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THE INNOVATIVE USE OF DISTANCE-LEARNING TRAINING MATERIALS IN VIRTUAL REALITY (VR) SPACES, AND THE OPPORTUNITIES TO APPLY THE FURTHER DIMENSIONS OF VIRTUALITY (AUGMENTED AND MIXED REALITY – AR/MR) IN MILITARY EDUCATION AND TRAINING AND IN TACTICAL PROCEDURES

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ABSTRACT: *The restrictions and regulations aimed at preventing the global spread of the SARS-CoV-2 (COVID) pandemic, which had its outbreak in 2019, have been exerting negative influence – and, in certain areas, positive impacts – on various dimensions of education and training for more than one year now. Despite the heroic cooperation, terrible and painful losses of human life could not be avoided. However, the effects of the restrictions on alternative education and training processes, on the development of individual digital competencies, and on the emergence of the latest technologies are indisputable.*

Education and training conducted in the form of distance learning are already based on considerable experience, and the examination of training materials, their application methods, and the less explored further opportunities have become a major research area in the last nearly one year.

The rapidly developing technological innovations for the use of virtual spaces (the dimensions of virtual, augmented, and mixed reality) still provide unexploited possibilities, not only in the field of education and training, but they may also play an increasingly important role in operational procedures. It is well demonstrated by one of the latest procurement projects of the United States Armed Forces, in which Microsoft Hololens augmented reality-based systems have been purchased in a substantial amount and of high value[1].

It must be stated that this "trend" is no longer only US soldiers' privilege, as a number of similar – though significantly smaller-scale – programmes are run successfully which support the training of certain groups of soldiers[2]*. For the time being, it means supporting the training of merely certain groups, since – in the framework of the Zrínyi Defence and Military Development Programme – the particular simulation capabilities are enabled and set up parallel to or following the scheduled supplies of the technical equipment. These tools are mainly in garrisons where they are required for capability development, and where the real*

[1] Sullivan, M. "Here's how the Army will use 120,000 Microsoft HoloLens headsets in battle". Fast Government. 5 April 2021. https://www.fastcompany.com/90630728/microsoft-army-hololens-deal, Accessed on 3 June 2021.

[2] Koszticsák, Sz. "Szolnok received a helicopter simulator." (in Hungarian) MTI. 11 February 2019. https://iho.hu/hirek/helikopterszimulatort-adtak-at-szolnokon-190211 Accessed on 3 June 2021.

assets and the operating and supporting staff are located. Up to now, such systems have been set up in the training of air force personnel – simulation systems related to the Airbus H145M helicopters, Joint Terminal Attack Controller (JTAC), helicopter door gunner etc. However, their appearance is expected in the training of land forces – armoured, artillery and infantry as well, in the near future.

The drills in military activities and in various tactical procedures are of primary importance so that the combat readiness level of the armed forces can be set and maintained, which is – even in peacetime – exceptionally demanding in terms of financial, material, and technical requirements. It is, therefore, essential to identify training procedures, such as the various simulation systems that enhance the achievement of training objectives and are cost-effective at the same time. In the modern preparation and training system of the armed forces, "the already available cost-reducing digital technical training systems will play an important part. From a merely technical viewpoint, we are in an easy situation since the technical training opportunities of the 21st century go as far as the imagination goes. On the international market, the simulation systems for tasks are available in all phases of training"[3].

KEYWORDS: *distance learning, virtual, augmented and mixed reality; hybrid learning materials*

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INTRODUCTION

A professional soldier may feel uplifted and inspired when standing near some new and state-of-the-art technical equipment, especially if it incorporates the latest achievements and innovations of the modern defence industry, and is able to support the armed forces in conducting their missions. Its role is only to support them, since not even the most modern military equipment is capable of working effectively without trained personnel. Naturally, it is only the future when the development of artificial intelligence and *autonomous system*s might reach the level at which – in compliance with the appropriate moral and ethical standards – the tools can be enabled to have certain decision-making and enforcement powers. However, I am certain that it is the person who must take the final decision in truly complex situations.

At the current development level of combat equipment, the thorough education and effective training of soldiers are the way to the full utilization of capabilities, and the development of the quality indicators is one of the main objectives for all instructors and trainers.

My personal motivation and commitment are also rooted in this conviction. In my research, as a trainer as well as a PhD student at the University of Public Service, I examine what form and methodology must be used to cater for the individual learning preferences,

[3] Révész, B. "The Hungarian Defence Forces may receive more cutting-edge technology." (in Hungarian) Honvedelem.hu. 10 December 2020. https://honvedelem.hu/hirek/ujabb-csucstechnika-erkezhet-a-magyar-honvedseghez.html Accessed on 3 June 2021.

learning strategies and motivations of the current military personnel while – besides the traditional and predominantly frontal teaching-based education processes – the alternative methods are also given greater importance and, thereby, students are provided with a variety of options for achieving their educational and training objectives.

