Strategy Research Project

Future Vertical Lift: A Holistic Approach to Development

by

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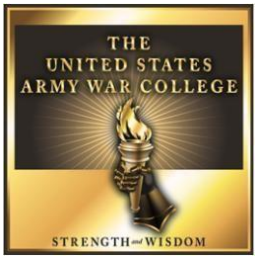

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14. ABSTRACT

Future Vertical Lift (FVL) is more than just an aircraft platform; rather, it is an extremely complicated system of systems composed of a diverse collection of enabling technologies. The Department of Defense (DoD) must develop and successfully integrate these enabling technologies to achieve the desired overmatch capability it requires for the Multi-Domain battlefield. In order to do this, the DoD must ensure successful completion of two imperatives. First, DoD must establish Joint Service Integrated Product Teams (IPTs) to develop those capabilities that are necessary to ensure mission success. Second, DoD must ensure parallel funding for both the platform as well as the critical enablers. In accomplishing these two imperatives, the services must avoid the typical service parochialism and competing requirements, which have doomed multiple Joint programs. The DoD must avoid the fate of previous complex Joint programs and field a capability within program cost and on schedule to ensure the future force has the capability to fight and win on the future Multi-Domain battlefield.

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Abstract

Future Vertical Lift (FVL) is more than just an aircraft platform; rather, it is an extremely complicated system of systems composed of a diverse collection of enabling technologies. The Department of Defense (DoD) must develop and successfully integrate these enabling technologies to achieve the desired overmatch capability it requires for the Multi-Domain battlefield. In order to do this, the DoD must ensure successful completion of two imperatives. First, DoD must establish Joint Service Integrated Product Teams (IPTs) to develop those capabilities that are necessary to ensure mission success. Second, DoD must ensure parallel funding for both the platform as well as the critical enablers. In accomplishing these two imperatives, the services must avoid the typical service parochialism and competing requirements, which have doomed multiple Joint programs. The DoD must avoid the fate of previous complex Joint programs and field a capability within program cost and on schedule to ensure the future force has the capability to fight and win on the future Multi-Domain battlefield.

Future Vertical Lift: A Holistic Approach to Development

Constant change and the emergence of multiple peer competitors, which have demonstrated significant technological advancements that exceed many United States (U.S.) current capabilities, mark today's complex operating environment. With the U.S. national military power focused on such a diverse collection of threats, the Department of Defense (DoD) must develop a force that has the ability to adapt and win within the myriad of operating environments highlighted in our most current National Defense Strategy.[1] In the Capabilities Needs Analysis (CNA) for Fiscal Year (FY) 16, General David Perkins, Commander, Training and Doctrine Command (TRADOC), stated, "To develop this force, the Army must think clearly about future armed conflict by considering threats, enemies and adversaries, anticipated missions, emerging technologies, opportunities to use existing capabilities in new ways, historical observations and lessons learned."[2] General Perkins continues, "Over the last 25 years, assumptions of air, maritime, space, and cyberspace domain superiority and the pause in great power security competition drove the doctrine, equipment, and posture of the Joint Force. These assumptions have since proven invalid faced with recent changes to peer capabilities and approaches."[3]

Because of this current state, the U.S. Army is in the process of evolving to the concept of Multi-Domain battle. This concept "describes how U.S. ground forces, as part of the Joint Force and with partners, will operate, fight, and campaign successfully across all domains—space, cyberspace, air, land, maritime—against peer adversaries in the 2025-2040 timeframe."[4] Due to the many technological advancements made by China and Russia over the past decade, the United States must continue to invest and develop future capabilities in conjunction with its implementation of the Multi-Domain

battle concept to ensure that the DoD regains the technology overmatch that it has enjoyed over the past four decades.

