Virtual reality and its applications in the process of leading military troops

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Abstract: Virtual reality (VR) has rapidly emerged as a new multidisciplinary research field. In recent years, its scope has grown beyond academic research, and industry is investing significantly in this area, both for research and for the production of VR-based products. Various industries such as information technology, biomedical engineering, construction, and instructional technology are investing in this technology. The military industry is becoming one of the main investors in VR technology as it presents a lot of opportunities for training, simulation and mission rehearsal. The military is always looking for new and innovative ways to improve the readiness and effectiveness of its forces, and VR technology has the potential to provide realistic, immersive training experiences that can prepare soldiers for a wide range of situations, including combat, peacekeeping operations and disaster response. Additionally, VR can be used to simulate and test new equipment and tactics, as well as to rehearse missions before they are executed in the field. This research aims to provide an overview of the current and future use of VR by commanders of military sub-units or units. More specifically, this article assesses the relevance of VR for the military domain, mainly describing how VR is used by the platoon leader in the troop leading procedures (TLP).

Keywords: Virtual reality (VR), Real world, Virtual world, Simulators Digital Military, Digital Transformation, Warfare Battle Scenario Simulation.

Realitatea virtuală și aplicațiile sale în procesul de conducere a trupelor militare

Rezumat: Realitatea virtuală (VR) a apărut rapid ca un nou domeniu de cercetare multidisciplinar. În ultimii ani, domeniul său de aplicare a crescut dincolo de cercetarea academică, iar industria investește semnificativ în acest domeniu, atât pentru cercetare, cât și pentru producția de produse bazate pe VR. Diverse industrii, cum ar fi tehnologia informației, ingineria biomedicală, construcțiile și tehnologia de instruire investesc în această tehnologie. Industria militară devine unul dintre principalii investitori în tehnologia VR, deoarece prezintă o mulțime de oportunități de antrenament, simulare și repetiție de misiune. Armata caută mereu modalități noi și inovatoare de a îmbunătăți pregătirea și eficacitatea forțelor sale, iar tehnologia VR are potențialul de a oferi experiențe de antrenament realiste, captivante, care pot pregăti soldații pentru o gamă largă de situații, inclusiv luptă, operațiuni de menținere a păcii, și răspunsul la dezastre. În plus, VR poate fi folosit pentru a simula și testa noi echipamente și tactici, precum și pentru a repeta misiuni înainte ca acestea să fie executate pe teren. Această cercetare își propune să ofere o imagine de ansamblu asupra utilizării actuale și viitoare a VR de către comandanții subunităților sau unităților militare. Mai precis, acest articol evaluează relevanța VR pentru domeniul militar, descriind în principal modul în care VR este utilizată de comandantul de subunitate în procedurile de conducere a trupelor (TLP).

Cuvinte cheie: realitate virtuală (VR), lume reală, lume virtuală, simulatoare militare digitale, transformare digitală, Simulare scenariu de luptă de război.

1. Introduction

Virtual reality (VR) is not a new concept, the main milestones in development being considered: the "alternative" reality proposed by Plato (Lele, 2013); "the sword of Damocles" – the first prototype of VR equipment; the detachment in the 1960s from the US military's combat simulation system (Liu et al., 2018). The "virtual reality" concept appeared as a necessity to distinguish immersive digital environments from traditional simulations (Ionescu & Calin, 1995).

Virtual reality (VR) technologies are maturing and the feasibility of developing cost-effective VR-based tools is increasing. The cost of VR hardware, such as head-mounted displays and motion tracking systems, has been decreasing over time, making it more accessible to a wider range of organizations. Additionally, advances in software development and graphics processing have made it possible to create more realistic and immersive virtual environments. Furthermore, the development of the 5G network and the increased computational power of devices allows the users to access VR applications remotely, providing more flexibility. As a result, more organizations, including the military, are beginning to explore the potential of VR for training, simulation and mission rehearsal. However, it's important to note that the use of VR technology still requires significant investment, both in terms of hardware and software development, as well as in terms of training and support for users. Armed forces are identifying various VR-based applications for their use, and it appears that this technology is likely to find more utility for the armed forces in the years to come. VR technology has the potential to revolutionize military training, simulation and operational exercise by providing realistic, immersive experiences that can prepare soldiers for a variety of situations, including combat, peacekeeping operations, search and rescue (Yin, 2010) and disaster relief. In addition, VR can be used to simulate and test new equipment and tactics (GAO, 2016), as well as rehearse missions before they are executed in the field (Carruth, 2017). VR has potential applications in CBRN (Mossel et al., 2015), logistics, military medicine operations (Yeo et al., 2011), military affairs (Luan et al., 2003), command and control, stress management training, and psychological and physical therapy for injured or traumatized military personnel (Pallavicini et al., 2016; Zbyszewski et al., 2013).

