Virtual Battlespace 3: Scenario Analyzing Capability and Decision Support Based on Data Farming

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ABSTRACT

Decision support and optimization are gaining relevance especially in a military context. The quality of military decisions and standard practices have huge impact on military success. Purpose of this study is to investigate the capability of Virtual Battlespace 3 (VBS 3) to support scenario analysis and decision making. The study reports on two approaches to deal with the software: (1) the development of a constructive approach to explore the analysis capability, usability and realism of the software and (2) a Data Farming approach to systematically explore the tactics both of the game engine as well as of the user's side for decision support. The study relies only on unclassified data and scenarios and the off-the shelf version of VBS 3.

In the constructive approach to explore analysis capability, usability and realism, we took a closer look on the software's models of weapons, vehicles and soldiers. We developed testbeds for series of experiments in each of these three scopes to understand the software's capability powers on the one hand, but also the limitations to realism and analysis capacity on the other hand. The analysis includes the influences of weather on soldiers, vehicles and environment, ballistics of weapons and soldier's exhaustion model. In our second approach, the Data Farming, we designed two scenarios and a software tool. We demonstrate the feasibility of Data Farming for decision support in VBS 3. The results include a validation of a standard operating procedure and a complex scenario of a logistics operation under combat conditions.

This study is a cooperation of the Universität der Bundeswehr München and the Bundeswehr Office for Defense Planning (Planungsamt der Bundeswehr).

Keywords: *Bundeswehr, Virtual Battlespace 3, VBS 3, Simulation, Experiment, Decision Support, Data Farming, NATO, Computer Assisted Exercise, Plugin, Office for Defense Planning, Weapon, Vehicle, Soldier, Realism*

1.0 INTRODUCTION

This paper presents two different approaches of using Virtual Battlespace 3 (VBS 3) in a way that was not originally intended for the software. Five students of the Bachelor programme and two students from the Master programme of Information Systems (Wirtschaftsinformatik) at the University of the Bundeswehr in Munich (UniBw M), as well as their three academic supervisors, were tasked to examine, if VBS 3 can be used as a tool for scenario analyzing and decision support based on Data Farming. All students are officers of different branches of the Bundeswehr, served for different periods of service and had different in-service education.

The project was initiated by the Bundeswehr Office for Defense Planning as the result of a previous project between the Office and the two Bundeswehr Universities in Munich and Hamburg. This first project was called "WarfareSims @ Planungsamt" and took place in 2015. Its purpose was to explore if the Serious Gaming software "Command: Modern Air & Naval Operations" is able to be used for military and analytical issues.

Bohemia Interactive Simulations (BIS) is a global acting vendor of military simulation- and training software [1]. The focus of BIS is to develop software, which is capable of being realistic, exact and affordable to support military training and the simulation of military forces on a tactical level. BIS therefore relies on the expertise they gained from developing videogames like Operation Flashpoint 2, ArmA III or Take On Helicopter and their predecessors, which can be classified as military simulations and Serious Games. VBS 3 is, according to the website of BIS, a flexible simulation training solution for scenario training, mission rehearsal and more.

The development of software that would suit the analytical needs of the Bundeswehr Office for Defense Planning is a costly and time-intensive effort. The Bundeswehr would like to have in-house analytical capability, because conducting studies using non-military commercial means would actually be cost-prohibitive. Many NATO nations, amongst them Germany, are already using VBS 3.So the question from the Office to the team of UniBw M was, if: (1) VBS 3 can be used to analyze military scenarios and (2) provide decision support by using the method of Data Farming.

The first team, consisting of the five students of the Bachelor program, did not reengineer the code of VBS 3, while the second team, consisting of the two students of the Master program, developed a tool with VBS Fusion to extract data from VBS 3.

The paper is organized as follows. The first part is about the constructive approach of using VBS 3 for analyzing capabilities, the second part respectively about the Data Farming approach. The last part concludes the results of the preceding parts.

