Risks and Rewards of FVL

The US Army balances technology, capability and affordability to build Future Vertical Lift.

By Frank Colucci

As director of the US Army Future Vertical Lift (FVL) Cross-Functional Team (CFT), Maj. Gen. Walter "Wally" Rugen values speed, standoff range and "decision dominance" to counter the US military's pacing threat — China. He told an online audience for the Center for Strategic and Budgetary Assessments (CSBA) in October, "We're laser-focused on standoff and overmatch, and we're focused on these advanced rotorcraft configurations that allow us to operate in relative sanctuary, which we view as outside the range of medium-range ballistic missiles…" Bigger, more advanced helicopters or tiltrotors to span the Indo-Pacific Command area will nevertheless cost more than today's Black Hawks and Apaches, and FVL has to weigh capability versus cost. "I think we have to be effective, and we have to be affordable," Rugen acknowledged. He added, "I think the risk of doing nothing is significant."

Army analyses of the Donbas conflict in Ukraine and other recent history showed helicopter operations stymied by modern air defenses. The CSBA study, "Living Within One's Means: Revisiting Defense Acquisition and Affordability — A Case Study of the Army's Future Vertical Lift Program," noted, "Adversaries have studied American successes, especially since the First Gulf War, and have developed systems that challenge existing capabilities." Enduring fleet Black Hawks and Apaches are meanwhile running out of space, weight and computing power for further upgrades. Rugen underscored that FVL includes open system avionics readily upgraded with new capabilities for joint-service, all-domain operations. "It's not just the truck, the air vehicle, but it's also how we are working the mission systems and [how we'll] have those ready for the future force."

Black Hawk and Apache acquisition programs overlapped, and the CSBA study considered FVL costs compared to today's helicopters and relative to modern Army budgets. Based on historical spending, the FVL Future Attack Reconnaissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA) should be affordable if development, procurement and operating and support (O&S) costs average no more than 1.6% of the Army's overall annual budget or 4.5% of its yearly procurement budget. Unlike past parallel programs, FVL aims to be a family or ecosystem of platform and systems. CSBA senior fellow Dr. Chris Haslick conceded, "Nearly every defense program has been declared unaffordable sometime in its acquisition cycle." He observed that FVL might likely suffer the same fate "if they want to do things the same old way."

CSBA calculated O&S accounted for 55% to 85% of life-cycle costs in past helicopter programs. The Army and industry alike look to model-based systems engineering (MBSE), digital threads and open avionics architectures to keep FVL affordable. Open systems promise plug-and-play survivability, connectivity or sensor upgrades without costly reliance on original equipment manufacturers. In a talk during the Association of the US Army (AUSA) exposition in Washington, Rugen said, "If the assumption is by our parametric cost estimators that 70% of our cost is in operations and support, we have the opportunity of drawing that down from 70 to 58% and achieving a [bigger] bang for the buck with an open system approach."

The CSBA report also sees potential savings by developing FVL platforms separate from common mission systems and payloads. An integrator, whether the government, aircraft maker or some third party, could draw on common components and technologies to enjoy economies of scale. Some technologies could enhance the enduring fleet. For example, the Apache sensors product office in coordination with Redstone Test Center and the FVL CFT this summer flew a binocular, high-definition color, helmet-mounted display in an AH-64E Version 6 attack helicopter. The 61° field-of-view display could replace the monocular Apache display system and go into FVL cockpits.

The official Department of Defense FVL vision still calls for rotorcraft scaled to five capability sets (CapSets) defined largely by range and speed. The Army's FARA fills the role of the retired

The Sikorsky-Boeing SB>1 Defiant continues its Joint Multi-Role flight test program to provide data for a Future Long Range Assault Aircraft. (Sikorsky)

A production Defiant X FLRAA in a sling-cargo mission would benefit from the efficiencies of a coaxial rotor system. (Sikorsky)

A wide field-of-view, color, helmet-mounted display tested in an Apache attack helicopter could also be used in FARA and FLRAA cockpits. (US Army)

Kiowa Warrior and today's cavalry squadron Apache, somewhere analogous to CapSet 1. The CapSet 3 FLRAA hauls people and cargo to replace, in part, today's Black Hawk. Haslick reminded his audience, "This is very important to remember these are not one-for-one helicopter replacements. [FVL is] really a suite of missions particularly centered on the scout and long-range assault missions in the high-end environment, and being able to penetrate, disintegrate and exploit advanced enemy integrated air defense systems."

