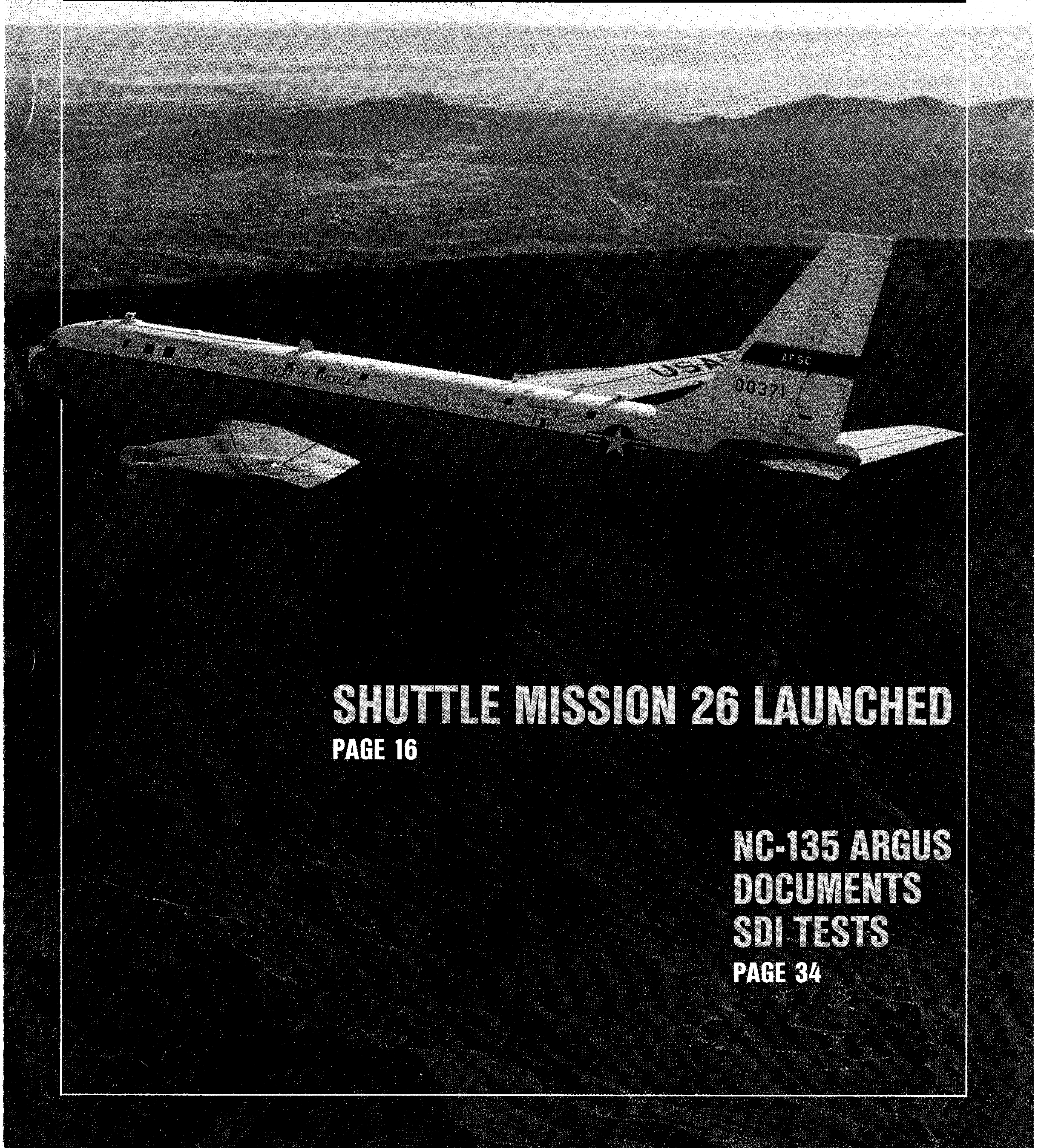
AVIATION WEEK

A McGRAW-HILL PUBLICATION

OCTOBER 3, 1988



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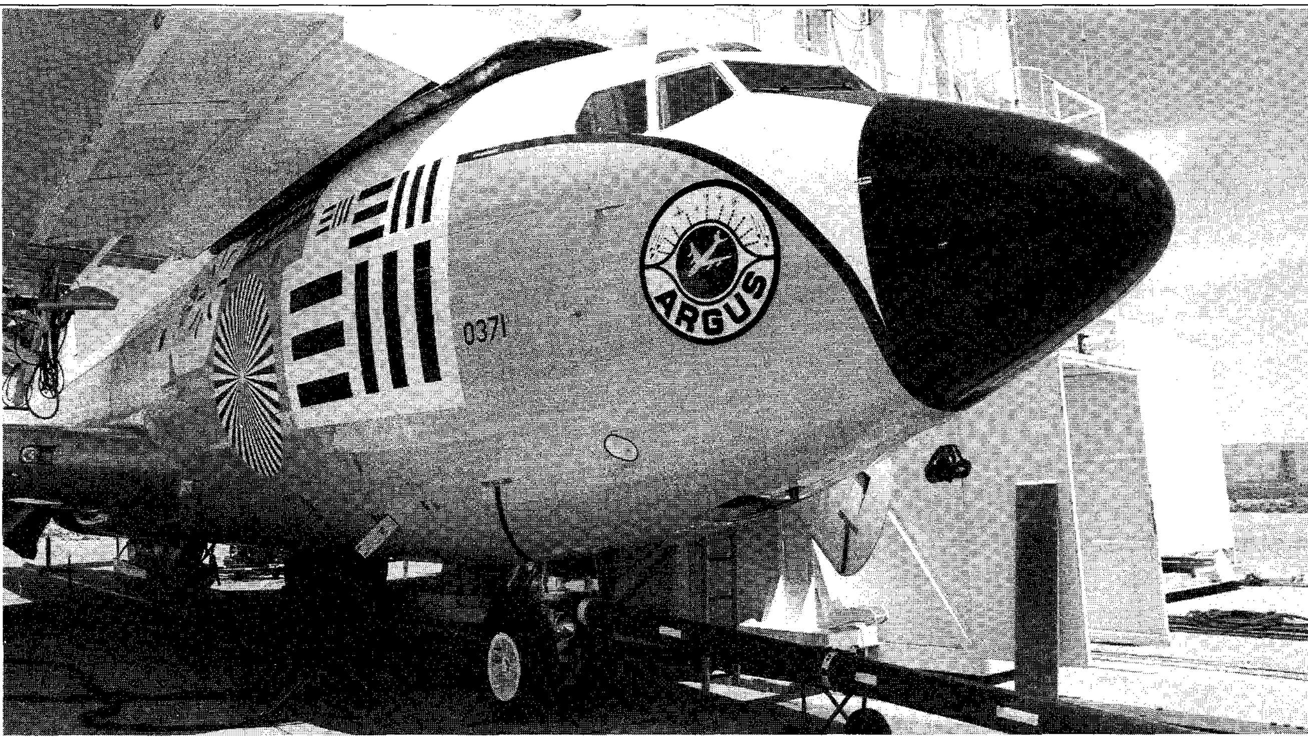
Special Mission Aircraft Aid SDI Sensor System Development

WILLIAM B. SCOTT/ALBUQUERQUE, N. M.



Air Force/Boeing Argus NC-135A aircraft is shown in a special semi-clean room "nose dock" that enables pre-mission checkout of optical data systems under controlled environmental conditions. Photo calibration patterns shown on the fuselage are not associated with the on-board data acquisition and tracking sensors, which are pointed out the left side of the aircraft cabin.

The Strategic Defense Initiative Organization is using two special mission aircraft to obtain high-resolution optical documentation of reentry vehicles, rocket plumes and specific SDI test events at ranges of 100-500 km. Together, they are providing significant information to SDIO's data base on reentry vehicles and missile plume signatures for sensor system development.

The primary aircraft is a heavily modified Air Force/Boeing NC-135A transport (S/N 60-0371) that has been in continuous service as a research platform since it was manufactured in 1960. The aircraft was originally built for the special mission role, so has never been configured as a tanker. It supported nuclear and solar testing in the Pacific during the 1960s, later served as the Airborne Laser Laboratory, and most recently was the SDI Optical Diagnostic Aircraft (ODA). The sensor platform was renamed Argus following an upgrade program about two years ago that added a high-resolution camera and target acquisition system, an infrared imager and an infrared spectrometer.

The second aircraft is a Learjet 35 operated for SDIO by Aeromet, Inc., under contract to the Army Strategic Defense Command (ASDC). Also configured with photodocumentation equipment, this high-altitude Learjet observatory (HALO) augments many of the same missions that Argus flies. HALO primarily supports ASDC requirements, however.

