectiveness, affordability, and ease of maintenance.

Less than three years later, on Feb. 28, 1998, air vehicle-1 (or AV-1) made its first flight at Edwards AFB, Calif. Program management shifted from DARPA to the Air Force in October 1998, and, a month later, AV-2 made its maiden flight. During a March 1999 test flight of AV-2, controllers mistakenly sent a signal to terminate flight, causing the UAV to crash. It was a total loss. In May, after a short safety review, AV-1 resumed flight testing, and, by June, Global Hawk participated in Roving Sands, its first joint exercise. AV-3 began flying in September 1999, with a fourth Global Hawk waiting in the wings at Edwards and a fifth nearly complete. In December 1999, a software problem sent AV-3 careening across the Edwards runway at 178 mph instead of its normal taxi speed of about seven mph. It ran off the runway, seriously damaging its fuselage and nose gear.

These growing pains, however, did not faze Entzminger. "I was some-



USAF photo by SSgt. Reynaldo Ramon

Contract personnel deployed forward and were a big part of Global Hawk's success. Here, Terry Collins of L3 Communications checks the aircraft's satellite uplinks and downlinks.

USAF photo by SSgt. Reynaldo Ramon

The UAV also got heavy use in the Afghan war.

what surprised there weren't more," he remarked later.

Rising Need

By the time of Operation Allied Force in spring 1999, US warfighting commanders were more than eager for a solution to the problem of keeping a constant eye on the battlespace. One key frustration was having to orchestrate several systems—satellites, U-2 aircraft, and other tactical reconnaissance platforms—to get the data they needed in time. It couldn't always be done. The Predator UAV, which had first seen operational service in 1995 over Bosnia, delivered sharp real-time video, but it only provided a "soda straw" field of view.

Tracking mobile targets across the battlespace demanded assets with longer coverage times and wider fields of view—and the communications links to speed the images to a processing center for analysis and into the combined air operations center for execution.

Global Hawk (now owned by Northrop Grumman) emerged as the likely solution. It was performing well in joint exercises. In fact, in late 1999, Adm. Harold W. Gehman Jr., then head of US Joint Forces Command, described it as "the theater commander's low-hanging satellite."

In early 2001, Global Hawk crossed the Pacific for exercises in Australia. Ramirez said that the pictures it provided were so sharp that, in one exercise, Global Hawk "caught the USS *Kitty Hawk* out at sea with an F/A-18 coming in to land."

The Australia deployment demonstrated not only that Global Hawk could fly unrefueled 7,500 miles across the Pacific but also that it could be retasked while airborne. "We figured out we could actually fly off the black line," said Maj. David Hambleton. "We could go wherever we wanted to—direct steer to a point in space that we hadn't thought about going to before. That was a big revolution in our thinking."

Exciting as the exercises were, Global Hawk was still an immature system. USAF had only five vehicles—all demonstrators lacking the full-scale mission systems or reliability features that would be added to production models.

Then came the Sept. 11 terror attacks and, three weeks later, the start of Operation Enduring Freedom in Afghanistan. Commanders wanted steady coverage of widespread areas to assist in the hunt for mobile targets such as al Qaeda leaders. Global Hawk had the right combination of sensors, so Maj. Gen. Robert F. Behler, then head of the Air Force's C2ISR Center at Langley AFB, Va., put together a team to determine whether to deploy Global Hawk. Soon, the team briefed Gen. John P. Jumper, Air Force Chief of Staff, that Global Hawk was ready to go.

USAF sent a pair of Global Hawks—AV-5, the Australia veteran, and AV-3, repaired after its high-speed taxi hijinks. The service also put together makeshift control and maintenance teams of Air Force and contractor personnel. "None had ever employed Global Hawk in an operational context," said Col. Ed Walby, the Global Hawk detachment commander and a U-2 pilot.

No Joystick Here

Global Hawk is about as big as a medium-size corporate jet, but it sports a long, sailplane-like wing. It has a bulbous nose that houses a large, steerable satellite antenna. The UAV is not piloted from the ground via joystick; its flight control, navigation, and vehicle management are autonomous.

The Global Hawk system has two ground stations: a launch and recovery element and mission control element. The LRE, which deploys with the aircraft, provides precision guidance for takeoff and landing, using differential GPS. The MCE gives the vehicle its flight plan and tells it where to point its sensors. The two units can deploy alongside each other or in widely separated parts of the world. While the MCE preprograms an initial flight plan, it can dynamically retask Global Hawk at any time the UAV is in flight.

Pentagon officials have said that the Global Hawk's synthetic aperture radar can provide images of targets at a distance of 100 miles. Its electro-optical-infrared system has identified targets at a distance of 30 miles.

