Technology for the Next Fight

By Frank Colucci

The AHS HELMOT XVII meeting provided snapshots of efforts to increase the speed, survivability and autonomy of vertical lift.

Radiant Technologies' Ground Fire Acquisition System (GFAS) was deployed on the AH-64D in 2012. The quick-reaction wingtip-mounted pods required no aircraft software changes. (Radiant Technologies photo)

HELMOT has traditionally been held every two years, organized by the AHS Hampton Roads Chapter and the Southeast US Region. This year's 17th biennial meeting indicates that the very first event took place in 1984.

Due to a last minute change in the US Army's conference policy, in 2012 AHS was only able to support the Army-sponsored JMR Phase 1 Industry Day meetings that were planned to be part of HELMOT XV. In 2014, a "HELMOT LITE" was held with classified meetings only. This year, HELMOT XVII was open to the public, but the government's classified presentations were held completely separately for the first time.

AHS International continues to work with our chapter members and US government agencies to adapt to the latest conference attendance procedures in order to maximize collaboration.

The first open AHS International Helicopter Military Operations Technology (HELMOT) meeting convened in six years gave attendees in Newport News, Virginia, a sampling of timely developments in US military vertical lift. With most US combat forces withdrawn from Afghanistan and Iraq, rotary-wing technologists heard how Future Vertical Lift (FVL), Degraded Visual Environment Mitigation (DVE-M), Manned-Unmanned Teaming (MUM-T) and other initiatives can leverage lessons learned.

Lockheed Martin speaker Don Reed told the audience of a warfighter who credited a peculiar helicopter with saving his life when it resupplied his endangered unit. The Lockheed Martin/Kaman K-MAX Cargo Unmanned Aircraft System (UAS) that Marines took to Afghanistan in 2011 brought supplies to units under fire and routinely delivered loads with 3 m (10 ft) accuracy or better. In one case, the pilotless demonstrator hauled 4,313 lb (1,956 kg) to a mountain landing zone at 15,000 ft (4,600 m). The Army's Autonomous Technologies for Unmanned Air Systems (ATUAS) effort subsequently enabled the unmanned helicopter to pick landing zones amid obstacles. Mr. Reed concluded, "If we have this kind of capability today, imagine where we're going to be tomorrow."

Unmanned helicopters remain just one area of military opportunities for a rotorcraft industrial base denied big commercial orders by depressed oil prices. AHS International executive director Mike Hirschberg reminded his HELMOT audience that the V-22 Osprey tiltrotor remains the only really new US military rotorcraft design fielded in the last 30 years and cautioned, "We have to keep the base really solid." He added, "We work best when we have industry, government and academia all working together." The Vertical Flight Technical Society lobbied Senate and House members in 2008 for the Congressional direction that initiated FVL, and has worked to increase funding for its Joint Multi-Role Technology Demonstration (JMR TD) started in 2010. The Science and Technology (S&T) effort today expects Bell and Sikorsky-Boeing teams to fly their advanced tiltrotor and compound helicopter demonstrators in 2017, and it continues Technology Investment Agreements with small, innovative design houses AVX Aircraft and Karem Aircraft.

Survivable and Smart

Future military rotorcraft nevertheless require practical, affordable technology. HELMOT technical chair Allen Walker of the Avionics and Networks Technical Area in the Army Aviation Development Directorate (ADD) advocated a model-based approach to test and qualification and opened the sessions with a warning: "If we can't integrate it into the system and qualify it, it's going to sit on the shelf." Gurnery Thompson from PRICE Systems, LLC, described improved predictive cost analytics and model-based engineering for rotorcraft. The updated TrueRotorcraft tool set developed for the Vertical Lift Consortium and used by the Army's Aviation and Missile Research, Development and Engineering Center (AMRDEC) started with a Bell Helicopter cost model and drew on Georgia Tech expertise to include test and evaluation costs, Technical Readiness Levels, and Operations and Support costs. According to Thompson, "With each technology, you can define its impact. How is it going to impact fuel consumption, reliability, production costs?"