2.0 CONSTRUCTIVE APPROACH

Five students of the Bachelor program of Information Systems at the UniBw M and two academic supervisors formed the team at the Universität der Bundeswehr München. The analysis was done as a study project, which is part of the second year in the Bachelor programme of Information Systems. This team built on the experiences with a course and joint project with the Bundeswehr Office for Defense Planning in the previous year. While this paper only presents the results of UniBw M, the project took place in cooperation with the Helmut Schmidt University Hamburg [2].

The students in this course had different backgrounds as officers in the German Armed Forces and different professional careers prior to the studies at UniBw. The students were encouraged to draw from their individual professional experiences to develop individual perspectives and questions in their study. They were inspired to look for scenarios and analysis methods in which the VBS 3 software could be useful for the Bundeswehr Office for Defense Planning. "Appreciative" and "Constructive in the sense of design science" as well as "Productive Use of an Off the Shelf Product" were the guidelines given to the students. The students were encouraged to take the perspective of a young officer – with an academic education of the University. What would a young officer do to build a faithful simulation with VBS 3? Where are problems and/or limitations in using VBS 3?

The team discussed that reengineering the code would not be an option and thought of a constructive way to deal with the software. Instead, after the first attempts to use the software and the tutorials and scenarios that come with the software, the students were also quickly experiencing the software’s artificial intelligence on the one hand but also some of its physics engine’s limitations on the other hand. By doing so the questions arose, what a soldier’s trust in the software is dependent of and how these dependencies could be possibly investigated.

From their military experience and training, the students were quickly able to identify that - particularly in complex scenarios - the software’s trustworthiness is highly dependent of the level of realism of the software’s models of soldiers, vehicles and weapons ballistics. So the students chose soldiers, vehicles and weapons as the three domains for which they wanted to develop testbeds. Subsequently, we describe motivation and experiences with all the three testbeds. Overall the team refunded their perspective to be appreciative and constructive – the aim is to find ways to make productive use of the VBS3 software as analysis tool.

2.1 Aims and Results of Soldiers Study

This study’s aim was to assess the representation of soldier's performance within the VBS3 software environment on a simulated running track under changing conditions of weather, terrain, weapon's carry mode and soldier's battle loads. Within VBS3, she built a standardized 100m long running track and conducted experiments within the range changing only the testing parameters, therefore ensuring easy comparison.

Figure 1: 100m running track, Weather: Snow.

The variations of the test parameters consisted of:

- Terrain - street, off-road, snow-cover
- Weather - fog, rain and snow
- Weapon’s carry mode
- Battle load - parameterized by weight for soldier to carry.

Surprisingly the results showed that there were no statistically significant differences between the various runs. Neither weather conditions and terrain, nor the different loadouts had a significant impact on the soldier's movement or exhaustion. There was no difference between a soldier equipped with 80 kilograms of weight and a soldier equipped with 20 kilograms of weight. The only exception hereby is the snow layer parameter, which by a height of 1,50m slows down the soldier's speed instantly (by contrast a snow layer of 0,4m has no effect).

2.2 Aims and Results of Vehicles Study

A scenario for military simulation includes, besides soldiers and weapons, also vehicles to create a realistic setting. VBS 3 offers a wide range of military and civil vehicles, which can be simply added and controlled during the creation of scenarios. The student was putting his focus on vehicle's movement and speed and if there are any influences to these parameters from outside, similar to the soldiers' study. In order to study those dependencies, he used different vehicle types (vehicles with small and big wheels, as well as tracked vehicles) and different weather and terrain conditions.

Figure 2: Different vehicle types, weather: fog.

Figure 3: Different vehicle types, snow height: 1,50m.

The result of this study was that weather conditions do not have any influence on vehicles movement. The only exception is, like in the soldiers' study before, 1,50m high snow. One observation which has been made is, that there are no groove tracks on wet terrain. The maximum speed of wheeled vehicles decreases from street to lawn/gravel to sand. The maximum speed of a tracked vehicle, however is not effected by terrain.