One such future capability is Future Vertical Lift (FVL). FVL is the future Vertical Takeoff and Landing (VTOL) aircraft for the Joint Force.[5] However, Future Vertical Lift (FVL) is more than just an aircraft platform; rather, it is an extremely complicated system of systems composed of a diverse collection of enabling technologies. The DoD must develop and successfully integrate these enabling technologies (command and control, survivability, and effects) to achieve the desired overmatch capability it requires for the Multi-Domain battlefield. In order to do this, the DoD must ensure successful completion of two imperatives. First, DoD must establish Joint Service Integrated Product Teams (IPTs) to develop those capabilities that are necessary to ensure mission success. Second, DoD must ensure parallel funding for both the platform as well as the critical enablers. This paper discusses the current state of Army Aviation's capability, this new concept of the Multi-Domain battlefield, and the FVL development program. This paper will conclude with a detailed discussion of the state of today's critical enablers, the need for continued transformation of these enablers, and the potential inhibitors to successful FVL development.

Current State

Current State of Army Aviation Capability

Since World War II, Army Aviation has played a critical role in the success of our nation's combat operations by providing responsive close air support fires, intelligence, surveillance, and reconnaissance (ISR) capability, and enhancing ground maneuver by providing transportation for personnel, equipment, and logistics. In testimony to the

House Armed Services Committee in 2016, Major General Michael Lundy, Commander of the U.S. Army Aviation Center of Excellence, stated,

> Aviation is the Army's largest portfolio, and an important element of the Joint, inter-organizational, and multi-national team. Aviation provides significant capabilities to maintain superiority over our adversaries by increasing lethality and survivability of the force, providing enhanced mobility into and within the theatre of operations, and enabling unprecedented awareness and battlespace integration.[6]

In fact, it would be hard to envision a combat operation today that would not include some form of aviation capability. However, there is no promise that future enemies will afford the United States the luxury to dictate the boundaries of conflict as noted by an article published in Jane's Defense Weekly, "As we shift to the Pacific Rim focus, future areas of operation (AOs) may be 16 times larger than those of our current AOs."[7] Within the Army's capability set, only Army Aviation has the ability to operate across such a vast AO, which highlights the importance of continued technology advancement. Lieutenant General (LTG) John Campbell, Army G-3, seemed to espouse this same idea in the Initial Capabilities Document (ICD) for FVL Family of Systems, "Current and future Joint Force operations are increasingly reliant on air delivery of/to maneuver forces across distributed environments and hostile territory."[8] LTG Campbell goes on to say, "Vertical takeoff and landing (VTOL) platforms are critical to the commander's success in maneuver and sustainment, situational awareness (SA)/situational understanding (SU)…networked communications, navigation, reconnaissance, surveillance, targeting and fires."[9]

In order to better understand the magnitude and complexity of the FVL program, it would be helpful to briefly review the current capabilities that FVL will replace. These capabilities will continue to undergo modernization to bridge the gap until the Army

begins fielding the new FVL aircraft in the 2030 timeframe. The AH-64 Apache has served as the primary attack airframe for the U.S. Army since the late 1980s, initially gaining fame for its performance in the 1991 Gulf War. Due to its longevity of service, the AH-64 has incorporated multiple upgrades over time to improve both lethality and performance. The future AH-64E will "renew the current Apache fleet by incorporating current technologies and a new airframe to extend the aircraft's useful life and make it one of the most technologically advanced weapon systems on the battlefield."[10]

Due to the recent retirement and divestment of the OH-58D from the Army's inventory, the AH-64 and Unmanned Aircraft Systems (UAS) fleet now assume the primary responsibility for the reconnaissance mission. The UAS portfolio consists of the Raven and Puma; Shadow; and Gray Eagle, which represent the small, medium, and large classifications respectively. This span of classifications provides varying degrees of range, duration, and payload capacity to support combat operations. The Army has initiated development of the Improved Gray Eagle to provide "significant increases in payload, range, and station time through fuselage and engine enhancements."[11]

The UH-60 Blackhawk continues to serve as the workhorse for the Army's tactical lift mission, medical evacuation (Medevac), and search and rescue (SAR). With 2,135 airframes, the UH-60 represents the Army's largest fleet of rotary wing aircraft.[12] The UH-60 has undergone considerable upgrades to improve performance and better meet mission requirements over its period of service since the mid-1970s. Transformation has taken this platform from the UH-60A, to the UH-60L, and now to the UH-60M. Additionally, the U.S. Navy, Air Force, and Special Operations Command (SOCOM) use this platform for varying missions.

