

Preparations for VR Tactical Training Simulator Efficiency Measurements

Tamás MARLOK,¹  Márk György TAKÁCS² 

After investigating the applicability of VR simulators in the Hungarian Defence Forces, we searched further for a specific training location in time and place, where VR tactical simulation can be effectively applied. We hypothesise that the effectiveness of infantry soldier training can be made cheaper and thus more efficient if it is properly thought through. For this purpose, we have prepared a measurement. The scientific background to this measurement is presented in this article, together with an examination of the practical potential of the technology and training. The measurement will be conducted based on this research, experimentally embedded in the training plan of officer candidates.

Keywords: VR simulation, rifleman training, infantry training, tactical training, virtual reality training, simulator effectiveness

Introduction

In our previous article,³ we have reviewed some of the fundamentals of VR-based training and tactical-level military training. We have examined the training needs of the Hungarian Defence Forces at the tactical level at the infantry. Subsequently, we have examined the options of the VR based training, and we have found, that there are numerous possible options for enhancing the quality of the training by implementing VR tools into the tactical level training.

To obtain empirical evidence on the transfer of skills and training effectiveness of VR training, we had to find its appropriate place in the tactical and shooting training curriculum and develop a testing framework.

In this article, we will present a series of experimental training tasks. With these tasks, our goal was to create exercises for the shooting range allowing soldiers to be trained with the help of VR based tactical training software, and we will present the theoretical background of these tasks, and the tasks themselves.

¹ PhD student, Ludovika University of Public Service, Doctoral School of Military Sciences; Director of Technology, Infinit Simulation, e-mail: tamas.marlok@infinitssimulation.com

² PhD student, Ludovika University of Public Service, Doctoral School of Military Sciences, e-mail: mark.takacs@infinitssimulation.com

³ TAKÁCS–MARLOK [s. a.].

What are the infantryman's fundamental skills?

It should be a scope of another thorough study to determine the exact system of skills needed for an infantryman, mainly because the immense number of interdependent skills needed to persevere in the brutal nature of the tactical level armed conflicts. Therefore, in this study, we will just focus on the individual tactical skills, which are also very complex. However, if we start the analysis from the question “What does the infantryman have to be capable of?”, we can have a good picture of our goal.

A well-trained infantryman has to be able to handle his gun at a professional level, hence it is his most important tool. Handling a weapon and shooting with it accurately requires both physical and cognitive skills. Of course, these skills are not valid only for the main weapon (most of the time, assault rifle), but for the secondary weapons, such as pistols and hand grenades, and of course the collective weapons, like machine guns, shoulder-fired anti-tank missiles and MANPADs (man-portable air-defence systems).

Besides handling weapons, it is also important to be able to handle other equipment. A large part of them is out of our scope, hence, they cannot be practiced in the VR environment (e.g. shovels, explosive charges, tourniquets and other medical equipment). But also, there is equipment that can be practiced with ease and with a great effectiveness in the VR environment. These are the radios, optical sights and night-fighting devices (NVGs and laser sights). In this regard, in this article we will only focus on these.

Regarding these skills, the programming and handling of the radio device itself (e.g. Harris PRC-152), can be practiced in the VR, but it is not necessary, it can be done in a classroom with a radio device. However, what is even more important: the proper radio communication and the implementation of radio-silence regulations can be practiced at ease. It seems to be an easy task (“I just tell them what I want in the radio”), but to send and receive short and accurate radio messages is a difficult task to execute in the stressful environment of the battlefield (even virtual), hence it needs to be practiced.



Figure 1: The authors with the VR training device

Source: the authors' photo

Now we can see just the very basic skills (only which can be practiced in our VR simulation) needed for an infantryman. To see the details and to have a well-structured view, we constructed this prototype skill set.

Skill set

1. Weapon handling

- appropriate firing position
 - does he use an appropriate firing position? (stability, correct aiming, using cover)
- correct handling of the weapon
 - utilising it against the appropriate target to a proper distance
 - using the appropriate type of ammo
 - respecting safety regulations (especially reactive weapons and hand grenades)
 - respecting the operating conditions of the weapon (in case of small arms, it only means not wasting ammo and fixing the jams)
- appropriate magazine changing and reloading (no jamming, no dropping of magazines, no unnecessary loading, etc.)

2. Marksmanship

- aiming
 - aiming errors (e.g. low, high, left, right aim); however, this part is under development, because the current VR technology cannot simulate correct aiming, but it is still applicable for teaching the necessity and the process of it
- shooting
 - correct trigger work (pull gently with one move)

3. Basic tactical skills

- individual soldier
 - understanding and using the terrain (can they select the appropriate cover at all?)
 - with the changing of the tactical situation, can he change the cover accordingly (at least the firing position)?