As VR technologies continue to mature, the opportunity to develop cost-effective tools based on VR will increase, making them more accessible to a wide range of organizations. Process of leading military troops (TLP) is a set of rules and procedures for planning and conducting military operations. They are used to ensure effective communication and coordinated action among the various units of the armed forces. The procedures for leading troops begins with planning operations. This includes determining the objectives of the operation, identifying the resources required and creating an action plan. Once the plan is created, it is communicated to all units involved in the operation.

Constant communication is required throughout the operation to ensure coordinated action. This can be accomplished through radio communications or command and control systems. Unit commanders are responsible for regularly reporting on their situation and responding to inquiries from their superiors. To ensure the safety of troops, force command procedures include action plans for emergencies or wartime situations. These may include plans for retreating, evacuation, or response to chemical or biological attacks. In general, force management procedures are essential to coordinated and effective force action in military operations. They enable commanders to make informed decisions and respond quickly to changes in the theater of operations while ensuring the safety of troops.

The military has recently been heavily involved in identifying various applications based on VR, and it seems likely that this technology will be increasingly used by the armed forces in the coming years. The technology has the potential to revolutionize military training, simulation and mission practice, and will be an important tool for the future modern warfare.

2. Research and development (R&D)

After a review of the literature, the current state of knowledge on virtual reality in military training was understood, but the fact that that VR is one of the best methods for training soldiers at the platoon level was not determined. In order to make such a claim, it was necessary to conduct an empirical study using observation, interviewing and performance evaluation methods in subunits that have benefited from such training methods.

By collecting data on the effectiveness of RV training in subunits that have used this method, its impact on troop performance, skill acquisition and overall readiness was assessed. This information may be useful for future application of such practices in military training. By identifying the strengths and weaknesses of training VR, the military can optimize its training practices to better prepare soldiers for the challenges they may face in the field. This can ultimately lead to more effective training practices and better prepared soldiers, which can improve the

military's overall readiness and ability to respond to real-world challenges in the field. In the attempt of developing a comprehensive assessment, the use of quantitative data, such as performance outcomes, completion times and physiological responses was considered, as well as qualitative data, such as surveys, interviews and participant feedback. This multifaceted approach allowed the gain of a comprehensive understanding of the effects of VR training on subunit performance, skill acquisition and overall readiness. It should be noted that each military context and specific VR training program may have unique factors to consider. Further research studies, assessments and evaluations tailored to specific subunit training objectives and requirements must be conducted to further improve our understanding of the effectiveness of VR training.

3. The military requirements for VR capability

The accelerated technological progress of the last decades in the ITC field has allowed the development of tools capable of providing different forms of simulation: VR, augmented reality (AR), mixed reality (MR). The comparative analysis of the performance of these tools has the role of selecting the best solution in relation to the training need/ phase (Table 1).

Table 1. Comparative Analysis of Simulation Tools in Training

Simulation Tool	Virtual Reality (VR)	Augmented Reality (AR)	Mixed Reality (MR)
Definition	Immersive experience in a virtual environment	Overlay of digital content onto the real world	Combination of VR and AR elements to interact with reality
Interaction	Fully immersive experience with dedicated hardware	Partially immersive experience with mobile devices	Partially immersive experience with dedicated hardware
Training Use	Simulating real-world scenarios, environments, and interactions	Enhancing real-world scenarios, objects, or processes for training purposes	Integrating virtual and real-world elements for training purposes
Sources	Lele, 2013 Deloitte, 2019 Vogelmeier et al., 2006 Brown et al., 2006	Morozov, 2018 Gurusubramani et al., 2019 Karlsson, 2015	Hughes et al., 2002 Small and Foxlin, 2004 Rathnayake, 2018
Pros	Realistic immersion and presence. Extensive training possibilities. Wide range of applications	Real-time contextual information overlay. Enhances real-world environment with digital content	Combines benefits of both VR and AR. Enhanced interactivity and immersion.
Cons	Expensive hardware requirements. Limited field of view. Potential motion sickness	Limited immersion and interaction challenges Dependency on mobile device limitations	Hardware requirements. Limited field of view

Although they are in different phases on the Hype curve (Deloitte, 2019), in order to maximize the growing opportunity of these technologies, it is necessary to evaluate and compare the decision-making performances after completing the training phase in which different types of simulation were used, independently or combined.

The field of virtual reality (VR) is truly dynamic and rapidly evolving. Ongoing research, technological advances, and innovative developments continue to push the boundaries of what is considered cutting-edge technology VR. New discoveries, advances and improvements are being made in various areas such as hardware, software, content creation, user experience and applications. Advances in VR technology are driven by a combination of factors, such as advances in display technology, computing power, sensors, tracking systems, input devices and software algorithms. These advances are helping to improve the overall VR experience, making it more immersive, realistic, interactive and accessible.

