Front End of the Kill-Chain

Northrop Grumman's DAS Gives F-35 Impressive SA & Ballistic Missile Defense Capability

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F-35A aircraft AF-1 and AF-2 arrive at Edwards Air Force Base for testing. Lockheed Martin photo.

On June 4, 2010, a Northrop Grumman-owned BAC 1-11 launched from the company's ES3 (Electronic Systems) Flight Test Facility at BWI-Thurgood Marshall Airport near Baltimore to help the firm demonstrate the multiple talents of its new AN/AAQ-37 Distributed Aperture System (DAS).

Developed as a uniquely capable omni-directional infrared sensor system for the F-35 Joint Strike Fighter, DAS showed off an eye-opening ancillary capability during the June flight over the Atlantic when the system detected the launch of a two-stage Falcon-9 rocket from Cape Canaveral. A video released by Northrop Grumman shows DAS footage of the missile being detected at the horizon break (without external cues) then tracked through first-stage burnout, second-stage ignition and through the rocket's second-stage burnout at a distance of more than 800 miles.

The demonstration sent a clear signal to DoD and other entities that Northrop Grumman's new product could be used for ballistic missile defense in addition to the purpose for which it was originally designed – as the front end of the kill-chain for the F-35.

"DAS truly revolutionizes the way we think about situational awareness," says Dave Bouchard, the director of F-35 sensor systems at Northrop Grumman's ES3 sector. The system's ability to simultaneously detect and track aircraft and missiles in every direction, "with no practical limit on the number of targets it can track," is what distinguishes it, he adds.

A still from a Northrop Grumman video of the Falcon-9 rocket launch captured on the F-35's Distributed Aperture System (DAS) from more than 800 miles away. Photo courtesy of Northrop

Northrop Grumman describes DAS as the only 360-degree, spherical situational awareness system in existence today. Comprised of six mid-wave infrared cameras located on the forward and center fuselage of the F-35, DAS can warn JSF pilots of incoming aircraft and missile threats, provide 360-degree day and night vision, fire control capability, and precision tracking of wingmen/friendly aircraft for tactical maneuvering.

Grumman.

Images gathered by the six DAS sensors are fused to create a seamless picture that can be likened to a bubble of situational awareness surrounding each aircraft. Pilots even have the capability of seeing through the floor of the aircraft. Further, because DAS is passive, an operator does not have to point the sensor in the direction of a target to gain a track.

"The plan from the beginning was that we would have the system's three main functions, missile warning, situational awareness IRST and navigation/FLIR, running simultaneously and passively," Dave Bouchard affirms.

"DAS is displayed in two primary ways," Bouchard continues. "DAS video is outputted to the pilot's helmet-mounted display. To whichever sector a pilot steers his head, one of the six cameras on the airplane will provide the image that shows up on his helmet mounted display. There's also a second channel on the system that displays inputs to a PCV (Panoramic Cockpit Display). The pilot can select from the available cameras which field of view he wants displayed on the PCV."

Northrop Grumman, Lockheed Martin, and the pilots currently helping to develop the JSF have begun the process of defining the symbology that will be presented to pilots along with video imagery in the helmet-mounted display. The same holds true for the symbology accompanying the images presented on the PCV. The goal is to make the presentation concise and informative without overloading the pilot.

When the system detects a missile or aircraft, DAS provides the detection information to the F-35's sophisticated suite of mission systems, known collectively as its integrated core processor (ICP). As Dave Bouchard explains, the ICP or what he refers to as the F-35's "fusion engine," then fuses the information.

"All mission systems sensors in the F-35 input to Lockheed Martin's fusion engine. Ultimately, the fusion engine determines the outcome. It's not that the radar will do this or DAS will do that. The radar and DAS input information into Lockheed's fusion engine and then that system provides the answer or output. DAS is a key player in the entire kill-chain with the system being on the front end."

Thus, DAS provides situational awareness for the pilot and aircraft while teaming with the F-35's AN/APG-81 advanced electronically scanned array (AESA) fire-control radar (also designed and produced by Northrop Grumman) and other mission systems to track, evaluate and potentially target incoming threats. The range at which DAS can detect targets is classified, but Northrop Grumman lauds the system for its "long range detection capability and near 20/20 visual acuity."

Northrop Grumman's BAC 1-11 in flight over central Maryland. This aircraft is being used to test the radar and DAS that will be employed by the F-35. Northrop Grumman photo.