Therefore, the aims of my research, besides defining the basic learning preferences of the target audience (the military personnel of the Hungarian Defence Forces) are as follows:

– to make recommendations on the methodological character of future distance-learning training materials (the content format in line with learning preferences, the applied platform, reference model, etc.);
– to create a new reference model applying and combining the existing and future distance-learning training materials and the opportunities provided by virtual reality space;
– to prove that virtual spaces (VR/AR/MR) open up opportunities even for developing and acquiring practical skills and abilities.

Another aim of my research is to lay the foundations for an educational and training platform and service launched in virtual and/or augmented reality spaces, which do not manifest themselves in physical reality, but are able to foster the development of a soldier's individual cognitive abilities (presenting and transferring new information within several dimensions of learning preferences – visually, audibly in writing, etc.). In addition, the platform and service will provide opportunities for the simulation of events and activities in the real physical space, where soldiers will be able to practise diverse tactical procedures and test feasibility in almost laboratory-like circumstances.

CONQUERING THE DIMENSIONS OF VIRTUALITY

It would be rather unfair to claim that the idea of virtual reality or virtuality is one of the achievements of modern science because there have already been initiatives with the objective of placing an individual or a group of individuals into a "space – situation – event" which either takes place at some point in time in the past or is set in a fictitious and futuristic world. One of the best examples of this is Feszty körkép (Feszty Cyclorama) in Ópusztaszer, Hungary, or The Bourbaki Panorama, in Switzerland. Due to their enormous size, both take their visitors out of the real world and mesmerize them with the lifelike presentation of a past event.

The display itself is impressive, however, the possibilities of visualising an event in space and time are rather limited. Furthermore, no interaction is possible among the various elements, therefore these otherwise magnificent works of art can be used for educational or training purposes to a lesser degree only.

The active use of virtual *realities* (where the plural is not accidental, for today one can distinguish between virtual, augmented, and mixed realities) is a genuinely modern technology. Nowadays its potential is primarily exploited by the entertainment industry where the video game sector is one of the fastest growing fields with near-real-life visualisations and experience-based service at the core of innovation. Naturally, the advances of technology are not confined to this sector since graphic design, data processing and analysing also affect IT and vice versa. Modern game developers and game engines are now able to create an almost real-life three-dimensional appearance in a video game, where using various devices and motion sensors one is able to interact with the game elements, manipulate and

control them; furthermore, these elements can manipulate their users. It seems obvious that these kinds of simulation programs have a place in military education and training.

THE CHARACTERISTICS OF VIRTUAL DIMENSIONS

For this study and for the design of future simulation programmes, it is essential to make a clear distinction between the various types of virtual dimensions and their basic methods of application.

Basically, one can distinguish between virtual, augmented, and mixed reality dimensions. In many cases, experts' opinions differ on the interpretation or the use of these, possibly due to the fact that the borderline between them is not very clear.

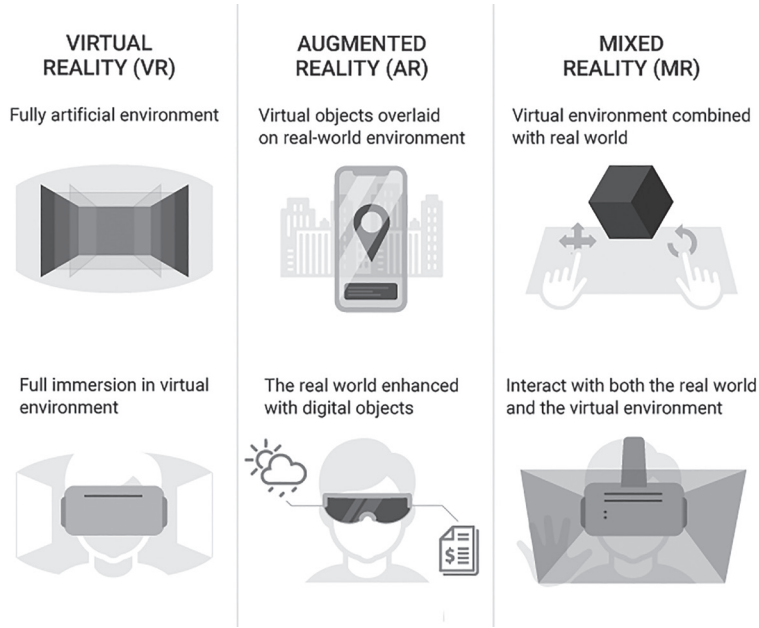

Figure 1 *The definition of virtual, augmented and mixed reality*[4]

"Virtual reality (VR) and augmented reality (AR) – although still used interchangeably by many – in fact, are two entirely different concepts. Virtual reality is not identical with augmented reality. Virtual reality differs from augmented reality in one very important aspect. Once virtual reality goggles are put on, you get into the dimension, space, room, or place where that particular game or application takes place and the outside world is totally blocked out. In augmented reality, however, you stay in the original, real surroundings in which the artificially created, virtual, otherwise non-existent objects or contents appear.

