Bell Future Vertical Lift Capstone

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Abstract: The research conducted by the capstone team helps to identify limiting factors of the Army's current doctrine for near-peer high intensity conflict involving air assault operations while incorporating Future Vertical Lift (FVL) aircraft. By using modeling software and changing the parameters of different aircraft to create a 'rubber' FVL airframe that fits the specifications of the Army's FVL program, the group's analysis determined how other parts of the Army need to adapt. Additionally, because of the complex nature of the problem and how the Army's pieces interconnect, an in-depth systems architecture was necessary to depict the interactions of components during an air assault operation.

Keywords: Future Vertical Lift, Systems Architecture, Air Assault Operations, Simulation, Modeling, One Semi-Automated Forces (OneSAF).

1. Introduction

Future Vertical Lift (FVL) is one of the United States Army's biggest modernization priorities. The Army states, as defined in the 2019 Modernization Strategy, FVL "platforms and technologies increase the maneuverability, endurance, lethality, and survivability of Army aircraft – increasing their operational reach and effectiveness against near-peer competitors," (United States Army). It began as a joint initiative across the entirety of the military with the Army spearheading the modernization. The joint initiative describes five 'Capability Sets' that outline five separate airframes that will take the place of currently employed aircraft. The Army has chosen to modernize capability sets 1 and 3, Future Attack Reconnaissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA), respectively. The goal of FARA is to fill the reconnaissance role previously held by the OH-58 Kiowa and FLRAA will replace the UH-60 Blackhawk and fill its assault role. The Army currently has two contenders for the FLRAA contract with two actual test demonstrators from Bell and Sikorsky-Boeing, the V-280 and SB-1. Five companies have submitted designs for the FARA contract: Boeing, Bell, AVX, Karem, and Sikorsky. Each capability set involves the increase of speed, lethality, cargo-load, maximum number of passengers, and survivability. Current Army doctrine does not account for the newly provided performance. In Multi-Domain Operations (MDO), which is how the Army envisions fighting in near-peer conflicts, air assaults will be a critical mission set for deep insertions behind enemy lines. Army operations have evolved into a complex system of interrelated branches. The Army's Modernization priorities, namely FVL, will provide Army operations with new and improved capabilities. These new capabilities will stress the current limiting factors of operations resulting in doctrinal changes to operations. To capture these changes, we developed systems architectures to capture the relationships within the context of an air assault operation and using One Semi-Automated Forces (OneSAF), a computer-aided model, analyzed FVL performance in a company-level air assault operation against a base-model, non-FVL air assault. The model, coupled with the systems architectures, bring to light discrepancies involving the use of FVL and will fuel future research.

Proceedings of the 2020 Annual General Donald R. Keith Memorial Capstone Conference
West Point, New York, USA
April 30, 2020
A Regional Conference of the Society for Industrial and Systems Engineering

2. Methodology

2.1 Air Assault Operation Overview

An interview conducted with Maj. J.D. Caddell, an infantry officer and instructor in the Department of Systems Engineering yielded an understanding of how an air assault operation is typically conducted (Maj. J.D. Caddell, interview, November 5, 2019). An air assault can be broken down into three phases, beginning with a reconnaissance phase. During this phase, a reconnaissance asset scouts out potential landing zones for follow-on lift assets to use during an air assault's lift phase. Once potential landing zones have been identified, the recon asset will maintain overwatch of the primary landing zone and communicate with the lift assets to initiate the lift phase.

Upon receipt of the landing zone location confirmation, the lift assets will begin the lift phase of the operation by loading all personnel, securing all personnel, and departing the forward operating base (FOB). The lift assets can travel to a false landing zone, where a false insertion will be conducted to deceive any enemy forces that could be in the area, or they can travel to the primary landing zone and evaluate the security at that location. If the primary landing zone is secure, the insertion is conducted, and ground personnel begin the ground phase of the operation. If deemed unsecure, the lift assets either travel to an alternate landing zone to conduct the insertion or back to the FOB.

