Virtual Reality Leadership Training Simulator for Dismounted Forces

Karl A. Bertsche, Markus Hoelscher,
and Claus Jarsetz

Business Development Operations Research,
Information and Communication Systems
Dornier GmbH
Friedrichshafen Germany
e-mail: karl.bertsche@dornier.eads.net

Mr. Bertsche is a project leader and has completed a study for the German army engineers considering explosive demolition in a Peace-Keeping Mission in the military OR-Section of Dornier (a company of European Aeronautics Defense and Space Company, EADS). He has written object oriented Programs concerning minefield effectiveness, and an analysis tool for the sustainability of German forces as well as a dynamic infantry combat model (AMIRIS). His most recent work has been the development of an analysis tool for the development of Anti Submarine Warfare Screens (ASW) for the Fleet Command of the German Navy. He was previously a nuclear engineer at Babcock & Wilcox in Virginia, U.S.A. He has a Masters of Engineering degree in nuclear engineering from New York University.

Mr. Hoelscher is a project leader and has completed a study: Mission Preparation for the German Special Forces Command in the military OR-Section of Dornier GmbH (EADS). He is presently completing a study: Improving Combat Capabilities of Infantry Forces at Night. He is also participating in the study: Application of Computer Generated Forces for the Dornier 3D Simulation Model IRIS. He previously worked as a software development engineer at EADS in Ulm, where he participated in the software development of identification software for a combat control center for an anti aircraft battery. In addition, he has written interface programs for database communications. He has a degree in the area of Software Development Technology. He has served in the German Infantry from 1988 to 1990 and has recently been promoted to an officer of the German Infantry Reserve.

ABSTRACT

For various Peace Support Operations the commanding officers of dismounted forces must demonstrate leadership by making appropriate decisions depending on the type of assignment and the situation encountered. Therefore, the following leadership characteristics are required:

- Correct Judgment of the situation.
- Accountable decision-making.
- Developing an appropriate plan of actions.

- Issuance of clear and concise orders.
- Developing proper reactions to a continually changing situation.

The commanding officer has to fulfill an assignment in a particular situation. His leadership performance will depend on the physical and psychological stress that he is presently experiencing and which he has previously been exposed to. Depending on the officers experience and abilities, his leadership performance will vary accordingly.

For most young commanding officers leadership performance is often insufficient due to a lack of experience and the appropriate training environment. In order to compensate this deficiency, the German army is looking for tools that will exercise and train these essential leadership qualities. One of the tools, which is to be considered, is a Virtual Reality Leadership Training Simulator for dismounted forces, which will allow the officers to gain experience by experimenting and exploring a variety of command options.

The goals of such a trainer will be to develop the virtual reality environment with urban and rural terrain, develop mission oriented training exercises/scenarios, where officers will learn to properly judge the situation, make accountable decisions, develop a plan of actions and issue clear and concise orders for a number of different types of situations encountered in the wide spectrum of peace support operations.

OBJECTIVE

This paper will cover a new concept in training techniques and the required hardware to develop such a training system. For this particular concept the application of virtual reality and 3 dimensional simulation techniques represent the base educational environment. Taking into consideration the world after 11 September. This training concept is more important then ever in order to prepare German Special Forces, KSK for the mission tasks which they are presently fulfilling and which they will fulfill in the future.

The basic conceptual ideas for a virtual reality training simulator concept was originally presented to the German Infantry School in Hammelburg on 2 August 2001 by the senior author's colleagues Mr. Helmut Hügle, Mr. Hölscher, and Mr. Jarsetz.

This paper will start out stating the basic problem or rather the position to this problem. An essential part of the paper will be defining the training goals and steps in fulfilling these goals. Here Leadership Training Requirements will be the important driving factors which will help us in defining the System/Concept of such a Virtual Reality Leadership Trainer.

Here is the field of tension where leaders find themselves during a mission. To the left are factors which impact the individual leaders performance. For example the environment, which includes climate, weather, season and the time of day. The situation reflects the military, political, sociological environment. Based on the physical and psychological stress which the leaders has been exposed to and based on their experience and trained abilities, will influence his situational awareness, his professional behavior and his leadership performance in total.