The CH-47 Chinook serves as the only heavy lift capability within the Army. Over its 50 years of service, the CH-47 has undergone considerable upgrades to improve performance and incorporate modern technologies. The current planned upgrade from the CH-47F to the CH-47G "will restore operational payload capability, efficiently incorporate engineering changes, and increase commonality between SOCOM and the conventional Army."[13]

Multi-Domain Battlefield

For almost 30 years, the Joint Force has conducted operations marked by uncontested air superiority. However, going forward, the Joint Force will likely execute its Multi-Domain operations in a contested environment. General David Perkins stated, "The Army's dominance on land had become dependent, if not contingent, on access to the air, cyber, and space domains."[14]

It is undeniable that U.S. air superiority enabled tremendous success in the 1991 Gulf War. However, following this overwhelming dominance in application of military power, primary competitors began to develop doctrine and technologies to inhibit the United States from enjoying uncontested, fully integrated combat arms operations in future conflicts. Over the past decade, competitors have demonstrated this doctrine and technologies in "Gray Zone" conflicts around the world. LTG Michael Williamson, Principal Military Deputy to the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, noted this specifically with respect to Russia in his testimony to the Senate in 2017: "In Ukraine for example, the combination of UAS and Offensive Cyber and advanced Electronic Warfare (EW) capabilities depict a high degree of technological sophistication."[15]

Due to the U.S. recent dominance in kinetic operations, future conflict against peer competitors is certain to include targeted EW and Cyber-attacks against the United States' ability to navigate and communicate. This same approach would also greatly limit situational awareness tools on the battlefield as well as limit or deny the ability to conduct weapon engagements. General Perkins stated, "We can expect all domains to be contested. Adversaries possess significant integrated air defenses and long range fires, as well as sophisticated intelligence, surveillance, and reconnaissance and information, electronic warfare, and cyber capabilities."[16]

Based on multiple demonstrations of successful implementation of these new technologies, Colonel Paul Cravey, Director Training and Doctrine Command Capability Manager for Unmanned Aircraft Systems, declared, "Emerging threats to Army Aviation are such that battlefields of the future will require synchronized cross-domain teaming to create windows in space and time for aviation to execute its core competencies."[17] General Perkins noted this same concern in the CNA, "The dimensionality of the future battlefield has increased the complexity of operations with a need to not only gain air dominance but cyber, EW, indirect fires and space dominance in order to facilitate tactical and strategic maneuver."[18] Finally, Major General Robert Dyess, Chief of Staff for the Army Capabilities Integration Center (ARCIC) inside Training and Doctrine Command (TRADOC), linked the reality of the future contested battlefield to the need for the Multi-Domain battle concept: "The complexities have challenged the nation's cost-benefit relationship with sophisticated, all-domain, anti-access and area-denial conflict. These implications are driving our need for a multi-domain battle concept."[19]

So what is Multi-Domain battle? General Perkins defined Multi-Domain battle as "an evolving warfighting concept designed to win in an ever-changing complex world, leveraging the lessons of the past with twenty-first century capabilities."[20] General Perkins goes on to say, "it is clear that we must understand the operational environment and visualize how the Army will operate with concepts that accurately address the requirements of future warfare. In 2018, the U.S. Army requires concepts that allow us to begin a modernization program to meet anticipated threats."[21] Based on this shared awareness, the U.S. Army identified six modernization priorities that will enable convergence across the future Multi-Domain battlefield: long range precision fires, next generation combat vehicles, Army network, air and missile defense, Soldier lethality, and FVL.[22]

Future Vertical Lift

FVL is a family of aircraft that represents the "next generation of VTOL aircraft" for use by the Joint Force over the next 40 years.[23] The FVL family will likely be four distinct classes of aircraft: light, medium, heavy, and ultra-heavy. Initial development efforts will focus on fielding the medium class variant in early 2030s, as these aircraft would target the replacement of the largest group of current DoD aircraft (UH-60 and AH-64 variants).[24]

FVL is one of six current Army "modernization priorities" focused on ensuring the U.S. Army retains a technology overmatch on the future Multi-Domain battlefield.[25] The FVL Initial Capabilities Document (ICD) highlights that many airframes within the "current DoD VTOL fleet reach the end of their expected useful life starting in the mid-2020s with increasing quantities unable to effectively counter the projected threat."[26] In a speech to the US Army War College (USAWC) resident students in December 2017,

General Dunford, Chairman of the Joint Chiefs of Staff, highlighted this same thought, "We have delayed modernization, and we have used our equipment more than planned."[27] The Army's operational tempo since the events of September 11, 2001 have greatly reduced the operational life of many of our aviation platforms, thus requiring a replacement sooner than planned. Although end of life of the current DoD rotorcraft fleet is a primary driver for FVL development, the limited performance capability of today's aircraft with respect to speed, range, and dwell time greatly restrict today's operations.