EXTENSIVE INFRARED DATA

Both the Argus and HALO aircraft have acquired extensive photo and infrared data on key SDI tests, including the Delta 180 and 181 experiments (AW&ST Feb. 15, p. 14; Jan. 12, 1987, cover; Sept. 15, 1986, p. 18). Initially, the aircraft were modified specifically for these SDIO tests, although they currently fly special documentation missions for other agencies as SDI-related schedules permit. So far, the aircraft have supported special tests on both the eastern and western test ranges, reentry vehicle and Delta-type SDI missions at the Army's Kwajalein Missile Range, tactical missile firings at White Sands Missile Range and specialized tests in Europe.

This AVIATION WEEK & SPACE TECHNOLOGY editor flew on the Argus aircraft here during a calibration and mission scenario practice flight on Sept. 12. The 2.8-hr. night mission was flown over the White Sands Missile Range in preparation for a deployment to Florida, using selected in-orbit satellites as photo targets for acquisition and tracking tests.

Although system boresighting checks were planned, a power supply failure in the high-resolution camera suite's control computer precluded several tests and prompted early termination of the flight. The airborne boresight verifications were completed later during a flight to MacDill AFB, Fla., from which Argus was scheduled to operate in support of a missile launch at Cape Canaveral on Sept. 19.

Argus is managed, flown and maintained by the Air Force System Command's 4950th Test Wing at Wright-Patterson AFB, Ohio, although it is based

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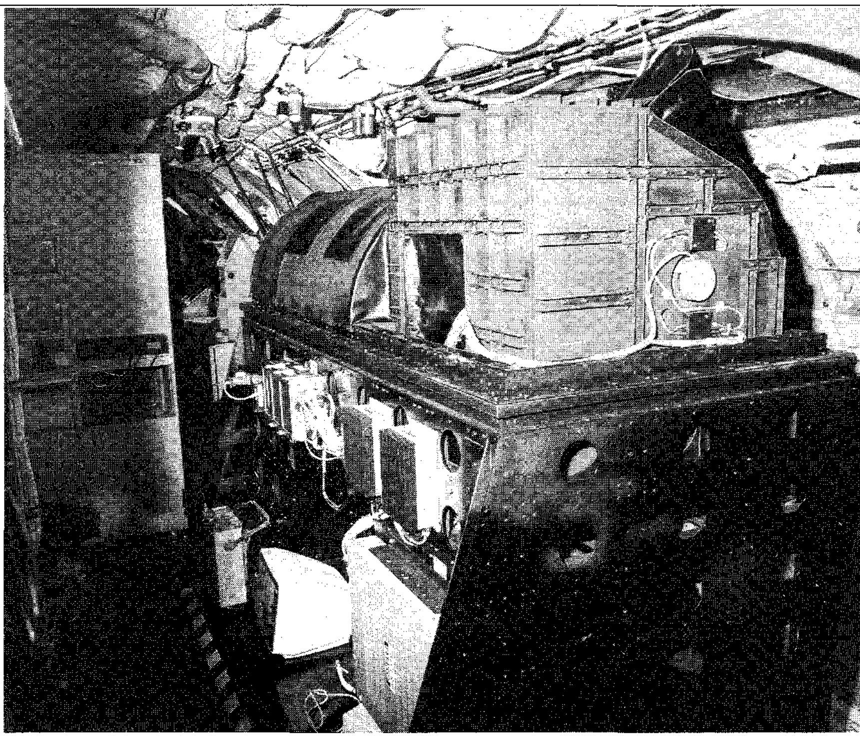

Argus high-resolution cameras, imaging infrared system and IR spectrometer are mounted in large enclosure (right) adjacent to the cargo door. Optical-quality windows of fused silica, germanium and zinc sulfide mounted in the door's surface can be changed to match equipment suite.

at Kirtland AFB, N. M. Most of the mission equipment was integrated—and now operated—by BDM Corp. personnel assigned to the company's Albuquerque office. BDM provides pre-mission analysis and planning, data modeling and post-mission data processing and reduction, as well as equipment and operations support. Although the aircraft is an Air Force asset, its modification to the Argus configuration was financed by SDIO, primarily to support the office's high-altitude tests and experiments.

