One last
for a unique aircraft

t hurrah

Wally Blacklock was the Advanced Surveillance Testbed's mission technician from 2000 to 2003. He now supports Boeing's Wedgetail program; a Wedgetail aircraft is in the background.
ED TURNER PHOTO

A look at the Airborne Surveillance Testbed, which generated knowledge that's still used by Boeing programs

By Lynn Farrow

Among the many definitions of family offered by the dictionary is this: "A group of people united by certain convictions or a common affiliation."

And united they were—hundreds of Boeing employees, along with their Raytheon teammates, who put together an amazing capability: a once-classified program called the Airborne Surveillance Testbed. The project was a key element of the U.S. Department of Defense's Strategic Defense Initiative and a precursor to today's missile defense technology. At the heart of the program was a specially-modified Boeing 767—the first commercial 767 Boeing designed and built.

"It's fair to say that this plane was so unique it literally stood by itself," said Henry Stahl, former AST flight-test director. "We did things with that airplane that no one else had done with a transport, putting sensors on it, adding exterior ventrals to provide more lateral stability, flying at altitudes that exceeded typical commercial service, landing on short runways. That is why everyone was interested in being part of the program."

The AST, retired in 2003, was recently dismantled. Yet the aircraft lives on through the knowledge gleaned by AST teammates who contribute to numerous Boeing programs.

THE HUMPBACK OF BOEING FAME

The AST program began in July 1984 as the Airborne Optical Adjunct program under the sponsorship of the U.S. Army Space and Missile Defense Command (formerly the U.S. Army Space and Strategic Defense Command). It was established as a technology demonstration project, and initial research was aimed at evaluating whether an airborne infrared sensor could reliably detect, track and discriminate intercontinental ballistic missile warheads from decoys and debris, then hand over the position of those warheads to ground interceptors as part of an overall U.S. missile defense system.

In 1991, at the time of the Gulf War, emphasis shifted to defending U.S. troops and installations from theater ballistic missiles—short-range missiles, such as Scuds—versus the longer-range ICBM (intercontinental ballistic missile), such as the Minuteman. The program's name changed to Airborne Surveillance Testbed. The test bed was used to gather precise data characterizing the flight, destruction and debris-fall of theater ballistic missiles as well as ICBMs.

As the prime contractor, Boeing furnished the 767 platform (serial No. 1) at no cost to the U.S. government and modified it to carry a Raytheon-built large-aperture infrared sensor. The most distinctive part of the plane was a hump, known as the cupola. Measuring 86 feet long and 8 feet high (26.2 by 2.4 meters), it resembled an inverted canoe and extended along the top of the fuselage from the cockpit to the wing. The cupola contained two removable modules, each with a viewing port that could remotely open and close during high-altitude flights, and was aerodynamically shaped to minimize the drag on the airplane. Two ventral fins were added to the rear of the airplane for increased stability during takeoff, landing and slow-speed flight.

Charlotte Lin (foreground) was the Advanced Surveillance Testbed program manager from 1997 to 2003. Also on the AST program were (from left) Roxane Bang (left) and Mark Feuerstein.
ED TURNER PHOTO

Housed in the forward module was the 3-ton (2.72–metric ton) infrared sensor, at the time the most complex ever built. To achieve the required high performance levels, the infrared sensor looked through an open port rather than a window.

"One of the real concerns was whether we could look out through an open port without distorting the image," said Phil Cassady, who was involved with the optical and aerodynamic design of the plane. To find out, Cassady said the team adopted a novel approach, conceived by Boeing's Ralph Haslund, to control how the air flowed over the open viewport.

"We very painstakingly designed the open port to be as aerodynamically smooth as possible; everything was inside the cupola," Cassady said. "The design was tested in the wind tunnel and during flight tests, and it worked well. AST was one of the first airplanes to demonstrate that this was possible."