The ground phase of the operation commences with a movement to an objective rally point (ORP). From here, a reconnaissance team scouts out the objective location to gather information and increase situational awareness. The team then heads back to the ORP where it assembles all remaining personnel. All personnel move to their respective assault positions soon after and conduct the assault on the objective. Upon the completion of the assault, the element may establish a defense to prepare for follow-on operations (if the mission involves an attack), or it may exfil from the objective and end the mission (if the mission involves a raid).
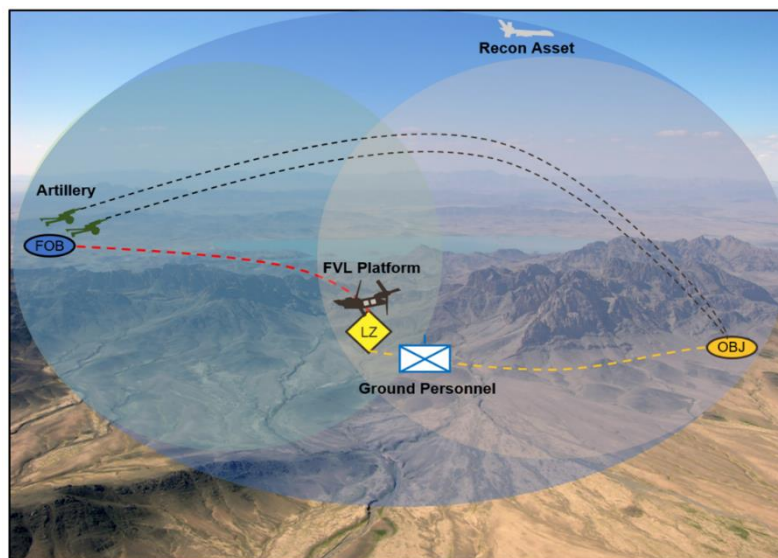
2.2 Operational Viewpoint

Figure. 1 Operational Viewpoint

Figure 1 depicts the high-level operational viewpoint (OV-1) for a typical air assault scenario which combines an air assault's three phases into one graphic. The shaded ovals represent radio communication links between different elements, with the green oval representing the connection between the FOB and the lift asset, the orange oval representing the connection between the lift asset and ground personnel, and the larger blue oval representing the communication between the recon asset and the FOB. The OV-1 was used as a guide to model the scenario in OneSAF, with lift assets traveling from a FOB to a landing zone, conducting an insertion, and a follow-on ground movement being conducted to an objective.

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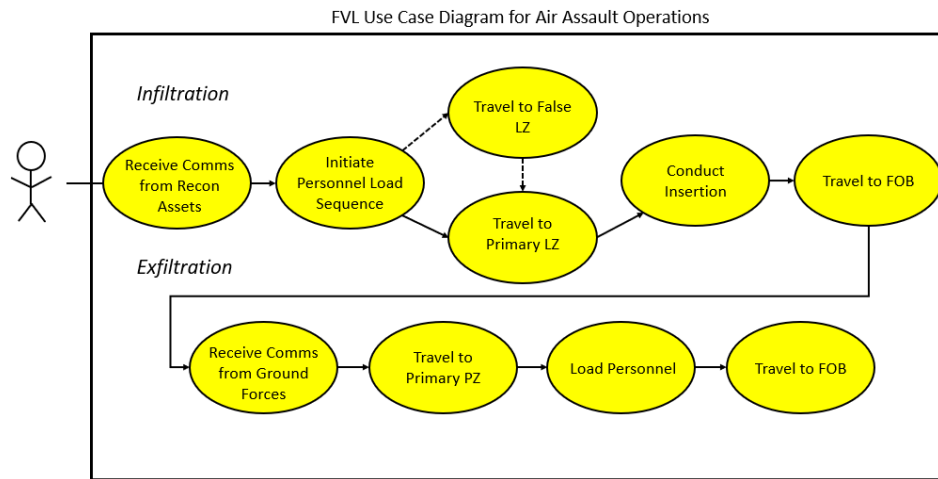
2.3 Use Case Diagram

Figure 2. Use Case Diagram

Figure 2 depicts a use case diagram for an air assault operation. This diagram shows how, from the perspective of the user, an FVL asset will engage in activities throughout an operation. The user is the pilot represented by the stick figure on the left. During the infiltration stage, the pilot receives communications from a recon asset regarding the location of landing zones. Once received, the ground personnel waiting nearby will load into the aircraft. The aircraft will then either travel to the primary landing zone and conduct the insertion, or it will travel to a false landing zone to conduct a false insertion before it travels to the primary landing zone. False insertions can be incorporated into a plan to misguide any enemy elements that could potentially be in the area of operation. Either way, once the insertion has been conducted, the aircraft will then travel back to the FOB and wait for a pickup request after the ground forces have conducted their mission (assuming an operation involves an exfiltration). For the purposes of our model, we assumed that the ground phase would be completed with ground forces destroying the enemy on the objective followed by follow-on operations at the objective (i.e. no exfiltration required). However, in an operation involving a planned exfiltration, the FVL asset would receive a request from ground forces to meet at a pickup zone, triggering the aircraft to travel to that pickup zone, load all personnel, and travel back to the FOB.