Radiance Technologies chief technology officer Dr. Peter Weiland recounted the evolution and integration of the Ground Fire Acquisition System (GFAS) combat-deployed in August 2012 on a battalion of AH-64D attack helicopters. The broadband mid-wave infrared sensor with hyper-temporal processing gave attack helicopter crews real-time situational awareness, identifying and locating enemy fires down to the type and number of rounds fired. It also cued the Apache's Modernized Target Acquisition Designation Sight (M-TADS) to return fire and gave analysts post-mission intelligence about the enemy. "As soon as they shoot their weapons, they give themselves up," summarized Dr. Weiland. GFAS has yet to be adopted for the Apache fleet, but Boeing has since developed a GFAS installation A-kit for the new AH-64E Apache Guardian. The sensor could enhance air-to-air targeting accuracy against UASs. Dr. Weiland shared the Army perspective: "We don't want to add another single-purpose sensor. The whole idea is to get multi-uses from them."

George Logan from ADD outlined the progress made in rotorcraft autonomy and teaming. The VUIT-2 (Video from UAS for Interoperability Teaming Level II) integration that gave AH-64Ds access to UAS imagery in combat led to the upcoming SUMIT (Synergistic Unmanned-Manned Intelligent Teaming) effort. SUMIT capabilities of interest include autonomy in mission task planning and synergistic unmanned-manned teaming. The program will look at improved Human-Machine Interfaces (HMIs) and decision aiding. A SUMIT contract award next summer will build a government-owned simulation testbed in Huntsville, Alabama, to integrate alternative HMIs, sensors and image generators in a Future Airborne Capability Environment (FACE)-compliant architecture and will focus on how an air mission commander controls a team of autonomous unmanned systems.

"If we have this kind of capability today, imagine where we're going to be tomorrow."

Scott Wigginton from the Army ADD provided a FACE overview and noted, "We're trying to get capabilities out to the warfighter faster, cheaper." Current software typically saddles military programs with sole-source solutions that don't scale well across different platforms, and each software block can consume 18 to 33 months of integration time. The FACE consortium of government and industry answers such shortcomings with a common operating environment defined by strict legal standards. The objective is to maximize interoperability and re-kindle competition with a layered software architecture that works on any FACE-compliant platform. "FACE is the interface, not the functional capabilities you need," explained Wigginton. The Army is investigating FACE as an open architecture for the digitized UH-60V, and the Navy looks to apply the standard to the updated MH-60R/S mission computer during Seahawk service life extension programs. FACE is also a foundational element of the FVL avionics architecture.

Lockheed Martin's unmanned Kaman K-MAX helicopter built a knowledge base of Cargo UAS operating experience in support of more autonomous rotorcraft. (Lockheed Martin photo)

Pending firm technical requirements, FVL is expected to provide some kind of optionally manned capability. Boeing technical fellow Dr. Tom Dubois offered the HELMOT audience his perspective on vertical lift and unmanned systems. He explained that a self-ferrying FVL able to "tether" on another aircraft, air-refuel automatically, and conduct dynamic Intelligence, Surveillance and Reconnaissance (ISR) without a pilot will need an Autonomy Level For Unmanned Systems (ALFUS) of 7 or higher. Dubois observed, "You are going to need a much tighter coupling between mission systems and flight controls."

Morgan Davidson of Utah State University described integration work aimed at an Autonomous Rotorcraft Remote Weapon System. The university-affiliated Space Dynamics Lab research center specializes in sensors, cryogenic systems and data processing, and it helped the Army Aviation Applied Technology Directorate (AATD) test a geo-aware, vibration-cancelling airborne remote sniper system (ARSS). ARSS tracking was tested on a Vigilante

Sikorsky-Boeing's analysis of the FVL Medium Assault and Attack requirements currently suggests two different aircraft with a high degree of commonality. (Sikorsky-Boeing graphic)

UAS in 2008, and the system subsequently fired a rifle from a UH-1 testbed. As an integrated ISR asset, ARSS can take targets from and push targets to a network. Follow-on technology can also be applied to a remote door gunner position on a manned helicopter or on some optionally manned aircraft. Plans call for firing trials on a Black Hawk in the first half of 2017.