Most research and development efforts focus on the challenges and limitations associated with VR, such as reducing motion sickness, improving ergonomics, increasing the field of view, improving haptic feedback and achieving a higher level of realism (Slater & Sanchez-Vives, 2016). In addition, interdisciplinary collaboration, including partnerships between technology companies, researchers and content creators, is driving innovation and pushing the boundaries of what is possible at VR.

Over the past decades, many experts and researchers have developed ideas and practical applications for integrating VR in academic and military contexts.

The majority of their research has focused on how virtual reality can be used in military training and exploring its applications for improving situational awareness, decision-making and soldier performance. Their work represents part of a wider community of researchers, developers and practitioners actively involved in exploring the potential of VR in these areas.

The VR technology has the potential to meet a wide range of military needs, including training, simulation and operational exercises. VR enables realistic, immersive training scenarios that can prepare soldiers for a variety of situations, including combat operations, peacekeeping operations and disaster relief. VR allows military personnel to practice and hone their skills in a safe and controlled environment. It also allows new equipment and tactics to be tested before they are used in real-world situations. In addition, VR can be used for psychological and physical therapy for injured or traumatized military members. Whether the technology of VR meets military requirements depends largely on the ability of the human-computer interfaces to provide the necessary means to convey stimuli and enable appropriate user responses. The VR system should provide the user realistic haptic feedback, i.e., a sense of touch, force and motion that makes the users feel as if they are in the virtual environment. The system should also be able to accurately track and respond to the user's movements, gestures and facial expressions. In addition, the VR system should be able to provide real-time data and feedback to users and instructors to enable real-time adjustments and performance evaluations. Overall, the success of VR in meeting military requirements will depend on the ability of its human-computer interfaces to provide the necessary means to deliver stimuli and enable appropriate user responses.

This includes the ability to accurately and realistically simulate a wide range of environments, situations and scenarios, as well as the ability to provide intuitive and natural ways for users to interact with the virtual environment, as presented in Figure 1.

Figure 1. Training using AR/VR technology ensures realism in tactical maneuvers and warfare skills

The VR system should provide realistic haptic feedback, accurate tracking and response to the user's movements, gestures and facial expressions, and real-time data and feedback for users and instructors that enable real-time adjustments and performance evaluations. It is also important for the system to have low latency, high resolution and a large field of view in order to provide an immersive experience. In addition, the user interface should be designed to be intuitive, easy to use and facilitate user interaction.

Military research on VR should focus on issues that are unique to the military and unlikely to be addressed by other potential users. These include the development of VR systems that can accurately and realistically simulate a wide range of environments, situations and scenarios, and the ability to provide intuitive and natural ways for users to interact with the virtual environment. In addition, research should focus on the development of VR systems that can provide realistic

haptic feedback, accurate tracking and response to user movements, gestures and expressions, and real-time data and feedback for users and instructors. Research should also focus on designing user interfaces that are easy to use and have low latency, high resolution and a wide field of view.

Another important area of research should be the study of the cognitive and physiological effects of VR on military personnel, particularly in the context of prolonged use and exposure to stressful scenarios. This could include studies on the effects of VR on spatial awareness, attention, memory and decision making, as well as on physiological measures such as heart rate, blood pressure and electroencephalography (EEG).

In addition, research should focus on developing VR systems that can operate in a networked environment and provide command and control, logistics and mission exercise capabilities. This would enable VR to be used as a force multiplier on the battlefield and improve communication and coordination among the various elements of the military. Overall, military research on VR should focus on issues that are unique to the military and unlikely to be addressed by other potential users of VR.

4. Accelerating digital adoption – military perspective

The Army seized the opportunity to achieve digital transformation, with the goal of breaking down silos and barriers and creating a "One Defense" mentality as the foundation. An update to next-generation enterprise resource planning (ERP) technology is at the heart of this transformation. Replacing hundreds of separate software systems, as well as thousands of interconnected supporting procedures, would require Defense to adopt new ways of thinking and working. The goal was clear: DoD would seize the opportunity to develop, engage and empower its workforce to become continuously change-ready - a key skill and competitive advantage for one of the strongest armed forces in the world.

Any discussion of defense digitization is hampered by the vagueness of the concepts and terms associated with it. The terms "cyber", "cloud", "Internet of Things", and "blockchain" are commonly used, but their precise definitions and uses are unclear. Although the economic case for digitization is clear, people may not be cognitively capable of understanding the full extent of its intricacies and consequences. In fact, some estimates show that digitization of products and services could increase industry revenue in Europe by more than €110 billion in just five years. So it's easy to see why the economic argument for increased digitization is so enticing.

