AARMS Vol. 23, No. 2 (2024) 19–37.

10.32565/aarms.2024.2.2

VR Training Opportunities in the Hungarian Defence Forces[1]

Tamás MARLOK,[2] Márk György TAKÁCS[3]

The aim of our study is to explore the potential of VR technology in the Hungarian Defence Forces. The justification for VR training starts with the classification of xR devices, where VR is a sub-group. Based on the literature and the experience gained so far, we examine what tasks each type of xR device is suitable for. We present the reader with the main technical parameters that may influence the usability of these devices in training. We review the GTS system[4] that we have been able to test, and which forms the basis for further research. To find the optimal placement of VR devices in the training system, we summarise the training practice of the Hungarian Defence Forces and – based on the first tests and according to the purpose of the GTS system – we dig deeper into the individual and sub-unit infantry training. Considering the current state of development, we present the training areas where the introduction of VR can be particularly beneficial.

Keywords: *military training, VR, AR, simulation, immersivity*

Introduction

The well-known fact that military developments bring breakthroughs in technology is still true, but some technologies are spreading and refining much faster in the civilian sector. An example of this is VR (virtual reality) technology. Extensive research was done in this area decades ago, but certain boundaries could not be crossed at that time. A major development started when the hardware and software of Oculus's first VR devices became open source and the potential for entertainment was recognised. As consumer VR devices gained popularity, many companies started to develop headsets and software. Later, these systems have achieved a quality that has allowed their use in critical training, such as

1 Project no. TKP2021-NVA-16 has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-NVA funding scheme.

2 PhD student, Ludovika University of Public Service, Doctoral School of Military Sciences; Director of Technology, Infinit Simulation, e-mail: marlok.tamas@uni-nke.hu

3 PhD student, Ludovika University of Public Service, Doctoral School of Military Sciences, e-mail: takacs.mark@uni-nke.hu

4 The GTS System is a VR system for Military and Law Enforcement tactical training developed by Infinit Simulation company (Online: https://infinitsimulation.com/).

firefighter and soldier training and medicine. Small start-ups and game development studios have started to apply the accumulated knowledge and experience of agile software development processes to enter the military market. The quicker feedback in the consumer market has allowed them to move faster than most specialised development companies or research institutes. In addition, products are cheaper to reach the test phase and can be more easily tailored to users' needs within specific projects.

The Hungarian Defence Forces already recognised the potential of the VR technology,[5] and now has the opportunity to use such a system, developed by a Hungarian company that combines military and law enforcement knowledge with half of a decade of VR development experience. Our article examines this company's system and explores in detail the opportunities and benefits of its deployment. To do this, we give an overview of the used VR technology and the system tested. We review the structure of military training and – based on our tests – fit the VR-based training software into the training structure where it is already applicable.

The discussed VR technology

xR head-mounted devices

We will discuss VR glasses, VR helmets, and so-called VR head-mounted displays (HMDs). It is essential to mention that virtual reality HMDs are part of a larger group. As their name suggests, these HMDs are worn on the head with built-in displays and speakers (headphones). The principal purpose of these devices is to make us perceive information generated by a computer.

The group is collectively referred to in the literature as xR devices, where 'x' stands for the variable where the corresponding letter is inserted. They are also called alternative reality devices. These tools have different approaches depending on their purpose, but they are based on a common technology, and their use is similar. Most strikingly, the output channels (image and sound) are placed directly on the senses and provide the user three-dimensional (stereoscopic) image and surround sound. They mainly use natural inputs, which is also a common trait. In case of natural input, the system can process the operator's body movements in human–machine interaction, which can be movements of the head, limbs and hands.

The number of such input channels may vary depending on the sophistication level of the device type and the target market. Some devices only track the movement of the head, but others can use additional sensors to interpret the exact position of the hand and even the fingers as input. The sub-groups will be discussed in the following sections.

5 Németh–Virágh 2021: 2–7.

Augmented Reality – AR

AR – or augmented reality devices – aim to augment the real space seen by the user with computer-generated and projected information, preferably in sync with the movement of the wearer's head. The projected information can range from a simple two-dimensional compass – or a directional marker – to a complex object projected onto a given location in three dimensions. The point is that the operator is looking at a real space, which could be real-time images from forward-facing cameras or through a transparent lens system like the HUD of an aircraft, which can have computer-generated real-time information projected onto it as a hologram. An example of such a device is the Integrated Visual Augmentation System (IVAS), which uses special Microsoft HoloLens technology and has been tested by the U.S. Army.[6] Previous research has also shown that similar AR (See-Through Near-Eye Displays) with transparent lens systems have physiological limitations because the image projected directly in front of the eye and the space seen through the lens can lead to focusing problems and simulator sickness. Such challenges are addressed using different technological solutions.[7] The AR system could be designed so that the device projects images from its cameras onto the display (pass-through) and places the information on it but this technology is expensive and will be specific to the MR systems discussed later.