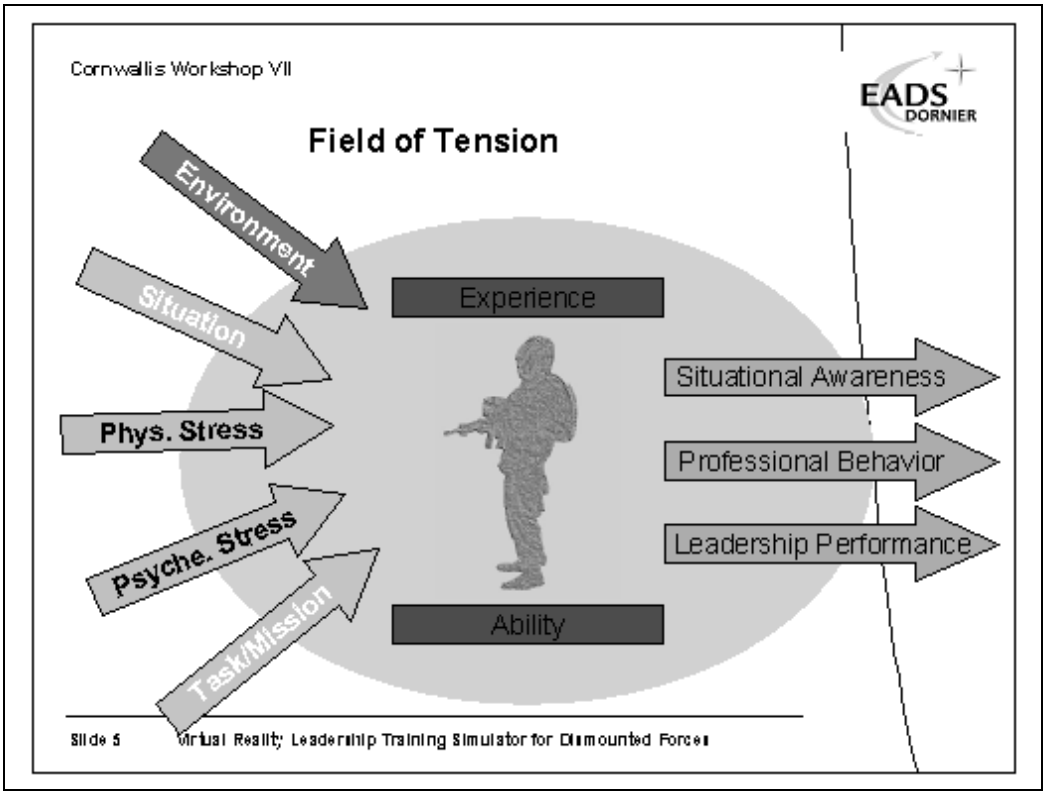

Figure 1: The Field of Tension.

The main objective of the proposed leadership trainer is to improve the leadership capabilities for a particular mission. This means that the leader is sensitized to the environmental conditions, military, political, sociological, and religious situation to properly judge the situation and be able to make appropriate decisions and be able to issue clear and concise commands to his subordinates.

For an officer this means getting familiar with diverse combat situations and therefore building up an experience base.

Through repeated exercises, leaders will be able to quickly judge the situation and make appropriate decisions faster. The actions may seem almost automatic as a result of extensive drills. By having repeatedly encountered similar situations within the simulator the amount of stress generated is therefore appreciably reduced.

In summary, this high demand on training can only be partially fulfilled with existing/ conventional learning methods such as classroom instructions/ lectures using terrain models and direct terrain training.

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Training with a simulator supported leadership trainer provides the officer with the opportunity to be placed into various combat and non combat situation all the way to a near real world mission environment, where adequate commands and measures are required of him. An additional benefit of this trainer is that it will also show the trainee (officer/leader) the consequences of (his/her) actions.