The global impact of the spread of digital technology is fast becoming a feature of contemporary world politics. The idea is that the rush to control new technologies, including hardware, software and algorithms, and the willingness to use them to gain an advantage over other countries demonstrates the growing importance of digital power. As a result, the European Commission has stated that establishing technical sovereignty in key areas such as the military, space and 5G and 6G mobile networks is critical for the EU.

In February 2020, the European Commission presented its long-awaited "Digital Package", explaining how Europe can benefit from AI, computing power and data spaces while controlling the threats associated with these technologies. The communications on "Creating Europe's Digital Future" and a "European Data Strategy", as well as the White Paper on AI, make no mention of defense. Synergies between civil and defense technologies will be further explored with the announcement of the new EU industrial strategy in March. Although the European Defense Agency (EDA) is already addressing the impact of digitalization on defense, the Commission's broader industrial approach is acceptable given the greater importance of digitalization in European society (Pallavicini et al., 2016).

To digitize land operations, ground forces must evolve. As a user of complex technologies, the Army is particularly affected by digitization. It requires not only the development and deployment of new technologies within the military, but also new ways of thinking and behaving at all levels. The land forces, together with other foreign partners from the military, government and business sectors, are responding to this challenge, with the Army playing a pioneering role. (Chen et. al 2020) The Army has developed a strategy and put procedures in place to jointly manage the complexity and pace of digitization of the land forces and prepare for future problems (Dahwan, et. al, 2021).

Robotics, artificial intelligence and digitization are no longer science fiction; they are already commonplace. In modern warfare, the use of new, imaginative technologies, as well as rapid technological growth, drives the armed forces to advance even further. In future military situations, the Army must be able to act in concert with its allies, demonstrating lethality and responsiveness, interoperability, adaptability and reliability.

Tomorrow's battlefield is as transparent and clear as glass. Direct networking of all parties, such as intelligence and sensors, as well as other military and civilian actors, will provide exceptionally fast visibility and tracking of friendly force activities. In future conflicts, only those commanders who quickly make the right decisions and deploy their soldiers to achieve the desired objective will triumph. The potential adversary of the future will fight in all dimensions with long-range, networked weapons. This will allow the enemy to place a blanket over tactically important locations. As a result, ground soldiers' freedom of movement is severely limited. Cyber attacks are used by opposing forces to disrupt, distort, or even prevent friendly communications. Traditional lines of conflict are becoming increasingly blurred. It is hard to tell if it is all a coincidence or if military action is already underway. The lines between combat zones are blurring, and the links between combatants are not always obvious.

In the future, the army will need to be networked with its NATO partners and allies to be multinationally agile and effective on the battlefield. As a result of digitization, Army compatibility and interoperability are expected to increase. This includes smooth and seamless integration of ground forces with the systems and organizations of NATO and other allies. The use of compatible technology should facilitate the integration and synchronization of additional capabilities from across the country, such as cyber and information space lessons learned. Every actor, from the field soldier to the operations center commander, can have the operational picture they need to make the best possible decision (Stepansky, 2017).

In a conflict, information superiority can quickly determine who wins or loses. To get an up-to-date operational picture in real time, people and machines must be connected via robust digital command and control systems. (Tudorache, 2021). Digital transformation is an important part of the Army's modernization strategy to achieve its goal of being a lethal and modern force. In the past, the Army has failed to keep pace with rapid technological change. This is due to restrictive institutional procedures, outdated regulations that have not kept pace with new technologies such as cloud and artificial intelligence, and a workforce that is unable to innovate on a large scale.

The Army's comprehensive digital transformation strategy is being led by the Office of the Chief Information Officer. It is a new approach that boldly invests in transformative digital technologies, reforms institutional processes and develops a workforce capable of operating in increasingly complex environments. The Army needs a comprehensive plan for doctrine, organization, training, materiel, leadership, personnel and facilities so that new digital technologies such as cloud, data and AI can radically transform operations. This will enable the Army to develop a more flexible, imaginative and tech-savvy culture. Maintaining digital superiority over strategic adversaries in both competition and war, as the Army's modernization program suggests, requires such an approach.

A "digital military" is merely a continuation of a long-standing trend: aircraft that enable soldiers to kill distant targets and return home; cruise missiles and ballistic missiles that carry the controller far beyond the sky; and armed unmanned aerial vehicles that enable an operator sitting in a storage container on the other side of the globe to observe a target for hours or days before deciding whether or not to kill it. It seems that technological advances are allowing us to remove at least some of the combatants from battles, if not the concept of war itself.