Such AR systems should be used in situations where the primary purpose of the activity is happening in the real world, and the device is providing visual cues and information to the user. It could be a checklist for the maintenance of an asset that also shows where to check a particular point, a situational awareness picture in a combat situation, or the current air situation in the airspace. Based on the presentation[8] of the Technical Director of the IVAS program, their device is also able to support fight (sensing, decision-making, target acquisition, target engagement), rehearse and train; however, new developments at the end of 2022 showed that the system still needs to be improved to stop causing nausea and headaches. Accordingly, it seems that the biggest physiological weakness of the see-through AR HMDs is still present.

---

6 Siter 2019.
7 Xia et al. 2022.
8 Regnier 2021.

Figure 1: IVAS system
Source: Britzky 2022

Mixed Reality – MR

Mixed reality devices are very similar to AR devices as they display real-world images and virtual information together in three-dimensional pictures. The difference, however, is that they can integrate the generated image into the real environment, i.e. real objects can cover out virtual objects and vice versa, and the users can interact with those virtual objects.

Figure 2: Mixed Reality HMD in use
Source: Flight Safety s. a.

It represents a higher technological level, because these kinds of HMDs do not use transparent lenses but create three-dimensional pictures for the user from the image of forward-looking cameras, and they also map the geometry of the surrounding space and superimpose the generated information before displaying it. This operation requires the incorporation of a LiDAR sensor and high-quality forward-looking cameras compared to other xR devices. There are earlier devices listed as MR devices, but we would classify them more as AR since they place virtual objects in space but in front of real-space objects.

Figure 3: Mixed reality from the user's viewpoint
Source: Antunes 2020

MR devices, therefore, allow a form of training where it is essential to perceive real objects, but the virtual space and the generated virtual content are also an essential part of the experience. Figure 3 shows the interior of an F/A-18C aircraft, where the hands, checklist, stick, rudder and throttle are taken from the real world, but all other visual information is computer-generated. Currently, the Varjo XR-3 Focal Edition[9] represents the quality that can be used even for training.

Virtual Reality – VR

The point of VR devices is to obscure the entire field of view, replacing the visual information entirely with a stereoscopic image synthetically created by the computer. Thus, it generates the entire environment, and any scene or audiovisual environment can be simulated. Since the user has no perception of the external space, this device should only be used in special safety circumstances.

[9] Varjo XR-3 Focal Edition (https://varjo.com/products/xr-3-focal-edition/).

Figure 4: The GTS equipment of Infinit Simulation on Hungarian Special Forces Soldiers
Source: GTS Brochure; Pápai Joci Photo

VR devices with additional equipment can be advantageous for training because of the natural input and fully simulated environment. Many such devices are commercially available, such as HTC Vive Pro, HTC Focus, Meta series, Varjo Aero.

Typical technical parameters

The typical technical parameters are similar for all xR devices, but here, we focus on VR devices. For these, the most essential technical parameters are those, which can compromise the experience of reality or the feeling of the presence of so-called immersivity.

The natural input mentioned above is a primary factor, which should be understood as the ability to move one's head in a computer-generated three-dimensional space and look around freely without the need for any other controller (mouse, keyboard, etc.). The movement of the head is detected by the HMD and – by tracking the movement in the virtual space – it generates the image from the viewpoint corresponding to the new position. As it can be seen, it is a complex process, starting from collecting and processing the data from the sensors and ending in displaying the image. This process causes some latency in all systems. It is called the "motion-to-photon latency" or response time, which is now sufficiently fast in today's VR systems. HMDs convey a stereoscopic, three-dimensional image to the user, as the built-in displays show a different image through the lenses to the right and left eye with a proper horizontal shift. Due to the parameters of the lenses and displays, the quality of the visual experience for different devices ranges widely. The most important ones are the size of the field of view, image resolution, brightness, refresh rate, colour and image distortion. In terms of image quality, the size of the field of view is of particular interest for horizontal viewing angles, which can vary from model to model but the generally offered 100–115 degrees are adequate.

Another crucial element is image resolution so that the image is not “pixelated”. Very high pixel density should be achieved on these built-in small displays. When looking at monitors, they take up about 50–55 degrees of our field of view with a certain picture resolution. For the same experience, the HMD display would require roughly twice the resolution. It is not yet possible with all devices, which in some cases limits their usability in training. The brightness and 75–90 Hz refresh rate[10] are all adequate in today’s available devices. Image distortion can be a problem in training and should be considered on a type-by-type basis. Some VR devices use Fresnel[11] lenses, which can cause a blurred, distorted image at the edges of the picture, so these types should be avoided or upgraded in military training.