So how does FVL enable success on the future Multi-Domain battlefield? With the promise for greatly expanded speed, range, and endurance capabilities in addition to revolutionary technology advancement, FVL will enable the convergence needed for the future Multi-Domain battlefield. FVL will facilitate this convergence by providing the ability "to overcome our adversary's integrated defense capabilities, avoid domain isolation and fracturing, and preserve freedom of action."[28] Finally, FVL "will enable joint force commanders to dictate the terms of operations and take the fight to the enemy at the time and place of the Army's choosing and with greater capability…while performing operations throughout the joint operations area."[29] However, the United States will only realize these desired effects if we successfully develop and integrate the enablers required to ensure a desired overmatch capability.

Desired Future State

Enablers Now and in the Future – The Need for Transformation

Today's resource constrained environment presents a "wicked problem" for Army senior leaders. How does the Army sustain and modernize the current aviation fleet, while simultaneously developing future capabilities such as FVL? That is why it is imperative that the Army take a holistic approach to the development of FVL and get it

right the first time, on time, and on schedule. The Army must look at the need holistically to ensure that it develops a system of systems that provides the desired overmatch capability for the future Multi-Domain battlefield. This includes development of the required enablers to provide resilient and responsive command and control, improve aircraft and pilot survivability, and provide weapon systems to produce the desired effects within the Multi-Domain operational framework.[30]

The current FVL development objectives call for a “parallel development of common systems and mission equipment” in addition to an aggressive increase in performance to meet future operational requirements.[31] These “common systems and mission equipment” will greatly improve downstream modernization, maintenance, and sustainment costs across the FVL Family of Systems as these components will be similar going forward, unlike today’s variation across all platforms. However, all too often, the development of these “common systems and mission equipment” takes a back seat to the development of the platform and drive train.[32] This myopic approach to development renders an aircraft that is unable to meet the desired mission requirements due to ineffectively integrating the needed enablers into a holistic design. Instead, developers often incorporate these enablers after the fact, in a federated approach, increasing weight and cost, robbing the platform of its power margin and greatly increasing total life cycle cost.

Additionally, due to the complexity of much of the enabling technology, Program Offices outside the FVL Program Office have the responsibility to develop many of these enablers. This split developmental approach presents two primary risks: security of funding and coordinated integration of the enabling capability. Program Offices

developing the enablers may not receive the funding priority of the platform development. A disconnected funding approach for FVL would result in increased development timelines of the required enabling capabilities, ultimately delaying integration into the platform or omission of the enabling capability altogether. The resource-constrained environment experienced over the past six years has exacerbated this funding risk for enablers. In order to mitigate this risk, the Army Aviation Enterprise must ensure these critical enablers receive the priority for resourcing to facilitate timely development and integration onto the FVL airframe. Additionally, the FVL Program Office must establish Integrated Product Teams (IPT) to proactively coordinate critical design information and schedules to mitigate the integration risk.

In his speech at the USAWC, General Dunford stated, “If we do not make the right modernization choices today, we will not have a competitive advantage in 2025.”[33] In this speech, he suggested that the Joint Force retains a competitive advantage today, but he clearly expressed concern with respect to both Russia and China’s priority to invest and develop technologies that diminish or combat the United States’ current competitive advantage. General Dunford culminated his thoughts on the U.S. modernization efforts by stating, “We must make sure our men and women are never in a fair fight.”[34]

This emphasis by the DoD’s most senior military officer highlights why the FVL enablers must be adequately funded and developed on schedule. These enablers are the technology that will provide the overmatch capability against those technologies employed by our competitors today. COL Paul Cravey highlighted this: “Army aircraft and maneuver forces will be constrained by deterrents unless enablers are used to

make the environment permissive enough to achieve temporary dominance or overmatch."[35]