4. Communications

- understanding the received order
- appropriately reporting the detected targets in his field of fire

Capabilities of the VR simulator used in the measurement

We started to build training and exam scenarios for the Infinit Simulation company's GTS VR tactical simulator. This system has been described in more detail in our previous article.⁴ This solution is a professional level system under development, with a dedicated instructor workstation integrating an accurate and detailed scoring and statistical subsystem. We already tested it on soldiers to prove that the simulation sickness and prior

⁴ TAKÁCS–MARLOK [s. a.].

IT knowledge are not factors when the trainees use this simulator. At the time of writing this article, the test results are still under final evaluation. The simulation of firing with firearms (rifle, pistol) is getting closer to reality, but some important elements are not yet perfect, such as the simulation of recoil. For this reason, transfer of skills learned in the simulation into reality will not yet be 100%.



Figure 2: VR familiarisation test at the MH Kinizsi Pál 30th Armored Infantry Brigade in October 2023

Source: the authors' photo

The jarring effect, fear of gunshot sounds, the weapon held incorrectly or with insufficient power in live firing can cause discrepancies, even when simulations are carried out with very good results. For this reason, the training and practice of some basic shooting elements are only a secondary objective while testing the current simulator. Therefore, the selected testing trainees should have already participated in at least one basic shooting exercise beforehand. Of course, several elements of basic marksmanship, such as safe weapon handling, adherence to safety rules and the parameters listed above (e.g. selecting firing position, proper use of cover, etc.) are measured, evaluated, and subject of skill development even in this phase.

Previous research⁵ has shown that simulation-based training can improve cadet performance even in basic pistol training. With our framework of exercises below, we aimed to provide and test higher level of training using VR technology, taking into account its limitations.

The original goals of the simulator development were to develop the good tactical decision making and the connected skills in combat situations. In a high-risk situation such as a firefight, cognitive skills and attention can be narrowed by the ever-changing environment and the trainees can develop their own techniques to counter it. Such techniques include stress management or attention-sharing techniques that can be demonstrated by the instructor and practiced with the soldiers for better results. Of course, it is important that training with a simulator should not lead to bad habits, i.e. the simulation of the complexity of the combat situation should always vary and preferably be adapted to the level of the practitioner's skills.

The experiment

We have implemented the VR based tactical training tasks into an actual training cycle of the HDF. The soldiers are participating in the same training program, however a half of the soldiers receive VR based training also, while the other half don't. After completing all tasks in the training program, the soldiers' performance is measured against each other, in order to get information (backed up by numbers) from the necessity and the usefulness of the VR based tactical training.

As we have mentioned above, the actual VR software we use supports best the training in the skills of identifying and acquiring targets, properly using the terrain, proper aiming, fast decision-making (at a very low tactical level) and communication.

Furthermore, we are convinced, that if we create gradually more difficult tactical tasks for the trainees, we can exploit the capabilities of the VR software, hence they are getting used to use their obtained knowledge (regarding using the terrain, marksmanship, decision-making, communication) while they are facing even more difficult tasks.

In order to have a valid picture for the effect of implementing of VR training into an actual training program, we have created sample tasks that can be practiced both in an actual shooting range and in the VR environment.

The measurement is multipurpose; therefore, we have focused on the followings while planning the sample tasks:

- knowledge transfer should be measurable: VR tasks have to resemble to the real-life shooting tasks, in order to support the practice
- the trainees could understand the necessity of employment of the previously learned tactical knowledge, and they could practice it in an immersive virtual reality
- we have tried to determine as many measurement aspects as we could, in order to have an even more accurate picture of the trainees' performance

⁵ KRÄTZIG-HUDY 2012.

- the sample tasks must be able to be executed the same way both in VR environment and both at the shooting range

For this purpose, we found the following tasks will suit the best.

The sample tasks

As highlighted above, trainees arriving to this stage of their training must have previously passed (at least) the basic shooting exercises of the basic training and the basic infantryman's training. In each task except for the first and second, trainees can obtain 20 points and if they make certain mistakes, they will receive deductions.