In summary, nowadays, most of these devices are adequate for training purposes but how and to what extent these parameters may affect their training capabilities will be examined in specific cases later.

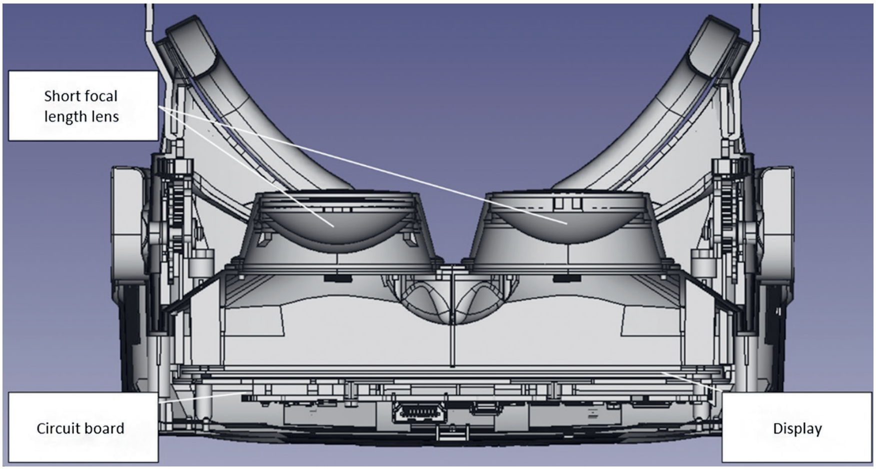

Figure 5: Cross-section of the Oculus Rift DK2 HMD
Source: compiled by the authors using FreeCad 0.19 software based on https://github.com/facebookarchive/riftdk2

Further key factors about VR technology

A key advantage of computer-based training systems is the possibility of complete (detailed) and automatic data collection. VR technology takes this to a higher level thanks to natural inputs. It is easy to see that the detail and volume of data collected in this way provides the potential to be processed by artificial intelligence. With artificial intelligence,

10 The refresh rate refers to how many times per second the hardware is able to draw a new image to the display. 75 Hz means that the hardware can generate and show 75 different images in one second to ensure moving image perception. Low refresh rates can cause flickering and eye strain.

11 Merriam-Webster Dictionary: a lens that has a surface consisting of a concentric series of simple lens sections so that a thin lens with a short focal length and large diameter is possible and it is used especially for spotlights.

various branches of machine learning could yield results that could even lead to changes in training methodology.[12] One aspect of a learner-centred approach could be the analysis of task execution data from the trainee's perspective. In addition, the effectiveness indicators of the sub-units can also be sought. Because of the photo-realistic visualisation, VR tools can even be used as input to computer vision systems, but that is a topic for a future article.

VR as a training tool

One of the key elements of successful training is interactivity, something that has been tried to be established even before computer systems. Later, with the development of computer technology, the training simulations became more and more effective.[13] In military technology – as a regular rule – the newest technical developments were tested and used; there were attempts to use VR HMDs in military training way before the technical parameters were sufficient. These systems – such as early DSTS versions – were built and tested, and the results[14] pointed to further opportunities for improvement. It is not surprising, as more than ten years have passed, and nowadays, even commercial products are much more advanced than the tested DSTS configuration. In the last decades, commercial development has outpaced military research in some fields; therefore, many companies have tried to step into the military development market with an agile development approach. Thanks to the sophistication, availability and modularity of the hardware and software tools, soldiers themselves have been able to produce advanced military devices.[15]

Going back to VR training tools, the possibilities are also available in Hungary with the most modern development, the Infinit Simulation GTS system, which is suitable for shooting and tactical training. From the very beginning, the system and software parameters have been designed and developed for a military training tool, considering the higher requirements. For the 2022 GSOF Symposium[16] and for the projects of the Ludovika University of Public Service (LUPS Budapest) we developed, fine-tuned and tested the system and its training scenarios, so we know its main parameters and capabilities. Later in this article, we explore its usability and integrability in the Hungarian Defence Forces (HDF) training. To find the place of optimal use, we review the important parameters of the GTS training system and the training structure of the HDF.

[12] Németh–Virágh 2022: 2–7.
[13] Martirosov–Kopecek 2017: 0708–0717.
[14] Reitz–Seavey 2016.
[15] Stilwell 2020.
[16] GSOF Europe s. a.

