The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement (Image courtesy of Boeing Co.)

Future Vertical Lift will revolutionize US Army combat aviation

Elbit Systems of America is well-positioned to enable this

The Army's forward-thinking Future Vertical Lift initiative is going to change the way that rotorcraft aviators maneuver and dominate future battlefields. To support this Army initiative, disruptive and game-changing technologies need to be implemented to ensure mission effectiveness, and industry is key to delivering those capabilities. Elbit Systems of America is drawing on its wealth of experience in this domain to position itself as a technology partner for FVL, and is well placed to deliver the required future vertical lift capabilities to the Army customer.

Rotorcraft have long been an integral part of US Army operations, having supported and facilitated the service branch's success in many challenging theatres across the world over the past 70 years.

The importance of this type of capability in supporting ground-based combat initiatives is identified by all levels of command within the US forces, and the ability of helicopters to efficiently operate in incredibly testing environments - be it jungle, desert or mountains - is credit to its success.

Helicopters have extended the range of ground forces in a variety of hostile conditions in support of these deployments, although the demand on the fleet is now showing.

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement (Photos courtesy of Bell)

Characteristics that have been identified as being a priority to the Army for FVL include range, speed, maneuverability, agility, mission flexibility, and survivability.

Some of these helicopter types have been in service with the Army for some 50 years, and there is a noted shortfall that has become evident between legacy airframes being retired and new types coming to the fore.

While the rotorcraft fleet of the Army has been upgraded and maintained to support the requirements of the service throughout enduring campaigns – most recent operations of significance for the fleet being in support of deployments to Iraq and Afghanistan – it has been identified that these aircraft are now reaching their limit in terms of service life, and new helicopters are needed.

A Family of Future Vertical Lift

This requirement is going to be met by a new family of aircraft that fall under the Army's Future Vertical Lift (FVL) program, which will result in a series of brand-new aircraft being developed to replace both the in-service and now retired legacy platforms.

The direction that FVL would take has been modified since it was established in 2009, evolving to be divided into four top priorities that will serve to meet all the demands of a future Army helicopter.

The two manned elements of this are: the Future Attack Reconnaissance Aircraft (FARA) that will replace the in-service AH-64 Apache and retired OH-58 Kiowa rotorcraft; and the Future Long-Range Assault Aircraft (FLRAA) that will replace the UH-60 Black Hawk.

Additionally, the Future Unmanned Aircraft Systems element of FVL will develop so-called Air-Launched Effects (ALE) that will be deployable from the developmental airframes as well as in-service aircraft to increase their range, lethality and survivability. The Army's in-service RQ-7 Shadow unmanned aerial vehicle (UAV) – a fixed-wing UAV that is currently used in conjunction with the AH-64 Apache in support of Army operations – is also being replaced with a system capable of vertical takeoff and landing.

The fourth priority – known as the Modular Open Systems Approach (MOSA) – will be the digital operating standard on which these aircraft operate, and will ensure interoperability with the Army's in-service Apaches, Black Hawks and CH-47 Chinooks that will operate alongside the new rotorcraft until they retire from service. This is a government/industry-wide standard on which mission equipment for FVL will operate.

Two teams, led respectively by manufacturers Bell and Sikorsky, are competing for the FARA design and fielding is expected by 2028. FLRAA meanwhile will be fielded by 2030, and Bell and a Sikorsky-Boeing team are competing for that award[1].

As with all the modernization efforts of the US Army, the FVL priority is being developed under an Army Futures Command (AFC) Cross-Functional Team (CFT). This also includes Program Executive Office (PEO), Aviation, which is responsible for program acquisition.

A total of eight CFTs are responsible for delivering six modernization priorities that have been identified by the US Army's AFC, which was stood up in 2018.

Future Focus

Characteristics that have been identified as being a priority to the Army for FVL include range, speed, maneuverability, agility, mission flexibility, and survivability. All of these will contribute to mission success against adversaries that are increasingly investing in their own capabilities.

According to the Army[2], the various elements of FVL need to be able to fly further and faster, carry heavier payloads, be easier and less expensive to maintain, be integrated with unmanned capabilities, and be optionally piloted as required.