When the word "digital transformation" comes up, defense is probably not the first industry that comes to mind when it comes to transformation initiatives. However, in order to keep up with the pace of technological development, it, like virtually all other industries, is undergoing a complete digital metamorphosis. In fact, digital progress is perhaps more important in defense than in any other field, both to keep the country safe in the face of physical and digital threats and to prepare for new kinds of battles (Harpel, 2018).

Defense contractors, like most other organizations, face similar problems in deciding where to deploy resources, how to manage business risks and how to increase the level of cybersecurity

during and after these transformation programs. Most importantly, the defense industry is under more pressure than any other industry to enable and deliver cutting-edge technology. However, as the pace of technological change continues to accelerate, the defense industry should carefully consider the pace of its adoption and seek competent and trusted advice to ensure a thoughtful, mature and rational approach to digital transformation. When it comes to technology in the defense sector, cybersecurity is one of the most important topics and issues. While it is a threat that all companies face, defense companies are undoubtedly among the most vulnerable. The problem is that when the defense industry is attacked, the entire country is at risk (Goztepe et. al, 2014).

Emerging technologies that meet these requirements are already having a significant impact on a variety of environments, but they cannot be deployed overnight. Any successful deployment is the result of a journey of digital evolution, with each change and upgrade controlled and implemented incrementally. IT Teams across the industry cannot simply discover and execute new systems or technologies without considering the infrastructure required to support them. Each of these technologies must be assessed for compatibility with existing infrastructure so that organizations can set the stage to ensure the success of these cutting-edge technologies when they are introduced. This may seem odd, considering that the defense industry is fast-moving by nature, fending off physical and digital threats before the rest of the world even knows they exist. However, it's not yet possible to digitally transform at such a rapid pace. If innovation develops too quickly, the effects could be catastrophic. Therefore, it needs to be slow and methodical, i.e., through regulated innovation.

Managing digital change at this deliberate pace requires the presence of people with the necessary skills, expertise and maturity, especially among engineers who must work within well-defined and documented boundaries. Finding and retaining these skills, on the other hand, is a difficulty for the industry. This becomes much more difficult when the industry is struggling with limited resources and the requirement to hire people with the appropriate security clearance. Working with a third party that has extensive knowledge of the defense sector can help overcome these obstacles. Such a technology partner can give access to engineers who are self-sufficient and have the required security clearance (Balkan, 2017).

5. Specific activities of the platoon commander for leading troops using VR

The Process of Leading Military Troops (TLP) is a set of rules and procedures for planning and conducting military operations. They are used to ensure effective communication and coordinated action among the various units of the armed forces. They include establishing the objectives of the operation, identifying the resources required, and creating a plan of action. Once the plan is created, it is communicated to all units involved in the operation. Throughout the operation, constant communication is required to ensure coordinated action. This can be accomplished through radio communications or command and control systems. Unit commanders are responsible for regularly reporting on their status and responding to requests from superiors. The purpose of the troop-leading procedures is to determine the optimal solution for a given tactical situation. The application of this procedure enables the development of unique solutions for each tactical situation and avoids the application of action patterns. This can prevent the opponent from predicting how one's own troops will act. The procedures for leading troops are schematically presented in Figure 2, are carried out in eight steps and structured on three distinct stages.
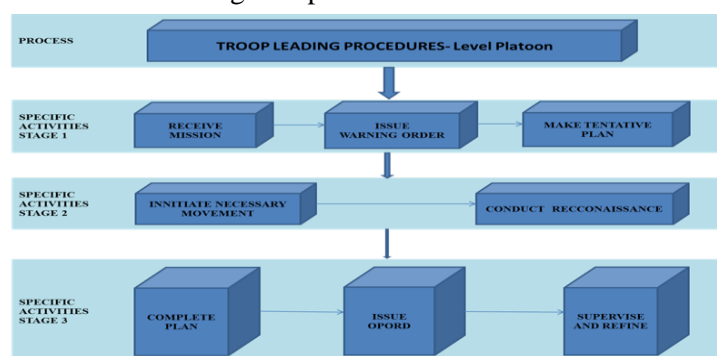
**Figure 2.** The procedures for leading troops at platoon level

Please note that the above representation is a schematic view of the authors and specific details and procedures may vary depending on military doctrine, context and mission requirements.

To ensure the safety of troops, leading procedures include action plans for emergencies or wartime situations. These may include plans for withdrawal, evacuation, or response to chemical or biological attacks.

"The most important thing I've learned is that soldiers follow what their leaders do. You can lecture and lecture them forever, but it's your personal example that they will follow" (Powell, 2012). In general, force management procedures are essential to coordinated and effective force action in military operations. They enable commanders to make informed decisions and respond quickly to changes in the theater of operations while ensuring the safety of the force. Process of leading military troops helps commanders develop plans for military operations when time is short and planning personnel are limited. TLP is a dynamic process used to analyze a mission, develop a plan and prepare for an operation and serves as an effective problem-solving/ planning process for the small unit leader. The leader's mission is essentially a problem to be solved, and TLP is a problem-solving framework that guides the leader through an abbreviated but flexible process to find a solution when time is limited.