Overview of the GTS

As mentioned above, the GTS system is designed for military and law enforcement tactical training from the beginning. The developer – Infinit Simulation – is a spin-off of a successful VR game developer company, and it aimed to bring more than half a decade of VR development experience to military training. They combine academic research, practical–tactical shooting knowledge, and VR software development experiences.

In its current state, the system can simulate the M4 assault rifle in VR using special hardware that looks and handles exactly like the real weapon. VR creates an environment for the user that is well designed to prepare them for situations that are difficult to simulate otherwise. In case of the GTS, this means environments and situations where a personal weapon must be used during training exercises. Beyond the environment – as the situation is created by software – it has complete flexibility. In the framework of a LUPS research and for the GSOF symposium, we had the opportunity to jointly design a checkpoint protection situational awareness exercise. This training exercise was tested, validated and refined before being used in LUPS Budapest research. In the scenario, the soldier loses his fireteam partner and must fight off enemy attackers with his carbine alone, while innocent civilians also emerge.

Figure 6: GTS system Checkpoint scenario observed via GTS Instructor Workstation
Source: screenshot by the authors

The system measures several parameters in addition to hits. The execution can be monitored on an instructor workstation at any angle in real-time and can be replayed.

The GTS was designed to be capable of the following training scenarios:[17]

- weapon familiarisation on virtual models
- shooting tuition, such as aligned sights, reloads, firing positions, piercing and ricochet
- basic tactical skill development, like target acquisition and target engagement order
- CQB practice: relevant angles, tactical advancing and situational awareness
- squad level engagements for team development (jump): contact drills and communication
- improving leadership skills and tactical leadership process
- complex tactical environment simulation with changing adversarial strategies

As well as providing a physiologically affecting, immersive experience, accurate gun hardware also trains muscle memory and helps trainees develop their skills faster through detailed evaluation. After this overview, we now move on to exploring the feasibility of training integration.

Training in the Hungarian Defence Forces

Organising and planning training in the HDF

At the time of writing, the new Chief of General Staff of the HDF has not yet been appointed. As in every military organisation, the usual rule stands here too, i.e. the deputy of the commander is responsible for the training.

There are several inspectorates in the HDF responsible for the development and continuous improvement of a branch or service. In this regard, they have rather a technical and equipment focus than training. Their influence on training is of course via the equipment, technology, and by creating strategy and long-term vision.

Below the commander – and next to the inspectorates – the main organisations at the strategic level are the directorates. The Training and Exercise Directorate (HDF TED) holds the main responsibility for the training with coordination of the Force Planning Directorate (HDF FPD).[18]

The HDF TED plans and organises the training at the strategic level in accordance with the vision of the COM and DCOM HDF. They plan and organise the annual national combined arms training exercises conducted by multiple HDF units and the multinational exercises conducted in Hungary. Furthermore, they inspect and approve the HDF units' annual training plans.

The approved annual training plans of the units are the main documents in which a given unit's commander can find all the necessary training exercises and tasks that his

[17] Quoted from the GTS product brochure.
[18] Honvédelem 2022.

unit has to carry out that year. There are four large types of training in the annual training plan: basic training, individual training, operator training and unit-level training.

Usually, the unit continues its training plan from the previous year. In so far as there is a basic training to be carried out by the given unit, a temporary basic training unit has to be formed. After the basic training – or after acceptance of recruits – unit-specific individual trainings must be conducted (e.g. driver training, para jump, turret gun training, staff officers' training, etc.). As a rule, there is a main training event every year, which is a combined arms (usually multinational) training exercise. This training exercise serves as a goal for the organisation when planning training at lower unit level (e.g. squad and platoon level).

The unit's annual schedule is the document, which specifies the training sessions and exercises for each subordinate unit and individual. The maximum level for each unit is its jump, which is planned and inspected by its superior, e.g. the jump of the platoon is planned and inspected by the company commander (more often the deputy commander). The time by which a given unit or subunit has to be forged together is the deadline. From this deadline, the deputy commanders and the G7 and S7 officers count down the available time for sub-unit jumps and individual training.[19]

Regularly, individual training sessions are planned and organised – and their curriculum is specified – by the battalion and the company.

Reviewing the types of training sessions

In this part of our study, we examine in detail all the four main types of training mentioned earlier.

Basic training

The goal of the basic training is to transform the individual from a civilian into a soldier. To achieve this goal, the most important feature of the basic training is to demolish the personality of the recruit and to rebuild it as a functioning soldier. The units and instructors conducting basic training must have all the necessary skills and rights (e.g. harsh drills, destroying the boundaries of privacy, rigid treatment, etc.).