These characteristics are well documented by the Army and are a clear indicator of the direction in which it wants its future rotorcraft fleet to evolve. The service has developed a list of capabilities required for FVL, all of which will contribute to a reduced workload for the pilots, and provide commanders with increased reach, protection, and lethality.

While the superior performance of the aircraft itself - as well as the sensors, weapons and protection systems that allow it to operate effectively – is crucial to the success of FVL platforms, there are also other considerations that need to be made in the execution of such a significant program.

As highlighted by then Vice Chief of Staff

1 *https://www.army.mil/article/236382/future_vertical_lift_pushes_forward_with_new_requirements*

2 *https://www.army.mil/article/217783/ccdcs_road_map_to_modernizing_the_army_future_vertical_lift*

3 *https://www.army.mil/article/202791/leap_ahead_future_vertical_lift_technology_must_be_affordable_says_army_vice_chief*

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement (Photos courtesy of Bell)

The Army is keen to ensure that the US aerospace and defense industry remains strong and is in a position to invest in disruptive technologies.

of the Army – now Chief of Staff – Gen James C. McConville in 2018, the affordability of the aircraft also needs to be considered, as well as the sustainment of the existing supply chain.

The FVL CFT's aim is to get new capabilities into the hands of soldiers as quickly as possible to speed up testing and eventual fielding, McConville said[3].

Furthermore, during the AUSA Annual virtual event in October 2020, the service's aim to implement FVL "rapidly and affordably" was repeatedly stressed by top Army program officials[4].

To accelerate service entry, the Army could consider technologies that are not completely developed but could be updated at a later date.

By adopting this approach and bypassing lengthy development programs it lessens the risk of technology becoming obsolete by the time it enters service. It also lays the responsibility on industry to invest in its own technological developments to ensure they are mature and production-ready.

This corresponds with comments made by Gen Walter Rugen, the Army's FVL CFT director, to the Lexington Institute earlier in 2020[5], when the general claimed that overmatch over adversaries was not the only consideration for FVL, but that the industrial base was also key.

The Army is keen to ensure that the US aerospace and defense industry remains strong and is in a position to invest in disruptive technologies. Speed of adoption of FVL is a priority, resulting in no shortfall in industrial capability.

In short, the Army wants a high performing family of vertical lift capabilities that operate on common infrastructure and can meet the emerging demands of the service, delivered in a timely manner that gets the technology into the hands of warfighters, thus sustaining the domestic rotorcraft industrial base.

A New Approach

This new approach moves the Army away from traditional methods that saw industry being awarded lengthy and often costly contracts that would facilitate them developing new capabilities from scratch to siloed platform-specific requirements.

The Army is now looking for interoperable and common technology that can be used across this new family of agile and flexible platforms. This technology can also be easily integrated with existing airframes, effectively bridging the gap between legacy and future rotorcraft as part of an accelerated and focused timeline.

The burden therefore falls on industry to deliver mature and disruptive technologies to the Army, and the benefit will lie with those that have been working on these technologies in the years leading up to the FVL program.

This is where Elbit Systems of America comes in. As a current provider of some of the most integral technologies used by the US Army today, Elbit America is using its experience in developing combat-proven systems to position itself as a partner for the FVL program.

Technology development is at the core of what Elbit America does, and it is well positioned to offer umatched helmet mounted display (HMD), electronic warfare, (ALE), computing and display technology to the US Army.

Elbit America has identified a number of key capabilities that will be game changing in the mission effectiveness of the US Army's future vertical lift fleet.

Its HMD is one of the most advanced in the world, and its sensing and computing systems are at the backbone of many of key military systems.

While the competition for the aircraft developments of FARA and FLRAA have been clearly defined by the Army, the subsystem elements are either in the early definition stages, or an acquisition process has not yet been decided on.

Examples of this include the HMD, distributed aperture protection systems, cockpit displays, air-launched effects (ALE) and processors, all of which need to be functional and tested capabilities that can be easily integrated into the FVL ecosystem.

One thing is clear throughout, however: FVL will rely more on these disruptive elements that will work both independently and together to reduce the workload of the pilots, and this is important in all elements of the aircraft design.