2.4 Building Model Scenario

In order to fairly compare the capabilities of the FVL aircraft with the current capabilities of legacy aircraft such as the UH-60L Blackhawk, the team and the client narrowed down the scope of the scenario from the original goal of modeling a brigade versus brigade simulation. A simulation to this scale proved itself infeasible for a team of four cadets to complete in the time window available. In order to scope the project to a size the group felt manageable, a company level air assault became the new objective. The question of how to analyze the performance of the FVL aircraft became the new focus. By concentrating on the operational viewpoint, speaking with subject matter experts, and searching the data collection tool within OneSAF the team found a combination of parameters to most easily answer the objective in the problem statement. Although the team is currently only able to interpret results from a single discrete event simulation, the team is learning to use the replication tool in OneSAF. The capstone team will simulate 50 runs of each scenario in order to satisfy the requirement of the Central Limit Theorem. Satisfying the Central Limit Theorem through more than 30 runs allows the team to build an approximation of the performance of the FVL assets along a normal curve including confidence intervals of the performance. As a result, the team will be able to give statistically informed answers to stakeholders in the decision brief.

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3. Results

3.1 Analytical Modeling

In order to gain a conceptual understanding of the results that our simulation model should provide, the team first developed analytical models to gain insights into certain characteristics of the legacy aircraft and FVL aircraft. The team analyzed characteristics for the UH-60, V-280, SB>1, and based on the FVL characteristics proposed by the Army. These models were built in excel and require several simplifying assumptions. The first model analyzed the max range (km) of aircraft over time, while the second model analyzed the number of troops that could be built up on an objective over time.

For the model that analyzed the max range of the aircraft over time we assumed that the aircraft would always be traveling at max speed. Similarly, we assumed that altitude, weather, or any other outside factors that effect aircraft performance would not have any effect the model. The group analyzed the range of aircraft over a two-hour time period in order to inform our simulation modeling. As a result, we saw that the FVL aircraft would be able to travel approximately twice as far in the time period.

For the model that analyzed troop build up we again assumed that the aircraft would be traveling at max speed. The assumed that the objective would be 50 km away and that we would analyze how many troops could be transported using one aircraft of a specific type over a two-hour time period. Additionally, we assumed that there would be a 15-minute additional time addition per trip to account for loading, exfiltration, fueling, etc. Finally, like the first model, any outside factor not previously mentioned that have effects on aircraft performance would not be accounted for. As a result, due to the speeds of the FVL aircraft we determined that they could complete one additional trip in the time window.

3.2 OneSAF Modeling

Results from the baseline OneSAF model are limited due to difficulty arising from the level of complexity associated with any combat simulation tool. In order to create a model both to satisfy the client's needs and respect the feasible scope for the capstone group, an iterative process of adding layers of complexity became the most efficient means of building the OneSAF model. To combat the demanding learning curve facing the capstone group, the team leveraged contacts at the Air Maneuver Battle Lab (AMBL) for scenarios already developed in order to use as a template or referencing tool, but AMBL and the capstone team's OneSAF were running on dissimilar operating systems. The AMBL gave the team advice to use scenarios which were already installed along with the OneSAF program. The capstone team selected two scenarios to use as an example and to reference the task organization logic within the scenarios. The first pre-developed scenario was a counter-insurgency scenario which utilized an air assault, while the second scenario was a peer level ground engagement. The combination of the two models and time spent referencing the OneSAF developer's manual lead the capstone team to developing a working baseline simulation. By using the data collection tool within OneSAF and R-Studio, the group found that the data output from the current single event discrete simulation is not in agreement with the previously conducted analytical modeling.

4. Future Work

4.1 Relationship Between an Air Assault and Other Branches

In an air assault operation, multiple relationships exist between different actors involved. Regarding the lift aspect of an operation, it is known that aviation assets are responsible for the safe transportation of ground troops to landing zones. Once an infiltration has been conducted, however, lift assets continue their mission by assuming a logistical support role (Maj. Gen. (Retired) Jeffrey Schloesser, interview, February 27, 2020). In this role, lift assets provide logistical support to ground forces throughout the duration of a ground mission by supplying personnel with ammunition, food, and water. Regarding an operation's artillery component, coordinated indirect fires from artillery assets positioned at either a FOB or a forward operating artillery element allow for the potential destruction of enemy personnel and equipment on an objective before a friendly ground element reaches that location. In an operation, artillery assets must be positioned within their maximum effective ranges to ensure fires can accurately impact an objective. Finally, depending on the situation, an unmanned reconnaissance asset (UAS) may be involved to scout out potential landing zones or provide overwatch of an objective. This would involve the use of intelligence personnel to control the UAS.