Therefore, next to this psychological transformation, the recruits must learn a great number of new skills. The bulk of them are not even skills but knowledge and correct employment of certain rules of the military. They then must learn the skills and practical knowledge, especially the handling of individual weapons (assault rifles, pistols and hand grenades).[20]

---

19 HVK 2019: 80.

20 Honvédelem s. a.

Individual specialist training

Normally, after the basic training, the recruits are transferred to their units, where they begin individual specialist training. The goal of this training is to teach the recruits all the necessary knowledge needed to fill the position for which they had been recruited. There are several types of individual specialist training, depending on the branch or service.

For example, at an infantry unit, there is leadership training for junior NCOs, and gunnery training for machine gunners, snipers, marksmen and AT grenade launchers. Basically, all units have some kind of heavy vehicle; therefore, drivers' training should cover all vehicles (tanks, SP howitzers, bulldozers, etc.).

Of course, there are differences depending on the recruit's rank. Enlisted soldiers will learn individual knowledge related to their position. Junior officers and NCOs may also start with learning to use all weapons and equipment they will have under their command, but they also must learn the decision-making processes they will employ as commanders.

Of course, if this unit is not an infantry unit, the individual must familiarise with the special weapon systems in service at his unit such as CBRN decontamination devices, AA missile systems, radars, aircraft, etc. All in all, we can state that this type of training is the one where the individual familiarises with complex weapon systems and equipment.

Crew-served weapon system's crew training

This type of training is a special one. Some would say that it is part of individual specialised training because a crew-served weapon or vehicle (e.g. medium machine gun, APC, or even an attack helicopter) is an individual part of a sub-unit.

These assets are operated by multiple individuals; therefore, we think it is better to distinguish the crew training and discuss it separately. There are two key elements of this type of training. The first is to master the task of each individual crew member. The second is to synchronise the activities of the crew members to perfectly operate the weapon system.

This type of training requires an enormous amount of time for practice with the weapon system that the crew will use. They must learn to use it under all circumstances (day and night, hot or cold, and in good and also extremely harsh weather).

Jumping of sub-units and units

The jump here is a special term for the common training of a given sub-unit or unit. After the successful individual and crew-served weapons training, the goal of the jump is to synchronise the activities of all unit members under the command of the commander, under all circumstances.

The jump consists of mainly tactics and shooting training. Optimally, from the company level upwards, combined arms training comes into focus, where the commanders and individuals learn the rules of working with individuals and units from different branches (tanks, artillery, engineers, air defence, CBRN, airborne ops, etc.).

This type of training, just as above, requires a lot of time. Firstly, the commanders and staffs must familiarise themselves with each other's branches, and then the units must begin cooperation, preferably in the virtual battlespace. The final step of this training (we can easily call this the peak of training) is the combined arms live fire exercise executed under all circumstances.

Matching the needs of training and the VR's capabilities

As explained above, training has multiple aspects, types and levels. According to the goal of our study, in this part, we briefly present the common part of the training's needs and the capabilities of today's VR technology.

Because of the above-described features of VR technology, we state that the primary role of VR training is now at the level of the individual. Therefore, at this level, there is already a wide range of options available.

Primarily, where the individual soldier employs a complex machine (tank, bulldozer, aircraft etc.), it is useful to teach the handling of the basic switches and handles in the VR because if something goes wrong, the – usually – expensive asset will get damaged. It is a lot cheaper and easier to build the dashboard of the complex machine in the virtual space and practice procedures multiple times than to use the actual military hardware for basic operator training. Furthermore, there are emergency situations (e.g. fire or explosion) that cannot be practised on the actual equipment.

For shooting training, of course, the live fire exercises are indispensable. However, this training requires a lot of resources to organise and execute. It is even more true if we consider that live fire exercises are carried out not just with small arms but with complex missile systems, tanks, etc.

VR is a perfect solution for practising the complex aiming and shooting procedures of artillery systems, AA missiles, etc. In case of small arms, VR can be a good solution for practising certain elements of marksmanship (range finding, target prioritising, giving and executing firing orders, etc.).

As we explained above, after finishing the individual training, the next phase is the crew training and the subsequent jump. At the present state of development, the current VR equipment cannot provide an adequate level of practicality, it needs software upgrade and scale-up. This scale-up is possible with sufficient development resources. The crew training of tank crews, AA missile systems, etc., consists of simultaneously executed individual training, so, VR is still a good solution here. However, in case of beginner jumping squads and platoons, the actually available PC-based tactical simulation software is adequate. So far, we have only been able to test the system at the soldier level, but according to the developers, it is capable for squad level and will be available at a higher level later, up to platoons or even company.