Shooting from a stationary position at different targets

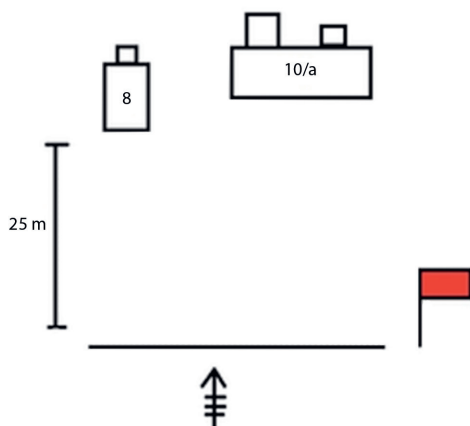


Figure 3: Schematic of “Task 1”

Source: compiled by the authors



Figure 4: Visual representations and environments of “Task 1”, “Task 2”, and “Task 3” in the VR simulator

Source: captured in Unreal Editor by the authors

The trainee stands behind a cover with the rifle at low ready position. Target 8 (standing rifleman) will appear first, and the trainee has 4 sec to hit it. After 4 sec, the target 10/a (machine gun fire team) will also appear, and it becomes the priority target.

The goal here is to measure the trainee's ability to quickly acquire and shoot an easy target and subsequently another at a fast pace. The other factor is whether, if the trainee cannot hit the first target (8), he will recognise the second (10/a), and realise that it is more important and act accordingly.

Scores:

- if he hits the first target (8) in 4 sec, then the second (10/a) in the next 4 sec, the trainee receives 10 points
- if he hits the second target (10/a) first, then the first (8), he receives 5 points, therefore he understood the priorities but the poor shooting skills prevented him hitting the first target first
- if he hits the first target (8) first but after 4 sec, then the second target (10/a) second, he receives 4 points, hence he failed to hit them fast and misunderstood their priority, but at least hit them
- if the trainee cannot hit both targets in 10 secs, he fails

Our goal with this task is to measure the marksmanship skills of the trainee by facing him with relatively easy (close range and stationery) targets, but he has to use his marksmanship skills fast. The trainee also has to retain his cognitive skills to acquire multiple targets and make quick tactical decisions according to their importance.

Shooting exercise in pairs at multiple stationery targets at a changing distance

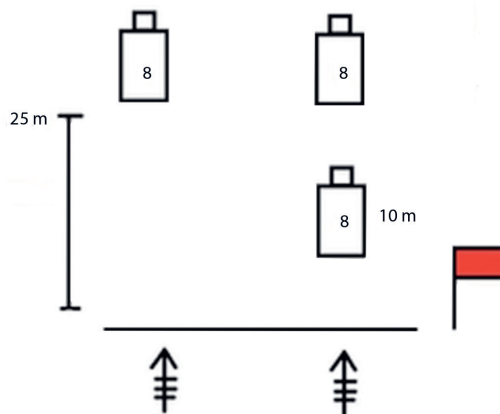


Figure 5: Schematic of "Task 2"

Source: compiled by the authors

The trainees are standing behind cover with their rifles at low ready. At first, the more distant targets appear, and the trainees have 4 sec to hit them. After 4 sec, the closer target appears.

Scores:

- if they hit the farther targets (25 m) in 4 sec, then the closer (10 m) in the next 4 sec, each trainee receives 10 points
- if they cannot hit both farther targets in 4 sec, but when the closer one appears, the one shooter that facing it hits it, while the other continues firing the farther, and they still hit both in 8 secs, they still receive 10 points each
- if they falsely identify the priorities and they hit the farther targets out of 4 secs, and only subsequently the closer one, they receive only 4 points
- if they cannot hit both targets in 10 secs, they fail

Our goal with this task is to measure the marksmanship skills of the trainees by facing them with relatively easy (close range and stationary) targets, but they have to use their marksmanship skills fast. They have to retain their cognitive skills to acquire multiple targets and make a fast tactical decision regarding their importance.

It is important to note that one of the two trainees is the commander, therefore he has the right to give orders on how to hit the targets. The points are divided equally though, because each trainee's life depend on their effectiveness.

Practice in pairs at stationary targets but in different distances and with different priorities

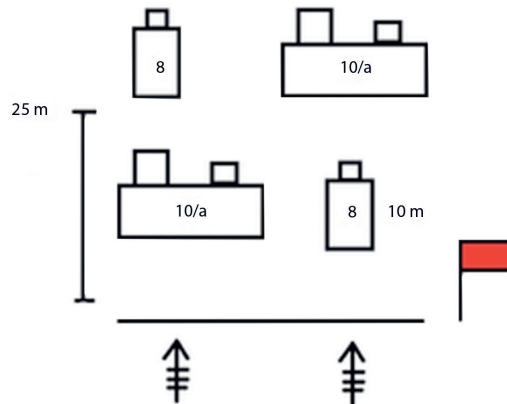


Figure 6: Schematic of "Task 3"

Source: compiled by the authors

The trainees are standing behind cover with their rifles at low ready. At first, the targets on the left appear, and the trainees have 5 secs to hit both. After 5 sec, the targets on the right appear and the trainees have another 5 secs to hit them. The ideal sequence of hitting the targets is: left 10/a, left 8, right 10/a, right 8. They have 10 secs altogether to hit all targets.