4 AUSA Annual FVL roundtable comments

5 *https://www.lexingtoninstitute.org/army-fears-if-future-vertical-lift-falters-serious-fallout-for-industry-might-follow-from-forbes/*

The heart of the FARA and FLRAA aircraft is going to be the cockpit, the epicenter of all the game-changing elements that will make up these next-generation aircraft.

System excellence

To demonstrate the numerous technologies that it could offer for FVL, Elbit America has developed a flying testbed that carries all of the various elements that can be used for flight testing.

The Elbit America Vertical Lift Test Bed (VLTB) is a modified Airbus AS355 helicopter that can be configured to integrate the variety of avionics, sensors, antennas, and cockpit systems for current and future rotorcraft.

From its home in Fort Worth, where Elbit America's systems integration lab is also based, the VLTB carried out some initial flight tests in March 2020, and resumed them once again in October. It has embarked on an ambitious flight campaign, demonstrating at customer sites including the US Army Aviation Center of Excellence at Fort Rucker in Alabama in October 2020.

During this demonstration, the technology that Elbit America is positioning for FVL was taken directly to the Army, providing aviators the opportunity to see how the systems perform firsthand.

Operational pilots have vigilantly worked side-by-side with the company's engineers to work on the testbed, which is a credit to the dedication that Elbit America has to offering the most suitable and mature systems for the FVL program.

Elbit America is focused on leveraging its combat experience and showcasing in a representative environment the unmatched lethality and survivability capabilities it has to offer to the Army customer.

"Being an attack pilot in a helicopter is an incredibly challenging task as it is, and future aircraft are going to have a broader scope of systems that these pilots are going to have to be responsible for in order to conduct their mission," says Paul Cooke, Vice President of Vertical Lift solutions for Elbit Systems of America.

"The components that we're offering to put into FARA and FLRAA aircraft is content that we feel would reduce pilot workload, will enhance their mission effectiveness, and network with the rest of the FVL ecosystem."

Superior Situational Awareness

The heart of the FARA and FLRAA aircraft is going to be the cockpit, the epicenter of all the game-changing elements that will make up these next-generation aircraft.

In the future, fighting from the cockpit is going to become much more complex than it is today, especially when you consider the massive amount of information that the future aviator will have to consume from on-board and off-platform sensors.

All of this information will have to be considered by the aviator during the mission so as to avoid threats and decisively engage targets. The task will therefore grow much more complex as all of these extra sensors are introduced into the mission.

This is what Elbit America is now working on: designing capabilities that will reduce the complexity of the overall task for the pilot.

A primary example of a system that will greatly benefit this aim is the X-Sight HMD. Elbit America is adapting the superior HMD technology developed for Gen 4 and 5 fighter aircraft and applying it to the needs of the future of rotary aviators.

Providing maximum survivability to rotorcraft pilots and offering the best situational awareness possible, the HMD can be used with standard issue Army helmets, providing enhanced sensing, processing and display capabilities to the pilot.

X-Sight provides maximum survivability by delivering critical information straight to the warfighters' eyes, which is particularly important for low-level combat operations where there is no margin for error.

It presents 3D conformal symbology and Synthetic Vision Symbology, fusing sensor data with tactical flight and mission data onto a wide field-of-view display in a 'transparent cockpit' format.

Pilots are not limited by the boundaries of the cockpit with X-Sight, receiving a 360-degree view around the aircraft. With no visual obstacles, survivability, efficiency, and safety are increased, further protecting the pilot and helping secure mission effectiveness.

The principle of the clip-on HMD is similar to that used in the Apache, Black Hawk and Chinook today, offering a seamless transition from in-service helicopters to the platforms of the future.

"X-Sight is a very extensive and capable

"X-Sight is a very extensive and capable HMD, more so than anything they've ever had before in the US Army,"

Paul Cooke, Vice President of Vertical Lift solutions for Elbit Systems of America

HMD, more so than anything they've ever had before in the US Army," adds Cooke. "Whatever the aircraft puts out via its sensors is what's going to be projected, so you're only limited by the capability of the sensors."

The binocular HMD is extremely capable with very wide field of views, and is able to be used in infrared and low light conditions, providing a view of elements and obstacles on the ground by projecting onto the pilot's visor the symbology of a multitude of outputs including altitude and airspeed.

