US Army's FVL program evaluating capability sets and technologies for Next Generation Military Helicopters

After a decade of combat from Operation Iraqi Freedom and Operation Enduring Freedom, the U.S. Army launched Future Vertical Lift (FVL) program to replace its ageing rotorcraft fleet including UH-60 Black Hawk used by the Army, Navy, Air Force and Coast Guard, CH-47 Chinook and the AH-64 Apache used by the Army.

Future Vertical Lift (FVL) is a program to develop a family of helicopters for the United States Armed Forces. These aircraft shall share common hardware such as sensors, avionics, engines, and countermeasures. The Army plans to award a contract for the FVL program in 2019, and is looking toward an operational capability by the mid-2030s. The JMR TD program and the follow-on FVL effort will also integrate a wide range of next-generation sensors, weapons and avionics, Army officials explained.

The goal is to create a new rotorcraft that uses new technology, materials, and designs that are able to carry heavier payloads at higher speeds for longer distances, are more reliable, easier to maintain and operate, have lower operating costs, and can reduce logistical footprints. The new helicopter will also be designed to use next-generation sensors to find enemies on the move and employ next-generation weapons to attack them, Army officials describe.

"FVL is a high priority. We have identified capability gaps.

We need technologies and designs that are different than what the current fleet has. It will carry more equipment, perform in high-hot conditions, be more maneuverable within the area of operations and execute missions at longer ranges," said Rich Kretzschmar, project manager for the FVL effort. It shall have an ability to both reach high speeds and hover like a helicopter.

Increasing rotorcraft range (and speed) could conquer "the tyranny of distance," as described in a recent Center for Strategic and International Studies panel on Future Vertical Lift. Extending the range of rotorcraft could make them "strategically self-deployable," meaning they might cover long distances without needing to hitch a ride on a massive transport vehicle to get to a war zone. Self-deployability and range might also help the Army decrease its reliance on ground convoys, which can be vulnerable to attack, writes Torie Rose DeGhett.

It will include a "fly-by-wire" technology allowing helicopter to fly along a particular course by itself in the event that a pilot is injured or incapacitated. This is the kind of technology which could, in the future, allow for unmanned helicopter operations.

Joint Multi-Role (JMR) helicopter program

The precursor for FVL is the Joint Multi-Role (JMR) helicopter program, which will provide technology demonstrations planned for 2017. In 2014, it awarded contracts to Bell Helicopter/Textron and a Boeing-Sikorsky team to develop competing airframes for the Joint Multi-Role effort. The first flights of the demonstrator aircraft, slated for 2017, will include developmental helicopter/aircraft from two industry teams – Bell Helicopter and a Sikorsky-Boeing team.

The JMR program has several subprograms, with the Future Vertical Lift-Medium set to replace the UH-60 and AH-64 and the FVL-Heavy set to replace the CH-47.

Sikorsky Boeing has released a new CGI video showing off its planned entry in the Army's Future Vertical Lift program. Dubbed the Sb>1 Defiant, the concept helicopter could replace the AH-64 Apache attack helicopter and the UH-60 Blackhawk transport helicopter with a common design that is faster, has a longer range, is more maneuverable, and is quieter than previous helicopters.

The Defiant will have a top speed of 250+ knots air speed, which translates to 287 miles an hour. That's more than a hundred miles an hour faster than the UH-60M Blackhawk transport, which tops out at 183 miles an hour. Defiant also has an unspecified longer range and the ability to perform at higher altitudes where the air is thinner. It also has improved low-speed maneuverability, which will be particularly useful in urban environments.

The point of JMR is to help inform requirements for future vertical lift and to mature technology, Leslie Hyatt, the Army's program director for FVL told National Defense. "It's going to help us understand and see if the technologies that they are developing [can be applied] in a program of record," she said.

Future Vertical Lift (FVL) program

Helicopters are currently categorized by weight as light, medium, heavy and ultra-heavy. The first Future Vertical Lift aircraft to be fielded by the Army will come in the medium-lift category, where attack and cargo lift helicopters reside, according to Maj. Gen. William Gayler, the new Army Aviation Center of Excellence commander at Fort Rucker,

Alabama. Because the Marines and Air Force are more interested in a medium-lift, the Army has decided to focus on that weight class for the first helicopters that will be fielded starting in the early 2030s, according to Gayler. The Army is still leading the effort. Mike Hirschberg, executive director of the American Helicopter Society (AHS) International, agreed FVL could be either unmanned or optionally manned, given its diverse mission sets.

