The 30,000 lb (13.6 t) class Bell V-280 Valor is approaching the one-year anniversary of its first flight on Dec. 18, 2017. It has flown more than 85 hours and reached 250 kt (463 km/h) and collected data on low-speed handling characteristics for an informed decision on FVL. (Bell photo)

Defiant, Valor and the Knife Fighter

As Sikorsky and Boeing plan first flight of their Defiant demonstrator, Bell recaps a year of Valor flight testing, and industry considers a nearer-term Future Attack Reconnaissance Aircraft.

By Frank Colucci

Mechanical issues discovered by the Defiant propulsion system test bed (PSTB) have led the Sikorsky-Boeing team to reschedule first flight of its SB>1 Joint Multi-Role technology demonstrator (JMR-TD) for early 2019. "It's a relatively mundane thing that has to be fixed," said Sikorsky director of Future Vertical Lift (FVL) business development Rich Koucheravy. "We're going to fix it appropriately, no matter how mundane it is."

The SB>1 Defiant is one of two JMR flight test demonstrators. Bell now has a year of flight data from its V-280 Valor advanced tiltrotor, but the Defiant compound helicopter remains another approach to scalable FVL. Based on JMR technologies, the FVL family of fast, long-range rotorcraft was supposed to begin with a Long Range Assault Aircraft (LRAA) in production after 2030. However, the US Army has surged ahead with a Future Attack Reconnaissance Aircraft (FARA) competitive prototype that may or may not leverage JMR technology. While both JMR demonstrators model a 30,000 lb (13.6 t) squad carrier, the Army describes FARA as a small, high performance "knife fighter." FARA and LRAA both assume a digital backbone readily updated with new capabilities and compatible with optionally manned capability.

The SB>1 PSTB — with engines, drivetrain, coaxial rotor system and tail propeller thruster identical to those of the flight test vehicle — needs to run 15 hours for flight release by the Sikorsky-Boeing Defiant team. The ground test rig in West Palm Beach, Florida, first turned its rigid stacked rotor blades in November 2018. According to Koucheravy, "The prop thruster was installed for a few runs but has yet to be engaged." Initial runs of the PSTB resulted in an undisclosed "minor discovery." Remedies will return the PSTB to test runs in late December. "That's the purpose of building the PSTB," summarized Koucheravy, "so we discover it off the aircraft and are able to implement the fix. We're working those fixes."

Defiant and Valor

Assembly of the SB>1 air vehicle at West Palm Beach is complete, and fixes implemented on the PSTB are applied simultaneously to the flight test article. Randy Rotte, Boeing Director of Global Sales & Marketing for Cargo Helicopters and FVL observed, "… every component on the aircraft has been tested individually in a SIL [Systems Integration Laboratory] to check its functionality, to make sure it actually does what it's supposed to do. PSTB is our opportunity to test everything as a system."

Sikorsky-Boeing engineers previously encountered difficulties with Defiant main rotor blades and transmission gears. "They were both about manufacturing," said Rotte. "They were not about necessarily design or configuration." To save time and money, Defiant main rotor spars were made on an unmodified tow placement machine with a horizontal mandrel that lacked stiffness needed for the long, extra-stiff SB>1 blades. A production machine would use a vertical mandrel to avoid the problem. First-run Defiant transmission gears likewise failed to achieve hardness required for the integrated drive system. Gears were re-ground to achieve desired hardness. "The blades and transmissions are

As of press time, the Sikorsky-Boeing JMR team had not released any new photos of the Defiant demonstrator or any other test assets in more than a year. This photo of the Defiant PSTB test rig from August 2017 is missing all the rotating hardware. (Sikorsky photo)

performing like champions," said Rotte. The PSTB has achieved 100% rotor speeds but revealed more anomalies that required fixes. Rotte explained, "It's nothing that has required a redesign of major components or any of those things."