SPECIAL EQUIPMENT INSTALLED

The aircraft is configured to carry eight separate sensors—five visible-band cameras, one infrared spectrometer and two imaging infrared cameras. These photodocumentation sensors are controlled by computer-driven acquisition and pointing systems, and all data are recorded on board. Special equipment such as low-power laser designators, star trackers and infrared imaging radiometers also can be installed as necessary for a specific mission. The sensor systems are built on modular pallets to simplify changes between flights.

All cameras and infrared sensors are positioned along the left side of the NC-135's cabin, pointed out the left side of the fuselage. The aircraft was configured previously with numerous special windows only on the left side, including several in the large cargo door located just aft of the flight deck. Because this particular NC-135 was designed for special missions, the cargo door is not a load-bearing structure, enabling new windows to be added in the door without affecting fuselage stress patterns.

An area just forward of the cargo door is reserved for a Cast Glance camera system, the only self-contained, general purpose photodocumentation equipment normally carried on the Argus aircraft. The system was not installed for my flight, because it was not required for the scheduled missile launch in Florida.

Cast Glance was developed at the Navy's Pacific Missile Test Center and has been used to support Navy, Air Force, NASA and SDI tests for several years. It consists of three visible-band cameras slaved to a single 7-in. aperture telescope and can be mounted in aircraft, on ships or at a ground site. When installed on Argus, the system uses data from the aircraft's sensor pointing system to acquire the target, although subsequent tracking of the target is done manually by Navy operators on the aircraft. Because it does not have a tracking "hand off" capability, Cast Glance is primarily used with targets having highly predictable trajectories, such as rocket launches.

HIGH-RESOLUTION CAMERA

Initially, the Navy system was the primary camera suite on the NC-135, providing target resolutions of 40 microradians with its narrow field of view (FOV) camera. However, the Argus upgrade effort added a high-resolution camera system with similar capabilities. For certain missions, the Cast Glance system is still used as an independent backup for the Argus suite, according to Col. John Otten, recently appointed Air Force Weapons Laboratory commander. Until his transfer last summer, Otten was assistant director of integration and test for SDI's kinetic energy program, and was closely associated with development of the Argus aircraft's photodocumentation equipment.

The cargo door area has both infrared and visible-band camera equipment mounted on a removable pallet. An RCA-developed IR imaging camera system with 100 microradian resolution and 160×244-element focal plane array occupies the most forward position, looking out an 18×18-in. germanium window. For shorter wavelength data, a 12×18-in. zinc sulfate window can be installed.

A dual waveband imaging radiometer (DWIR) can be installed in the same position for certain missions, although it displaces the RCA IR imager. Developed by GEC Avionics, United Kingdom, the DWIR will provide imaging in two different wavebands simultaneously by scanning in the horizontal plane to create both a line and frame scan. The system provides a 625-line video output. This unit is typically installed on those missions covered by a joint United Kingdom/SDIO agreement.

Argus also is equipped with a short

wavelength infrared spectrometer that uses a continuously variable filter to measure the spectral flux density of rocket plumes. Operating in the 0.7-5.5-micron range, the system also has been used to gather data on reentry vehicles. All data are stored digitally, and an experimental system now being developed could permit on-board evaluations of infrared spectral information shortly after a test event.

In the visible spectrum, a high-resolution camera assembly is the primary photodocumentation system. Capable of 30 microradian resolution, it consists of a 100-in. focal length Contraves SR100 telescope with 12.5-in. aperture linked to a Xybion low light level, multispectral video camera. Gain and other camera parameters can be remotely controlled from an operator station.

This unit can be configured with a laser designator that emits a beam through the telescope to illuminate a dark target during the acquisition phase, according to Otten.

A "ballistic camera" mounted on a separate pallet aft of the high-resolution system has a 10-in. aperture, f/1.3 lens and a manual shutter. Normally used for "streak" photography, the camera can either be slaved to other systems tracking a target or stabilized on a single point in space.

The final data acquisition camera is a wide-angle, low light level video unit mounted near the aft personnel door. It has a 76-mm., f/.87 lens and can be slaved to the on-board pointing and acquisition systems.

To ensure all sensors and their associated windows are free of moisture during the data phase, gaseous nitrogen is distributed around each camera/IR system and across its window prior to and during data acquisition phases.