On Nov. 18, 2001, Global Hawk AV-5 was flying a routine check-out mission over Afghanistan when it was called to provide imagery of a brewing crisis. Taliban and al Qaeda detainees began a riot at Shebergan Prison near Mazar-e-Sharif in northeastern Afghanistan. Hambleton, who was on duty at the CAOC, said, "There was a call for some reconnaissance to go up there and figure out what was going on." Global Hawk, with its infrared sensor, was a natural choice, but AV-5 was operating near Kandahar, a few hundred miles to the south at the time. Mission control element pilots redirected AV-5 to the north.

"We got some really good infrared imagery, saw where the fires were," Hambleton said.

Dynamic retasking became Global Hawk's stock in trade, marking a major step forward from the UAV's original concept of operations. Typically, ISR assets gather hundreds of assigned images along a route worked

out well in advance. Planning guarantees the aircraft won't waste mission time flitting from point to point. Yet commanders in Operation Enduring Freedom demanded faster reaction. Global Hawk responded.

"We got ... more and more into the ad hoc tasking, because it was easy," Walby said. It took just "a few keystrokes and mouse clicks" to steer Global Hawk to a new heading while the sensor operator redirected sensors. Global Hawk flew a designated route to Afghanistan and then responded to new tasking. Classified voice, electronic chat, and e-mail functions created a real-time communications arena. The CAOC, Global Hawk mission controllers, and the image exploitation experts formed a strong and flexible network. It was able to carry out real-time tasking as events demanded.

Maj. Gen. David A. Deptula, the CAOC director, said of Global Hawk: "Because we controlled it from the CAOC, we could put it where we needed it, when we needed it, and for the duration we needed it." The infrared sensor on AV-5 proved particularly valuable in tracking an enemy that preferred to move at night.

In late November, US Central Command began preparations for an attack on al Qaeda hideouts in the mountains of Tora Bora. Working the UAV's sensors in spot mode, CENTCOM assembled a collage of images of trails and caves in the area, each image covering about 1.5 square miles. US analysts spotted al Qaeda campfires and "could, on occasion, see people on trails," said Hambleton. So good was the resolution that analysts could see al Qaeda fighters on foot.

The images revealed which caves were active and which were not. Campfires "were at locations that provided good overlook for approaches into the area," said Hambleton. Electro-optical images pinpointed possible Taliban encampments. "We essentially scanned the area, figured out who was where, where activity levels were, and that got us to vector in Predator, the AC-130, Strike Eagles, B-52s, all the different assets," he added.

During the coalition attack on Tora Bora, Global Hawk was tasked to drop its planned imagery collection profile and instead "go VFR direct straight up to Tora Bora and start taking pictures," said Hambleton. At 2 a.m. local time on Dec. 10, Global Hawk picked up Taliban campfires, lookouts on ridges, and cave entrances and then relayed the information back to the analysts. Minutes later, Global Hawk detected star-shaped infrared flashes, indicating direct AC-130 hits on those targets.

Both AV-3 and AV-5 flew missions through the end of 2001, logging 17 combat sorties in all. The partnership broke up on Dec. 31 when AV-5 ran into trouble over northeastern Afghanistan and crashed while attempting a six-hour flight back to base. USAF then grounded AV-3. A safety review cleared AV-3 and newly deployed AV-4 to resume flying in late March 2002. Both aircraft continued providing spectacular coverage of the battlespace. One IR image snapped over eastern Afghanistan on May 2 clearly showed about 50 enemy fighters on a mountain trail, strung out like pearls on a necklace.

The new pairing—AV-3 and AV-4—completed 47 flights by July.

The combat debut of Global Hawk "cracked the door open for an understanding of how unmanned systems could operate from great distances," Walby said. "It demonstrated a reach-back capability," so that "we could have the guys controlling it linked with the guys who needed it."

Over Iraq

As war in Iraq drew near, AV-3 was the only available Global Hawk. However, it had been modified with both the SAR and EO/IR sensor packages. Again, as in Afghanistan, military members and contractors partnered up. They didn't have "a chance to forget what we learned in OEF," said Walby.

As they had for Enduring Freedom, the launch and recovery team deployed to a base in Southwest Asia. However, this time, the mission controllers set up shop at Beale AFB, Calif. Global Hawk's pilots and sensor operators would be directing AV-3 from halfway around the world.

Another critical node was located in Reno, Nev. This was the Nevada Air National Guard's 152nd Intelligence Squadron, tasked with analyzing the Global Hawk imagery. The ANG analysts would push their on-the-spot analysis to the in-theater CAOC over electronic chat, voice, and e-mail communications avenues.