[4] Gleb, B. "VR vs AR vs MR: Differences and real-life Applications". Rubygarage. 4 January 2020. https://rubygarage.org/blog/difference-between-ar-vr-mr Accessed on 8 June 2021.

In augmented reality, you look at something through the camera of a mobile phone or tablet and a specific application adds pictures and information."[5]

Therefore, in the case of VR you are totally isolated from your surrounding environment, while in AR you perceive your own physical dimensions and can act in them, but additional virtual, passive, and non-interactive objects also appear to support your activities.

Mixed reality, compared to the previously discussed VR and AR, represents a higher level of development, where you can interact with both the real, physical world including its objects and virtually created ones by means of a motion-simulating active device.

The creation of virtual reality is based on the principle of stereoscopy, which "combines all imaging techniques for creating or enhancing the illusion of three-dimensional vision in an image. Three-dimensional vision occurs when the brain processes and combines two offset images perceived by our eyes in real time (stereopsis). Consequently, if two offset images are shown to the left and right eye separately, it yields a perception of 3D depth."[6]

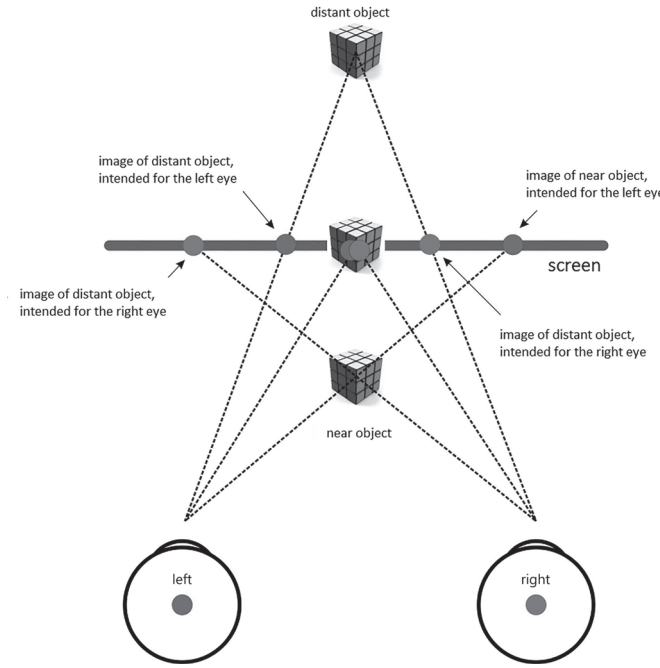

Figure 2 *The history of three-dimensional visualization techniques*[7]

[5] "What is the difference between extended reality and virtual reality?" (in Hungarian) Holoszoba.hu. 7 February 2017. https://holoszoba.hu/mi-a-kulonbseg-a-kiterjesztett-valosag-es-a-virtualis-valosag-kozott/ Accessed on 8 June 2021.

[6] "Sztereoszkópia". Museum-digital.de. 28 March 2020. https://rlp.museum-digital.de/index.php?t=tag&id=5966&navlang=hu Accessed on 8 June 2021.

[7] Fekete, T., Antal, Á., Tamás, P., Décsei-Paróczi, A. "The history of three-dimensional imaging." (in Hungarian) Mogi.bme.hu. https://mogi.bme.hu/TAMOP/3d_megjelenitesi_technikak/ch06.html, Accessed on 8 June 2021.

It is vital to point out that virtual dimension techniques are based on the deception of the human senses, especially the eyes. Handling this is a formidable challenge in itself, but for safety reasons it is also important to determine the negative effects of these techniques on the human body from an anatomical point of view, both in the long and short term.

The early applications for VR space, especially ones involving physical movement, resulted in a negative experience for the users. This phenomenon is rooted in anatomic cognitive dissonance and the conflict of convergence and accommodation. The former means, "your brain becomes confused when your body and brain perceive two different stimuli. For example, you are sitting comfortably in an armchair, with a helmet on, and a controller in your hand when your brain receives a signal that you are running for your life in the jungle. This kind of cognitive dissonance can easily cause confusion, dizziness and discomfort.