In parallel with the PSTB, the Defiant software integration lab ties a flight simulator to a lab version of SB>1 flight controls. According to Rich Koucheravy, "Whenever this flight simulator is 'flown,' the entire flight control system of the Defiant is exercised." The lab is used to continue software and hardware development for the digital, full-authority fly-by-wire control system and to rehearse test flight profiles. The software integration lab and other Defiant simulators also conduct operational analyses in operationally relevant environments. "We then capture the time-history data from these flights for the purpose of analyzing how Defiant can and will provide the Army with an advantage on the battlefield, as compared to existing medium helicopters."

Even without flight test data, the Sikorsky-Boeing agreement with the Army allows the team to provide routine reports including component bench testing, PSTB testing and lab data on flight control hardware and software. Koucheravy explained, "We also have wind tunnel data that we have provided the Army within our reports. Personnel from the US Army Aviation Development Directorate (ADD) … routinely attend our meetings and receive other data from the program. Lastly, we send a status report monthly to leaders throughout the US Army Aviation Enterprise."

Randy Rotte told reporters, "Now it's just that last step of turning all the simulators and analysis into flight and real data."

A year after its first hovering flight at Amarillo, Texas, in December 2017, the Bell V-280 JMR-TD had logged nearly 85 flight hours and more than 180 rotor-turning hours. In airplane mode, the Valor advanced tiltrotor had attained 250 kt (463 km/h) true airspeed and 4,500 fps (23 m/s) rate of climb, and sustained flight at 11,500 ft (3,500 m). The V-280 had also made 45-degree banked turns at 200 kt (370 km/h) indicated airspeed and flew more than 370 miles (600 km) on a ferry flight. Compared to the V-22, Bell claims the Valor has greater control power and exceptional low-speed agility due to increased blade flapping in the proprotor system. Bell has a fully functioning systems integration lab to exercise Valor flight controls and provide data to the Army.

Raider and FARA

Outside the scope of the JMR-TD, Sikorsky continues to fly the company-funded S-97 Raider. The 11,000 lb (5 t) armed scout demonstrator integrates the Defiant air vehicle technologies: coaxial rigid rotor system, integrated propeller thruster, fly-by-wire flight controls and active vibration suppression. It has so far attained 200 kt (370 km/h) in forward flight and 25 kt (46 km/h) sideways and rearward. The Raider has flown 60-degree banking turns at 160 kt (300 km/h) and demonstrated fuselage-level acceleration and deceleration.

The JMR-TD was designed to support an 'informed decision' on FVL. The LRAA-sized demonstrators and Karem's Optimum Speed Tiltrotor nacelle model FVL Capability Set 3 aircraft but provide scalable science and technology for other 'CapSets.' CapSets 1 and 2 define smaller manned and unmanned aircraft. AVX Aircraft has already refocused its JMR study efforts on a CapSet 1 scout. The Army Futures Command has meanwhile called for industry proposals for an optionally manned, next generation FARA with a reduced cognitive workload and ultra-reliable, maintenance-free systems for high operational tempo. The agile knife fighter is also supposed to tap unmanned aircraft systems and air-launched UAS to manage a team to breach integrated air defense systems (IADS). Just how fast and how long-ranged the FARA will be is to

The 11,000 lb (5 t) Sikorsky Raider demonstrator has been flown to to 200 kt (370 km/h) and is a risk-reduction demonstrator for both the larger FARA (CapSet 1) and Defiant/FLRAA (CapSet 3) programs. (Sikorsky photo)

be determined, but the rotor system has to fit "urban canyons," and the digital backbone has to provide Open Systems flexibility. [This echoes the RAH-66 Comanche, which had a similar digital quarterback role, but was cancelled in 2004.]

The Army required industry responses to the FARA Competitive Prototype (FARA CP) solicitation in mid-December 2018 and plans to put four to six players under Phase I contracts around June 2019. Phase I delivers initial design and approach data to down-select two Phase II winners who will fly single prototypes in early 2023. The government plans to furnish industry users the 3,000 shp (2,240 kW) T900 or T901 improved turbine engine (ITE) as selected by the Army, but FARA plans allow for a 2,000 shp (1,500 kW) T700-GE-701D surrogate, depending on advanced engine availability. FARA CP Phase 3 evaluates the competitive prototypes and may down-select a winner for Phase 4 full system integration, qualification and production. The Army envisions FARA initial operational capability around 2028.