Armed Reconnaissance

Big FVL signature modernization efforts are in source selection. The Army chose Bell and Sikorsky in March 2020 to design, build and test FARA competitive prototypes. The winner of the FARA engineering and manufacturing development (EMD) contract in early fiscal 2024 should begin low-rate initial production around 2028 for a first unit equipped by 2030. Cost- and timeline-sensitive, FARA fills the armed scout role of the two-seat RAH-66 Comanche canceled in 2004, the ARH-70 Arapaho canceled in 2008, and the OH-58F Kiowa Warrior Cockpit and Sensor Upgrade abandoned in 2014. Rugen told the CSBA audience, "I don't think the Army can afford another acquisition failure on its watch. We're very focused on that."

By mid-October 2021, the two FARA competitive prototypes were more than half-finished at Bell in Amarillo, Texas, and Sikorsky in West Palm Beach, Florida. With a target gross weight around 14,000 lb (6.4 metric tons), both FARA contenders leverage fly-by-wire flight controls to reduce crew workload and enhance maneuverability and survivability. They share the 3,000-shp (2,240-kW) General Electric T901 improved turbine engine.

The Army pegged the speed of the new scout at 180 kt (232 km/h). It also capped main rotor diameter at 40 ft (12.2 m) to navigate urban canyons like the fight in Mosul, Iraq. Recently, these numbers have drawn criticism as being unrealistic (see "Commentary: Decision Time for FARA," *Vertiflite*, Sept/Oct 2021). Rugen conceded, "Is that something that we're going to die [for] on that hill? No. All of our attributes are just that, something we'll look very acutely at and trade if the trade is compelling or not trade if it's not compelling." Early FVL guidance, for example, modeled hot-day performance at 6,000 ft (1,830 m) density altitude, but relaxed to 4,000 ft (1,320 m) to mitigate development risk and cost.

The tandem-seat Bell Invictus is an articulated-rotor helicopter with lifting wings to offload the rotor for high-speed cruise flight. Renderings of a ducted-fan tail gave way to a conventional tail rotor — Comanche-era studies concluded a stealthy Fantail paid for low radar cross section and good sideward handling with extra weight and increased drag above 150 kt (278 km/h), but FARA emphasizes speed. The Invictus uses an auxiliary power unit in flight to supplement its engine. It hides air modular effects launchers in its underwing bay and carries a 20-mm cannon in a nose turret. The proposed FARA crew station remains under wraps, but Bell videos have described using automation to shed electrical loads and protect critical systems without crew intervention in battle damage situations.

Sikorsky's Raider X is a compound helicopter that integrates close-stacked rigid rotors with an innovative auxiliary tail thruster to attain FARA speeds without lifting wings. Like the smaller, lighter S-97 Raider demonstrator, Raider X has a side-by-side cockpit and a cabin with room for the modular effects launcher or special operations troops. The Raider demonstrator has hit 207 kt (282 km/h) and logged 100 hours in 88 flights, as well as 137.7 ground run hours to build a body of coaxial drive knowledge. The rigid rotor has also demonstrated responsive handling, enhanced low-speed hover, off-axis hover, and level acceleration and braking. The higher empty-weight fraction of a rigid-rotor compound helicopter is partially offset by advances in composite materials. The first Raider, rebuilt after a hard landing in flight test, debuted as a tradeshow mock-up at the AUSA expo in October.

Air Assault

FLRAA promises industry the biggest potential production program with a high-speed, long-range rotorcraft to replace the Black Hawk helicopter. The Joint Multi-Role Technology Demonstrator (JMR TD) effort gave FLRAA a head-start with the Bell Valor tiltrotor and Sikorsky-Boeing Defiant compound helicopter. JMR defined a troop carrier capable of 230 kt (425 km/h) cruising speed to effectively double helicopter productivity moving troops and cargo. Allowing for tiltrotor and compound helicopter parts, the demonstrators modeled 30,000-lb (13.6-t) aircraft to replace the 22,000-lb (10-t) Black Hawk. Bell and the Sikorsky-Boeing team are proceeding with preliminary weapons system design; either the advanced tiltrotor or the compound helicopter will begin EMD in fiscal 2022 for a first unit equipped in fiscal 2030.

The Martin V-BAT UAS was one of the runway-independent unmanned aircraft systems tested by the Army to make an informed choice on the Future Tactical UAS. (US Army)

Sikorsky's S-103 Raider X for (foreground) is based on the test data and lessons learned from its S-97 Raider, as well as the Sikorsky-Boeing SB>1 Defiant (shown in the rear) development work for JMR/FLRAA. (Sikorsky)

The tiltrotor achieves maximum efficiency in wing-borne flight and gives the US Army new opportunities to self-deploy the FLRAA over long ranges. (Bell)

The Bell Model 360 Invictus stows its modular effects launchers in under-wing bays to deploy ALE or kinetic weapons. (Bell)

Bell considers the V-280 Valor with fixed engines, straight wing and V-tail a third-generation tiltrotor more affordable than the Marine Corps V-22 Osprey and tailored to the Army mission. In October, the company announced it had chosen Rolls-Royce to provide the AE1107F engines for its proposed FLRAA, non-tilting versions of the AE1107C turboshaft on the 52,600-lb (23.9-t) V-22. Refined composite fabrication and the digital thread (a high-fidelity, three-dimensional engineering mockup) promise to reduce FLRAA production and life-cycle costs.