Bell Helicopter unveiled its V-280 Valor JMR Technology Demonstrator in September, stating at the time that it was 65% complete. This photo was taken Aug. 1. (Bell Helicopter photo)

Aircraft Survivability engineer Tim Rouse from the AATD mission systems branch examined the challenge of total aircraft survivability and said, "The way we're doing business now does not support the integrated survivability idea." Where stand-alone systems now detect and jam threats, holistic solutions should integrate situational awareness and decision making with other survivability measures. The Aircraft Survivability Integrated Product Team (ASIPT) includes representatives from AMRDEC, the Army's Communications-Electronics Research, Development and Engineering Center (CERDEC), the Air Force Research Laboratory (AFRL) and other authorities. It seeks multi-layered, affordable solutions ranging from signature management to route planning to ballistic protection. The ROSAS (Route Optimization for Survivability Against Sensors) effort that developed a 3-D survivable route planner for aircrew is now part of the Rotorcraft Detection System effort. The ASIPT also looks at Signature Reduction for Advanced Threats including conformal apertures and antennas, and advanced infrared suppressors. Also under study is a Rotorcraft Threat Protection System (RTPS) expected to develop a hard-kill capability — kinetic or energy-based — to shoot back at threats. The results of ASIPT investigations will contribute to the FVL Science and Technology base.

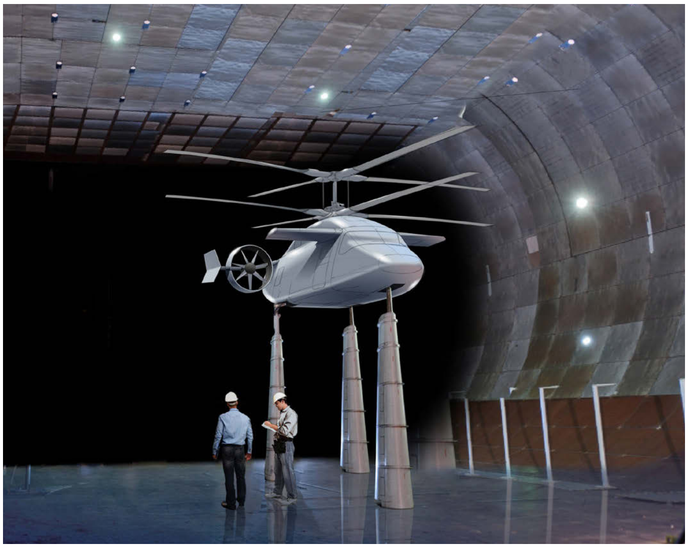
Army aviation wants to use degraded visual environments to enhance survivability; the science and technology of DVE Mitigation was addressed by ADD program manager Kris Kuck, and test pilot and assistant program manager Maj. Paul Flannigen. DVE-M integrates see-through sensors, cockpit symbology and modernized control laws (MCLAWS) to take pilots through the full spectrum of DVE conditions. "What works in brownout may not work in whiteout and may not work in fog," said Kuck. The DVE-M program seeks answers for a 360° solution applicable to multi-ship formations in brownout, whiteout, rain, fog, smoke darkness and other obscurants at any point in the mission. "We're not building a system. We're building a knowledge base for the [Product Manager and Program Executive Officer] to help him build a system."