Furthermore, X-Sight is full color, which would be a first for the US Army.

An enhanced feature of X-Sight is the digital night vision integration, further increasing survivability while also decreasing the workload of the pilot.

This is because if the forward looking infrared (FLIR) goes down, rather than having to remove the HMD to fit separate night vision goggles to the helmet, and this image is projected into X-Sight and is projected onto the visor in the same way the other sensor information is.

There is also power redundancy in the HMD, and it can operate in the event of a power loss via a battery backup of some 90 minutes. In addition to the benefits this provides in emergency situations, it also means that there is power to the system when outside of the aircraft, so operators can walk to and from the aircraft in low light conditions and still be able to utilize the IR and night vision capabilities.

Elbit America is applying lessons learned from multiple programs to its development of X-Sight, including the helmet display and tracking system that it provides for the Army today.

"Having implemented low latency capabilities and requirements in the F-35, we are applying our past experience here, and developing a primary flight display through and through," Cooke notes. "X-Sight is a truly mil-spec HMD, designed with the pilot and the challenging environment in which they operate in mind."

Digital Backbone

So as to deliver a family of common elements across the FVL family of systems, as well as to ensure that the incoming systems are interoperable with incumbent capabilities, a common digital backbone is required.

The Army has therefore initiated the development of an Aviation Mission Common Server (AMCS), a program that the service says will be the center of the future Common Digital Backbone of FVL, and will be a key enabler for multi-domain operations for Army aviation in the future[6].

AMCS is a capability upgrade and replacement for the current Army IDM-401 modem system, and will be a flexible open systems architecture and distributed processing resource that will perform non-flight critical computing tasks, data processing, radio and communications management, and graphics generation functions.

It will use MOSA concepts, with AMCS being the hardware element of the digital infrastructure that will essentially power FVL data that is being delivered to pilots and operators.

BG Gen Robert L. Barrie, Program Executive Officer, Aviation, told the virtual AUSA Annual event[7] in October 2020 that MOSA is "absolutely, 100% the top of our list from a 'what do we need to do to maintain affordability of the broad aviation fleet and to be able to continue to be able to evolve requirements over time?'".

Furthermore, he noted that AMCS will be "the bridge" between enduring rotary fleets and future vertical lift platforms. It will serve as "a gateway" to allow the hosting of applications and software processing independent of FVL OEMs, so that capabilities can be rapidly integrated onto the fleets using AMCS as the host.

Elbit America was selected in July 2020 under a 22-month Other Transaction Authority (OTA) mechanism to develop two AMCS multicore processor prototypes that will be tested by the Army ahead of a competitive downselect.

"This would be utilized on the FARA, the FLRAA, and will be backwards compatible for the legacy aircraft, namely the Black Hawk, Apache, and the Chinook," Cooke notes. "Many of these will be produced and utilized for the Army to give them the capability they require, and to run all of the differ-

6 *https://www.asafm.army.mil/Portals/72/Documents/BudgetMaterial/2021/Base%20Budget/rdte/RDTE_BA_5A_FY_2021_PB_RDTE_Vol%202_Budget_Activity_5A.pdf*

7 Comments made at AUSA Annual virtual event

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ent elements required by the fleet through this one component."

This is likely to be developed as Government Furnished Equipment (GFE), so the selected processor would be used as standard across all elements of the Army aviation fleet going forward.

Elbit America's AMCS mission processor is adaptable, modular, full-integrated, and low cost, and will increase the lethality and survivability of the fleet while providing the army with the ability to adapt and modify its mission.

In fact, the Army is relying on this processing capability today, as it is an integral part of the service's Apache attack helicopter fleet.

The heart of the AH-64D model is Elbit America's Mission Processor, or MP, while the AH-64E variant has the company's Multicore Mission Processor, the MMP, two of which are utilized to provide all of the functionality of the onboard systems.

"I would say the MMP is probably the most advanced multicore processor being utilized within aviation today," Cooke claims. He notes that the proof of this is its ability to provide functionality in support of the most demanding of rotorcraft functions: attack.