This could be applied not only to military leaders such as NGO / IO coordinator personnel in a PSO mission.

SYSTEM CONCEPT

The system concept of the virtual reality leadership trainer relies on three dimensional simulation modules with an appropriate man-machine interface, which will allow the trainee to submerge into a total virtual environment. The system will have various terrain covers and numerous constructed shapes to choose from. The effects of fire arms and combat weapons will be simulated close to reality. The environmental conditions such as day, night, twilight, smoke, fog, haze glare and clear conditions can be created within the virtual world. In addition the force structure can be redefined for the own and opposing forces, which are part of the simulation system.

By combing combat simulation with virtual reality allows a close to reality environment for working out a plan of action, considering various situations and changing environmental conditions. Based on this virtual situation the decision-making process and the issuance of orders are carried out much in a similar fashion as in the real world. By continuously recording the events and corresponding actions, an objective evaluation of the leadership performance can be carried out. The officer can therefore improve his/her leadership capabilities implementing a trail and error method.

An additional advantages is the combination of simulation and the virtual reality environment with its high resolution representation in order to accomplish a near to reality preparation of a mission. There is also the possibility to use this training equipment during an on-going mission. By supporting such tasks the acceptability of such VR training equipment will certainly be welcomed by the trainees.

By applying high resolution simulation single objects such as soldiers, civilians, weapons, diverse pieces of equipment, buildings and vehicles can be created and applied.

A potential cost saving is achieved, by having an onsite implementation of the simulation and by not using any type of ammunition. Another benefit is its benign environmental impact whereby no emissions or pollutants are created. Landscapes, scenery and buildings remain intact. Personal injuries during exercises are minimized. Since the exercises will be stored in large databases the time for preparation will be short. In addition different exercises can be run in parallel for leaders/officers.

In order to optimize the training exercises, three different operational systems each with its own hardware platform, which use the same core simulation software will be designed.

- The first design would be a PC based training support system for self study purposes (Figure 2).

- The second system would be network connected PCs in a classroom in order to better understand reactions of other participants and learn tactics on a more real live situation (Figure 3).

A much more advanced simulation system would be an immersive system possibly with a head mounted display to compliment the exercises performed in the classroom for the base course and for the advanced course on leadership training. This system may be also be used for preparation of exercises and mission rehearsals.