The aft module eventually held the U.S. Navy's Captive Carry SM3 seeker, a Raytheon-built infrared sensor which tracked theater ballistic missile targets.

"As a pilot, the chief attraction to me was the chance to fly a plane that looked so radically different," said Mark Feuerstein, one of the last Boeing pilots to fly the AST. "Form follows function, and the design of the plane made the AST behave differently, especially at lower speeds."

HOW THE SENSOR WORKED

The AST infrared sensor contained 38,000 detectors, which were sensitive in three different color regions of the infrared spectrum. The hotter an object was, the bluer it appeared—while cooler objects appeared red. The temperature of the object could be measured by determining the amount of energy seen in each of the three infrared colors.

The detectors in the AST sensor were cryogenically cooled to extremely low temperatures, enabling the sensor to pinpoint objects that emitted very small amounts of heat in the cold vacuum of space. Sensitive enough to detect the heat of a human body at a distance of more than 1,000 miles (1,600 kilometers), the AST sensor demonstrated an unmatched capability to detect a wide range of ballistic target objects simultaneously during their midcourse phase, when their temperatures were extremely low. Temperature comparisons and other techniques could then be used to aid in discriminating warheads from other nonlethal objects.

The Boeing 767 aircraft was specifically chosen as the platform to carry the infrared sensor system into the stratosphere, because it could fly at altitudes of 45,000 feet (13,700 meters), getting above most of the earth's water vapor and weather systems.

Other major components included analog and digital signal processors and the mission data processor. Located in the main cabin, the analog signal processor built by Raytheon digitized signals from the sensor at a rate of 387 million conversions per second. A sensor signal processor, also built by Raytheon, processed this raw information at a rate of 15 billion operations per second and generated object-sighting messages. A mission data processor, originally built by Honeywell, and later replaced with one built by Harris, took the object-sighting messages and established "tracks" on each detected target object—then predicted where the objects were going.

> "The chief attraction to me was the chance to fly a plane that looked so radically different."
> —Mark Feuerstein, on the appeal of piloting the AST

TYPICAL MISSION

Although home was Boeing Field in Seattle, the Airborne Surveillance Testbed flew to many locations all over the globe.

Charlotte Lin, Boeing AST program manager from 1997 to 2003, said each mission involved two customers. One was the user program or sponsor, such as Ground-based Midcourse Defense, which would provide the targets and the request for what to do with them. The other was the AST customer, such as Space and Missile Defense Command, which would state the mission's objectives.

Using the customer information, the AST mission-design team would plan a mission, ensuring the aircraft was in the optimal flight path and close enough to the target to collect quality data. Position the aircraft too close to the target and the target would move out of the field of view too quickly. "There was always a tradeoff on where to put the aircraft, and the mission-planning crew was responsible for figuring all of that out using the tracker and mission-planning software. There were many in the 'family' that helped make sure we met our mission objectives," Lin said.

On a typical mission, the mission crew featured about 20 members, including representatives of Boeing, Raytheon and the Army customer. But there were scores of other team members who worked around the clock to make each mission successful. In addition to the mission-design team, there were the preflight ground crew; technicians and mechanics who repaired the AST; the mission-execution team that choreographed each mission down to the second; and the postflight analysis team.

"This was the closest I've seen to a program full of utility infielders. Everybody would pick up and support anyone else whenever they could," said Wally Blacklock, a former AST mission technician who currently supports Boeing's Wedgetail program. "You couldn't be one deep. Everybody was willing to work outside of their skill code. You learned that you could depend on each member of the team. That was critical."

Within 30 minutes after takeoff, the AST would begin in-flight testing—a dress rehearsal to verify all systems would operate properly. The testing included tracking satellites as well as going through the exact maneuvers the aircraft would make during the actual target viewing. Satellite tracking was the closest thing to viewing an actual target, because it used all elements of the system.