Therefore, here we have to underline, that the individual, who spent hours of training and familiarisation in VR will use the real equipment with greater confidence and less likeliness of causing damage, and with this confidence, the jump will be also more time- and cost-effective.

The most effective field: Infantry individual training and sub-unit tactical training

The subsequently listed features are true to all aspects of individual and small unit infantry and shooter VR training:

- It is not necessary to go out to the actual training ground or shooting range (it saves a lot of time and sustainment of the exercises).
- The soldiers will not get used to the terrain and features of the training ground, hence in the VR simulation, an almost indefinite number of maps can be built.
- The complexity of the terrain can be gradually increased parallel with the complexity of the training exercise and with the progress of the individual.
- Any type of circumstances (day, night, fog, full moon, crosswind, etc.) can be simulated independently of the actual weather.
- All activities of the trainees can be monitored, measured and recorded for later and more objective assessment. The system is also able to visualise certain parameters like field-of-views, direction of barrel, safety zones, pulse and even eye movement.

After considering these common features, we should focus now on individual training. At the current level of development, VR has the most opportunities at this level.

The first field of training is shooting training. With the above-mentioned advantages, the individual can practice:

- aiming (with multiple types of small arms, depending on the special "controller")
- assessing distance of targets and terrain features
- acquiring targets and prioritising them according to the previously received or on-the-spot received orders
- the procedure of the shooting itself (if the controller is authentic, all small-aiming and shooting errors can be monitored)
- while executing these tasks, the level of stress and the complexity of the task can be increased by decreasing the available time for the task with trained muscle memory, more and more difficult targets, decreasing visibility, etc.

If the individual has been trained at the infantry units, the next step is the fire team or the squad. Usually, a fire team consists of 3–5 soldiers armed with assault rifles, machine guns and/or AT grenade launchers. Two fire teams make a squad, but in case of some infantry units (e.g. armoured infantry), the squad is not large enough to form two fire teams. A fire team can be the manoeuvre or the base of a fire element in a tactical situation. The VR currently has a lot of possibilities to practice the following:

- Organising a constant fire. We mean that in case of contact with the enemy, it is indispensable that at least half of the fire team is firing his weapon, regardless of whether someone is changing the magazine, reloading the machine gun, or changing its barrel.
- The core of the fire team is the machine gun. Therefore, the riflemen and the AT grenade launcher must synchronise their fires in time, in the field of fire, and in density with the fire of the machinegun. It requires a lot of ammunition and time at the shooting range, which can be substituted with VR.
- These tasks can be conducted even in difficult circumstances. The number and density of targets, the weather and visibility can be changed in accordance with the training level of the fire team/squad regardless of the actual terrain and weather on the shooting range.

After the squad has been partially trained and their fire has been synchronised, it is time to hit the training field and practice everything with actual manoeuvres with real distances and the weight of the real equipment. At this period of training, the guidelines are the tactical tasks that can be conducted by the infantry squad. It is useful that the training continues with the easier and more basic contact drills: breaking contact and envelopment.[21]

The break contact is a basic defensive contact drill during which an infantry sub-unit (fire team, squad, or platoon) receives fire from a superior enemy, and the sub-unit must break contact, extract itself from the enemy fire, and withdraw to a favourable position to reorganise itself. As with all tactical tasks, this also consists of the close coordination of fire and manoeuvre. There are multiple types of breaking contact, depending on the sub-unit’s formation (always determined by the terrain, weather and mission), and the direction and effectiveness of incoming enemy fire.[22] These features can be loaded into the VR simulation much more easily than creating them the training ground with OPFOR.

As we mentioned above, at the current level of development, VR is not capable of simulating tactical manoeuvres in full size. Therefore, we also stated that in all tactical tasks that consist of manoeuvre and fire, VR is perfect for practising firing and constrained manoeuvre skills. During breaking contact, the following skills and tasks can be practised in VR.

- Acquiring the target with 3Ds (direction, distance, dimension).
- Giving and receiving orders and information regarding the enemy and the incoming fire.
- Quickly organising effective counter-fire to suppress the enemy, or at least decrease the effectiveness of its fire.
- Each soldier must use his weapon according to the situation and received orders (finding the designated target, using the capabilities of the weapon with regard of its caveats).

[21] Ranger Training Brigade 2011: 6-1–6-2.
[22] Ranger Training Brigade 2011: 6-4.

- The commander – quickly assessing the situation – organises the system of fires (target reference points, firing sectors, high priority targets, concentrations of fires, restricted firing lines, other caveats and limitations, such as ammo expenditure, etc.).
- Coordinating changing magazines, reloading machine gun, changing barrel, and reloading the AT launcher during breaking contact.