The latter occurs when you are looking at an object or person and your eyes set the focus depending on the distance you are from that particular object or person. Convergence refers to the fact that the closer the object or person you are looking at is the more your eyes converge. Accommodation, on the other hand, is when your lenses are set depending on the distance from what you are looking at, so that the light coming from the object falls on the area of sharp vision. These two processes take place simultaneously therefore in the real world things that look near are near, the ones that you see at a distance, are a long way away. In virtual reality, however, you are looking at two displays placed in front of your eyes, and regardless whether you want to focus on the nearby things or the ones further away, your eyes will only focus on the objects that are very close. Eye muscles are confused, accommodation practically ceases to function, and this confusion can lead to fatigue, discomfort or vomiting."[8]

SIMULATION SYSTEMS IN THE TRAINING SYSTEM OF THE HUNGARIAN DEFENCE FORCES

In the current training system of the defence forces, it is the simulation systems developed for the crew of military helicopters and JTAC (Joint Terminal Attack Controller) personnel that represent the most advanced technology.

In spite of their high acquisition costs, these systems have resulted in significant savings in expenditure, however, they are only capable of providing effective supplementary training for a minority of the personnel. This training is supplementary, since the time spent in real operational or exercise environment cannot be replaced with time spent in simulation systems; the experience gained in such environments are not equivalent. However, practising in simulators still forms an important part of the training, since a wide range of possible situations can be simulated, which can provide effective help in developing the skills of quick decision-making and reaction capacity.

It is important to note that these simulation systems are also based on virtual reality, however, the users do not normally wear VR goggles because visualisation is carried out by outside projectors. On the one hand – from an ergonomic point of view – it is rather positive since it eliminates the problems of cognitive dissonance. On the other, however, the accidental lack of realistic spatial perception still remains an important issue.

[8] Bari, M. "Oculus promises virtual reality free of vomiting." (in Hungarian) 24.hu/tech. 18 May 2018. https://24.hu/tech/2017/05/18/hanyasmentes-virtualis-valosagot-iger-az-oculus/ Accessed on 16 February 2020.

The simulation programme developed for helicopter door gunners is totally different in approach from the one described above, being entirely based on virtual reality. The pilot is responsible for the manoeuvres of the aircraft to ensure that it reaches the designated landing zone on the pre-defined aerial route. The scope of duties of a door gunner is at least as complex as that of a pilot since he is responsible for providing protection for the aircraft. "However, in some cases it may include providing aerial escort and security for columns of convoys on the ground, which is carried out in different ways in an urban terrain and in open ground. In order to avoid helicopters falling prey to friendly fire of door gunners while changing position, door gunners must spend many hours in simulators. As many hours as necessary so that both the pilot and the door gunner could carry out their duties automatically, safely, and effectively."[9]

Obviously, at the level of the average infantry soldiers – based upon the enormous user demands and the character of their fundamental tasks – planning needs a different approach and a different way of thinking.

It can be stated of all the three simulations systems above that the system of activities is fixed in one position, that is, users do not or hardly move while using the simulation devices, the substantial part of their activities takes place in virtual space. So in case of assignments that are fixed in one position (pilot in the cockpit, door gunner, JTAC operator, the crew of infantry fighting vehicles, turret gunner, etc.) and no change of position occurs, applications based on virtual reality may take a market leader position and be capable of supporting the system of training.

In the case of infantry sub-units that comprise a large number of personnel, however, the situation is fundamentally different. The vision and spatial recognition of soldiers cannot be eliminated by placing VR goggles on them since they carry out tasks that basically involve movement and position change (e.g. occupying a line or an objective). In such cases, systems based on reality may be the solution, where soldiers – while acting in real physical space – may be provided with supplementary information (geographical position, weather conditions, compass markers, "friend-or-foe" identification signals, real-time video signal transmitted by autonomous devices, etc.) to help them carry out their basic functions. Obviously, it must be examined how much the supplementary AR interfaces support or hamper soldiers in implementing their duties and what effect the entire system has on the cognitive capacity of soldiers and the length of recreation after the operation.

VR-AR PROJECTS SUPPORTING MILITARY TRAINING AND EDUCATION BASED ON INTERNAL RESOURCES

In the training and education system of the Hungarian Defence Forces, the ambitions affecting virtual and augmented reality – apart from the procurement of simulators supporting the training of helicopter crew and JTAC operators mentioned above – are rather modest for the present. One might think it is still viewed as a supplement to traditional training systems rather than an independent area of training.

All the simulation devices that have been procured, deployed, and have become operational to date belong to prestigious suppliers in a segment of the international arms industry (Thales, Saab, etc.), a fact that is apparent in the elaboration and effectiveness of the

[9] Trautmann, B. "Imagined flight – more than simulator." (in Hungarian) Haborumuveszete.hu. 16 September 2016. https://www.haborumuveszete.hu/phirek/9/alakulatok-hirei/kepzelt-repules-tobb-mint-szimulator Accessed on 8 June 2020.

simulation systems, and obviously in the expenses of their procurement, installation, and maintenance[10].