"The high level of functionality that the Apache has to provide, the MMP does all of that," he says. "It ties all those systems together, bringing in the software, the sensors, the weapons and the flight characteristics, all through that one MMP that makes sure that the aircraft functions as it needs to."

"We have a wealth of experience within Elbit America in interfacing processors in aircraft, integrating all these different modules that are in the various systems that need these overall mission processors. Elbit America has an extensive history in advanced processing for the US Army."

Enhanced Visualization

The Army has communicated that the future fleet needs to be able to operate in all light and weather conditions, as well as in degraded environments where visuals are limited, including sand, smoke, smog, clouds, fog, rain, snow, brownout and whiteout conditions.

The ability to do this will increase the survivability of the aircraft, as well as enhancing the scope of the mission and the operational possibilities that it can endure.

According to the Army[8]: "Degraded visual environment (DVE) technology will enable operations including the ability to see the enemy without being seen, which will greatly increase lethality and survivability. Part of readiness is being able to operate in different environments, so DVE will make a critical impact when it's fielded by increasing combat power as well as preventing mishaps."

Mission effectiveness can be improved with the application of visual and synthetic panoramic vision technology, and the combat-proven Brightnite Forward-Distributed Aperture System (F-DAS) from Elbit America is a complete sensor system that can provide just that.

This is an end-to-end lightweight distributed sensor solution that can augment standard night vision systems with a clear fused image displayed to the eyes of the aircrew via their HMD.

It is multispectral so can take advantage of different parts of the spectrum as required, and will stitch and fuse together these visuals in a low latency format to provide the information directly to the helmet of the pilot and/or co-pilot.

Utilizing an uncooled FLIR sensor fused by a multi-spectral synthetic vision system (SVS) and color conformal 3D mission symbology, it provides enhanced aircrew survivability in DVE conditions including brownout and whiteout.

This is camera agnostic so can be tailored to the requirements of the customer, and can serve multiple crew members independently of each other.

This will be important to the system's potential role in FVL. It will provide the required information to both the pilot and co-pilot of the FARA and FLRAA aircraft if the cockpit is configured in andem or side-by-side in front of the other; they do not need to share the same screen to be able to receive the same crucial information.

"If you have some type of structure coming up to the front or to the side of the aircraft, the F-DAS will detect anything that is a threat," according to Hader. "And that is one of the greatest threats in army aviation,

8 *https://www.army.mil/article/217783/ccdcs_road_map_to_modernizing_the_army_future_vertical_lift*

...the Army wants to employ a range of Air-Launched Effects (ALE) that will extend the reach, lethality and survivability of the FARA and FLRAA aircraft

given how low they are normally flying.

"This applies both day and night: it can also distinguish buildings, vegetation, trees and other obstacles. It does a lot for the pilot's survivability both day and night."

This is an integral contributor to the safety of pilots, tirelessly collecting visuals and threats to the aircraft. Machine learning allows algorithms to be trained to scan all of this incoming information for obstacles and targets, and the system can alert you when it detects those things.

It never gets tired, and it never stops.

Air Launched Effects

In its effort to be able to counter adversaries that are increasing the stand-off range of their own systems, the Army wants to employ a range of Air-Launched Effects (ALE) that will extend the reach, lethality and survivability of the FARA and FLRAA aircraft.

These could be in the form of small drones that can be forward-deployed to provide reconnaissance or decoy for the aircraft, and which could carry small sophisticated electronic warfare (EW) self-protection systems of their own to extend the electronic range of the FARA and FLRAA helicopters.

For example, Elbit America's Micro Self Protection Electronic Attack and Reconnaissance (SPEAR) is a compact, modular, passive and active EW system ideally suited to small platforms, and can be used to provide early warning detection and protection for forces.

Derived from the company's SPEAR family of EW systems, this ultra-compact variant provides the same standard of electronic support but with a reduced size, weight and power. Alternatively, the podded installation of SPEAR could be an option for FVL, or the mid-sized Light SPEAR version of the self-protection system.

Not only will ALE components benefit the aircraft, they will also provide valuable intelligence to ground forces operating below. Additionally, it can have a defensive role in protecting those ground forces.