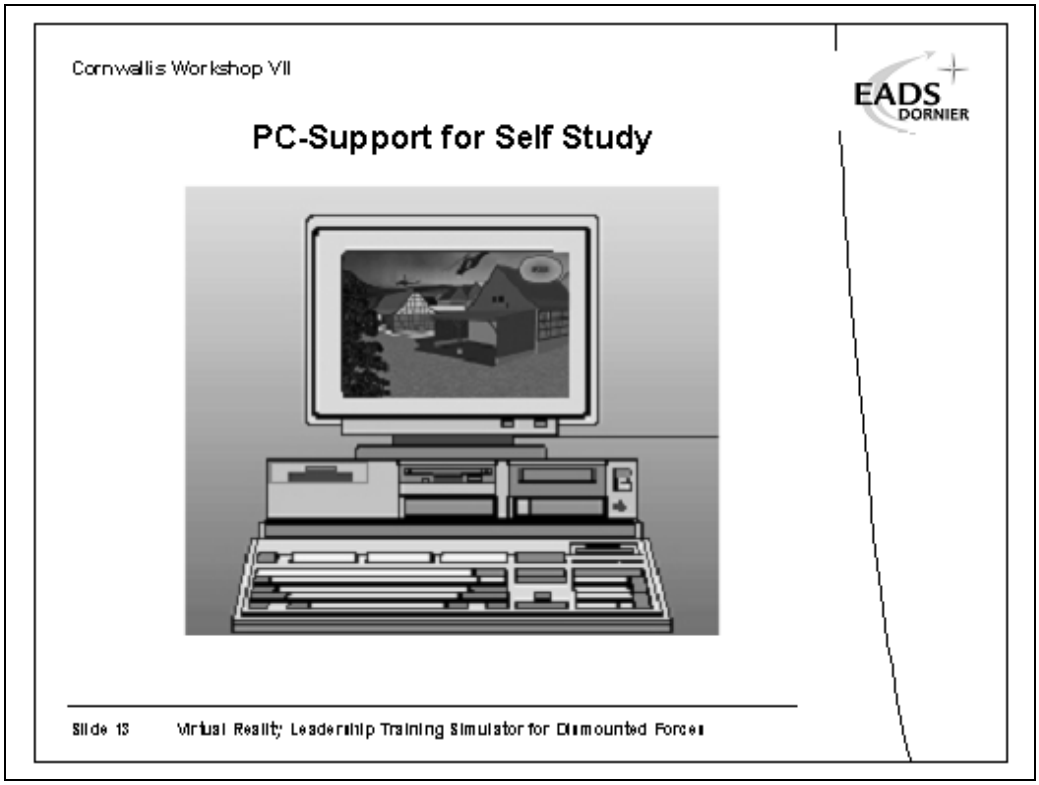

Figure 2: PC – Support for self-study.

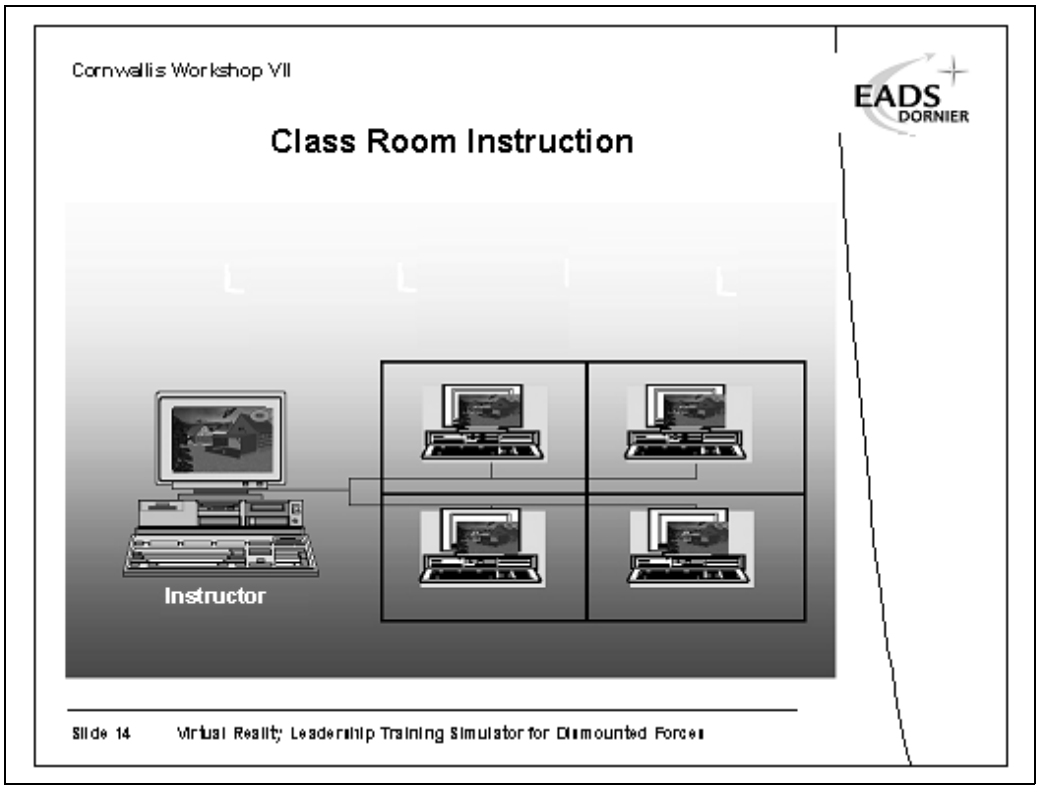

Figure 3: The class room instruction system.