UNIQUE TRACKING SYSTEM

The primary distinguishing feature of the Argus and HALO photodocumentation aircraft is the data acquisition and tracking system. "These aircraft [are unique] in the way they acquire and track targets at long ranges," Otten said. "For years, the hardest thing for photodocumentation aircraft to do has always been pointing the cameras at the target. We've found several ways to aid this pointing and handoff problem, [primarily] because we always work with cooperative targets." The pointing system software was developed—and now is maintained—by Aeromet, Inc., for both the Argus and HALO aircraft.

During the mission planning process, a projected trajectory file is developed for the particular target that will be documented on that mission. All profiles and intercept angles are programmed and loaded into the Argus computers, providing the tracking system with a place and time to start looking for the target. The projected trajectory can be updated during the mission with real-time radar data uplinked to Argus from ground-based tracking stations that acquire the vehicle either through on-board beacons or skin reflections from the target body. This information is used to compute new tracking system instructions, based on the Argus aircraft's altitude, speed, attitude, and position at that time. The tracking and pointing system then directs the onboard sensors to the correct area.

All photodocumentation sensors on the aircraft—including the high-resolution camera system—are controlled by the acquisition and tracking system. Computer-determined azimuth and elevation pointing commands derived from four sources—the nominal target track files, ground radar data, a dedicated on-board inertial navigation system, and manual adjustments by an operator—drive the pedestals on which the cameras/sensors are mounted, communicating with each unit through a MIL-STD 1553B data bus. Demonstrations have established that the total line of sight error between the Argus aircraft and its target is about 0.1 deg.

Key factor in obtaining high-quality optical data is getting the aircraft in the right position at the correct time

Once the system is pointed in the proper direction, a special acquisition camera fitted with a wide field of view zoom lens actually finds the target, then reduces the FOV to provide better resolution or increased gain to the tracking system feedback loop. The low light level camera's Fujinon lens is a commercial type used routinely by television sports crews. It will zoom from 36 mm. to 2,400 mm., providing a FOV that ranges from 20 deg. (wide angle) to 0.5 deg. The camera can acquire very dim objects rated as low as +9 stellar magnitude, a measure normally used to characterize star brightness.

The final critical factor in obtaining high-quality optical data with the Argus system is getting the aircraft in exactly the right position in space at the correct time. This task requires the Air Force pilot, navigator and test director to coordinate closely with the BDM optical director to ensure the aircraft's sensors are directed at the target when it comes into view.

On the Sept. 12 calibration and practice flight, several profiles were flown that simulated those required to cover the missile launch mission in Florida. It was apparent to this observer that Capt. Walt Price, the navigator, had a particularly difficult time and distance problem to solve. He continually monitored the NC-135's INS-Doppler system to obtain wind and ground speed information, which he entered into a Zenith 184 portable computer that was programmed specifically for Argus missions. Through a menu-driven format, Price added current aircraft and time parameters, then commanded the computer to determine the proper time, distance, heading and true airspeed necessary to ensure the aircraft was in position on time.

COMPUTER-DETERMINED TIME

He then directed the pilots—Maj. Bill Herzog and Capt. Jim Ratti—to orbit temporarily at an initial position. At the computer-determined departure time, the pilot rolled out on the proper inbound heading and adjusted speed as required to hit the desired latitude/longitude on schedule. The navigator counted down the last few seconds as that point was approached, and directed a precise bank angle be established when he called "zero," indicating Argus was on station and in a data acquisition mode.

The test director, located in the cabin where he could monitor several video displays, called for 1-2-deg. bank angle changes during the data phase, ensuring the sensors remained pointed toward the target for several minutes. The pilots were constantly adjusting power and bank angle to maintain a stable position. Their task was complicated further by the high altitude—typically 36,000-41,000 ft.—where the NC-135's performance and maneuvering margins were severely limited.

Byron Thompson, a BDM director of test operations, served as the assistant optical director, reading a script of mission events throughout the maneuver. This chronology alerts camera control and data systems operators when missile/rocket staging will occur, enabling them to adjust equipment gains as target lighting levels change.

The two practice maneuvers demonstrated that the high degree of discipline and coordination required of all 12 crewmembers are directly related to the quality of data obtained. In this case, both maneuvers were clearly acceptable, and one achieved the desired position exactly on target—zero position error and zero time error, according to Price.

Over the last two years, the Argus aircraft has supported eight data acquisition deployments. One required two missions per day for three weeks. In Fiscal 1989, the aircraft is scheduled to support another 18 deployments, five for SDIO and the remainder for other agencies. This increased activity is indicative of the growing number of tests scheduled as Phase 1 SDI experiments get under way, Otten said. □