In addition to achieving an overmatch capability, a joint development to these enablers would provide commonality across the future fleet, greatly reducing total life cycle cost, increasing maintainability, and reducing strain on logistical support. Colonel Kevin Christensen, Chief of Force Support Division, Force Management, Application and Support for the Joint Staff J8 highlighted this: "When we go to support the warfighter in theatre we haul around 23 separate mission systems, each with its own line of supply, and we're not as interoperable as we could be."[36] This is because DoD's fleet comprises "25 separate mission design series aircraft, with a mass of 6,600 aircraft" total.[37]

Joint development of these enablers would also set the conditions for Joint interoperability, which would greatly assist with convergence on the Multi-Domain battlefield. Brigadier General Gary Thomas, Deputy Director, Force Management, Joint Staff J8 stated, "I can think of instances where we had a lot of services working together on the battlefield, but because they can't share that information, there is a tremendous amount of knowledge that we can't push out to the force."[38] FVL is the Joint Force's opportunity to get this right by successfully developing and integrating a holistic system of systems. The timely development and integration of the following enablers must occur in order to provide the desired overmatch capability in the 2030 timeframe.

FVL Command and Control

The Joint Force must be able to communicate and coordinate activities in order to achieve the desired effects at the proper time and space. Today's force is unable to accomplish this seamlessly from the tactical to strategic level. Therefore, this must be a

priority for future material solutions. For the purpose of this discussion, we will consider avionics, digitization and networks, and mission planning and execution as enablers to support command and control.

In order to better support the future Joint Force on the Multi-Domain battlefield, FVL is seeking strategies to provide “open architecture (OA) to future cockpits” that will seek to improve interoperability and commonality across the services.[39] This OA will “enable common mission systems (e.g. sensors, effectors, communications, navigation, etc.).[40] As part of this OA, FVL will “build standard interfaces” which “will allow the Army to move forward with a cockpit design that it could leverage off multiple competitors in the future,” thereby reducing total operational cost.[41]

Although the Army is the lead service responsible for development of FVL, the Navy is the lead for the Common Systems Integrated Product Team (IPT).[42] This IPT will leverage “functional decomposition standards (i.e. Joint Common Architecture (JCA))” and “provide open interfaces for portability and interoperability across platforms (e.g. Future Aviation Capability Environment (FACE)).”[43] As described by Bill Crawford, Aviation and Missile Research, Development and Engineering Center Public Affairs, “FACE is working to establish a software common operating environment that allows portability and the creating of software product lines for the entire military vertical lift community.”[44] This joint approach, if successful, will facilitate future commonality and interoperability.

DoD must successfully develop advanced avionics that meet the needs of the future force. Avionics are those systems within an aircraft that facilitate command and control and navigation. Although avionics systems provide similar functions across DoD

platforms, many of these systems are not interchangeable. Colonel Kevin Christenson described a situation where he was unable to provide support for aircraft from a different service, “When Marines landed their helicopter at his Army helicopter unit’s base in Afghanistan, ‘all I could give them was meals and a cot.’”[45] Colonel Christenson went on to say, “[T]he avionics architecture ought to be plug and play, so if an Army airplane is at a Marine facility and a radio or navigation system needs to be swapped out, we can do that.”[46]

That is the intent behind FVL’s OA design concept with respect to commonality and sustainment. However, is the DoD developing game changing avionics that will provide the desired overmatch capability for the future Multi-Domain battlefield? FVL could benefit from new antennae technology that will improve communication performance and that allows “everything to be conformal into the platform.”[47] Additionally, the FVL requirement calls for both Line of Sight (LOS) and Beyond Line of Sight (BLOS) communication for networks and manned and unmanned teaming (MUM-T), but are we developing avionics capabilities that ensures resilient command and control across all domains in the future challenged or denied environment?[48]