Shown in Figure 2 is a PC based self-study support system to convey to the trainee the basic tactics and measures to implement. The software requirements for the operation of this

system are the most stringent, since it must work under nearly every conceivable condition and must therefore be extremely robust.

The hardware and software for the class room instruction is nearly identical to the PC based self study support system. The differences lie here in the network capability and the larger number of scenarios for the class room model (Figure 3).

The instructor station determines which scenarios will be exercised and the instructor software is designed to load the databases with respect to force structures and participants, terrain and environmental conditions. This station will also contain evaluation software to assess how well the individual trainees are performing their leadership duties.

By using this distributed class room system tactical decision making can be exercised. A significant benefit will be that the individual trainees must assume various roles of opponents. This will sensitize the trainees not only to see their mission objectives but also that of their opponents.

Even though the previous training tools mentioned allow a three-dimensional simulation of scenarios like the various commercially available 3D tactical video games, the planned immersive system will bring the trainees closer to a near real world situations than he has ever experienced before (Figure 4).

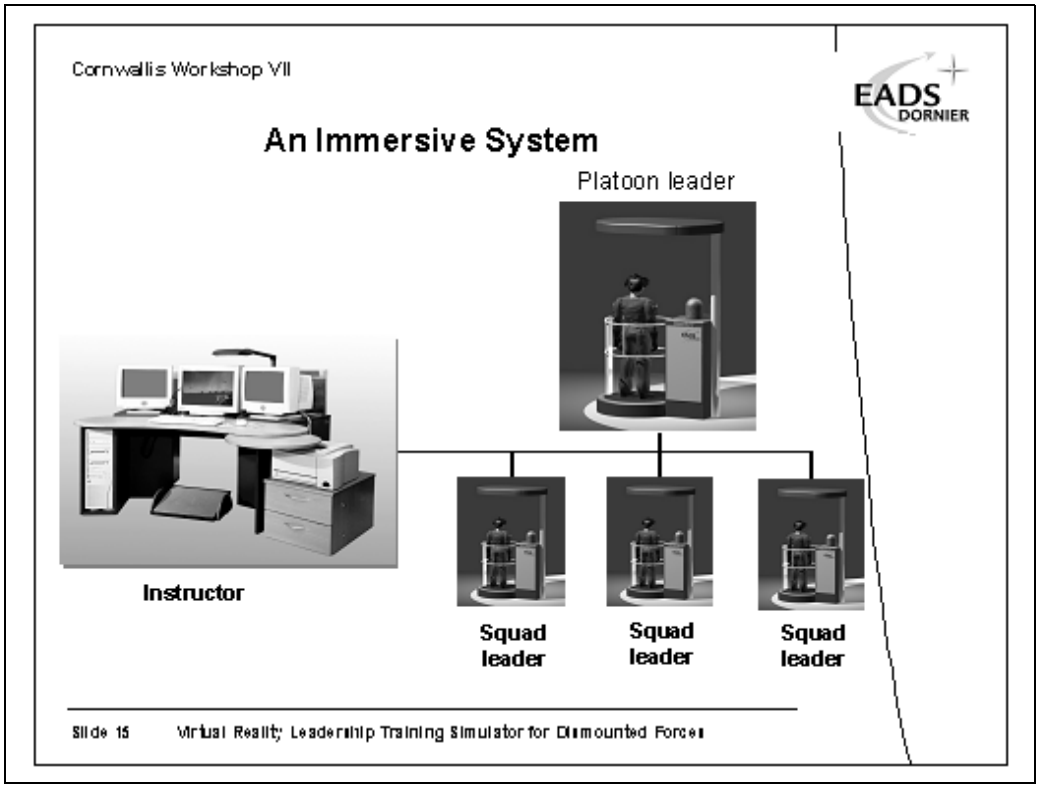

Figure 4: An immersive training system.

This reality can be achieved by head mounted display systems which can produce an environment that the leader will encounter in a planned mission. This will include his C4I systems available to him, but it will also include the avatars (persons) who will receive orders and convey messages in the action space. Now the interactions will be much more physical

and psychological than the classroom training produces. Here the various field equipment will virtually appear and react similar to the real equipment.

