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Army Mission Planning Using Drone Imagery and Virtual Reality

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Abstract: In order to improve the efficiency of mission planning for the US Army, we developed a method of using virtual reality that will better prepare soldiers before entering their mission. This proposed system is being referred to as Leader's Enhanced Mission Planning (LEMP). The intended audience for LEMP is primarily soldiers in leadership positions, as they will be the ones to pass down any necessary information to their subordinates. Introducing virtual reality will help prepare soldiers by putting them into a virtual replication of the world that they will encounter once out on their respective mission. While this technology has endless possibilities, this project focuses on an enhanced planning checklist a leader can use to appropriately plan an operation while getting the most out of technology currently available today, as well as in the future.

Keywords: Leader's Enhanced Mission Planning (LEMP), Virtual Reality, Planning Checklist, Mission Planning

1. Introduction

The United States Army continues to explore new methods and means to gain tactical and operational advantages over its adversaries. Technology exploitation has been, and continues to be, an important factor behind our military's effectiveness giving us key advantages in combat. Phrases such as "owning the night" have stemmed from our ability to leverage technological systems better than our adversaries. Now, there is the potential to revolutionize the way the Army conducts mission planning through emerging advances in virtual reality.

The beginnings of virtual reality reach back to the 1960's when Ivan Sutherland, considered the father of virtual reality, built the first head-mounted display (Hillis, 1999, p. 9). In recent years, virtual reality has gained a large following in both the civilian and military sectors. The gaming industry opened a new world to gamers that now allows them to completely immerse themselves in a digital world. Conversely, the military is only beginning to scratch the surface of virtual reality's potential. Already there are numerous projects exploring how virtual reality can be used by the Army, but one promising and important application for this technology could revolutionize the way units plan and prepare for operations.

2. Overview

The current use of virtual reality in the U.S. Army is limited but recent technological advances are reinvigorating military research and development. Moreover, new recruits and young soldiers are increasingly technologically adept at understanding and using technology to perform the mission. T.R Witcher, author of the article *Virtual Reality Games Fuel a Military Training Revolution*, discussed how the affinity for technology of the many young soldier has evolved. Dr. Mark Nesselrode, a retired Captain in the Navy who is now a solution architect for training at General Dynamics Information Technology, states that the average soldier is about 20 years old and grew up around technology (Witcher, 2017). He argues that they have a better sense of it and that familiarity is an asset for our operational force (Witcher, 2017).

Virtual reality also has the potential to provide a safer and cheaper way to train soldiers further augmenting simulation technologies in use for training today. That said, there will need to be an investment in the near term to further research and develop training suitable for virtual reality and an initial cost to purchase and install the systems at the desired training points. Once instantiated, the Army will save on gas to transport units to and from the training areas, ammunition to use in the field, and the time it will take to plan and execute training exercises. If proven to have adequate training effectiveness, it will provide a safe alternative that can easily be repeated as desired. Additionally, there is a plethora of unexplored uses for this immersion technology that the Army is interested in exploring further.

The Engagement Skills Trainer, a system that has seen widespread implementation by the U.S. Army for marksmanship training, is one of multiple virtual simulation based programs that have been adopted by the Army in the past.

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Furthermore, the US Army Armor School at Fort Benning, GA uses the Close Combat Tactical Trainer to improve the communication and proficiency of armored units. These programs, while useful, are based on older technologies that do not represent the capabilities of newer virtual reality technology, notably the immersion associated with modern virtual reality platforms. The Army is currently executing a diverse Science and Technology portfolio to explore the best ways to leverage these newer technologies in order to perform more robust collective training.

While there are multiple research and development efforts focused on applying virtual reality for training, one of our goals for this project is to highlight the potential that virtual reality offers the Army beyond just the training environment. Our vision for virtual reality within the Army is to alleviate the mental load on soldiers and achieve a novel, realistic perspective of the battlefield. We began our exploration of this type of application by focusing on leader's reconnaissance as a use case. To that end, we conceptualized the use of virtual reality to put the recon team in a virtual world simulating the actual objective naming the concept Leader's Enhanced Virtual Reality (LEVR).

With the introduction of a new technology to the Army, smooth integration into the large organization is often a large source of resistance. Thus, we agreed that another goal for this project would be the creation of a user checklist that integrates current procedural norms with the projected capabilities of LEVR. Based on our experience and knowledge of emerging technologies, we made assumptions on the near future state of technology where drones could send back detailed renderings in and around the objective. Using these renderings, leaders could use LEVR to brief and show the best way to attack the objective, see who and what is on the objective, and best ways to get in and out of the objective. Essentially, LEVR would allow a unit to be at the objective without setting foot on it through its immersive capabilities.