Phase I DVE-M component technology demonstrations were flown in brownout conditions at Yuma Proving Ground in August and will extend to snow, fog and rain conditions in Europe next year. Confidence in the integrated sensor-symbology-flight control solution will lead to Phase II mission demonstrations in fiscal 2018, followed by takeoffs, landings and hovers with the best solution in fiscal 2020. The EH-60L test aircraft made obstructed-field landings and approaches at Yuma using MCLAWS, Lidar/radar/FLIR sensors, and geogrid symbology on panel and helmet displays. MCLAWS meanwhile gives the H-60L flight controls pilot-selectable stabilization. Maj. Flannigen noted, "The sensor image is not the answer. The sensor gives you situational awareness, but SA is no good if you can't fly the helicopter." Still to be refined is the optimum mix and timing of visual, aural and tactile cues in the DVE-M Integrated Cueing Environment.

Integrating FVL

DVE-M, like other technology developments, is aimed at some FVL replacement for today's helicopters. Five FVL Capability Sets now define vehicles of different sizes for different missions, and the JMR Technology Demonstration begun in 2013 lays the technical foundation for an FVL request for proposals around 2019 and an operational vehicle around 2030. The HELMOT audience heard technology presentations from all four industry players in the JMR TD.

AVX Aircraft president Troy Gaffey told HELMOT attendees about the AVX Coaxial Compound Helicopter (CCH) technology for the JMR TD and FVL. AVX is a "virtual OEM" (Original Equipment Manufacturer) already partnered with Northrop Grumman to demonstrate Tern VTOL UAS technology for the Defense Advanced Research Projects Agency/Office of Naval Research. The team will deliver a 2,000 hp (1,500 kW) proprotor gearbox to drive 24 ft (7.3 m) diameter coaxial rotors on the Tern ground rig in 2017. Gaffey noted, "The technology in this proprotor is basically what we will be proposing for the Future Vertical Lift."



AVX hopes to test a half-scale Coaxial Compound Helicopter in the NASA 40 ft by 80 ft wind tunnel testing as part of an extended JMR Technology Investment Agreement. Like Bell's V-280, the CCH attack and utility variants have common fuselages. (AVX Aircraft graphic)

AVX completed JMR Task 1 wind tunnel tests on its CCH model in February 2016 and remains under contract to analyze the CCH rotor/fuselage interaction and conduct studies of rotor dynamics and spacing. A hoped-for Task 4 could put a powered CCH model in the 40 ft by 80 ft (12.2 m by 24.4 m) National Full-scale Aerodynamic Complex (NFAC) wind tunnel at NASA Ames and lead to a competitive FVL bid teaming AVX with a major manufacturer. The CCH concept combines a low drag/high-hover-efficiency coaxial rotor with ducted thrusters. AVX envisions aircraft from a 10,600 lb (4.8 t) UAS to a 60,000 lb (27.2 t) tilt rotor transport. A conceptual 25,000 lb (11.3 t) CCH with 62 ft (18.9 m) diameter rotors would carry 12 troops and four crew at 212 kt (393 km/h) with current technology engines or 230 kt (426 km/h) with two 3,000 shp (2,240 kW) engines from the Improved Turbine Engine Program (ITEP). Gaffey explained that low CCH disc loading reduces power required in a hover and potentially offers the Army a more affordable FVL. He offered, "We can put enough power in there to achieve whatever is required. It's just going to drive up acquisition and operating costs."

Brian Ehringer, chief of engineering for the Bell V-280, told the HELMOT audience how the Valor JMR demonstrator draws on V-22 experience to provide a third-generation tiltrotor that can evolve into a family of FVL platforms. The advanced tiltrotor with its straight wing and fixed engines was designed for affordability. The wing skin, for example, is fabricated from composite broad goods without costly tape or tow placement. Broad goods used on proprotor yokes meanwhile cut parts count by 75% and cost by 50% compared with more complicated V-22 components.