VR – LEADERSHIP TRAINER REQUIREMENTS

Due to this highly detailed virtual reality world, the methodological and instructional requirements will initially be much more demanding than in the previous conventional training environment. The reason for this is the high level of detail encompassed within the 3D- simulation models.

The organizational requirements are initially also significant especially when it comes in generating the databases for the scenarios. Again since the level of detail is so much higher, much larger databases encompassing all the detailed data are required.

Also the technical requirements are very extensive when considering the audio- and visual and operational equipment. Head mounted displays must be extremely lightweight. They must generate sharp and smooth motion pictures of the virtual surroundings. The sounds must be realistic and synchronized with the actions and reactions generated.

The costs incurred by procuring such a system must be offset by the costs of performing actual present day training exercises.

What are those methodological-instructional requirements? These are basically the teaching objectives and course orientation. It is also important to limit and focus on the objectives of the course.

The instructor needs to tailor his course to the abilities and skills of the personnel to be trained. The instructor also needs to show and demonstrate how the simulation reacts to interactive reactions and actions from the trainee.

The trainees must also be familiar with the visualization of the real environment conditions. The trainees must be able to negotiate through the virtual terrain. Once the visualization effects have reached a certain degree of detail, where the senses are activated, user acceptance is then assured.

From an organizational point of view, the courses must start out with a base course, which introduces the trainees to the various training tools and to the basic training concept. In addition, trainees should have the possibilities to attend refresher courses and continue to improve their leadership capability training.

The course contents must be oriented to the needs of the target group. This indicates that the officer receives the leadership training that he has been requested to take. The virtual reality training equipment should be at a centralized location, which allows a large and efficient usage of the facilities.

In addition the network distributed classroom system and a PC based mobile system can be used for further self-training exercises. The system should always be available when needed. It must have network capabilities to interact with other participants of a scenario. The

system must allow the interchange of information to other commercial off-the-shelf products. Even though the basic organization of the software development is very complex, starting a training exercise will require a minimum of organizational efforts.

The technical requirements such as technical reliability play a significant role in the acceptance of the provided training equipment. Not only the hardware but, for the most part, the software must be designed in a robust fashion. Unintentional input mistakes must be recognized by the software and an input error messages are to be transmitted to the user for his information. Functions not explicitly needed, which are inappropriate at certain steps in generating a scenario, must be deactivated during these phases.

By choosing a standard PC-Platform with an INTEL/AMD -based processors and by using the Microsoft WINDOWS operating system a minimum of logistical effort is required. Implementing these hard- and software platforms also allows the use of standardized post processing tools. The software to be developed must be of modular design. This will facilitate software maintenance and software upgrades. The required databases must be easily adjustable by using self explaining editing windows. However the original supplied databases can always be reloaded into the system at the start of the scenario development.

The economic requirement of such a training center is to limit the development of the training equipment to the agreed upon training goals. This of course does not inhibit the system to be developed further, since it is of modular design. Employing commercial off-the-shelf products allows for a fast evaluation and visualization of the exercise results.

In order to keep the costs low, redundancy must be kept at a minimum. No redundancies are required for most of the computer equipment, since this equipment is composed of conventional PCs and can be replaced at short notice with improved performance. Employing the leadership trainer can eliminate training deficiencies and possible costs of leadership errors. The availability of such a training tool can result in a more effective use of the short training periods.

Relying on the up-to-date PC technology will make an upgrade to improved technological hard and software less expensive. This is especially important if your application has high demands on graphics and multimedia hard and software. A number of CAD-Applications can be employed in order to quickly construct objects in the generation of real world scenes.

Employing head mounted displays allows a close to reality visualization system for accurate display of the simulation. An artificial intelligence (AI) expert system should be used for simulation of the decision process for computer generated forces and civilians.

The instructor can communicate and interact with the trainee (soldier, civilian) within the simulation software system. It should be possible to communicate to other simulations and training environments via network (possibly with high level architecture, HLA)

For the scenarios of the leadership trainer for dismounted infantry the following mission tasks must be incorporated:

- Combat in urban terrain (with and without civilian population).