On March 8, 2003, AV-3 arrived in the theater and was tasked for three missions that technically fell under Operation Southern Watch, the enforcement of the no-fly zone over southern Iraq. Those missions became part of the prewar air campaign that helped strip away Iraq's air defenses. The UAV helped locate surface-to-air missile set-ups and potential Scud sites.

Night 1 of Operation Iraqi Freedom found AV-3 aloft and working just south of the 33rd parallel. That evening, as wartime rules of engagement took over, "all the fighters started flowing north," said Maj. Bill Cahill,

USAF photo

In 2001, an autonomous Global Hawk crossed the Pacific for exercises in Australia. Along the way, the aircraft demonstrated that it could be retasked in flight.

USAF photo

A Global Hawk in flight. AV-3 was one of the few sensors that operated in the late March sandstorm in Iraq. Its radar sensor permitted relentless attacks on the Republican Guard.

one of the Global Hawk liaison officers at the CAOC. Shortly thereafter, the Global Hawk team was told to push AV-3 north, too.

AV-3 kept "nibbling" a little bit farther north and a little bit farther east, so that, by the end of the mission, it was 60 miles or so north of the 33rd parallel. Cahill recalled, "We were the first ISR platform to punch north of the 33rd to work some of our target deck."

Global Hawk played a pivitol role in coalition strikes on targets such as the Republican Guard. Strike planners could dispatch aircraft such as the F-15E to conduct strike coordination and reconnaissance (SCAR) for designated target areas, known as "kill boxes." However, the F-15E was not an optimum platform for that work, said Cahill. "If you're trying to fly around in an F-15E and look through your LANTIRN pod, it's going to take you an exceedingly long amount of time to cover a [given] area," he explained.

To make SCAR work easier, Team Global Hawk organized missions that would put AV-3 over the kill boxes three hours in advance of an attack. "We'd flow [AV-3] in there and the [imagery] collection managers would say, 'Here is the area where we think there are fielded ground forces, Republican Guards units,' " said Cahill. One typical AV-3 radar image showed military vehicles dug into a field between a highway, buildings, and a belt of trees.

Operation of the UAV was a truly global process. Over Iraq, Global Hawk snapped photos and beamed images back to the ANG analysts in Nevada and secondarily to the in-theater CAOC. The analysts scrutinized the electronic take and shared data about the imagery within a special, secure online chat room. At the same time, they forwarded actual imagery over the Internet. Next stop was the interdiction desk on the CAOC floor. Then, fighters on station over Iraq got the target information by voice from either an E-3 AWACS command and control aircraft or directly via an onboard data link.

With AV-3 relaying a steady stream of imagery, precise attacks could be made within a few hours. "You're able to affect the fight that day," said Cahill.

Global Hawk also linked up with the B-1B and B-2 bombers, providing a "last-look" assessment on whether a bomber's designated mean points of impact, or DMPIs, still contained Iraqi tanks and artillery. If not, the bomber could hold its bombs for use against unplanned pop-up targets. The UAV's analysts would be looking at the same image as the bomber mission planners, leading to "a really quick chat report," said Cahill. Both elements would use common reference numbers to identify the relevant DMPIs.

Similar tactics worked with F-16CJ fighters. The fighters, flying suppression of enemy air defenses missions against the last remnants of Iraqi air defenses in the north, would carry mixed loads of weapons—Joint Direct Attack Munitions, Joint Standoff Weapons, Wind-Corrected Munitions Dispensers, and High-speed Anti-Radiation Missiles. Global Hawk was sent through earlier to spot likely targets—a process that made the air war more efficient. With cross-cuing from other platforms, the UAV would locate and capture images of suspected air defense sites and then pass the information back through Nevada to the CAOC. The CAOC contacted the F-16CJs on VHF radio to notify them of the targets.

AV-3 was also one of the key sensors allowing coalition air strikes to continue in Iraq during a fierce sandstorm in late March. While AV-3's optical and infrared sensors were blinded by the dust, the aircraft could focus its radar sensor on the Republican Guard below—checking to see if those forces were still at point A or B. Once again, Global Hawk passed updated information on to fighters and bombers using JDAMs to continue the attacks.

Gen. T. Michael Moseley, the Gulf War II air boss, praised the unmanned aircraft. "Sometimes you guys write that fighter pilots don't like UAVs," he told reporters during the war. "I love UAVs! I like them for any number of reasons. I like them because of the persistence; I like them because you can stay over a target for hours."

The ability of the Global Hawk team to integrate information rapidly for strike planners brought about new tactics. "It's just eye watering what you can do if you take advantage of all this," said Cahill.

On May 5, AV-3 touched down back home at Edwards. Like a warbird of old, it arrived home sporting a collection of nose art stencils representing each mission flown in Afghanistan and Iraq. ■

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