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4.2 Integration of FVL into Baseline Scenario

Once the baseline scenario completes the verification and validation phase, the group will update the baseline's task organization, data file, and entity characteristics. In order to accurately show the capabilities of FVL assets, the air assault distances will be increased given the increased speed, range, and payload of these FVL aircraft. The data file will be updated to represent the publicly disseminated speed and range of the FVL assets. The distance of the air assault will be increased from 51 kilometers to 250 kilometers. At this distance, the UH-60L Blackhawk requires a Forward Arming and Refueling Point (FARP) prepositioned whereas the FVL assets are advertised as capable of reaching the objective and returning to base without the added operational risk of the FARP. By stretching the air lift distance, there are effects on the artillery and the sustainment of the ground force being lifted in. At 250 kilometers, artillery will need to be air assaulted into position within range of the objective in order to support the ground commander. This is important distinction between the baseline scenario and the FVL scenario. In the FVL scenario, the feasibility of a FOB is no longer tactically capable given the increased capabilities of enemy forces. The FVL scenario will respect the capabilities of traditional direct, indirect, and CAS capabilities in order to accurately portray to the effect of friendly forces in combat against a near peer or peer threat.

4.3 Collect Results from analytical and OneSAF modeling

After the completion of the FVL scenario, the group will focus on a few important parameters directly related to answering the problem statement. The group will compare the lethality, survivability, and time to mass forces on the objective in each scenario to analyze the effect of FVL aircraft in the system. These parameters are important to analyze considering the client and the U.S. Army are interested in the increased lethality of the military in modern combat. The group will define the lethality of friendly forces as a quantitative value of the percentage of enemy forces killed or incapacitated. The survivability of friendly forces in the model will be the percentage of friendly forces not requiring medical attention above the ambulatory classification. Each of these parameters were selected as the most simplistic measures of increased system performance within the scope of the problem statement. A comparison of the baseline output and the FVL scenario output will serve as the basis for contrasting the differences in the system characteristics and performance of each model.

4.4 Analysis of limiting factors

The main goal of this project is to leverage the systems architecture and simulation modeling in order to gain insight into how introducing FVL into the Army's system of system will result in factors that limit the potential of Army combat operations. Once the system architecture is built that describes the relations between the air assaulted force and the units that enable it, we will then begin our analysis of how introducing FVL assets will affect the existing relationships. The group plans to use the simulation model data to provide a quantitative approach to determining these limiting factors, however due to the scale of the scenario possible and the lack of modeling experience it is more likely that the analysis of limiting factors will be done qualitatively.

5. Follow on Capstones

5.1 Advanced MDO/FVL scenario modeling

In the future, follow on capstone teams should use the tools the current team has provided, the resources collected, and the scenarios the team has developed to build a more complex model. A more complex model should be developed to simulate Multi-Domain Operations with the FVL aircraft. The U. S. Army leadership explains MDO by saying, "The Army solves the problems presented by Chinese and Russian operations in competition and conflict by applying three interrelated tenets: calibrated force posture, multi-domain formations, and convergence" (TP 525-3-1). Next years capstone should focus on the calibrated force posture of friendly forces. In the U.S. Army publication, it states that "Calibrated force posture is the combination of position and the ability to maneuver across strategic distances" (TP 525-3-1). FVL aircraft are being developed in order to satisfy the calibrated force tenant of MDO which calls for more range, maneuverability, and informed positioning of troops on the battlefield. In terms of modeling an MDO scenario, the team should focus on the increased range and speed and range within the highly contested battlespace described by Army leadership in TP 525-3-1. Additionally, detection of personnel and aircraft in MDO will have the greatest impact on the survivability of the troops and aircraft. Thus, modeling cyber denial and applications of attacks on enemy air defense systems is required. OneSAF has the capability to model cyber denial, cyber-attacks, and misinformation through a tool within the program called COBWebS which stands for Cyber

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Operations Battlefield Web Services. In general, now that the current capstone team has provided the capstone team all the necessary resources, it is expected of future capstones to be more efficient in the modeling. The current team has gathered all the information required to beat the learning curve, so great leaps forward are the expectation for years to come.

6. Conclusion

The integration of FVL, as well as other modernization priorities, into the Army's current system of systems will undoubtably effect Army doctrine. In order to determine some of the effects of FLRAA concept, the team has begun building the necessary systems architectures, such as the OV-1 and use-case diagram. Along with the architectures we plan to build describing the relationships between an air assault force and its enablers, we will be able to build a framework for how an air assault force works under the Army's doctrine today. Additionally, we were able to determine that OneSAF is a modeling software that meets the demands of the project. Although obstacles were encountered in the modeling process, we have begun building a valid air assault model based on the architectures already built. Finally, the simulation modeling, analytical modeling, and qualitative analysis will provide us with insight into factors that limit the overall mission effectiveness when FVL is introduced.

7. References

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