During the process of creating this checklist and discussing the concept with subject matter experts, we came to the realization that although virtual reality could be applied to a leader's reconnaissance, it would be better applied to the entire mission planning portion of an operation. As we became more familiar with the capabilities of virtual reality and envisioned the future of this technology in the Army, it became clear that the technology could actually revolutionize the way that leaders plan their missions. The integration of virtual reality from the start of the mission planning phase will allow for a more detailed analysis and more immersive experience while leaders continue to follow the general five paragraphs of the contemporary operations order, or OPORD (Situation, Mission, Execution, Sustainment, and Command & Control). Current doctrine regarding a leader's reconnaissance provides that a patrol leader simply confirm or deny their pre-established operational plan based on the most current intelligence gathered from a small scouting party. Thus, we concluded that LEVR would not leverage the full potential of the technology. We see a future where intelligence officers, mission briefers, and mission planners interact through a collaborative virtual environment to plan, brief, and rehearse operations. Furthermore, this environment could be kept up to date by drones and other technologies that are revolutionizing the realm of Intelligence, Surveillance, and Reconnaissance (ISR). Thus we expanded our concept towards a Leader's Enhanced Mission Planning (LEMP) system and the creation a checklist that integrated the future with current mission planning methodology.

3. Assumptions

Over the course of developing our checklist we had to make some assumptions that would help us in enhancing mission planning using virtual reality. The most critical assumption that our project relies on is that we assumed drone technology will exist that can provide sufficient data feeds to render a wide variety of objectives in the virtual reality system. Furthermore, these drones would be difficult to detect; an important factor in allowing friendly forces to maintain the initiative while gaining a near omniscient understanding of the enemy and the objective. We believe that this level of drone technology will be available in 10 to 15 years. We further assumed that virtual reality will not be limited by a drone's ability to completely and fully render an objective. These assumptions were based on a site visit to the University of Southern California Institute for Creative Technologies (ICT), which is a University Affiliated Research Center managed by the US Army Research Laboratory. While at ICT, we learned that they have been working on both drone technology and virtual reality programs that could be used within the next five years. The demonstrations of their research helped provide a baseline for what is within the realm of the possible in the near term.

4. Stakeholder Analysis

While there are many stakeholders for this enhanced form of mission planning, we believe that the first units to leverage this technology will be the US Army Special Forces. Their primary missions include counterterrorism, direct action, foreign internal defense, special reconnaissance, and unconventional warfare. As "the tip of the spear," we believe that these highly trained, highly resourced units will be the first to implement this technology as it has the potential to remove substantial amounts of uncertainty in their high-stake operations. For this reason, we interviewed Lieutenant Colonel Kent Solheim, 3rd Battalion

Commander of 3rd Special Forces Group at Fort Bragg, NC, to get his input on our concept. The goal of our proposed checklist is to ensure that users will be able to focus on the mission at hand and gain value from the introduction of virtual reality. According to LTC Solheim, this can be best achieved by a system that is able to assist soldiers in finding, fixing, and finishing the enemy in a manner that is more effective than the tactics that are currently being used. The current mission planning procedures of the Army can be improved to increase knowledge of the objective, collective mission understanding and overall improve safety of personnel. In order to do this, it was critical that we gain feedback to adapt and adjust the checklist to best fit the need of future users. It was also critical that we focus on the scope of the potential use so we zeroed in on smaller operations, such as raids and seizing of objectives. Those uses are also the most common missions we are exposed to here at West Point giving us personal experience with the current state-of-the-art.

To further refine our vision, we conducted several interviews with soldiers who could one day be using this technology for their mission. Our goal was to gain their perspective and insights as to what the ideal system would provide before they would ever be at risk on the objective. As we collected their firsthand knowledge and experience, we explored how we could integrate their recommendations and experience into our checklist. Additionally, when faced with the problems that they shared based on current tactics, techniques, and procedures, we asked ourselves if virtual reality could have solved or prevented the problem. This approach allowed us to put together a list of requirements for a future mission planning system. We then approached the task of creating the Leader's Enhanced Mission Planning Checklist under the assumption that all of these needs were being met through developed ISR capabilities.

4.1. Level 1 System Requirements for LEMP

After conducting our stakeholder analysis, we were able to build the higher level requirements for LEMP. These requirements are built upon what we believe will make LEMP effective in the future and address stakeholder concerns, but they are also heavily reliant on our assumptions about future technology. The following are our Level 1 System Requirements for the proposed system:

- The system shall compile data from all sources into a three dimensional (3D) virtual environment
- The system shall assist planners by automating parts of analysis
- The system shall allow for remote collaborative planning
- The system shall access updated data from ISR assets

To be sufficient, the above requirements must be met. They address the needs of the stakeholders and represent a system that is better than what is currently available to plan for missions. Based on our analysis, we deemed that these requirements will help improve the planning phase of a mission with the assumptions that the technology will be available and capable of meeting the Level 1 requirements.

