

NAWCAD support behind the scenes: Enabling F-35B trials on Italy's Cavour



Test engineers in an ATR mission control room practice with pilots in a simulator before sea trials. (U.S. Navy photo by Julie Kelly)

Last month's successful completion of F-35B tests on the Italian jump-jet carrier Cavour capped years of behind-the-scenes prep work by Naval Air Warfare Center Aircraft Division (NAWCAD) engineers and technicians.

From takeoff and landing practice in the manned flight simulator (MFS), to installing instrumentation on the aircraft, to onboard video, data and communications support during the sea trials, NAWCAD engineers and technicians did their best to make the "Ready for Operations" campaign a success for the F-35 Patuxent River Integrated Task Force (ITF) and Italy's Marina Militare.

NAWCAD began preparing for the sea trials when a team from the Atlantic Test Ranges (ATR) conducted an initial visit in 2018 to the Cavour in dry dock at Taranto, Italy. A second trip followed in 2019. "The first trip was for a survey and planning," said Donovan Farrell, co-team lead for ATR. "Following that second trip the ship made the modifications we asked for."

Ship personnel cut pass-through openings in walls for cables, added a table in the flight control center for laptops and monitors and cleared space in the hangar bay for a pair of ATR mobile control rooms.

"We also made our own adaptations for power," he said. "Most outlets were 220 volts, but the

hangar bay was 380, so we built customized transformers to operate our 110 equipment."

Cable installation

One of the biggest preparatory tasks was installing the cabling that carried data, video and control signals throughout the ship.

"We installed 3,000 feet of fiber-optic cable," said Nate Combs, co-lead for the ATR team. "We pulled it around the ship and through the ship, and our communications

team made all the terminations. There were 100 terminations just for the control rooms. And then we had to uninstall it when the tests were over."

One team member rode on the top of the commanding officer's elevator to run fiber-optic cable down the elevator shaft to the hangar bay. He then installed cable from a man lift along the hangar bay ceiling the length of the ship to bring it down to the mobile control rooms.



ITS Cavour: ATR instruments gather data from bow to stern for the sea trials. (U.S. Navy photo)

- Weather stations (anemometers)
- Video tracking camera
- Telemetry antennas

Laser scanner survey

An ATR survey group measured and recorded the exact dimensions of the deck approach and ski-jump ramp where the F-35Bs would conduct their exercises. They used a laser scanner to create lifelike ship imagery for the MFS and an optical transit to align the GPS antennas.

"We scanned the deck and ramp to record the position in space of hundreds of millions of

points," said Warren Kerr, survey lead. "Then we recreated the image in a computer from that cloud of points. It's like the French pointillism painting technique, an image made of countless tiny dots."

The MFS engineers wanted a density of one point every quarter inch, he said, "but we gave them much more. Most of our scans had a point every one-thousandth of an inch."

The survey team had the original computer-aided design (CAD) files for the ship, he said, "but we didn't know how closely the real ship matched the design."

But with the laser scanner and transit measurements, the team knew the ship's dimensions with near-literal pinpoint accuracy. "The CAD files are what the ship was designed to be," he said. "We gave them the reality."

Simulator training

The data from Kerr's team served as input for the startlingly realistic digital ship models that MFS engineers built for pilot and crew training.

"The survey gave us the deck geometry files," said Robert Parlett, F-35 simulation engineer. "We had the exact deck profile and curvature of the ramp. And some of the engineers took pictures when they were in Italy."

The simulator training took place in three phases: test pilot takeoffs and landings, control room operations and emergencies, and ship's crew training. As pilots and crew trained in the simulator, test engineers in an ATR mission control room could communicate with them and receive data from the virtual aircraft and ship.

"The simulator has a hard-line fiber link to the mission control room," said ATR's Mike Wilson of the Test Management Branch. "It feeds into

software that lets the F-35 engineers in our control room monitor it in real time."

Before the simulated training began, the test engineers built data displays to their own specifications and transferred them to the mission control room. There, ATR's Real-time Telemetry Processing System presented the displays so the engineers could view data and video from the simulators as the pilots went through the training.



