A pilotage distributed aperture system (PDAS) from Lockheed Martin Missiles and Fire Control now gives cockpit and cabin crew of the Bell Valor Joint Multi-Role Technology Demonstrator (JMR-TD) spherical situational awareness. Bell chief engineer for V-280 advanced tiltrotor systems Paul Wilson observed, “This sort of sensor capability [has] never been available before on a rotorcraft.” The federated PDAS ties head-tracking helmet displays to six staring infrared (IR) sensors and enables multiple independent users to look anywhere around the aircraft, even through aircraft structures. “All you need is the processor to make a line-of-sight from anyone on that platform,” said Wilson.

The JMR-TD aims to help the Army make informed decisions about Future Vertical Lift (FVL) platforms with different capabilities. PDAS, with its modular, open-system processor, also lends itself to different platforms. Lockheed Martin plans to fly a tactical installation kit on a Black Hawk helicopter next year. According to advanced rotary-wing systems product manager Alex Shepherd, “Our company had an interest in forming requirements for the next generation of sensors going on this platform and those applicable to our current fleet of aircraft.”

Lockheed Martin today integrates the Northrop Grumman AN/AAQ-37 distributed aperture system (DAS) on its F-35 Joint Strike Fighter, but last year chose a cheaper, more sensitive and more reliable Raytheon substitute for the high-flying jet. Low-flying rotary-wing applications nevertheless posed different challenges and drove a separate five-year development effort at Missiles and Fire Control in Orlando, Florida. Fixed-wing fighters, for example, have space, weight and power for internally mounted, actively cooled infrared sensors. “In the Army scenario, there’s very little cooling air available on the aircraft,” explained Shepherd. “From an environment standpoint, it’s harder to vibration on the rotary-wing platforms, and some of the temperature extremes at low altitude can impact the system.”

PDAS connects its convection-cooled, mid-wave IR sensors to an open architecture processor (OAP) that stitches sensor fields-of-view together seamlessly as the user moves the helmet field-of-regard. It shows each user black-and-white video with superimposed symbology for the Valor pilots or crew chief to clear a landing zone by day or night. “It’s a very clever image-stitching algorithm,” noted Wilson. The same system could help Valor crews see through degraded visual environments (DVE) for safer landings or build situational awareness among airborne troops before they deploy.

**By Frank Colucci**

The Bell V-280 tiltrotor trials a fighter-like distributed aperture system applicable to other rotary-wing platforms.

Six staring infrared sensors on the Valor nose, empennage, roof and belly give multiple crewmembers all-round visibility. (All photos from Lockheed Martin except where noted)
The V-280 has demonstrated its handling qualities at low speeds and fastrope deployment in a hover, conditions made safer by all-round situational awareness. (Bell photo)

The Lockheed Martin pilotage distributed aperture system on the Bell Valor ties aircraft sensors to a Thales Visionix Scorpion helmet-mounted display via an open architecture processor.

The Lockheed Martin PDAS arose from an advanced independent research and development effort under the company’s sensors and global sustainment business. It leveraged sensor technology matured on the company’s big F-22 Raptor fighter jet.

The F-35 DAS pipes processed imagery to an expensive, custom-fit, helmet-mounted display system worn by the solo pilot (see “Heads Up, Eyes Out, All Around,” Vertiflite, Sept/Oct 2018). The PDAS test configuration on the Valor JMR-TD feeds two head-tracked helmet displays simultaneously. A production system could support six users. “The biggest thing that you need for the change from fixed-wing to rotary-wing is system latency,” offered Shepherd. Army researchers found latency greater than 55 msec from photon to eyeball in low-altitude flight causes motion sickness. “Overcoming that problem is one of the key things associated with helicopter applications.”

Unlike the highly integrated F-35 DAS, the Valor PDAS does not interface with other aircraft systems. “For experimental purposes, we don’t run things through the avionics on the aircraft,” said Shepherd. “In our demonstrations, we were a federated installation.” The OAP nevertheless has a modular open system architecture (MOASA) and complies with Future Airborne Capability Environment (FACE) standards. More integrated applications might tie PDAS to automated aircraft survivability equipment (ASE) or autonomous flight controls. “That’s part of how we intend to inform FVL capabilities — show the utility of having that output for the user or for machine learning, other algorithms that reduce pilot workload.”

PDAS imagery could also be shared with off-board users via datalinks. According to Shepherd, “The hallmark was to get away from one-aperture, one-eyeball and move to multiple sensing where the sensors are used by everyone on the aircraft but are able to do multiple things. On rotorcraft, weight is of primary importance.”

The AN/AAR-56 missile launch detector (MLD) on the air dominance fighter turns infrared events into warning cues but does not show the pilot real-world video imagery. However, YouTube videos show high-quality ground imagery captured by the MLD sensors on a test helicopter. The rotary-wing PDAS consequently enhances both situational awareness and survivability, according to Shepherd. “All our threat-warning capability is baked into this. That runs as a parallel output.”