5. Methodology

In order to identify and define ways that Army mission planning could be improved through new technology, specifically virtual reality. We referenced the West Point Department of Systems Engineering's System Design Process (SDP), focusing first on the problem definition phase. Slightly unorthodox to typical systems thinking, we limited our scope to explore only how virtual reality can be applied as a solution to the needs of our stakeholders. While there is inherent risk in limiting solutions, our initial research in the field suggested that the capabilities of virtual reality would benefit mission planning in the Army, and further research in the field should be encouraged.

After becoming familiar with the existing literature on virtual reality technology, applications, and general benefits, we began to look for more specific applications that related to our goals and the needs of LEMP. We then worked with our capstone project client, Mr. Chris McGroarty, Chief Engineer for Advanced Simulation at the U.S Army Research Laboratory, to better understand where current Science and Technology efforts might apply. He suggested that a trip to the aforementioned ICT in Los Angeles, CA would show practical elements of our vision n research and development. It was here that we found the technological groundworks for the Leader's Enhanced Mission Planning system that we envisioned. The visit allowed us to get a better grasp on the validity of our assumptions and spurred additional thought regarding the future of mission planning.

From this connection with ICT, we discovered that the Army had indeed already started experimenting with a virtual planning environment. In fact, the Department of Military Instruction (DMI) at West Point is currently working in conjunction with programmers at Pennsylvania State University to create a virtual reality enabled mission planning program. A visit to DMI and hands on time with the prototype provided greater insight into the capabilities of the future as well as baselined the current state of the research by seeing the low technology maturity of the work, which is still in the research phase. Furthermore,

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we used the experience to better assess and further refine our checklist. Having a working prototype showing elements of the system we envisioned while drafting our checklist made it easier to recognize gaps in our work.

Ultimately, the goal of this checklist is to provide a step-by-step procedure for mission planning in a virtually rendered environment from the reception of an order to the end of the mission. One of our primary goals in formulating the checklist was to root the procedure in existing Army doctrine and procedures. As a starting point, we relied heavily on our experience being students at the United States Military Academy and lessons on warfighting, small unit operations, and platoon operations from the Department of Military Instruction. Additional resources that aided in formulating this checklist were existing standard operation procedures applied by different units up to battalion level and the Ranger Handbook.

The novelty and usefulness of this checklist is not the content -- it was not our goal to revolutionize doctrinal procedures of planning -- rather, the LEMP Checklist allows soldiers to utilize an emerging technology to its maximum potential by taking existing procedures and applying it under the assumptions that the technology will exist. Furthermore, this checklist will spur future development of the virtual reality systems, ensuring that soldier-friendly interfaces are designed.

The final step in the SDP is to analyze the added value that our checklist provides over the traditional mission planning process. In almost every step of the checklist, soldiers will be provided with more information about the objective by the virtual reality system enhancing their readiness and preparation for the mission. One of the biggest impacts of virtual reality mission planning is the ability for leaders to place themselves in enemy positions. For example, in a traditional enemy analysis, leaders are limited to guessing where enemies on the objective will be. In the new method of planning, leaders would now be able to place themselves in those specific spots and truly see what the enemy would be seeing. The added benefit of being able to analyze each vantage point would allow the planning process to be more accurate in making key decisions. Similarly, the benefits of virtual reality can be seen during every step of the checklist; the very basis of mission planning involves making decisions based on a limited set of information, but with virtual reality mission planning this access to information would be far more plentiful and accurate.

6. Leaders Enhanced Mission Planning Checklist

STEP 1 Review Mission Requirements	STEP 2 Key Terrain	STEP 3 Obstacles	STEP 4 Enemy Analysis	STEP 5 Avenues of Approach	STEP 6 Observation and Fields of Fire	STEP 7 Cover & Concealment	STEP 8 Electromagnetic Spectrum	STEP 9 Mission Planning-User Input	STEP 10 CBRN
Task/Purpose	Decisive Terain	ID Man-made/Natural Obstacles	Enemy Composition	Modified Combined Objective Overlay (MCOO)	Automated Analysis of Observation and FoF One-World Terrain*	Automated Analysis of Cover and Concealment One-World terrain*	ID Wavelengths - How is the enemy communicating?*	Task Organization - Task/Purpose	Indicators: Material
Key Tasks/CDR Intent	People-Local Influence	Render Inside of Buildings*	Enemy Disposition	Size/Quality of Roads, Trails, Waterways	Objective, Enemy, Locations, Buildings	Routes to/from Objective	Where are the cell towers?*	Infiltration Method	Indicators: Personnel
Where are we going?	Bandwidth/Cell Towers/Infrastructure*	Determine Enemy Obstacle Plan	Enemy Capabilities	ID PACE Plan for Route to/off Objective	Optimal positioning	Enemy Locations Covering Objective	Does the enemy use cell phones? Facial Recognition/Fingerprint Login*	Finalize Plan - Graphical Representation	Chemical Agents
	Gain High Ground-Site Analysis	Identify Strengths/ Weaknesses in Obstacles	Strength/Morale	Road Usage/Traffic Patterns	Breach Sites		Positive ID Target	Start Point (SP), Release Point (RP), Check Point (CP)	
			Enemy Mission and Objectives	Aircraft Capabilities- Landing Zone, Pick-up, Drop Zone	Weapon Capabilities*		Current/Frequently Visited Locations	Available Equipment	
			Enemy Courses of Action	Subways, Sewers, Etc.				Vary Conditions and Refine Plan	