- The types of combat situation to be considered are attack and defense on the levels of platoon, squad and team.

- Not only combat in urban areas are to be considered but also combat in wooded areas are also of importance.

- General mission tasks such as reconnaissance, deployment, and securing of field positions are fundamental tasks that are part of the base course on leadership to be taught.

Not only conventional combat mission tasks but also mission tasks common to peace support operation are to be considered. Some of these operations could be operating a check point, crowd control or possibly the disarming of former belligerent forces.

There are several training levels to be considered. The lowest level but very important and intensive learning program is the self study course or continuing education, which would be installed on a PC or could be accessed on a restricted web-page.

A more intensive measure of training would be a training course with an instructor. Here a trainer and other trainees are available for guidance and interchange. An even more intensive training exercise would implement extensive scenarios and a total virtual immersive training environment. A final step would be a full mission rehearsal with the virtual leadership trainer.

VR – LEADERSHIP TRAINER EDUCATIONAL CONTENTS

Up to now we have looked more at the global trainer requirements and training levels. Now we want to look more closely toward the actual training goals of the leadership processes. By having a virtual environment the officer/leader can actually judge the terrain by himself/herself (Figure 5). Based on his/her judgement of the terrain he/she gets a certain degree of situational awareness and based on his personal impressions must make careful judgements of the situation he is encountering and finally decide the course of action to be taken. This could mean to launch an attack or possibly devise defensive measures against an immanent attack. Combat could take place between regular or even against irregular forces.

By using the leadership trainer the entire scope of the applicable rules of engagement could be exercised. The leadership actions in a peace support operation may be entirely different than in an immanent combat situation. In such situation a PSO officer may only be required to demonstrate his presence but without actions. Different military sources have conveyed that these situations are much more difficult to judge if the rules of engagement are not as well defined as for a combat situation.

The instructor station will be used to develop the appropriate scenarios. This means the selection of digital cells for combat in urban terrain (house to house combat) or combat in wooded areas. For these different terrain types additional objects such as buildings, troops, ground vehicles, tanks, cars, trucks and Helicopters can be introduced. The instructor station also has the entire scenario script, which contains all intended actions of the opponent.

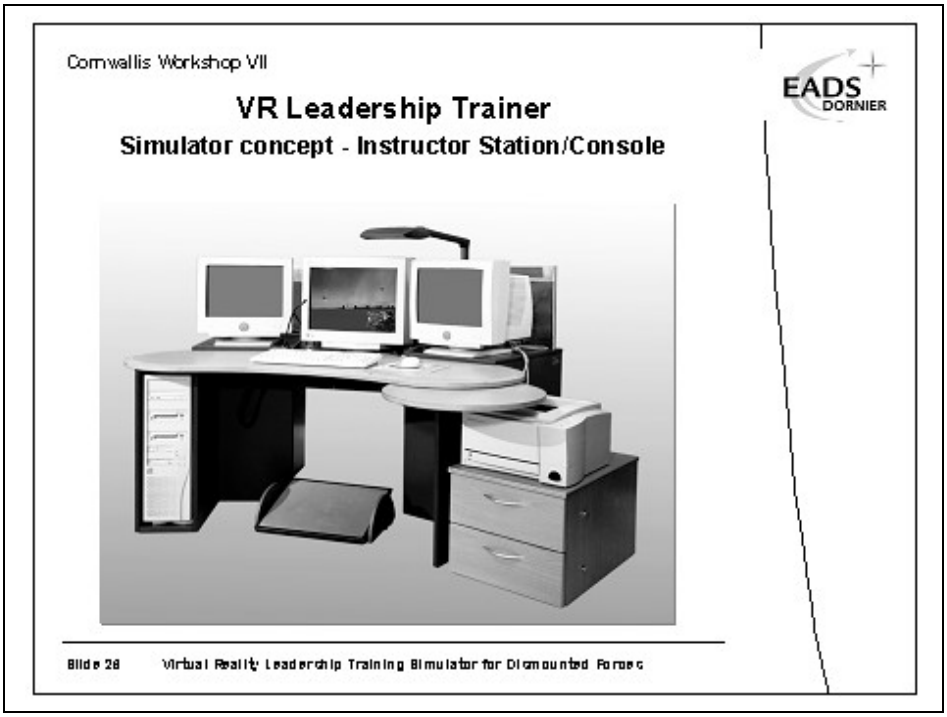

Figure 5: Simulator Concept – Instructor Station/Console.