After reviewing the basic defensive drill, the basic offensive drill can be the subsequent topic. The basic offensive drill is the envelopment. Conducting the envelopment at the sub-unit level means that the sub-unit gets into contact with an inferior enemy. After the precise specification of the target (with the 3Ds), the commander quickly forms a manoeuvre and a base of fire element. As we stated before, at this moment, VR is more useful in practising firing skills. During an envelopment, the following can be practised.

- acquiring the target with 3Ds (direction, distance, dimension)
- giving and receiving orders and information regarding the enemy and the incoming fire
- quickly organising the two elements
- describing to the base the fire element, the direction of the manoeuvre, the signals of lifting fire, and the ceasefire
- organising the effective suppressing fire for the manoeuvre
- executing the lifting fire and the ceasefire

The last basic drill is the knockout of a bunker, the so-called SOSRA drill. The acronym means Secure, Obscure, Suppress, Reduce, Assault. Again, the VR is more useful for the firing tasks, which are as follows.

- Secure: isolating the bunker from its adjacent forces, practically with effective fire at the flanks.
- Obscure: launching smoke grenade to an adequate place to obscure the visibility of the enemy (this should be practiced thoroughly because of the difficulties of anticipating the wind).
- Suppress: effectively suppressing the enemy with fire, while the breaching element approaches the obstacles.
- Reduce: at this part, also the suppressing fire should be maintained at a high level.
- Assault: the coordination between the manoeuvre and the base of fire element is crucial. It means that all the signals and firing orders should be practiced.[23]

After all elements of these drills, that can be practised in VR, are thoroughly practised in all circumstances, real-life exercises must follow without any shooting at a slower pace. Then comes the real pace, the blank ammunition under all circumstances and finally, the live fire exercise day and night. In this complex and resource-consuming process, VR can save us an enormous amount of time, ammunition and weapon life by providing an opportunity to practise all necessary techniques for effective fires.

---

[23] Ranger Training Brigade 2011: 6-8.

Of course, not only basic infantry drills should be practised, war is a much complex phenomenon. Therefore, we must underline that by practising these drills, the soldiers and sub-unit leaders can acquire a lot of useful experiences in order to better execute the more complex tasks.

These tasks are fighting in built-up areas (FIBUA) and peace support operations. The FIBUA consists of lots of small individual movement techniques that can be practised even at this level of development of the VR. These are:

- firing from behind corners and windowsills
- entering into rooms (the so-called slicing)

Of course, the main topic is again the fires. Firing in built-up areas often means that soldiers must fire at targets at a vertical angle. This angle largely influences the trajectory of the bullet (in extreme situations, the target is spotted under an obstacle, but the bullet flies over the obstacle to hit the target). These features can easily be programmed into the simulation, and this can provide an opportunity to train these shooting skills without building this complex shooting range.

During peace support operations, firing skills are also essential. Soldiers must thoroughly know the ROE (rules of engagement). These rules define the situation against which targets a soldier can and must use his weapon. In real life, these situations are extremely stressful, and the soldier and the commander must make a decision in a fraction of a second.[24]

VR is perfect for practising this, therefore practically indefinite types of situations can be simulated, from the basic and clear to the insanely complex. The soldier can be put on guard duty, at a checkpoint, or anything else, and the situation can be any kind. From the simple, clear threat of an attacking gunman through complex suicide bomber and small arms attacks, to complex attacks with decoy targets and civilians in an environment full of limitations and restrictions.

The individual in the VR can practice:

- employing the rules of engagement
- when it is allowed to use his weapon, against which type of targets
- carefully avoiding causing collateral damage
- respecting restrictions and constraints (e.g. do not fire churches or orphanages)
- choosing the appropriate amount of destructive power (weapon and/or ammunition types)
- all the basics of firing mentioned above at the tactical drills

Now we can see that at the current level of development, VR can enhance training in multiple situations. We must underline here that VR does not substitute actual real-life training. We think that the greatest opportunity in VR currently is the following:

- classifying threats and targets
- practising giving and executing firing orders

[24] Department of the Army 2010: 5-3.

- organising fire systems of fire teams and squads
- employing the ROE in a peace support operation
- practicing firing with vertical angle

Finally, we must emphasise again that VR can provide these opportunities in an environment that gets gradually more difficult in parallel with the trainees' progress. Furthermore, all exercises can be recorded and replayed for further and more objective assessment.

Conclusion

In our paper, we have examined the capabilities of VR at the current level of development. We have found that in the focus of training, the Hungarian Defence Forces can profit a lot if VR is correctly implemented at the adequate levels. These levels are individual specialist training, sub-unit level training and crew training of complex military hardware.