As a platoon commander, there are several specific activities that can be done to lead troops via virtual reality (VR). Overall, the specific activities of the platoon commander for leading troops via VR can help improve the performance, readiness and effectiveness of the troops, which can lead to better outcomes in training and operations. Some of these activities to guide troops through virtual reality (VR) may include:

a. Personnel training: One particularly important activity is the use of VR by the platoon leader, who seeks to train subordinates (those involved in executing specific scenarios) in the use of sophisticated equipment and advanced tactics without exposing themselves to high risk or high cost. This training activity can be conducted in a variety of closely related methods, as shown in Figure 3. It is particularly important that this is conducted continuously, from simple to complex, to provide accurate and valuable feedback at all times.
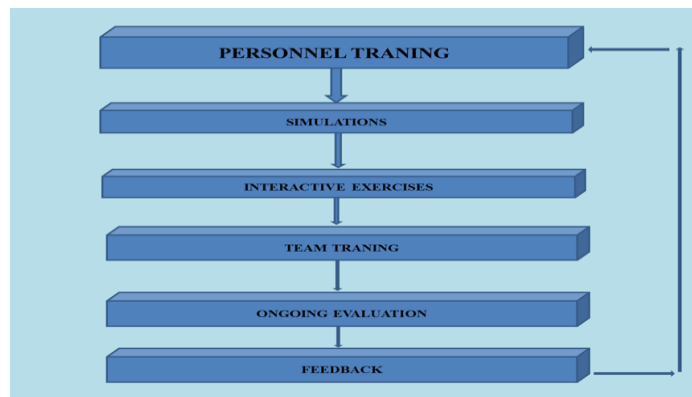
Figure 3. Types of methods use in training activity

This training activity can be achieved through a variety of methods, such as:

- Simulations;
- Interactive exercises;
- Team training;
- Ongoing Evaluation;
- Feedback.

Those responsible for training and instructing subordinates, especially platoon leaders, can use VR to create realistic simulations with sophisticated equipment and advanced tactics without exposing themselves to high risk or high cost. With VR, interactive exercises can be created to train personnel in various skills, such as decision-making in critical situations, teamwork or real-time communication.

b. Mission Planning: The platoon leader can use VR to create and analyze various battle scenarios so that he or she can better understand the challenges and risks associated with a

particular mission. Deployment planning through virtual reality (VR) can be done through various methods, such as:

- Scenario simulation;
- Data analysis;
- Team communication;
- Plan testing;
- Plan Evaluation.

Using these methods, the platoon leader can simulate different battle scenarios and test different plans of action, thus being able to identify possible risks and develop solutions to avoid them. With VR at hand v the leader can perform an accurate analysis of meteorological, topographical and traffic data in an attempt to better understand conditions in the operational area and make informed decisions. It also creates the possibility to communicate with the team for mission planning and to develop an optimal mission plan, and later, after implementation, the effectiveness of the action plan can be evaluated and informed decisions can be made on changes needed to improve mission performance in the future.

c. Simulate battle scenarios: The platoon leader faced with scenario design has the opportunity to simulate various tactical combat scenarios, including the risks associated with different tactics or equipment, in VR. This can help understand the consequences of different actions and make informed decisions in crisis situations. Simulation of combat scenarios through virtual reality (VR) can be achieved through various methods, such as:

- *Creating virtual combat environments*: The platoon leader can use VR to create virtual combat environments with terrain, buildings, vehicles, and other elements to simulate various combat scenarios;
- *Introducing random factors*: The platoon leader can use VR to insert random factors such as weather, traffic, or enemy reactions to make combat scenarios more realistic and harder to predict;
- *Weapons and equipment control*: The platoon leader can use VR to enable control of weapons and equipment in combat scenarios to simulate their use in real combat situations;
- *Real-time communication*: The platoon leader can use VR to enable real-time communication between members of the battle group in combat scenarios, simulating real-world communication during a mission;
- *Performance evaluation:* The platoon leader can use VR to evaluate the performance of the battle group in combat scenarios.