The Open Architecture Processor (OAP) for PDAS evolved from the common sensor electronic units used in other Lockheed Martin applications. OAP hardware and MOASA standards can help save weight and power on helicopters. Shepherd explained, “If this were to be adopted as a solution, the clear advantage of OAP is to consolidate multiple processing boxes. Right now, pilotage, ASE and DVE systems, they generally come with their own processing resource requirements. They come with their own boxes. When you count the number of processing boxes associated with these capabilities, if I had a multifunction system, I could free-up weight for gas, bullets, etc.”

You See What?
The US Army Night Vision and Electronic Sensors Directorate (NVESD) at Fort Belvoir, Virginia, test-flew a Raytheon advanced distributed aperture system (ADAS) on a UH-60 from 2008 to 2011 (see “Look All Around — And Through,” Vertiflite, July/Aug 2012). The Lockheed Martin PDAS arose from an advanced independent research and development effort under the company’s sensors and global sustainment business. It leveraged sensor technology matured on the company’s big F-22 Raptor fighter jet.

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MOSA has other potential payoffs. “PDAS is architected such that other sensors on the aircraft can be fused into the picture that goes to the operator,” said Shepherd. Multi-modal sensor fusion in PDAS could, for example, integrate infrared imagery with radar or lidar obstacle avoidance cues and other inputs. The Army Combat Capabilities Development Command (CCDC) Aviation and Missile Center (AvMC) at Redstone Arsenal in Huntsville, Alabama, manages the Degraded Visual Environment –Mitigation (DVE-M) project and plans to demonstrate sensor-driven guidance in different degraded visual environments in 2020. Its DVE-M test aircraft is a modified EH-60L with lidar, radar and three fused forward looking infrared (FLIR) sensors plus a distributed aperture system. The objective is 360-degree situational awareness through a bi-ocular, helmet-mounted display.

Under a cooperative research and development agreement with NVESD, Lockheed Martin flew more than 10 PDAS risk-reduction flights on a Black Hawk in 2017 around Fort Belvoir and Washington, DC. The Army directorate declined to discuss PDAS results, but the trial installation used a single mount with three sensor heads to cover only the forward hemisphere of the helicopter. A productionized tactical kit would put sensors all around the aircraft. “We intend to approach it with six as the standard,” said Shepherd. “Some believe we could get away with five, but six provides the full 4-pi steradian [the complete sphere around the aircraft] coverage without any gap.”

So far, PDAS has used two different head-tracked displays and overlaid color symbology on sensor imagery. Shepherd acknowledged, “One of the things we’ve benefitted from is the government over the last several years developing symbology. We received aeromedical symbology via CRADA [Cooperative Research and Development Agreement]. Where possible, we’re adding things from other programs on our own, whether from Apache or fixed-wing programs.”

PDAS displays tested so far are compatible with the standard HGU-56P aviator’s helmet. The Thales Visionix Scorpion monocural common helmet-mounted display prototype uses a hybrid optical-inertial head tracker and has its own cockpit interface control unit. Adhesive stickers around the Valor cockpit provide head-tracking reference points. Lockheed Martin engineers also tried an SA-62/S biocular helmet display from SA Photonics and a monocural display from NVESD on the Black Hawk. “Our goal was to integrate with a monocural and a biocular display in order to evaluate both,” explained Shepherd. “Typically, what we’ve seen is the Apache users trained in monocural displays know how to use them. The guys who fly goggles like the biocular [display]. It’s a training thing I believe.”

The helmet displays in the Valor plug connect to PDAS with physical cords, but Paul Wilson noted, “Wireless capability is available. We’ll have the capability to downlink [imagery] as well.”

**Platform Possibilities**

The Bell Valor and Sikorsky-Boeing Defiant demonstrators model the Army’s Future Long Range Assault Aircraft (FLRAA) meant to replace the Black Hawk. Bell completes its period of performance this September and plans other technology insertions. “The PDAS is an example of that new capability,” said Paul Wilson. Bell put six sensors on the V-280 demonstrator in March 2019 — two on either side of the nose, two on the empennage, one on top of the fuselage and one centered on the belly.

By May 2019, the Valor had logged more than 110 flight hours and topped 300 kt (555 km/h) true air speed. The ferry flight from the Bell Amarillo, Texas, military assembly facility to the company’s flight research center at Arlington Municipal Airport stretched 370 nm (685 km) across Texas. “That’s not the maximum capability of the aircraft,” noted Paul Wilson. Equally significant for the FLRAA mission, the V-280 also demonstrated low-speed agility with control power for pitch, roll and yaw, enhanced by the greater blade flapping built into the third-generation tiltrotor.

The Valor has flown with doors open and hovered for fastroping; sling loads are planned for later this year. Autorotations have been performed in the V-280 simulator and flown by the smaller AW609 tilt rotor. While the tip-to-tip span of the Army JMR-TD obviously makes the V-280 a big aircraft for confined landing zones, PDAS gives the crew a clear view of obstructions and other hazards, even in degraded visual environments. “Our goal is to give them an out-the-window view on VFR [visual flight rules] on a clear day,” said Shepherd.

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**High quality imagery from Lockheed’s AN/AAR-56 missile launch detector led to the PDAS development.**

**PDAS mid-wave infrared sensors were installed in six positions on the V-280 to provide 360 degree spherical coverage. (Bell photo)**