After reviewing the training options in these training types, we have thoroughly examined the VR's options in the field of individual and sub-unit level infantry tactics training. We have found an enormous number of opportunities where VR can save a lot of time and other resources (money, ammunition, lifespan of weapons, etc.) for the HDF. Furthermore, VR has other advantages regarding the methodology of the training. VR technology enables the difficulty of training to be increased according to the purpose of the unit and the capabilities of the trainees. Furthermore, the training events can be recorded and replayed for more objective assessment and analysis.

All in all, we can firmly state that even at the current level of development, VR-based training can have a lot of advantages and can further help the training process if used at the correct level and at the correct phase of the process.

References

Antunes, Jose (2020): Varjo XR-1: The World's First Virtual Reality Headset with Chroma Key. *Provideo Coalition*, 12 March 2020. Online: https://www.provideocoalition.com/varjo-xr-1-the-worlds-first-vr-headset-with-chroma-key/

Britzky, Haley (2022): The Army Is Finally Getting Its Futuristic Heads-Up Display into More Soldiers' Hands This Year. *Task and Purpose*, 28 January 2022. Online https://taskandpurpose.com/news/army-ivas-fielding-2022/

Department of the Army (2010): *Army Tactics, Techniques, and Procedures ATTP 3-21.9.* SBCT Infantry Rifle Platoon and Squad.

Flight Safety (s. a.): *FlightSafety's Mixed Reality Flight advances to the final round of the AFWERX Mixed Reality B-52 Air Refueling Challenge.* Online: https://www.facebook.com/FlightSafetyInt/photos/flightsafetys-mixed-reality-flight-advances-to-the-final-round-of-the-afwerx-mix/4410966498924950/

GSOF Europe (s. a.). Online: https://www.gsofeurope.org/agenda

Honvédelem (2022): A Honvéd Vezérkar [HDF General Staff]. *Honvédelem*, 21 December 2022. Online: https://honvedelem.hu/alakulat/honved-vezerkar.html

Honvédelem (s. a.): *Bevonuló önkéntes tartalékosok figyelmébe*. Online: https://www.hadkiegeszites.honvedseg.hu/onkentes_tartalekos_rendszer/kikepzes_tartalekosok

HVK (2019): *Felkészítési és kiképzési program a hivatásos, szerződéses katonákkal feltöltött gépesített lövész- és harckocsizászlóaljak részére*. A HVK Hadműveleti Csoportfőnökség Kiadványa.

Martirosov, Sergo – Kopecek, Pavel (2017): Virtual Reality and its Influence on Training and Education – Literature Review. In Katalinic, B. (ed.): *Proceedings of the 28th DAAAM International Symposium*. Vienna: DAAAM International. 0708–0717. Online: https://doi.org/10.2507/28th.daaam.proceedings.100

Németh, András – Virágh, Krisztián (2021): Virtuális valóság és haderő – katonai alkalmazási lehetőségek. *Haditechnika*, 55(5), 2–7. Online: https://doi.org/10.23713/HT.55.5.01

Németh, András – Virágh, Krisztián (2022): Mesterséges intelligencia és a haderő – A mesterséges intelligencia területei. *Haditechnika*, 56(3), 2–7. Online: https://doi.org/10.23713/HT.56.3.01

Ranger Training Brigade (2011): *Ranger Handbook SH 21-76*. Fort Benning, Georgia: United States Army Infantry School.

Regnier, Jason (2021): IVAS Program Update. *TAK Offsite Event*, 1 December 2021. Online: https://www.youtube.com/watch?v=bYxJeI2IYO0

Reitz, Emilie A. – Seavey, Kevin (2016): *Virtual Dismounted Infantry Training: Requiem for a Dream*. Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2016.

Siter, Bridgett (2019): Soldiers Test New IVAS Technology, Capabilities with Hand-On Exercises. *U.S. Army*, 20 November 2019. Online: https://www.army.mil/article/230034/soldiers_test_new_ivas_technology_capabilities_with_hand_on_exercises

Stilwell, Blake (2020): Special Operators Outsmarted the Military-Industrial Complex. *We Are the Mighty*, 29 April 2020. Online: https://www.wearethemighty.com/mighty-tactical/special-operators-improvise-on-field/

Wade, Norman M. – Larsen, Christopher (2017): *The Small Unit Tactics Smartbook*. The Lightning Press.

Xia, Xinxing – Guan, Frank Yunqing – Cai, Yiyu – Magnenat Thalmann, Nadia (2022): Challenges and Advancements for AR Optical See-Through Near-Eye Displays: A Review. *Frontiers in Virtual Reality*, 3. Online: https://doi.org/10.3389/frvir.2022.838237