2.3 Aims and Results of Weapons Study

For a military simulation like VBS 3 the accurate representation of weapons and ballistics is essential. Therefore, two students chose weapons and ballistics as their subject for the study and took a closer look at how these systems are implemented in VBS 3. The students wanted to figure out if the software´s models of ballistics and projectile trajectory are conforming to their expectations and if there is any influence of weather to projectiles. Furthermore, they examined the model of the H&K G36, especially the correctness of the reflector and telescopic sight.

In order to test the implemented models, the two students developed a testbed in form of a shooting range. This shooting range consists of two parts, one for close range targets from 5m to 50m and one with targets at larger distances from 100m to 1000m.

With this testbed, the students were able to perform their test and validate the observed results. The ballistic and especially the projectile trajectory, observed in the After Action Review (AAR), confirmed the expectations of the students. The weather, however, has no influence on the projectile trajectory. In order to analyse the sights of the G36, the students used their military knowledge. For the test of the telescopic sight, they used aiming points at 200, 400, 600 and 800 m, as taught in their basic training.

The result was, that the 200m mark is correct but the model of the telescopic sight is imperfect, particularly the marks for 400m, 600m and 800m. So the projectiles, which should be on target when the 400m mark is used on a target in 400m distance, will fly over the target. The reflector sight works realistically for its combat range up to 200m.

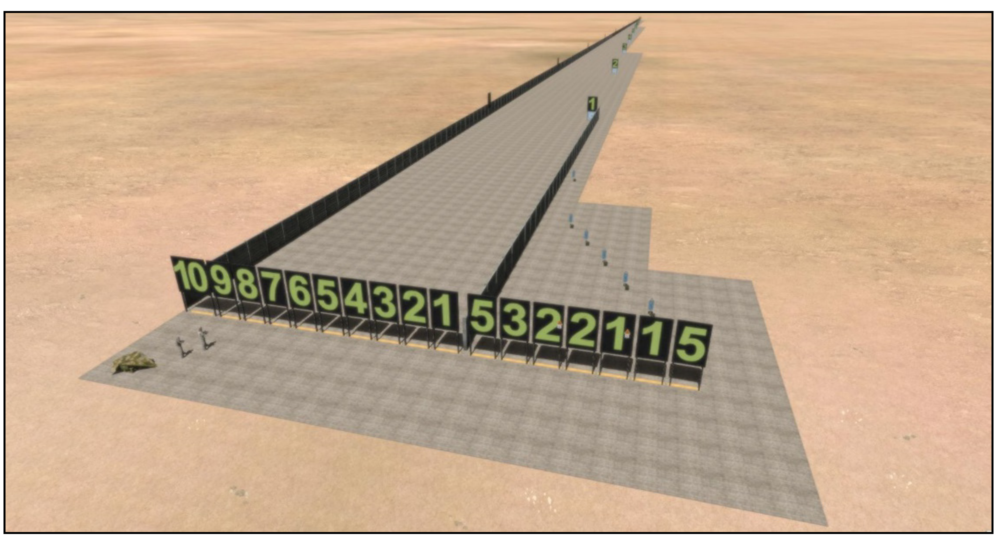

Figure 4: Shooting Range.

2.4 Summary Constructive Approach

Five students from the Universität der Bundeswehr München were tasked to take a look at the software VBS 3 to find out if it is possible to use it for analytical purposes. In three different studies (soldiers, vehicles and weapons) the results of the examined systems differed in maturity and their conformation to reality. The simulation showed a very high level of detail. Various implemented vehicles, weapons and gadgets can be found. To test those systems, the students used their creativity to solve problems or find work-arounds, in addition to their expertise as officers and officer candidates and their military background. They also utilized their knowledge, gained from computer game-play like ArmA III from Bohemia Interactive, which is very similar but not identical to VBS 3.

The results have been as follows:

- The overall movement and mobility of a soldier is not affected by the weight he carries or the environmental conditions.
- So for the vehicles, environmental conditions do almost not have influence to the speed or mobility.
- By contrast the ballistic model of a projectiles trajectory did comply entirely to our expectations.
- The telescopic sight of the G36 does not work as anticipated and is slightly not true to scale.