One might justifiably ask that when the tasks of relatively minor significance in the long list of basic missions of the Hungarian Defence Forces, or their advancement can be expected to take place later, what solution will be provided for effective training? Is it possible to support VR-AR training programmes and ideas that have more modest budgetary needs but can be efficiently applied and based on the "grey matter" of trainers and instructors solely?

In my view, the answer to this question is affirmative. This statement is based upon the fact that within a short period of time following the Sharable Content Object Reference Model (SCORM) distance-learning training materials (the distance-learning modules of volunteer reserve officers, and NCO basic course), which were devised by civilian capabilities in 2018 and 2019, identical, sometimes more developed, internal resource-based digital learning materials were published which are even capable of effective support for the education and training needs of the Zrínyi Programme (the digital training material of civilian employees in 2020; LEOPARD2A4HU).[11]

Following the same logic and based upon the experience that trainers and instructors who actively carry out their tasks in the system of training and education can formulate the operational needs of the training capability that supplements the educational process, great achievements can be made in the field of development of training capabilities provided there is trained information technology personnel available who can implement the objectives.

In the next part of the paper, a few project initiatives and ideas will be described that our colleagues are currently working on.

A FUSION OF TRADITIONAL SCORM DISTANCE-LEARNING TRAINING MATERIALS AND AUGMENTED REALITY APPLICATIONS

The targeted completion of distance-learning training materials with media elements is of outstanding importance, since in the vast majority of cases these materials are intended for learners whose learning preferences are not known. For this reason, the learning process must be structured in a manner that provides the necessary information for all preferences in a written, oral, or visual form.

Even in the case of traditional frontal lectures, instructors tend to illustrate the information relevant to a topic with pictures, videos, and animations. Although these make three-dimensional demonstration possible, the projected media elements still appear on a two-dimensional surface.

[10] Koszticsák Sz. "Szolnok received a helicopter simulator."

[11] Ördög Kovács, M. "Digital study materials aid in training." (in Hungarian) Honvedelem.hu. 1 February 2021. https://honvedelem.hu/hirek/digitalis-tananyaggal-segitik-a-kikepzest.html Accessed on 9 June 2021.

A fusion of traditional SCORM training materials with applications based on augmented reality might provide a much more representative and advanced-quality opportunity of visual representation – supplemented with several elements of learner–training materials interaction – where the content of the training material built up in the application (e.g. a real, three-dimensional model of a static or moving technical device) is activated by a picture or a diagram integrated in the distance-learning training material.

In this case, on certain surfaces of the training material, supplementary signs must be placed, which draw the learner's attention to the fact that additional content is available, related to the training material. Focusing the application window of the smart device on the training materials displayed on the computer screen, the supplementary contents appear in real three-dimensional representation. Buttons and surfaces that are necessary to activate additional information can be placed on both the surface of the smart device and in the augmented reality space created before on the smart device for interaction – magnification, rotation, activating supplementary information related to certain parts.

If need be, the application could be complemented with sensory devices that make the representation of real physical spatial movement possible in virtual space (Leap Motion Controller), a solution that can ensure a much more advanced possibility for interaction with virtual models. However, this approach is closely connected to the area of mixed reality.[12]

This seems to be the most cost-effective solution until the quality level of augmented reality goggles on the market reaches that of the virtual reality goggles. As soon as the great developing companies – e.g. Microsoft, Oculus, Qualcomm – are able to offer augmented /mixed reality goggles in an accessible price category ($2-300) as opposed to the current $800-2,500 each, the number of hybrid or solely AR/MR training modules will undoubtedly enter the area of training and education.

At certain points of the learning process a pair of augmented reality goggles of adequate quality could be synchronized with the learner's personal computer if necessary, and will activate the training contents placed in augmented reality space without user interaction. Learners will be able to interact freely with these training contents, especially with three- or more-dimensional models, using their hands – since no longer will they need to keep their smart devices in their hands in order to display AR space –, or by simply "clicking" certain surfaces in the space, they can activate built-in sub-programmes concerning the models.

VIRTUAL REALITY BASED APPLICATIONS USING 360-DEGREE VIDEO RECORDINGS IN ORDER TO IMPROVE SITUATIONAL AWARENESS

The system of military activities – especially in a state of emergency and when participating in international operations – is characterized by extraordinarily high-level stress and risk factors. The security status might change in a split second, to which you need to respond within the same amount of time to safeguard your own and your comrades' life and safety, as well as bearing the mandate of the operation and the rules of engagment in mind,

[12] Habók, L. "Interaction engine: kezünkből csinálna VR kontrollert a Leap Motion". hwsw.hu. 25 August 2016. https://www.hwsw.hu/hirek/56069/leap-motion-interaction-engine-vr-vive-oculus.html Accessed on 9 June 2021.

causing the slightest possible collateral damage to civilian lives, property and the natural environment. These criteria can only be fulfilled after an effective high-quality training course has been completed and the appropriate situational awareness has been established.