SPEAR is able to identify weapons and targets, as well as the enemy on the ground, and in a defensive posture can then jam adversarial systems that could be used against friendly forces.

Highlighting the importance of ALE to FVL, Rugen notes: "Those air-launched effects bring a tech maturation of a mesh network forward," adding that "the effects will be able to find, fix and finish what's hunting us"[9].

Superior Display

Elbit America is a market leader in Large Area Display (LAD) development, providing LADs to the F-15EX, the new Block III F/A-18, the V-22 and numerous other military aircraft – something that the company hopes to be able bring to the FARA and FLRAA cockpit designs.

It has developed 8x20 LAD components suited to the AH-64E, CH-47F and Bell-Boeing V-22 Osprey tiltrotor aircraft, and has worked with original equipment manufacturer Boeing on these developments, specifically at its Systems Integration Lab in Philadelphia.

These systems are capable of having touch display, and the LAD can be configurable by the pilots to show one large screen, or they can break it down into multiple screens to present a lot of information on that one 8x20 inch display in front of them.

As an example, flight information and engine information, including heat levels and RPMs, can be shown, as well as map navigation and weapons data.

As with the F-DAS capability, this can be modified to the cockpit configuration, be it tandem or side-by-side seating seating, with large area displays integrated where required.

LAD devices ultimately serve to reduce the burden on the pilot/co-pilot, providing high resolution and relevant data on easy read displays in one place so that operators are not constantly searching for the required information.

A smaller display being offered by Elbit America is the Configurable Touch Display (CTD), which can augment the LAD or be configured as a keyboard, depending on the graphical user interface selected to be projected onto the CTD.

The modular smart display has a 6" x 3.6" active area display and infrared touch-screen with force sensing capability, and has potential for adoption in the FARA, FLRAA and

9 *https://www.army.mil/article/236382/future_vertical_lift_pushes_forward_with_new_requirements*

"Augmented reality takes all of the information from across the aircraft systems and sensors and it presents it to the pilot in a new way that allows them to team with it to make better, quicker, more precise decisions and survive on the battlefield,"

Mark Stiner, Elbit America's Senior Director of Sector Marketing

legacy aircraft if required.

Fully flight tested, this modular and adaptable is production ready today.

Future Tech Testbed

This wide range of components is being regularly tested on the company's flying testbed, proving the effectiveness and interoperability of the different elements, and readying them for FVL requirements as they come to the fore.

Elbit America is focused on delivering the best possible solutions to the US Army customer having applied significant investment to its world-leading system offerings, and when incorporated into the FARA and/or FLRAA aircraft these elements would provide increased survivability, situational awareness, agility, lethality, range and ease of use to operators.

The company understands the mission requirements of the US Army rotary-wing fleet, and works on behalf of army aviators to make sure that they can operate as efficiently as possible, and ensure that they come home safe at the end of the day.

Letting the Army be the Judge

The best way to prove that these technologies work is to get them into the hands of the warfighter, and Elbit America has used its initiative to do just that.

In October 2020, Elbit America took its AS350-based Vertical Lift Test Bed to the US Army Aviation Center of Excellence at Fort Rucker, Alabama, to showcase the maturing technologies that the company is developing that could be implemented into the FVL program.

Army Aviation officials over several days were given the unique opportunity to see for themselves the sophisticated technologies that Elbit America has to offer, including the game-changing level of augmented reality and situational awareness that the combination of the X-Sight helmet and Brightnite sensor systems have to offer.

"Augmented reality takes all of the information from across the aircraft systems and sensors and it presents it to the pilot in a new way that allows them to team with it to make better, quicker, more precise decisions and survive on the battlefield," Mark Stiner, Elbit America's Senior Director of Sector Marketing, notes.

"It's important for our company to get feedback from the senior Army leadership about how the system works, and how we can continue to develop it in partnership with them, so it will work on the current aircraft as well as the new ones they're developing."

This combination of capabilities if fielded would enhance daily operations and reduce the workload of FVL pilots, and is just one example of the complementary technologies that Elbit America can bring to the program.

Elbit America is not just developing its FVL technologies on paper, it is working hard to show tangible, proven, and mature results that will have a profound impact on the effectiveness of Army Aviation rotary-wing pilots over the coming decades.