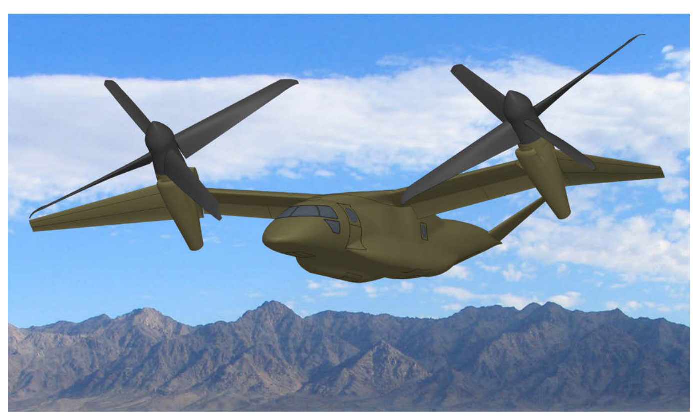
By the time of the HELMOT meeting, the V-280 JMR demonstrator was more than 65% built. Wing and fuselage were mated in April and gearboxes installed in November. Flight control and systems management software was running with control hardware in the Bell Systems Integration Lab. A Lockheed Martin cockpit integrates large displays with tailorable windows. The Bell JMR demonstrator will use General Electric T64 engines. FVL Capability Set 3 defines a utility/assault transport to replace today's UH-60 Black Hawk, but Bell engineers believe the same V-280 wing and Future Advanced Affordable Turbine Engines (FATE) could provide the basis of an FVL attack variant with 95% commonality.

SB>1 Defiant manager Doug Shidler described how the Sikorsky-Boeing team intends to demonstrate an advanced coaxial helicopter with an integrated auxiliary propulsor. The Defiant JMR TD scales up successful X2 technologies to carry 12 troops and four crew at 250 kt (463 km/h) with hover-out-of-ground effect (HOGE) at 6,000 ft / 95°F (1,800 m / 35°C). The tail propeller engages at 150 kt (278 km/h) and promises the fast, agile demonstrator level-body acceleration, a vertical rate of climb around 500 fpm (150 m/min), and a vertical rate of descent of 10,000 fpm (3,050 m/min) without fear of Vortex Ring State. Piloted simulations are underway at Boeing Philadelphia.

Sikorsky is meanwhile flying the 16,000 lb (7.3 t) S-97 Raider with and without an operating tail propeller at West Palm Beach, Florida, in part as a risk-reduction article for the SB>1. The Defiant team is simultaneously building both the SB>1 demonstrator and its Propulsion System Test Bed at West Palm Beach and aims for a JMR first flight by the end of 2017. Where the SB>1 uses familiar Honeywell T55 turboshafts, the bigger FVL will need the power of FATE. Requirements for a utility FVL (Capability Set 3) are yet to be set, but an FVL attack variant could marry tandem cockpits to the same dynamics. Shidler observed, "Our perspective is to drive the requirements down, so it becomes a real affordable aircraft."

Karem Aircraft vice president Dr. Ben Tigner provided an overview of Optimum Speed Tilt Rotor technology for FVL. The OSTR with light, stiff blades and rotor speeds variable over a 2:1 range promises high propulsive, aerodynamic and weight efficiencies to carry more, over greater distances with less power. "We draw the DNA of the OSTR much more from the fixed-wing world than the rotary-wing world," noted Tigner. "On-station times should not be measured in minutes. They need to be measured in hours, sometimes days." Electromechanical actuators for Individual Blade Control (IBC) eliminate hydraulics. Karem has test rigs for blade loading, IBC avionics and tilt actuators, and the OSTR hub in operation; Karem plans to run a powered single-rotor test stand.

Whatever their shape, fast, agile, smart new rotorcraft will be highly integrated, affordable and supportable systems. HELMOT XVII technical chair Allen Walker reminded the AHS audience, "We're living in very challenging times.... If it was easy, they wouldn't need us to do it."



Karem's FVL Capability Set 3-compliant configuration is the KVL-3 Mustang. Karem hopes to run a full-scale powered single-rotor tiedown test, in both helicopter and propeller modes, as part of JMR. (Karem Aircraft graphic)