The positive and appreciative result of the team´s study project is, that in parts and depending of the scenario, VBS 3 is capable of being used as a tool for analytical simulation purposes. VBS 3 is indeed no software for constructive simulation, but has a very high level of detail, which empowers customers like the Bundeswehr Office for Defense Planning to use it as an analytical tool. When users are aware of the maturity of the used models and its limitations regarding a scenario's realism, the software is very well utilizable for such purposes.

3.0 DATA FARMING APPROACH

The Data Farming Approach is derived from the proposed method in the master thesis by Luther and Strobel [3]. The method is used to verify the possibility to use Data Farming generated data from VBS3 to analyze capability in order to support decision making. Two scenarios with fictitious operations were created specifically for this purpose. Luther and Strobel constructed a VBS fusion based plugin, since VBS 3 does not support Data Farming off the shelf. This plugin consists the function of extracting data from VBS 3 into an Excel sheet using High Performance Computing and thereby creates a fully automated Data Farming process. The sub process which includes the analyzing and virtualizing of the generated data was accomplished manually.

3.1 Test Scenarios

The two basic movements of a squad are the squad column ("File Formation) and the squad line. The squad column is a narrow formation, which allows the squad to easily adjust their movement to the terrain and using cover along the movement direction. By contrast, the squad line is a wider formation, which allows the squad to trespass open and uncovered parts of the terrain, with a fast and consistent movement, while the formation offers the highest force against enemy fire.

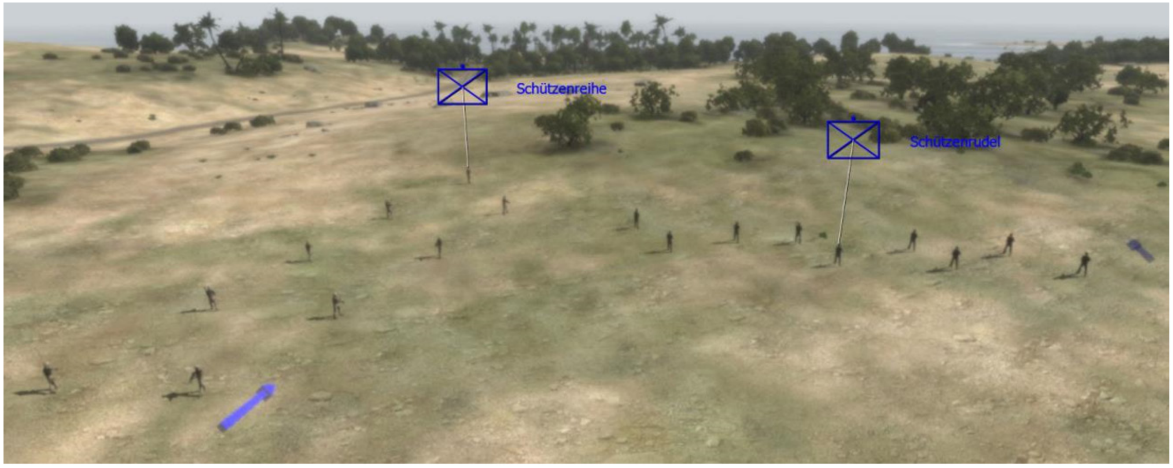

Figure 5: Comparison of squad column (left) and squad line (right).

In this scenario, combat training contents like basic movements, are examined experimentally. Therefore, military elements got evaluated by their effectiveness and credibility. This can be compared with observations from the reality, in order to prove the realism of this simulation. For this fictitious operation, an infantry squad (BLUFOR) is ordered to patrol a path, which includes crossing a clearing, in order to reach to the final waypoint, accomplishing the mission. Behind the forest aisle are stationed armed enemies (OPFOR) within an alarm-post.