Figure 1. LEMP Checklist

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The checklist above shows the steps a leader would go through while using the virtual reality system. The checklist stems from Army doctrine on planning a mission, but integrates the benefits of virtual reality creating mission plans. The yellow highlighted blocks in Figure 1 show some of the areas that a virtual system will be able to help enhance planning and briefing a mission. Under “Observations and Fields of Fire”, One-World Terrain, or a program similar to it, will be of extreme value in being able to show weapons’ capabilities and effectiveness at any given distance. This program has the capability of automatically analyzing sight lines of two soldiers, one friendly and one enemy, when placed on an objective. Furthermore it can analyze cover and concealment of routes, and determine weapon effectiveness based on a database of weapon capabilities. Essentially, the advantage of this system allows leaders to have a better idea of the environment and capabilities of both friendly and enemy forces without the mental strain of doing the analysis by hand.

The “Electromagnetic Spectrum” column represents a new consideration of future mission planning. We believe that future ISR capabilities will allow us to depict the electromagnetic spectrum within LEMP. This could help track signals of the enemy who might be using electronic devices to set off bombs and Improvised Explosive Devices, or IEDs. Second, it could help to determine the enemy location, who they have been in contact with, and “dead spots” on the objective that could affect communication during the mission. We believe this to be an essential and effective tool to mission planning because it can help pinpoint enemy locations using cell signals, determine spots where communications could go out, and find weaknesses in the enemy’s communications.

Another interesting finding from our development of the LEMP checklist is how technology changes the methodology of mission planning. Traditionally, a mission planner would conduct the Enemy Analysis after conducting a full terrain analysis. This is because of the high level of uncertainty of enemy disposition and the need for traditional planners to conduct an analysis from the perspective of the enemy to create a likely disposition of enemy forces. Instead, our checklist puts this step in the middle of the terrain analysis, because we believe that this uncertainty in enemy disposition will be minimized by future drone technology. These drones will keep intelligence current and accurate, affecting the planning process by making it more deliberate and fast. If this assumed capability is not in effect, planners should revert to the traditional conservative approach. However, we predict that the faster flow of accurate information from objective to planner will allow for planners to spend less time worrying about how the enemy situation could change to allow for a more rapid creation and execution of a plan.

7. Conclusion and Recommendation for Future Work

Much of the work that we have done rests on the plausible assumption that technology will advance to the point where LEMP becomes a reality and not simply an idea. In order for LEMP to truly be effective, continued progress needs to be made in both the fields of virtual reality and drone technology. Drones are key to capturing the data that virtual reality systems will utilize to render mission objectives in a virtual setting. The virtual environment has the potential to provide large amounts of data to a leader in an effective manner, but this can only be done if ISR capabilities develop to collect that data without compromising the mission. LEMP has the potential to enhance the Army’s ability to plan for missions. It has the potential to reduce casualty rates and increase the chances for mission success. Our checklist aims to guide users through the mission planning process while immersed in a virtual environment to truly extract the added value the system has over traditional planning.

Although our group has made progress, there is still much more to do to truly realize a LEMP system. Had the means been available, we would have created an experiment in order to validate our conclusions regarding the value of virtual reality enhanced mission planning. We recommend that a comparison be made between the traditional strategy of mission planning versus LEMP. To do this, an experiment can be conducted by presenting units with a series of scenarios and have them plan for the missions using both methods. Feedback from these soldiers will be imperative to improving the checklist and virtual reality system towards the ideal mission planning capability. Furthermore, this study can be done before the LEMP system is complete by using prototype programs, such the Department of Military Instruction prototype with Pennsylvania State University, to conduct a simple experiment testing the hypothesis that operations conducted with access to virtual reality planning tools are more likely to result in success and better performance measures.

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