"Situational awareness means the perception of the environment and the environmental elements in the light of the events occuring around us. It plays an important part both in time and space. It requires active attention, an observation analysis and some intuitive prediction of possible outcomes and consequences. Everything within this concept plays an active role in certain professions as well as in every civilian person's life, for some people more than for others. It is of primary importance in professions, such as law enforcement and security jobs, traffic control, and in any jobs of high-level responsibility and high risks. In day-to-day life, it may play an important part in transport or in avoiding situations with negative people."[13]

Therefore, creating appropriate situational awareness may be a matter of life and death in certain cases. This is one of the reasons why it is essential to train soldiers in lifelike situations at the end of particular training phases and during final exercises.

In order to drill soldiers in various activities and tactical procedures, it is an established routine to analyse video recordings that examine (pros and cons) the feasibility of such procedures in diverse situations. This practice is absolutely applicable, but in these cases, the soldiers are "merely" external observers of the given situation, and they are not able to experience its 360-degree dimensions. However, controlling an assembled crowd in an operational area, crossing a terrain under the threat of some suspected explosive weapon, or protecting a VIP – all require full three-dimensional perception of the situation.

The various VR applications in which the situations are recorded using 360-degree cameras can effectively support the creation of the appropriate situational awareness, even in the preparation phase prior to a foreign deployment. Certainly, this idea is not a new discovery; there exists a number of programs that have been designed with the same purpose. The initiative of the United Nations Organization, named UNVR, is an example, which is basically aimed at "sensitizing" certain decision-makers of the member states (potential project support providers) in relation to various UN missions.[14]

Some possible internal VR programs to improve situational awareness:

– *A VR application supporting the UN military observers' aerial reconnaissance exercise*
  Conducting aerial reconnaissance, registering the opposing parties' military equipment and activities, and documenting the movements and actions of troops banned from military activities or movements, and actions taking place in control zones are an integral part of the military observers' training programme accredited by the UN (International Military Observers' Course – IMOC).[15] All this requires a considerable number of air assets and hours flown, which entails expenses of millions of HUF from the national military budget. Provided that the simulated activities along the flight path can be recorded with 360-degree cameras, after the one-time development of the VR

[13] Pazsit, Z. "Situational awareness." (in Hungarian) blog.pazsitz.hu. 6 August 2019. https://blog.pazsitz.hu/pszichologia/szituacios-tudatossag/ Accessed on 9 June 2021.

[14] "VR Films". UN Virtual Reality. 2019. http://unvr.sdgactioncampaign.org/vr-films/#.YMD6y_kzZPY Accessed on 09 June 2021.

[15] Kelemen, I. "Patrol exercise and aerial reconnaissance." (in Hungarian) Honvedelem.hu. 7 October 2019. https://honvedelem.hu/galeriak/jarorgyakorlat-es-legi-felderites.html Accessed on 9 June 2021.

program and the procurement of the necessary additional equipment (VR equipment), the program can be reused on countless occasions during theoretical preparation, and it will presumably have a positive impact on the actual implementation as well.

– *Procedures at legal/illegal checkpoints in case of peaceful or hostile crowds – a supporting VR-application*
  Examining how operations must be carried out and how security must be organised at legal /illegal checkpoints and in case of peaceful or hostile crowds is an integral part of the courses and training events that prepare soldiers for operational tasks. In cases when soldiers need to interpret and define 360-degree security to the full extent of space, a 360-degree VR application can be an opportunity to make the training more effective.
– *VR applications supporting the tactical procedures training*
  Practising proper tactical procedures (marching formations and movement in the field, the process of examining the terrain, mine and improvised explosive device awareness in threat areas, searching objectives, etc.) comprises a basic part of practical military training. Being able to execute them automatically at the level of 'muscle memory' might be the key to the survival of the individual soldier and their comrades in theatres of real tactical operations or peace operations. According to the methodology of military training, demonstration and illustration play an important role in the training process: the instructors first demonstrate the activity divided into small steps then the entire procedure to the trainees, then they practise the recruits until their performance level achieves proficiency.

Obviously, trainees can only view and examine the activity from one perspective during the demonstration phase, which, in the case of a complex process (e.g. the relative position of soldiers to one another, or individual sectors of observation, or more complicated marching formations that might be affected by the terrain), makes the process of understanding and acquisition more difficult.

In my view, what might help is the use of a methodologically well-based virtual reality application that is capable of demonstrating the proper implementation of tactical procedures, where one can freely switch between views of a squad or a platoon, and can examine the individual movement and activities from any perspective.