In addition to avionics, DoD must successfully develop functional digitization and network capabilities that maintain connectivity across the Joint Force. This capability enables Mission Command and is especially important as future competitors seek to interrupt or deny the U.S. command and control advantage. The Army must ensure that the development of FVL’s digitization and network capability meets the command and control needs of the future Joint Force across the Multi-Domain battle operational framework. The Initial Capabilities Document calls for FVL to be “fully interoperable with

a variety of Joint mission command networks and systems" as well as "Sensor data (data links, bandwidths, format, etc.) should be fully compatible with the Future Mission Network (FMN) environment, Joint Service air/ground, allied, civilian, and mission command systems."[49]

With requirements to be a "fully interoperable network" and "increased Situational Awareness and Understanding," it seems the Army is attempting to enable resilient command and control in the Joint Force, but does the Army truly understand the totality of these two requirements?[50] Today, capabilities such as Blue Force Tracker 2 (BFT2), Advanced Field Artillery Targeting and Direction System (AFATADS), and other digital traffic reside on these networks to improve situational awareness and provide desired effects. However, with planned platform speeds of up to 300 knots and ranges out to 424 kilometers, will FVL possess the ability to maintain network connectivity while traversing across all areas of the Multi-Domain battle operational framework?[51]

Finally, the DoD must expand its capability to conduct mission planning and execution. Today's Army Aviators conduct mission planning using the Aviation Mission Planning System (AMPS). The AMPS "provides Army aviation state-of-the-art interoperability and mission planning tools to enhance situational awareness, command and control, and safety. AMPS automates aviation mission planning tasks, mission rehearsal, and flight planning."[52] FVL calls for "joint mission planning systems compatibility" to ensure aviators across the Joint Force can share information garnered through mission planning, thereby improving situational awareness and safety across the force.[53] Additionally, FVL calls for the ability to conduct "enroute planning and be

capable of automation of critical battle tasks" and the "ability to react to mission changes enroute and at LZ."[54]

In addition to this requirement for the ability to plan, FVL calls for "an integrated common air, ground and maritime picture to the pilots, crew and passengers, with automatic reporting (internal to the flight of aircraft, external to appropriate C2 agencies) of threats, inclement weather and other hazards encountered."[55] Today, there is no capability that can provide a "real time" common operating picture (COP) to pilots once they embark on a mission. However, the Tactical Airspace Integration System (TAIS) could provide this capability in the future with further development. TAIS provides "integrated information management with other digital mission command systems" and is "a mobile communications and digitized battlefield information system providing air-ground synchronization and airspace integration within the operating environment."[56] Developing this enabling technology would be a "game changer" for the Multi-Domain battle. The ability to quickly plan and distribute change of missions as well as share critical elements of the COP would provide the situational awareness and additional flexibility needed to compete and win on the future volatile, uncertain, complex, and ambiguous (VUCA) battlefield.

Survivability

As previously discussed, peer competitors have invested heavily in the development of technologies to counter previous U.S. domain advantages. Therefore, future combat operations will likely include a highly contested environment. The FVL Threat Summary describes a highly contested, technologically advanced, Integrated Air Defense Systems (IADS) environment with counter precision guided munitions capability.[57] One of the primary focuses of FVL development is the "improved ability to

overcome threats" and to provide "enhanced survivability."[58] Based on this, it is imperative that FVL develop the required enablers to secure resilient operations in this promised, contested environment. In order to do this, the Joint Force must develop adaptive Aircraft Survivability Equipment (ASE), provide ability to operate in degraded environments, ensure secure operations of navigation systems and other enabling avionics, and provide an optionally manned capability.

The DoD must successfully develop advanced ASE. Today's DoD aircraft possess a limited capability to disrupt or defeat threat weapon systems. The speed of technology advancement, and the investment of our adversaries in these technologies, has served to exacerbate this capability gap and made it increasingly difficult for the Joint Force to maintain a competitive advantage. In order to regain its competitive dominance, DoD must ensure development of programs such as the Advanced Threat Detection System (ATDS).[59] FVL must fully integrate these technologies into the overall design, rather than treating them as an afterthought, as this technology will be critical for survivability on the future battlefield. Additionally, these systems must be robust and provide expansion capability, allowing the Joint Force the ability to quickly implement solutions to defeat future threats as they develop.