The Defense Department's program to develop the next generation of rotary wing aircraft will do away with categories based on weight and will instead break them down into capabilities, a senior leader in the program said on Jan. 21 as reported by Stew Magnuson in national Defense.The Army's acquisition approach divides up the family of helicopters into five "capability sets." The first set is the lightest variant while the fifth is the heaviest. Capability set 3 refers to the medium-lift variant.

Mission sets are to include cargo transport, utility, armed scout, attack, humanitarian assistance, medical evacuation, anti-submarine warfare, anti-surface warfare, land/sea search and rescue, special warfare support, vertical replenishment, airborne mine countermeasures, and others. The FVL family of aircraft will be required to have either optionally piloted or autonomous flight capabilities.

Capability Sets

"The trend now is to break the aircraft down into "capability sets," he said. There will be four or five capability sets, he said. Capability set 1, for example, might encompass reconnaissance, close-air attack and direct attack. There are new categories that are going to be rolled out soon," said Jose Gonzalez, deputy director of land warfare, munitions and tactical warfare systems. Gonzalez listed reconnaissance, close-air support, direct attack, marine interdiction, medical

evacuation and urban assault and security as some of these new capabilities.

Once the capability sets are decided upon, it will be up to the services as to which ones they want to pursue first. “We should be seeing a material development decision for an Army-led future vertical lift program, leveraging the joint multi-role program, very soon,” he said. “Once a material development decision is made on the first capability set, an analysis of alternatives will be the next step. “We haven’t done an analysis of alternatives, so we don’t know where is the biggest bang for the buck.”

The two capability sets, defined by US Army Training and Doctrine Command, the service’s requirements authority, were communicated in two request for information, released in February. These were a light reconnaissance, attack and assault/lift type with a cruise speed greater than 200kt (370km/h) and 229nm unrefuelled range; or a mid-weight, general-purpose aircraft with a top speed of 230-310kt and 229-450nm range. With class 2 fulfilling the Apache’s attack role and the UH-60’s utility mission. The next-generation aircraft, which would combine the speed of a fixed wing aircraft with a helicopter’s vertical lift capabilities, could be fielded by the 2030s.

While the Army will likely lead the first program, Gonzalez said, “We are really trying to do this in a joint manner.” There are six elements to the future vertical lift strategic plan, and one is “joint requirements,” he said.

Technical Requirements

Although requirements are still being refined, new aircraft will need to have hover, speed, range, and payload and fuel efficiency characteristics “beyond any current rotorcraft”. They should fly faster reaching speeds of 230 kn (260 mph; 430

km/h) with more maneuverability, carry more payload up to 12 troops, operate in “high-hot” conditions at altitudes of 6,000 ft (1,800 m) and temperatures of 95-degrees Fahrenheit, reach further without refueling i.e. combat radius of 424 km (263 mi) and overall unrefueled range of 848 km (527 mi).

The engine will require alternative, advanced engine/power system configurations that enable enhanced mission capability, such as improved time on station, increased mission radius, and quieter operation. Due to the different configurations of the airframe, power outputs from 40 shp to 10,000 shp are being studied.

Common Hardware and Software

A key advantage of a joint FVL program is that it will engender further inter-operability between the services and, for example, allow an Army helicopter to easily be serviced with maintenance at a Marine Corps Forward Operating Base, Dan Bailey, JMR TD program director said.

They are to share common hardware such as sensors, avionics, engines, and countermeasures. The commonality program could provide the aircraft-specific programs with everything from bolts and generator controls to hydraulics and maintenance toolkits.

Maintenance costs, in turn, are heavily driven by the price of parts, James Kelly, a Pentagon logistician who works on the F-35 said. If future aircraft have more parts in common and fewer unique ones, that means acquisitions officials can get bulk discounts on the parts they buy and logisticians can stock fewer different parts.

Model Based Software Development

Army, Navy, and industry are also defining common software standards including a new “model-based” approach to software architectures that will require a culture change among programmers and defense bureaucrats alike. “Once this standard gets defined, hopefully we only write it [a piece of software] once and it can be used in all the different aircraft,” said Boeing’s Thomas DuBois, speaking alongside Hargreaves.