d. Communication with subordinates: As is well known, communication at the military subunit level is critical. With new technologies, the platoon leader has the ability to communicate with his subordinates in real time via VR and provide them with instructions and information during a mission or exercise. Communicating with subordinates through virtual reality (VR) can be achieved through various methods, such as those presented in Figure 4:
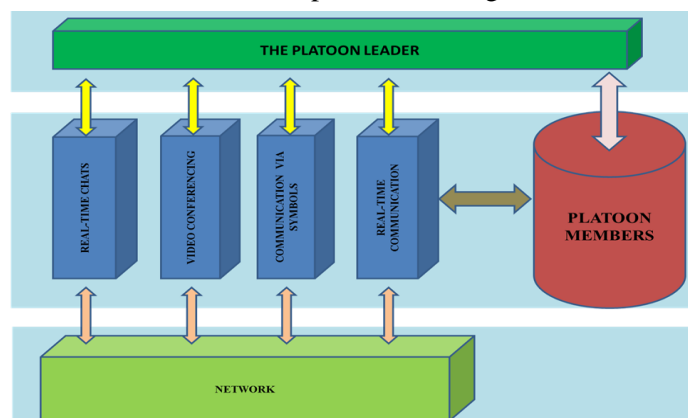
Figure 4. Types of methods use from platoon leader in communication with subordinates

- *Real-time chats*: The platoon leader can use VR to communicate with his subordinates via real-time chats and provide them with instructions and information during a mission or exercise;
- *Video Conferencing*: The platoon leader can use VR to hold video conferences with subordinates to discuss progress, problems, or other mission-related issues;
- *Communication via Symbols*: The platoon leader can communicate with VR using symbols or signals to quickly convey instructions or information when verbal communication is not possible;
- *Real-time communication*: The platoon leader can use VR to enable real-time communication between members of the battle group so that they can communicate in real time during a mission or exercise.

e. Performance appraisal: Performance appraisal through VR can provide a more accurate and detailed picture of subordinates' performance so that informed decisions can be made about their improvement and development. Performance appraisal through virtual reality (VR) can be achieved through a variety of methods, such as:

- Recording and analysis;
- Testing;
- Feedback;
- Benchmarking.

The decision maker responsible for managing and evaluating the personnel participating in the training has the opportunity to record the performance of subordinates during the training or exercise in order to evaluate the knowledge acquired and the skills trained. Based on this, he/she can provide feedback and make suggestions for improvement immediately after the training or exercise.

6. Benefits of using VR in the troop leading process (TLP)

Recently, it has been noted that virtual reality technology (VR) can provide a number of benefits for military training and operations (Yamamoto & Altun, 2020). In addition to the obvious cost savings and instructor safety benefits, VR also allows early detection of errors and improves the training process by engaging more senses. VR also provides a wealth of post-training data and statistics and, most importantly, allows military members to experience dangerous and life-threatening situations that cannot be practiced in real life. In addition, many different scenarios can be practiced during a single VR training session, as resetting the scenario requires only a few moments of loading. This saves both time and money for military units, as soldiers can complete a wide range of exercises without having to switch between different training centers. But that's not all. Some of the key benefits are:

- *Improved training*: VR can provide a more immersive and realistic training experience for soldiers, allowing them to practice in simulated environments that closely resemble real-world situations;
- *Increased safety*: VR training eliminates the need for live-fire exercises, reducing the risk of injury or death;
- *Enhanced situational awareness*: VR can be used to create virtual simulations of battlefields and other operational environments, allowing soldiers to better understand the layout of the land and plan their actions accordingly;
- *Cost-effectiveness*: VR training can be less expensive than traditional training methods, as it eliminates the need for expensive equipment and facilities;
- Access to remote training: VR allows soldiers to train in locations and conditions that would otherwise be difficult or impossible to replicate;
- *Reduced downtime*: VR can be used to provide soldiers with continued training during downtime, helping to keep their skills sharp and ready for action.

Virtual reality (VR) is a rapidly evolving technology with applications in a variety of areas, including force management. The use of VR in this area can provide numerous benefits, such as training personnel, mission planning and simulating combat scenarios.

Using VR, troop leaders can simulate various combat scenarios and better understand how to respond in crisis situations. VR can also be used to train personnel in the use of sophisticated equipment and advanced tactics without exposing them to real-world risk or incurring high costs.

VR can be used to simulate various VR battle scenarios as part of the force management process. VR can be used to create and analyze various battle scenarios so that force leaders can better understand the challenges and risks associated with a particular mission. VR can also be used to test different courses of action and determine the best options, including the risks associated with different tactics or equipment. In this way, troop leaders can better assess the consequences of different actions and make informed decisions in crisis situations.

To logically conclude this part of the article, the benefits of using virtual reality for the military are summarized as follows:

- Training is less costly

This advantage stems from the fact that virtual reality technology allows the military to train in simulated environments that closely resemble real-world situations, reducing the cost of traditional training methods such as live-fire exercises and expensive equipment and facilities.

- Increased efficiency

Another benefit of using virtual reality for the military is that it can make training more efficient. Virtual reality technology allows soldiers to practice in simulated environments that closely resemble real-world situations, which can help them learn and retain information more effectively. In addition, VR eliminates the need for live-fire exercises, which can be time-consuming and logistically complex. This allows soldiers to spend more time on training and less time on administrative tasks.