Applications demonstrating the process of terrain examination, or mine and improvised explosive devices awareness in threat areas, and searching objectives could be structured on the same logic, where the proper implementation of established and accepted procedures may be demonstrated for trainees.

Naturally, it must be emphasized for trainees that the use of the given procedures might depend on the operational situation, the activities of enemy forces, weather conditions, and that the procedure demonstrated in the application can only be viewed as one of the several suggested ways of implementation. In a live operational environment, it is the right and duty of the on-scene commanders to choose a procedure after thoroughly considering the situation.

VR-AR PROJECTS SUPPORTING REAL-TIME TACTICAL PROCEDURES

The possibilities of the use of programmes and applications based on virtual, augmented, and mixed reality in the field of training and education are more or less proven; several progressive initiatives exist in the civilian industrial sector. Examples include the car industry, where the proper implementation of the assembly of parts is supported by augmented reality

applications, or medical diagnosis, where with the aid of visual representation of certain examinations (e.g. surgical interventions) of diseases can be treated with greater efficiency.

One can ask whether such technology can be applied in the field of military tactical procedures, which can contribute to the success of combat engagement directly, and to the survival of the personnel using military technology indirectly.

In my opinion, the answer is yes. In the following, an attempt will be made to prove this merely on theoretical basis.

One arm that has the greatest mobility and firepower in ground forces is armour. Main battle tanks have been a key element in ground operations since the beginning of the 20th century; their main task is to penetrate enemy lines and ensure victory in the depth of the battlefield. During the two world wars, these formidable combat vehicles played extremely important roles, and their rationale has not been questioned ever since.

A tank is a complex weapon system, an armoured fighting vehicle developed for direct contact with the enemy. A tank is the ideal combination of firepower, armour protection, and mobility. Firepower is provided by weapons mounted on a tank, in most cases a large-calibre gun in a rotating turret and supplementary weapons. Armour protects personnel, the engine and ammunition; the level of protection depends on the thickness and the material of the armour, the way in which its parts are fitted together, and the angle of armour plates. The main characteristics of mobility include speed, the capability of moving on rough terrain, and effective range. Mobility can be influenced by a variety of factors: the type and performance of the engine, the suspension and arrangement of the running gear, the width of the tracks, the system of transmission, the thickness of the armour, and the total weight of the vehicle.

In my view, a further indicator of the survival of main battle tanks could be the effectiveness of visual reconnaissance. If the optical devices of a tank are capable of representing the surrounding field around a tank in a greater range of vision, and their magnifying parameters are highly advanced, then the crew of the tank will reconnoitre and identify enemy units faster and open fire at them.

An example is the LEOPARD2A4 main battle tank that has good tactical characteristics, in which the visual reconnaissance is supported by a PERI R17 gyro-stabilized panoramic commander sight periscope and prisms built in the turret.

The commander's sight ensures the visual observation of the space around the tank with a 27°×7° field of view, horizontally 360°, vertically 33°, (from –13° to +20°) with magnifications of 2× and 8×.

Based upon the specifications above, it can be stated that the efficient visual observation of the ground around the main battle tank requires continuous and precise work from the commanding personnel, with regard to the size of the area to be observed and the relatively limited range of the field of view.

One might ask whether, apart from the traditionally installed optical equipment (PERI R17 commander sight, the EMES main range finder, the FERO-Z18 auxiliary telescope and the prisms), new systems of cameras with a 360° field of view could be installed to ensure more effective reconnaissance. Could the three-dimensional image be transmitted and displayed on a head-up display placed on the headgear of the crew of the tank? Could the projected image be synchronised with the movement of the head with a gyroscopic motion sensor?

In my view, the answer is yes. It is feasible in technical terms, however, several important factors need to be considered:

– The vulnerability of camera systems: The traditionally installed equipment is fitted with strong armour protection in order to provide protection against the destructive effects of hostile weapons. If need be, the camera systems available on the market must be retrofitted with armour, or further research must be conducted to develop the equipment that has the appropriate indicators for protection.
– Integrability into the fire control system: The "brain" of the tank is the fire control system, a ballistic computer, which calculates the appropriate ballistic elements relying on basic information such as the speed of the tank, inclination angle, target distance, etc. An important question to be answered is whether the three-dimensional image generated by the camera systems can be synchronized with the main targeting systems. If there is a lack of cooperation between the systems, the advantage of the rapid visual detection enabled by the three-dimensional cameras is lost since the traditional targeting system must be used, which wastes time and requires careful divided attention.
– The availability of Identification Friend or Foe (IFF): Besides rapid visual detection, it is essential that the own or friendly forces' military equipment can be identified clearly, which is an extremely difficult task in low visibility conditions. It would be an enormous benefit if computers were able to calculate the GPS-based positions of the own forces' military equipment in a three-dimensional image provided by the cameras, whereby assisting the crew in avoiding friendly fire and in opening fire on hostile tanks. Obviously, the protection of the collaborative computer networks also needs to be taken into account, as the advantage gained might easily lead to a major downside, and provide an opportunity for hostile forces.