Scores: the max is 20 points, if they make mistakes, they will have minuses as follows:

- targets 10/a have higher priorities. If they hit both targets but one of the 8s goes down first, then it is -1 point (if the difference is less than 1 sec, there is no minus, hence it means that they have practically shot at once)
- if the targets on the right appear, there are targets still standing on the left, there are deductions as follows: if the 8 stands, -2 ; if the 10/ stands -4 ; if both are standing -10
- both trainees have a fully loaded magazine (30 ammunition). If they fulfil this task with less than 6 ammos per person, there is no deduction. If they fulfil it with 7–10 ammos, then -2 points. If they fulfil it with more but in time, then -4 points
- if they fail to hit all targets in 10 secs, they fail

Our goal with this task is to measure the marksmanship skills of the trainees by facing them with relatively easy (close range and stationery) targets, but they have to use their marksmanship skills fast. They have to retain their cognitive skills to acquire multiple targets and make a fast tactical decision regarding their importance.

It is important to note that one of the two trainees is the commander, therefore he has the right to give orders on how to hit the targets. Although, the points are divided equally, because each trainee's life depend on their effectiveness.

Exercise in pairs, moving forward with the coordination of fire and manoeuvre

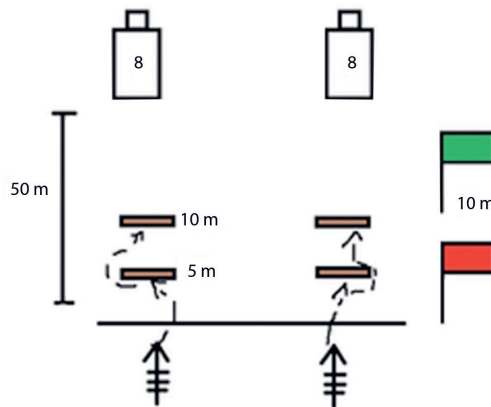


Figure 7: Schematic of "Task 4"

Source: compiled by the authors

The trainees are standing behind a knee-high cover with their rifles low ready. They have 12 bullets in 2 magazines (6 bullets in each magazine) per person. When the two targets appear, they have to use the cover appropriately (kneeling firing position). The one in charge has to give orders to commence movement with coordinated fire and manoeuvre (the actual correct order depends on the SOP of the training unit).

After the order is given, one of them has to safe his rifle and start moving forward, while the other starts shooting at the target. When the first trainee reached the first cover, he starts shooting at the targets, while the other commences the movement forward. This is repeated to the second cover (in line with the green flag, this is the limit of advance, LOA). The task is finished when the two trainees have reached the second cover and they have hit both targets 4 times (the targets will remain laying down after 4 hits).

Scores:

- if both targets remain standing, they failed
- if any of the targets remain standing, -10 points
- if there is a moment, when they are changing magazine simultaneously, there is also a deduction. If this period is longer than 5 sec, they failed. If it is 3-5sec, -8 points. If it is 1-3 sec, -3 points
- if there is a moment when one trainee commences movement while the other is not ready to fire, they fail

With this task, we also have multiple goals. First, we can measure the trainees' weapon handling skills, hence they have to switch between safe mode and single shots fast and accurately. Without mastering this skill, they will pose more threat to their comrades than the enemy.

Then there is the marksmanship, because, they will have easy targets, but they will have to shoot after a short rush (panting and gasping) from a swiftly occupied firing position. Then there is the ever-important communication, hence they have to coordinate their fire and movement.

Exercise in pairs, simulating clearing a part of a trench

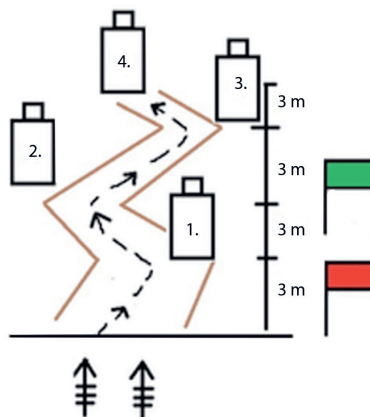


Figure 8: Schematic of "Task 5"

Source: compiled by the authors



Figure 9: Visual representations of “Task 5” in VR simulator

Source: captured in Unreal Editor by the authors

Trainees are kneeling in a trench (or rather in a corridor made from light materials, looking like a part of a trench), behind each other. One is in charge, and he decides the formation and he gives orders for the movement. The exercise starts when they are all set, and the “Line hot!” or “Harchoz!” orders have been given.