In addition to investment in advanced ASE to improve survivability, DoD must also invest in technologies that allow the Joint Force to redefine where and when it fights. In order to realize a true overmatch capability, FVL will need to incorporate technologies that are not available in today's aircraft. One such technology is Degraded Visual Environment (DVE). Weather and battlefield obscurants limit today's aviation operations. DVE "will allow U.S. Army Aviation assets to maintain an asymmetric

advantage on the battlefield, much like the adoption of night vision technology in the past."[60] DVE will not only enable aircraft to take off and land in degraded environments, but FVL calls for "an onboard system capable of detecting targets and hazards with fused sensors in adverse weather and battlefield obscurants," which "must also be capable of identifying and engaging threats while operating in DVE conditions."[61] Successful development and integration of DVE into FVL would provide U.S. aircraft an asymmetric advantage over our adversaries.

The DoD must also develop resilient capabilities that survive in the highly contested electronic warfare (EW) environment. Today's technologically advanced Joint Force is heavily dependent on Global Positioning Systems (GPS) to enable success across the spectrum of operations. From navigation, communication, weapon systems, to command and control, most combat systems are reliant upon GPS connectivity. Because of this known fact, it is almost certain that future operations against peer competitors will realize an attempt to disrupt our ability to use GPS and other enabling systems through electronic warfare attacks. The DoD must invest and develop Assured Precision Navigation and Timing (APNT) capabilities to ensure "continuous access to PNT data which directly impacts effective use of combat forces and our ability to mass effects, conduct SEAD, command and control, and optimize employment of our strategic, operational, and tactical assets."[62] This development must provide a resilient capability to "operate in electromagnetic environments."[63] FVL must leverage the development of this capability and incorporate it into its design to improve survivability and ensure continuity of operations.

The final way to improve FVL survivability is to develop an optionally manned capability. Lieutenant General Jon Davis, Deputy Commandant for Marine Aviation, stated, “The Marines in particular want optionally manned aircraft.”[64] Colonel Ramsey Bentley, TRADOC Capability Manager for FVL stated, “There are ‘numerous missions’ that could be unmanned or optionally manned, including surveillance and logistics resupply. But there are others the Army still considers to be manned missions only, including personnel transport, medical evacuation and attack operations in close proximity to personnel.”[65] By removing the pilot from extremely high-risk missions, an autonomous aircraft can improve survivability for the Joint Force by protecting our most valuable resource, our people.

Effects

Due to the complexity of today’s battlefield, the future Joint Force must be able to engage the enemy with weapon systems to produce the desired effects within extremely diverse environments. The nature of these engagements must be appropriate to the intensity of the conflict. In order to do this, FVL must avoid the trap of fighting the last battle and look to the future to understand the needed capability to produce the range of future desired effects, both lethal and nonlethal. Additionally, FVL must develop these capabilities through the lens of the anti-access aerial denial (A2AD) battlefield of the future.

Today’s Army Aviation weapon systems can produce lethal effects on various targets ranging from heavily armored tanks, bunkers, buildings, to troops in the open. The current inventory includes the AGM-114 family of Hellfire missiles, the 2.75” Hydra 70 rocket, and various machine guns. Each of these weapon systems has various warhead/ammunition combinations to achieve the desired effect against ground targets.

However, FVL must develop weapon systems to overcome today's capability gaps. The FVL Assault Variant requirement calls for an expanded weapon's capability to include an off-axis close proximity reactive weapon(s), small PGMs (Advanced Precision Kill Weapon System (APKWS) equivalent), air-to-air and air-to-ground capability, and weapon systems for perimeter security without the engines running.[66]

Additionally, the FVL requirement calls for the capability of "employing lethal and nonlethal weapons for offensive and self-defense purposes. Nonlethal effect shall be scalable. The lethal munitions shall be selectable for multiple desired effects."[67] This ability to produce scalable, nonlethal effects must be a development priority due to the diverse environments in which these engagements will occur due to the constantly changing character of war. The Army Research, Development and Engineering Command (ARDEC) is working to develop future weapon capabilities. ARDEC was tasked "to develop a 'stretch vision' for aviation lethality."[68] One such capability sought for FVL is the ability to deliver electronic warfare (EW) effects. These EW effects must be "capable of cockpit controlled employment of all externally mountable, conformal cyber, counter-cyber and EW delivery systems."[69] The development of this nonlethal capability is paramount for the Joint Force to possess the flexibility to produce the full range of desired effects on the future Multi-Domain battlefield.