Once the test position was reached a series of sensor alignments

In this 2001 photo, the Airborne Surveillance Testbed makes a landing. The AST, the first commercial 767 aircraft Boeing built, was specially modified to support the U.S. Army Space and Missile Defense Command's technology demonstration program.
GREG AKESON PHOTO

on stars was made. Contact with the ground launch site was initiated and the countdown would start, the target would be launched and tracking would begin—unless the mission was put on hold. "When you go on mission hold, the airplane just can't stop in place, so you'd continue to orbit," said Lin. "Once we were on hold for what seemed like forever. We debugged the sensor and uploaded additional data and instructions. So when the mission came on line again, we were ready to go with an improved sensor processing load. All of a sudden, countdown began. We were in the wrong place, and you can only move a 767 so quickly. But we got in a good position to capture the data." Although typical AST missions lasted six to eight hours flying time, the actual tracking sequence lasted approximately 20 minutes.

When the mission ended, there was still critical work to be completed. Analysis teams took the classified data tapes from the onboard computers and reduced and scrutinized them before handing them over to the customer. There was usually a "quick look" briefing with the sponsor 10 days after mission completion to review postmission data. Final documents were due 90 days after the mission.

As the program progressed, the data team continued to improve its analysis techniques and the system's ability to collect better data. Not only did the customer community have enormous confidence in the data analysis being produced, but also AST data became the benchmark to which other sensors compared their data.

Between 1984, when the Airborne Optical Adjunct contract was awarded, and 2003, when the aircraft was retired, the AST exhibited exceptional performance and demonstrated the utility of an airborne infrared platform in a tactical missile defense role. The aircraft gathered and analyzed infrared data on numerous programs that Boeing supports today, such as Ground-based Midcourse Defense, Standard Missile III, Arrow and Delta II. During its years of service the AST completed more than 100 target-viewing tests with a better than 95 percent mission success rate (defined as achieving all requirements of a mission).

LESSONS STILL IN USE

Some of the techniques and software developed and tested by the program found a home in other Boeing-led defense programs. One of those was the Airborne Laser program. Unlike AST, whose mission was to track and observe strategic launches, ABL is designed to detect, track and destroy ballistic missiles in their boost (or launch) phase of flight. But both programs use passive infrared detectors for their particular mission.

"The tracking and mission-planning software that was the heritage from AST is also the core of the tracker that we use on board the ABL to take the passive infrared information and generate track positions. Using what we call 'engagement boxes' the mission-planning software helps align the aircraft and the target in exact locations where we want to conduct the testing," explained Rich Flanders, director of ABL Adjunct Missions. "Imagine the ABL in an orbit box and the target in an orbit box. That's two moving assets in their precise locations at the right point in time so that when testing begins, there is zero collateral damage outside these engagement boxes. That's the mission-planning piece and critical to our program because, unlike AST, the ABL carries active lasers."

Thanks to the AST experience, ABL's mission-planning software features onboard replanning capability. This enables the crew to perform last-minute modifications to mission plans.

Knowledge from the AST program continues to be tapped in other ways as well. Today, former AST teammates are sought after for their expertise with infrared sensor data handling and analysis. These subject matter experts work on a variety of Boeing programs, where their AST background helps them to design simulations and write real-time software for the mission processors. This includes adjunct missile defense capabilities proposed for existing airborne warning systems that reflect real-world experiences gained through the AST program.

"Knowing that the technology developed for the AST program is being used in today's ballistic missile defense systems is very gratifying. That's why it was such an honor to be part of the program," Blacklock said. ■

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AST reunion coming

Members of the Airborne Optical Adjunct/Airborne Surveillance Testbed program are planning a reunion on Aug. 26 from 1 to 6 p.m. (Pacific time) in Bellevue, Wash. If you were part of this program and would like more information about this gathering, please contact Bob Moyer (425-643-1056 or moyer.robert@comcast.net) or Roxane Bang (206-655-9967 or roxane.l.bang@boeing.com).