The first target appears in the trench, and the first shooter hits it. Subsequently, the first shooter (Shooter A) reports the “tango down” and orders the second shooter (Shooter B) to move forward to the closest corner of the trench. When the Shooter B passes Shooter A, Shooter A switches his gun into safe mode. In parallel, he becomes responsible for the security of the area above the ground level (against targets outside the trench).

When Shooter B achieved the first corner, the second target appears over the edge of the trench and Shooter B hits it. Subsequently Shooter B reports the hit, and Shooter A reports him that he has started moving forward to the next (second) corner. When Shooter A passes Shooter B, B switches his gun into safe mode, while A switches his gun into semi mode.

When Shooter A arrives at the second corner, the third target appears and Shooter A hits it. From this, everything goes on repeatedly until the last target is hit. At that time, the instructor orders “Ceasefire!” or “Tüzet szüntess!”.

The maximum is also 20 points at this task. If one shooter’s gun is not in semi or auto mode when the other is moving, then –10 points. If the target is not hit by the forward shooter, then –8 points. If the target is not hit 2 seconds after, it appears in front of the forward shooter, they failed the task.

The training purpose of the developed tasks

In the first task, our goal was to create a simple situation, when the trainee has time to spot and hit the target. But if he does not hit it under adequate time, he will face with another (even more dangerous, thus more important) target. In this task, the instructor can have a clear picture of the trainee’s proficiency in weapon handling, shooting and basic tactical knowledge (understanding a very basic tactical situation in an uncomplicated environment).

In the second task, we have made the task a bit more difficult and simpler at the same time. It is simpler, hence there are two trainees for three targets, and more difficult, because the two trainees have to divide the targets between each other, in order to effectively hit them. In this task, we tried to face the trainees with a bit more difficult task, but we wanted them to use the same skills as in the first task: fast aiming, understanding the tactical situation (which target is more dangerous and more convenient for which shooter).

In the third task, our goal was the same as in the second, just in an even more complex environment. The trainees have a relatively short time to hit the first bunch of targets, then the second. They have to understand the tactical situation in two aspects: understand which target is more dangerous, and understand the physical space's layout to find the more convenient targets for each shooter. In this task, they use the same skills as in the previous.

In the fourth task, we have raised the challenge. In this task, we still want the trainees to use their skills of fast aiming and fast target acquisition, but they have to use them after a short rush and in synchrony with their comrade. They have to be able to quickly find an adequate firing position (not too visible but stable) after each short rushes. They have to send and receive easy reports regarding fire and manoeuvre, and they have to handle their guns accordingly (safe mode, fire mode, changing magazine etc.). These necessary activities belong to the skills of weapon handling, marksmanship and basic tactical skills.

In the fifth task, we increased the challenge compared to the fourth. It is a bit easier, though, because the targets appear only in line with the trench, but is also a bit more difficult task, hence the trainees' movement corridor is narrow, and they have to spot targets both inside the trench and on the edge of the trench. In this task, the trainees use the same skills as in the fourth, but they have to have more developed skills in order to be successful.

Conclusion

In the past, there have been measurements of VR effectiveness and skill transfer, but these were conducted on not professionally developed devices or on rudimentary technology. In our experience, the majority of shooting and tactical instructors are still averse to similar technology. They think it is best to learn basic tactical and marksmanship skills only at the firing range. We partially share this opinion, but there are many tasks and situations that simply cannot be practiced at the range on the desired level, mainly because of the lack of ammunition and the limited availability of the firing ranges. We have taken great care to ensure that such trainers can see the potential of the system from a professional point of view. In addition, certain crucial skills can be fully and more easily developed on a professional system with proper instructor supervision.

It is also important to note, compared to previous experiments, that today's young soldiers are no longer averse to the use of such equipment. Besides that, as we developed the exercises above, we have created parallel separate tasks with identical scoring system, but inside a realistic combat situation. This is not simply gamification for the sake of experience, but also to show how the skills practiced during exercises can be used correctly in a real combat environment, e.g. under enemy fire. The tested system did not

start from the technological side, but by putting together a framework that took training aspects into account. As we discussed in our article, VR cannot yet fully simulate the dynamics of firing and battlefield environments, but it gives a huge advantage in tactical training through exercises designed with the right level of sophistication and integrated into training. The VR training possibilities we detailed here are only the tip of the iceberg.

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