There is a long list of further areas to be examined, and a number of theoretical as well as practical questions need answers before an ideally workable theory is put into practice, and may support the crew in battle.

Choosing which virtual dimension (VR – virtual reality or AR – augmented reality) must be used in the creation of the program is of primary importance since certain capabilities and indicators, such as the range of the field of view and the feasibility of the interface, etc., might appear as advantages in one dimension or disadvantages in another.

A key issue is what range of the field of view is provided by the tools, goggles, and head units belonging to the different dimensions.

In virtual reality, the field of view may be covered with content up to 170 degrees (Pimax 8K VR goggles), and the reliably functioning Oculus VR goggles are also capable of covering a 90- or 100-degree range of the field of view.

The data provided by the important devices (e.g. firing modes, the commander's computer system, the details of the ammunition reserve and the grenade launcher system, the position of the tank/turret, etc.) can be placed in the areas close to the peripheries. In this case, the advantage of virtual reality as an operational dimension is that it allows an interface without divided attention. Its drawback is, however, that it leads to further isolation among the members of the crew on the battlefield, which has already been disconnected from the outside world. In addition, an extra computer unit needs to be set up between the installed devices and the VR head unit for the visual representation of the data provided by those devices.

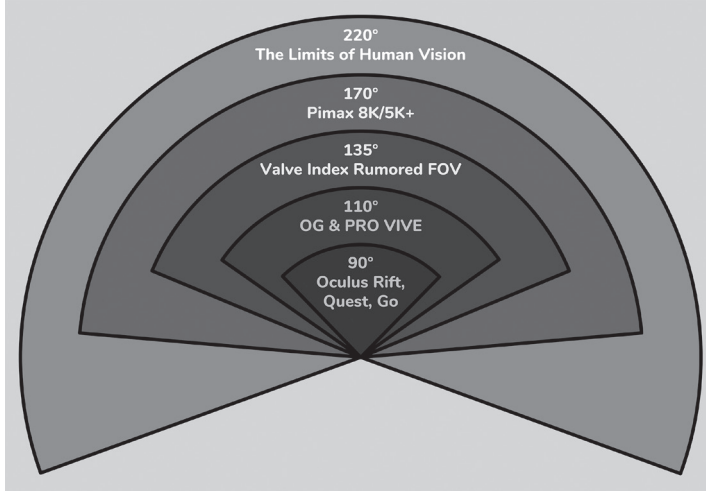

Figure 3 *The field of view of VR tools*[16]

When using augmented reality, a considerably more limited field of view is provided, which, in the case of one of the most widely acknowledged devices, the Microsoft Hololens 2 AR goggles, is 43°×29°. One advantage of the augmented reality dimension is that the crew members are not isolated, that is they can stay in visual contact within the battlefield. Furthermore, the displays of the installed equipment are visible through the parts not covered by content, and there is no need to develop auxiliary computer units in order to enhance data transmission. On the other hand, a great disadvantage from an ergonomic point of view is that the attention of the crew is divided between the field of view of the goggles and the equipment on the battlefield.

SUMMARY

As I stated in my introduction, for me as a professional soldier, it is inspiring and uplifting to stand near a modern technological device, especially when it incorporates state-of-the-art and cutting-edge military technology, is innovative, and capable of supporting the armed forces to accomplish their mission successfully. It also feels gratifying when a group of soldiers master the theoretical basis for handling the new device systems of the Zrínyi Programme or start practical training using digital training materials developed by specialists, graphic designers and communication experts. Indeed, virtual, augmented or mixed reality programs and applications can add substantially to the productivity of the courses aimed at developing these skills.

Obviously, we are still at the very beginning of this process when it is essential to understand and learn to apply the basic principles of VR-AR technology in order to help achieve

[16] "FoV Comparison". OculusQuest. Reddit. 2019. https://www.reddit.com/r/OculusQuest/comments/b9veej/fov_comparison/ Accessed on 14 June 2021.

proficiency in the various graphics educational software (3D model design- Blender) or game engines (UNITY, UNREAL).

The next step marks the most crucial point in the process, namely the development and approval of project ideas aligned with the training programmes. Here, it is of key importance to convince the strategic decision-makers that they can rely on the human resources of the Hungarian Defence Forces to realize even such seemingly futuristic projects. With a relatively low budget and at well below market price, it is possible to build high-quality training capacities of international standard or beyond, which are able to cost-effectively meet the objectives of military education and training in the long run.

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