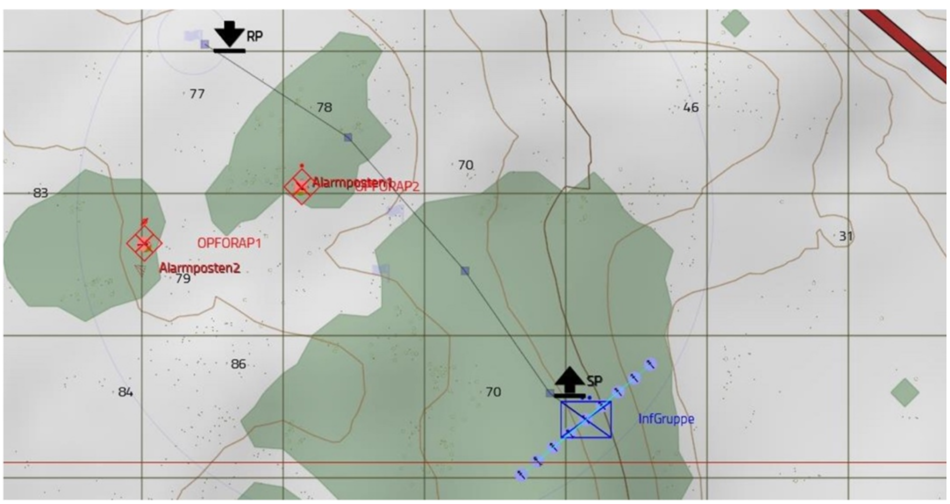

Figure 6: Area of detail of the scenario with BLUFOR (blue) and OPFOR (red).

The mission in this scenario is to complete the patrol from the start point (SP) to the release point (RP). Appearing enemy forces need to be engaged. Before trespassing the forest aisle, the infantry squad has to arrange the best tactical formation to minimize casualties and the use of resources, but also to maximize the squad's strength against the enemy. The infantry squad (BLUFOR) contains nine soldiers. One squad leader, two grenadiers, two antitank soldiers, two gunners and two machine-gunners constitute the infantry squad. The alarm-posts include a troop leader and a machine gunner each. Four waypoints have to be passed, shown as grey squares in Figure 6 above. Waypoint 1 is the SP, where the group is marching off. Waypoint 2 is the beginning of the forest aisle which needs to be trespassed. Waypoint 3 is the destination after the dash and the last waypoint is the RP of the patrol. Between waypoint 2 and 3 the infantry squad gets under enemy fire. In order to complete the mission, the enemy alarm-posts (OPFOR) need to be destroyed and the last waypoint need to be reached.

3.2 Theoretical Background

Data Farming is a method for decision support which was introduced by Brandstein and Horne in 1998. The usage of the Data Farming process is primarily for analyzing purposes of complex systems [4]. While the standard simulation process generates just one result whence a general assertion cannot be made, Data Farming based simulation results bring a wider spectrum of parameters, which makes an assertion more convincing. Data Farming creates a big amount of data, by running a specific simulation, which needs to be analyzed with statistical methods to make a clear point about a given problem. In order to rerun a made model several times within limited timeframes, High Performance Computing is required. Since Data Farming takes a very relevant position in Information Systems studies, Luther and Ströbel used their knowledge finding out, if scenarios created with the simulation VBS 3 can be linked with Data Farming to create analyzing capability and decision support for military interests.

3.3 Experimentation

For the Experimentation, Luther and Ströbel developed a VBS plugin. Base for the development of this plugin was VBS Fusion, which is a comprehensive Application Programming Interface (API) for VBS 3 requiring C++ as programming language. The strategy for the development correlates with the waterfall model coming from software engineering. The development was realized with object-orientated modeling and programming. For the implementation, Microsoft Visual Studio 12 with its C++ development environment, was used.

For the experimentation, in order to fulfill the requirements, the Nearly Orthogonal Latin Hypercube (NOLH) design was chosen. The significant power of this design is the “gap-filling” of the entire solution space with a small amount of design points [5]. To analyze the error variance within this stochastic experiment every design point was executed 30 times. For the scenario, an experiment design of 33 design points, from which everyone has been executed 30 times, provided statistic usable data.