ATR surveyors use an optical transit and a laser scanner, which is on the tripod at far right. (U.S. Navy photo by Warren Kerr)

The first simulation session was takeoff and landing training for the ITF pilots. "The purpose was to create all sorts of non-ideal conditions, so pilots and aircrews would know how to respond at sea," Parlett said. "For example, the ship would drive at different headings and speeds with a wind direction of 300 degrees blowing at 18 knots with gusts to 20."

Virtual forces

The simulator also creates replicas of the forces acting on the virtual aircraft along with data from virtual measuring instruments installed on it. As an example, the upward curvature of the ramp produces more force on the nose landing gear than the main landing gear. That in turn creates an upward pitching force on the aircraft.

"The scanner survey data gives us a geometry file—the exact profile of the deck and curvature of the ramp," he said. "Our software has a gear-force model, and it interacts with the geometry file to generate a pitch rate."

The second simulator training phase involved the landing signal officer and airboss in the flight control station. "They can watch the aircraft takeoff and land," he said. "It has a 180-degree view and simulates their real-world environment. We tried really hard to emulate it exactly."

The phase two simulator training carried out actual missions, including operations like a recovery fill—refueling to a specified weight

with the engine running before taking off again. The training also simulated emergencies, he said, "things like aircraft failure, ship failure and an aircraft getting stuck after landing."

The third simulation phase was crew training for Cavour crew members. "I drove the ship, but they did the communicating and made all cadence calls," Parlett said. "Cadence includes how they say things, but also the pace and phrasing. The timing between 'ready' and 'clear for takeoff' on an airfield and on the ship can be totally different because it may take much longer to get ready on the ship."

Instrumentation and telemetry

Additional test instrumentation was installed for the trials by manufacturer Lockheed Martin Corporation and NAWCAD's Prototyping, Experimentation and Instrumentation (PIE) Department. Aircraft data included airspeed, angle of attack, engine temperature and thrust along with tens of thousands of other possible parameters.

PIE installed instrumented landing gear for the trials, said Marco Paz, F-35 instrumentation Navy lead. "There are three landing gear, and we want to know the strains on them in takeoff and landing as well as things like the stroke distance and position."

During one F-35 transfer from the hangar bay to the deck, the nose gear instrumentation was damaged. But the onboard PIE team was able to repair it quickly, despite extremely high winds on deck. The chief test engineer for the F-35 ITF gave the PIE team kudos for the fast repair.

"We've experienced it before," Paz said, "so our guys were ready to jump on it."

Data from the landing gear sensors and other instruments goes to a data acquisition, recording and telemetry (DART) pod located in the aircraft's internal weapons storage area. The DART pod, which PIE configures and maintains, broadcast the instrument data, and the telemetry antennas ATR installed around the ship picked it up.

"Altogether we had four telemetry receivers—three small telemetry acquisition system antennas that we can steer to follow the aircraft and one fixed omnidirectional antenna by the ramp," Farrell said.

The telemetry stream included GPS information received by the aircraft and broadcast from the DART pod. But there was also a separate set of GPS data for the ship picked up by antennas that ATR had installed.

GPS, video and weather

The ATR system included two pairs of GPS antennas for redundancy—two near the bow and two on the island. The ATR GPS was part of a ship motion package, which also includes an inertial navigation system (INS), said GPS analyst Ted Miller. "The INS measures the roll and pitch of the ship, and GPS gives its position, azimuth (horizontal) angle and height."

ATR's optical group meanwhile tracked the aircraft through video cameras placed around the ship.

"We had three tilt-and-pan cameras installed on the ship's island that we could control with a joystick to follow the aircraft on their approaches and takeoffs," Combs said.

Weather data also was the responsibility of the optical team. They installed two 38-foot-high, pole-mounted anemometers on deck—one at the bow and one at the stern—to check for clean air behind the bow wake.

The team also stationed a mobile, laser-based anemometer called a lidar at the bow to measure winds at 65 feet. "We wanted to make sure the wind was the same at the higher elevation as it was at 38 feet, and it was," Combs said.

"All in all, it was a pretty good team effort," he said. "We got an 'ataboy' from the ITF. They said 'best TM (telemetry) on a ship yet'."

By Robert Kaper
Senior Technical Writer
Atlantic Ranges & Targets Department



Italian officers train in a simulator that emulates the Cavour's flight control station. (U.S. Navy photo by Kyra Helwick)