In model-driven development, “you actually record what the interfaces are, the semantics, and that information is available to anyone who wants to use it… down to the very end of the chain where you’re actually going to produce code,” Michael May, the associate director for software and embedded systems in the office of the assistant secretary of Defense for research and engineering said. What’s more, the model-based approach includes “formal methods” (a programming term of art) for rigorously assessing whether a particular piece of code will actually work.

Joint Multi-Role (JMR) helicopter program

The precursor for FVL is the Joint Multi-Role (JMR) helicopter program, which will provide technology demonstrations planned for 2017. The Joint Multi-Role (JMR) phases will provide technology demonstrations. JMR-TD will develop the aerial platform; JMR Phase I will develop the air vehicle; JMR Phase II will develop mission systems. The Army plans to acquire as many as 4,000 aircraft from the FVL program.

US Army has awarded development contracts to two industry teams as part of Joint Multi-Role Technology Demonstrator, Sikorsky and Boeing with their SB>1 Defiant medium-lift helicopter based on Sikorsky’s X2TM coaxial design that features counter-rotating rigid main rotor blades for vertical and forward flight.

The second was Textron’s Bell Helicopter V-280 Valor, a tiltrotor design , a winged-aircraft with two rotor blades over each wing seeks to achieve airplane speeds and retain an ability to hover and maneuver like a helicopter. The new contracts are aimed at engineering a new fleet of aircraft for all the services by 2030.

Industry teams building Joint Multi-Role Technology Demonstrators (JMR TD) for an Army flight test in late 2017 have said the Army has asked them for more information on any possibility of sliding the schedule to the left. Bell Helicopter said it is confident it can field its V-280 Valor tiltrotor helicopter in the 2020s. The JMR TD phase will inform the Army’s requirements for the FVL program that will come online in 2019.

Sikorsky-Boeing demonstrator

Sikorsky-Boeing demonstrator, called the SB>1 Defiant, uses a coaxial rotor system configuration. This is a design structure, referred to as a compound configuration, which relies upon two counter-rotating rotor blades on top of the aircraft and a thrusting mechanism in the rear.

“To make a rotorcraft go fast you have to off-load the rotor lift onto something else or else you run into problems when you try to reduce the speed of that rotor. Typically, you do that with a wing but Sikorsky-Boeing came up with a lift-offset design,” Bailey added.

The pusher-prop on the back of the aircraft is a small propeller behind the counter-rotating rotor heads. It is what can give the aircraft airplane-like speeds. It operates with what’s called positive and negative pitch, allowing the aircraft to lean up or down and move both forwards and backwards, Boeing officials have said.

Bell’s V-280 Valor tiltrotor aircraft

The company is offering its V-280 Valor tiltrotor aircraft to the Pentagon for its Future Vertical Lift (FVL) programme to replace legacy helicopter technology beginning in the 2030s. The concept aircraft advances the design of the V-22, the first tiltrotor aircraft flown by Marine Corps and Air Force, according to Vince Tobin, vice president of Advanced Tiltrotor Systems for Bell Helicopter.

Bell’s V-280 has finished what’s called a system-level design review where Army and Bell developers refine and prepare the design of the air vehicle.

Bell Helicopter is working to make next-generation tiltrotor technology more affordable for the military, company CEO John Garrison said at the Association of the US Army’s annual conference in Washington, DC. “The warfighter needs speed, range, and payload; this is what the customer is saying they need,” company CEO John Garrison said during a press briefing. “But they also need sustainability, reliability, and affordability. A lot of the technology development works towards hitting the important goal of affordability.”

Garrison added that the Pentagon can save on support infrastructure requirements if it chooses Bell’s V-280 for FVL because the aircraft is so fast. “With V-280 technology, you’d need one or maybe two [forward refuelling bases] to cover the same territory and distance” for which legacy helicopters need 10-11 refuelling points. “Think of the support infrastructure you save by not needing that,” he added.

Bell’s fact sheet on the V-280 indicates it could carry four crew and 14 passengers, with a range of up to 800 nautical miles, beating the Black Hawk’s range by nearly 500 miles. That would make the V-280 especially suited to evacuating injured soldiers.

The V-280 also has the advantage of being able to travel on its own to conflict zones and land in inhospitable terrain. For one-way trips, the plane's range goes up to 2,100 nautical miles, making the V-280 "strategically self-deployable," or independent of massive transport vehicles.