Data, that has been extracted for analyzing purposes were formations, distance of soldiers, daytime, different weather conditions, experience and cautions of BLUFOR and OPFOR.

3.4 Results

After analyzing the collected data, the guidance, in order to optimize the number of casualties and injured forces, is to arrange the “File Formation”. However, this formation has, beside the optimization, a negative impact on the exhaustion level, which is nevertheless not the most relevant factor. Other formations decreased the exhaustion of each soldier in squad, but caused a higher number of casualties, which definitely should be avoided. Additionally, other important information extracted from the analyzed data were, that this operation should take place at night, including the consciousness option “combat” of the squad, to minimize casualties and the exhaustion level at the same time. The “Wedge Formation” is not recommended because of its high number of casualties. Different weather conditions had no influence on the test run results. Generally spoken, the recommendation of second lieutenants Luther and Ströbel for trespassing the forest aisle, would be a wider formation like the squad line, because of the ability to trespass simultaneously and fast. If enemy contact is existing, every member of the squad has the ability to react and is able to engage the enemies position.

3.5 Summary Data Farming Approach

Luther and Ströbel from the Master program of Information Systems had the idea of combining Data Farming with VBS 3. As preparatory work for the master thesis, the two students had to develop a VBS Fusion based plugin, which served as Data Farming tool, since VBS 3 does not support Data Farming. The amount of data created by using this Data Farming tool exceeded the expectations of second lieutenants Luther and Ströbel. Additionally, manually analyzing the collected data has shown to the students, that the scenario results are partly concomitant with the military expectations.

The analysis demonstrates/shows that the results agree with the joint service regulations which by themselves have been based solely on military practice and experience and which are standard teaching in combat training practices in the Bundeswehr. It can be said, that VBS 3 in combination with the developed VBS Fusion plugin is qualified for Data Farming and decision support.

4.0 CONCLUSION

The discipline of Information Systems is – among other topics – about the productive use of technology in organizations [6]. Five students of the Bachelor- and two students from the Master program of Information Systems at the University of the Bundeswehr in Munich, as well as their three academic supervisors, were tasked by the Bundeswehr Office for Defense Planning to examine, if VBS 3 can be used as a tool for scenario analyzing and decision support based on Data Farming.

The first team, comprising of the five Bachelor students and two academic supervisors, was tasked to examine VBS 3 for the capability of being used as an analytical tool. Therefore, the team processed the three different studies: soldiers, vehicles and weapons. The overall purpose of the project was, to give a positive and appreciative statement about the software's analytical capabilities and not to be over critical with non-crucial imperfections. It was the first time that the students worked with a simulation software and so they took a short preparation phase, which they used to get an idea of the cardinality and the possibilities of the software. After this preparation phase, they were able to develop and implement testbeds, to examine the given models of soldiers, vehicles and weapons of the simulation regarding theirs possibilities to provide a realistic and representative environment for analyze purposes. The overall result is that VBS 3, while it is not originally meant to be used as an analytical tool, can be used as such one in parts, depending on the simulation's used models and the scenario which has to be analyzed.

The second team conducted a Data Farming Approach with the aim to test the software's capability for decision support based on Data Farming. Two different scenarios have been developed by the students. The first one as proof of concept and the second, larger one to substantiate their assumption. VBS 3 does not empower customers like the Office of Defense Planning, to use it as a Data Farming tool, because it is meant to be used as training software. Therefore, the two students had to develop a VBS Fusion based plugin, with which they were able to extract data from VBS 3 into an Excel sheet. This plugin was used to perform stochastic experiments, based on the Nearly Orthogonal Latin Hypercube. For the scenario utilized in this paper, they used 33 design points, which have been executed 30 times each. As an overall result, the two master students stated, that the analyzed data partly also confirms their military expectations. A wider formation is more appropriate to a narrow one, if open space has to be overcome. Their results show, that VBS 3 can be used for decision support based on Data Farming. However, the results are depending on the correctness of the models and the quality of the engine of VBS 3.

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