Over 214 flight test hours, the Valor JMR TD attained 305 kt (565 km/h) in level flight and demonstrated impressive low-speed and hover agility. Bell videos cite fast, wing-borne flight at low altitude as a survivability enhancer. Valor testing included sling-lifting cargo and fast-roping troops from a hover. However, the tiltrotor remains most efficient in wing-borne cruising flight. Bell noted a tiltrotor FLRAA able to sustain 240 kt (445 km/h) in cruising flight can deploy from Hawaii to the Philippines in 20 hours, and fly-by-wire flight controls present intriguing operational possibilities. Government relations director and experienced Army aviator Terry Horner noted the big Global Hawk and other unmanned aircraft systems routinely self-deploy. "So, you could take advantage of that fly-by-wire technology and the digital backbone to move the aircraft inter-theater or intra-theater by itself to link up with the crews."

The Sikorsky-Boeing team announced in October the SB>1 Defiant JMR TD had attained 247 kt (457 km/h) in straight-and-level flight with power to spare. The demonstrator had also flown sideways at 56 kt (103 km/h) and carried a 5,300-lb (2.4-t) sling load to emphasize the efficient hover performance of the coaxial compound helicopter. According to Sikorsky's FVL business development director Jay Macklin, "We will continue to fly into the new year and validate elements of speed, maneuverability and increase load factors in support of our FLRAA design optimization activity."

In contrast to the Defiant demonstrator, the Defiant X FLRAA is optimized to the Army's mission set with aerodynamic changes to enhance handling, Comanche-like exhaust ducting to suppress infrared signature, and a tricycle landing gear to improve landing and taxiing stability in combat and austere environments. Sikorsky-Boeing officials have yet to disclose the engine chosen for their big compound helicopter.

Significantly, Sikorsky supercomputer capacity available for both FLRAA and FARA has expanded enormously compared to what was available during development of the Marine CH-53K heavy-lift helicopter. According to Macklin, "On the CH-53K, we could run computation simulation of specific elements of the design. We will now be able to simulate the interactional effects within big chunks of the aircraft." The Army will receive full digital mockups of Defiant X and Raider-X to fly them virtually in piloted simulations.

MOSA and More

The Modular Open System Approach (MOSA) will migrate from the big FLRAA to FARA, and then to Future Unmanned Aircraft Systems (FUAS), which is comprised of both the small Air-Launched Effects (ALE) and the runway-independent Future Tactical UAS (FTUAS). In September, the Army issued a request for white papers asking industry to describe solutions with high technology and manufacturing levels — FTUAS Increment 1 — to replace the catapult-launched, runway-recovered Shadow UAS.

The Invictus FARA competitive prototype is in work at the Bell Military Aircraft Assembly Center. (Bell)

One concept for the Bell 360 FARA cockpit centers on a large touch-screen to manage sensor imagery and systems information. (Bell)

According to FUAS integration lead Lt. Col. Ryan Greenawalt, an FTUAS Increment 1 contract should be awarded in the second quarter of fiscal 2022 for a first unit equipped in fiscal 2023. In parallel, an Increment 2 rapid-prototyping effort should begin around the same time and could potentially transition to a program of record in fiscal 2025.

Also under the FUAS signature modernization effort, ALE promises to give both FARA and FLRAA standoff range to confound enemy air defenses by lethal and non-lethal means. Surrogate ALE have already been launched at Yuma Proving Ground in Arizona (see "Wingman on Demand," *Vertiflite*, March/April 2021). The "ALE Small" prototyping effort will culminate with a flight demonstration in fiscal 2024. Upon completion of the flight demonstration, a decision will be made on whether to transition to a program of record or potentially conduct further prototyping. The modular effects launcher for ALE Small and Large has already been tested with surrogate vehicles in Project Convergence at Yuma.

The concurrent pieces of the FVL ecosystem should also revitalize the US rotary-wing industrial base. However, the CSBA warned of the impact should FARA and FLRAA competitions be won by a single suppler. The CSBA report noted, "With regard to the industrial base, there are no other US rotary-wing platforms on the horizon besides the FARA and FLRAA. The decision made on the FARA and FLRAA will have enormous implications for this portion of the US Defense industrial base."