"Certainly the AESA radar and the DAS should be a strong combination given what the radar can do looking forward of the aircraft and what DAS can do with its 360-degree sensor coverage," Bouchard notes.

Northrop Grumman claims that with DAS, "surface-to-air missiles can no longer hide." DAS "instantaneously detects" tactical SAM and man-pad launches, predicts the target, alerts the pilot and allows time for a choice of countermeasures. The firm says the system makes a counter-attack possible before the shooter can hide. The capability would aid any future AEW role the F-35 may take on.

The detection capability also applies to anti-aircraft fire, artillery and tactical ballistic missiles. Upon detection, DAS shares information with the F-35's ICP, enabling its AESA radar and EOTS (Electro-Optical Targeting System) to image and identify the target and then launch an immediate counterattack if necessary.

Another feature of the system is its IRST (infrared search/track) which can detect and track approaching aircraft from any angle. Northrop Grumman maintains that DAS "virtually eliminates" surprises, even during non-radar or visual intercepts. "With DAS and high off-boresight weapons, the F-35 can actually have a kinematic advantage over a pursuing aircraft. The enemy can either break off the attack, try to defeat the inbound missile or suffer the consequences."

This scenario (among others) is illustrated in a video (AN/AAQ-37 EO DAS for the F-35) available on its website and on You Tube.

According to the company, the system's ability to provide continuous tracking and identification of wingmen and other "in-range aircraft" pays special dividends during close-in engagements. Where other automatic identification systems fail, DAS maintains tracking and ID correlation even during air-combat-maneuvering despite the similar appearances of some aircraft or the loss of visual contact by an F-35 pilot.

Further, Northrop Grumman professes, "With DAS, instead of engaging in a classic dogfight, the F-35 has the option to simply exit the fight and let its missiles do the turning." It's a bold claim, but if the system works as advertised along with the JSF's other mission systems, it should give F-35 pilots a clear advantage in aerial combat.

DAS aids in navigation as well, employing imagery from its IR cameras to replace night-vision goggles (NVG) and providing better overall visual acuity. Projected directly onto the F-35 pilot's helmet visor, the imagery is independent of cockpit lighting and is said to protect pilots against "blinding laser devices."

DAS imagery can aid pilots in everything from landings in foggy or dusty conditions to day and night aircraft carrier approaches. The images gathered by the sensor system are unaffected by moon illumination and urban lighting, yielding clarity in nighttime imagery "unimaginable with NVGs" according to Northrop Grumman.

The potential of DAS as a ballistic missile defense system came as no surprise to Northrop Grumman, says Phil Edwards, the firm's manager of business development for DAS.

"Our analysis showed that we would be able to accomplish this. What the video shows (viewable in the "news releases" section of the NG website) is our demonstration of this capability with the two-stage missile launch that took place in June. So we have this additional capability, and our intention is to publicize that so that it could be utilized based on the needs of the Department of Defense."

Edwards confirms that Northrop Grumman intends to offer DAS for platforms other than the JSF.

"There's nothing about the DAS system that would prevent it from being applicable to other platforms if that was desired. Integration would be the only real developmental work required."

The biggest challenge in the development of DAS for the JSF was adapting the system for the three variants.

"There are six DAS sensors on each variant," Dave Bouchard explains. "They're in relatively similar positions on each model. The challenge was to design one camera that could withstand the vibration and shock it might encounter in any of the 18 positions it might be located on the variants. Those 18 different locations have potentially 18 different sets of physical constraints depending on the variant of the airplane. Being able to design a camera that can withstand a carrier landing or withstand STOVL vertical takeoffs and other evolutions while offering the performance that it has despite very harsh environmental conditions for an IR system was very difficult.

Flying aboard Northrop Grumman's BAC 1-11 since 2005, Bouchard reports that DAS will fly with the Block-1 software version of the F-35 and that there is room in the DAS system for growth. The next step is development and integration work with Lockheed Martin.

"Our software has been delivered to Lockheed Martin for all three main capabilities. We've completed our qualification testing at Northrop Grumman (ES3) in Baltimore and we're in the process of starting the next four to five years of flight test aboard Lockheed Martin's "CATbird" (Cooperative Avionics Test Bed, a modified Boeing 737) F-35 test bed. And we'll continue to work on follow-on capabilities for the DAS. There will be a Block-4, then a Block-5 and a Block-6."

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