"The V280 is indeed a combat aircraft, capable of assault, attack," Woodward said. "It's marinized, so it can work in sea environments." Bell communications manager Andy Woodward told Business Insider.

Evaluation of Tiltrotor Design

It combines the vertical lift capability of a helicopter with the speed and range of a conventional fixed-wing aircraft. For vertical flight, the rotors are angled so the plane of rotation is horizontal, lifting the way a helicopter rotor does. As the aircraft gains speed, the rotors are progressively tilted forward, with the plane of rotation eventually becoming vertical. In this mode the wing provides the lift, and the rotor provides thrust as a propeller.

A tiltrotor is an aircraft which generates lift and propulsion by way of one or more powered rotors (sometimes called proprotors) mounted on rotating engine pods or nacelles usually at the ends of a fixed wing or an engine mounted in the fuselage with drive shafts transferring power to rotor assemblies mounted on the wingtips.

The tiltrotor's advantage is significantly greater speed than a helicopter.

In a helicopter the maximum forward speed is defined by the turn speed of the rotor; at some point the helicopter will be moving forward at the same speed as the spinning of the backwards-moving side of the rotor, so that side of the rotor sees zero or negative airspeed, and begins to stall. This

limits modern helicopters to cruise speeds of about 150 knots / 277 km/h.

However, with the tiltrotor this problem is avoided, because the proprotors are perpendicular to the motion in the high-speed portions of the flight regime (and thus never suffering this reverse flow condition), meaning that the tiltrotor has relatively high maximum speed—over 300 knots / 560 km/h has been demonstrated in the two types of tiltrotors flown so far, and cruise speeds of 250 knots / 460 km/h are achieved.

This speed is achieved somewhat at the expense of payload. As a result of this reduced payload, Experts estimate that a tiltrotor does not exceed the transport efficiency (speed times payload) of a helicopter

Additionally, the tiltrotor propulsion system is more complex than a conventional helicopter due to the large, articulated nacelles and the added wing; however, the improved cruise efficiency and speed improvement over helicopters is significant in certain uses. Speed and, more importantly, the benefit to overall response time is the principal virtue sought by the military forces that are using the tiltrotor.

Tiltrotors are inherently less noisy in forward flight (airplane mode) than helicopters. This, combined with their increased speed, is expected to improve their utility in populated areas for commercial uses and reduce the threat of detection for military uses. Tiltrotors, however, are typically as loud as equally sized helicopters in hovering flight.

Tiltrotors also provide substantially greater cruise altitude capability than helicopters. Tiltrotors can easily reach 6,000 m / 20,000 ft or more whereas helicopters typically do not exceed 3,000 m / 10,000 ft altitude. This feature will mean that some uses that have been commonly considered only for fixed-wing aircraft can now be supported with tiltrotors

without need of a runway. A drawback however is that a tiltrotor suffers considerably reduced payload when taking off from high altitude

U.S. Army selects Rockwell Collins to support Future Vertical Lift program

The U.S. Army has contracted Rockwell Collins to conduct collaborative studies to support the future development of vertical lift military aircraft. Under the contract, Rockwell Collins will research advanced system designs and integration processes for the Architecture Implementation Process Demonstration, as well as assist Army officials with investigating new technologies and technological capabilities.

“Rockwell Collins is pioneering modeling and analysis methods for complex electronic equipment development, such as those envisioned to be required for FVL,” Rockwell Collins rotary wing director Heather Robertson explained in a press release. “These technologies automate error-prone, costly manual methods for specifying and designing products, which helps us to deliver value to our customers.”

The company went on to add the research will aim to shed light on issues regarding the affordable development of complex mission systems in addition to informing industry partners on new techniques and processes

References and Resources also include:

http://www.defensenews.com/story/defense/land/army-aviation/2016/04/29/first-future-vertical-lift-helicopters-medium-lift-aaaa/83714968/

https://www.flightglobal.com/news/articles/us-army-starts-firm

ing-fvl-requirements-as-rfi-deadl-424023/

http://nationalinterest.org/blog/the-buzz/us-armys-new-futuristic-helicopters-wont-be-anything-you-18394?page=show

http://www.upi.com/Defense-News/2016/11/15/US-Army-selects-Rockwell-Collins-to-support-Future-Vertical-Lift-program/7891479222043/

http://www.popularmechanics.com/military/aviation/a26040/sikorsky-boeing-defiant-fvl-medium/