- Other opportunities

The use of virtual reality in the military offers many opportunities to train and operate in simulated environments that closely resemble real-world situations: These can include simulations of different types of terrain, weather conditions, or even different types of enemy combatants or equipment. In this way, soldiers can better prepare for a wider range of possible scenarios and use their skills in a more versatile way. In addition, VR can be used for remote training, allowing soldiers to train in locations and conditions that are otherwise difficult or impossible to replicate. This includes training in harsh or extreme environments such as desert, jungle and arctic, or training in urban environments that are difficult and expensive to replicate in the real world.

- Risk Free

Virtual reality technology allows soldiers to train in simulated environments that closely resemble real-world situations, but without the risk of injury or death. This can be especially beneficial when training in dangerous or high-risk scenarios, such as combat or explosive ordnance disposal. By eliminating live ammunition exercises, VR can reduce the risk of injury or death for soldiers and other personnel, allowing them to focus on training and improving their skills without worrying about the risk of injury.

- Scope of simulations and flexibility

Another benefit of using virtual reality for the military is that it allows a wide range of simulations and flexibility in training. Virtual reality technology allows soldiers to practice in simulated environments that closely resemble real-world situations, which can include a variety of different scenarios and conditions. This can include simulations of different types of terrain, weather conditions, or even different types of enemy combatants or equipment. In this way, soldiers can better prepare for a wide range of possible scenarios and use their skills in a more versatile manner. In addition, training at VR can be easily customized to meet the specific needs of soldiers, allowing for training tailored to their individual skills and focus. This flexibility allows for more efficient use of training time and resources and can help Soldiers become more effective in the field. However, there are still some hurdles to overcome on the road to futuristic training for warfare VR.

- Security

Virtual reality for the military can enhance safety during training and operations by allowing

soldiers to train in simulated environments that closely resemble real-world situations, but without risking exposure of sensitive information or equipment to the public or potential adversaries. This can be especially important during exercises involving classified information or equipment. This technology can enhance the physical security of soldiers by allowing them to train in locations and conditions that are otherwise difficult or impossible to replicate, which can be useful in situations where actual training is not feasible.

- Cyber Diseases

Virtual reality technology can also be used for cyber defense and cyber disease training. A variety of cyberattacks and network breaches can be simulated, allowing soldiers to practice identifying and responding to different types of cyber threats. This can help soldiers better understand the tactics and techniques of cyber adversaries and develop more effective countermeasures. In addition, virtual reality can be used to simulate multi-layered scenarios that combine cyber-attacks with physical attacks, such as cyber-physical systems.

We also think it is worth noting that virtual reality technology can also be used to simulate disease outbreaks, allowing soldiers and medical personnel to practice identifying, isolating and treating patients with infectious diseases. This allows them to better prepare to adapt and respond in a relatively short period of time to minimize the desired impact of the adversary.

7. Conclusion, limitation and future work

Wars can be fought with weapons, but they are won by men. "It is the spirit of the men who follow and the man who leads that wins the victory" (Patton, 1941). Every mission should have a good leadership team with excellent communication skills, able to listen to each other in any stressful situation. All team members should be exemplary and possess the right attributes and core competencies to develop concepts for subsequent missions. Commanders and subordinates must have the knowledge and ability to use the military tools at their disposal, such as the Troop Leading Process (TLP) and Military Decision-Making Process (MDMP), to meet deadlines and successfully accomplish missions.

The use of VR in the troop command process can provide numerous benefits, such as personnel training, mission planning and battle scenario simulation. This can help troop leaders better understand the challenges and risks associated with a particular mission, test different courses of action and make informed decisions in crisis situations. VR can also be used to train personnel in the use of sophisticated equipment and advanced tactics without exposing them to high risk or high cost. As VR technology evolves, its use in the context of force management is likely to become increasingly important.

Virtual reality technology (VR) has great potential to change the way military organizations train their personnel, plan missions, and lead their forces. The immersive nature of VR simulations can provide a realistic and dynamic training environment that can prepare troops for a variety of scenarios. VR can also be used to improve situational awareness and communication between troops. For example, VR can simulate battlefield conditions and allow troops to practice coordinating and communicating with each other in real time. This can help troops be better prepared and more effective in real-world scenarios. In addition, VR can also be used for post-deployment analysis to identify opportunities for improvement and optimize future operations. This can help troops learn from their experiences and continuously improve their performance.

As VR technology continues to advance, it is likely to become an increasingly important tool in the military's arsenal. However, it is important to note that the technology is not a substitute for real-world training and experience. Instead, VR should be seen as a complementary tool that can enhance the overall readiness and effectiveness of military forces.

Acknowledgments

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