In addition to the desire to produce nonlethal effects, FVL calls for the reintroduction of an air-to-air capability. Although previously a mission set of the OH-58D, the Army shed this capability in the early 2000s. With the future prospect of operations in a contested airspace and the threat of attack by both manned and unmanned enemy aircraft, the Army needs a capability to provide responsive air-to-air

fires across the operational framework. Finally, FVL calls for the ability to "identify and engage threats while operating in degraded visual environment conditions."[70] The ability to prosecute the desired effect at the time and place of our choosing, in environmental conditions that our adversaries cannot operate within, will provide a true overmatch capability for the future force.

To truly realize the synergistic effects of the future force's capability, the Army must ensure development and expansion of MUM-T. "MUM-T is the synchronized employment of Soldiers, manned and unmanned air and ground vehicles, robotics and sensors to achieve enhanced situational understanding, greater lethality and improved survivability."[71] The FVL requirement specifies "up to Level of Interoperability (LOI) 5," which provides the capability to control "multiple air, ground and water vehicles, as well as Optionally Piloted Vehicle/Aircraft (OPV)."[72] Levels of this capability exist today within the AH-64 platform to control some UAS, however expansion of this capability promises to expand operations to achieve desired effects in otherwise impermissible environments while also improving safety for manned platforms. FVL must further develop this capability as it could provide the much needed time and space to enable Joint Force entry into the future highly contested battlefield.

Inhibitors to FVL Development

Now that we understand the development and integration efforts that must occur to ensure an overmatch capability for FVL, it is appropriate to briefly consider those elements that could potentially inhibit successful development and fielding by 2030. First, the current fiscal constraints realized by the ever-tightening DoD budget poses the greatest threat to the development of FVL and its required enablers. Not only is the overall DoD development budget shrinking in the face of other government priorities and

the growing national debt, but also the enabling programs compete for dollars against the development of the FVL platform, because other Program Offices are responsible for their development.

Secondly, the nature of these highly complex Joint development efforts frequently result in competing requirements between the services, inherently driving up cost and increasing development timelines. One would naturally think Joint programs would garner unchallenged support from Congress because multiple services are working together and advocating for the same capability, thus the effort would receive the necessary funding to ensure success. Unfortunately, one does not have to look very far back in history to see these challenges exhibited in the Joint F-35 program. The combination of cost and schedule overruns typically spells disaster for the program.

Another potential inhibitor that DoD must consider is the service culture itself. The FVL requirement calls for an optionally manned capability.[73] Many within the various service Aviation communities could view this autonomous capability as a threat to their future job security and existence as a pilot in manned platforms. However, this optionally manned capability is attractive to senior DoD leaders as it would reduce risk to our force by providing the option to use the autonomous platforms in the most highly contested areas of the Multi-Domain battlefield to establish freedom of maneuver windows or corridors for follow on manned systems.

The final potential inhibitor to successful development of FVL is the delay in or failure to develop the desired technologies. FVL proposes to utilize multiple far-reaching technologies to garner the desired overmatch capability; however, there is no guarantee these technologies will ultimately be realized. In order to mitigate this risk, DoD initiated

developmental efforts with both industry and the ARDEC to increase the probability of success.

Conclusion

From the previous discussion, it is evident that FVL is more than just an aircraft platform; rather, it is an extremely complicated system of systems. Only by approaching the FVL development as a system of systems, will the DoD fully realize the capability it requires. In order to do this, the DoD must initiate and complete the development of the needed critical enablers in parallel with platform development to ensure FVL provides the desired overmatch capability for the future Multi-Domain battlefield. This includes securing funding for both the platform as well as the critical enablers. Additionally, the DoD must create effective Joint Service IPTs to develop those capabilities that are necessary to ensure mission success. In doing so, the services must avoid the typical service parochialism and competing requirements that have doomed multiple Joint programs. The DoD must avoid the fate of previous complex Joint programs and field a capability within program cost and on schedule to ensure the future force has the capability to fight and win on the future Multi-Domain battlefield.

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