With the instructor station the scenario can fully be prepared, controlled and watched over. Additional controls will allow the scenario to be recorded, recorded scenarios can be played back for evaluation purposes. One other and very important feature is the simulation resume button at any point on the play back position. By using these features an evaluation of the training exercises can be carried out. This is a virtual representation, how the instructor station may look like in the future. One screen will contain the simulation. Another may contain a scoring of the individual trainees

Figure 6 shows the two-dimensional military situation of an impending urban attack of blue forces one defending RED forces. The BLUE Platoon has reorganized itself into two attack squads and one fire cover squad. Two RED infantry squads are defending their position within the buildings. The BLUE platoon must enter the RED buildings and drive-out the RED forces form those buildings. Figure 7 shows a three-dimensional view of the previous situation.

In the case of the virtual reality workstation for platoon-, squad-. and team-leaders. The visualization is performed through a head mounted display. The changes in position and rotations are recorded through a tracking system. Lateral and transverse motion is created via a space mouse. Other inputs are all entered also via a space mouse. A separate communication system is installed in the workstation.

In future, the viewing system will be developed as follows. What we have already is a partially developed PC-based viewing system. This system could be augmented with a three-dimensional monitor or a head mounted display. In order to generate motion within the system a tracking system and space mouse are required. Initial tests have already verified this capability.

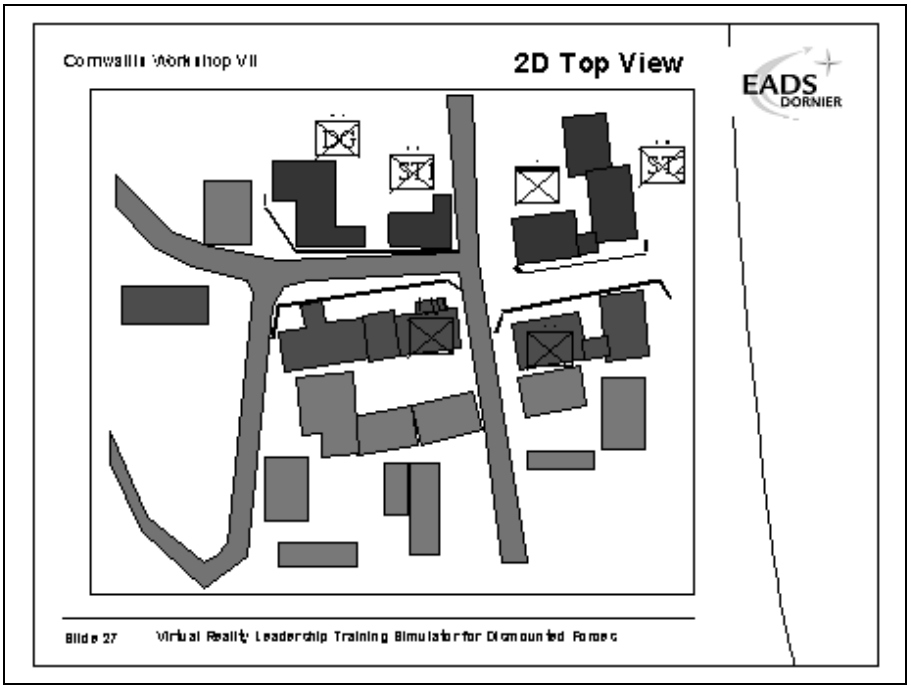

Figure 6: Two-dimensional view of a military situation.

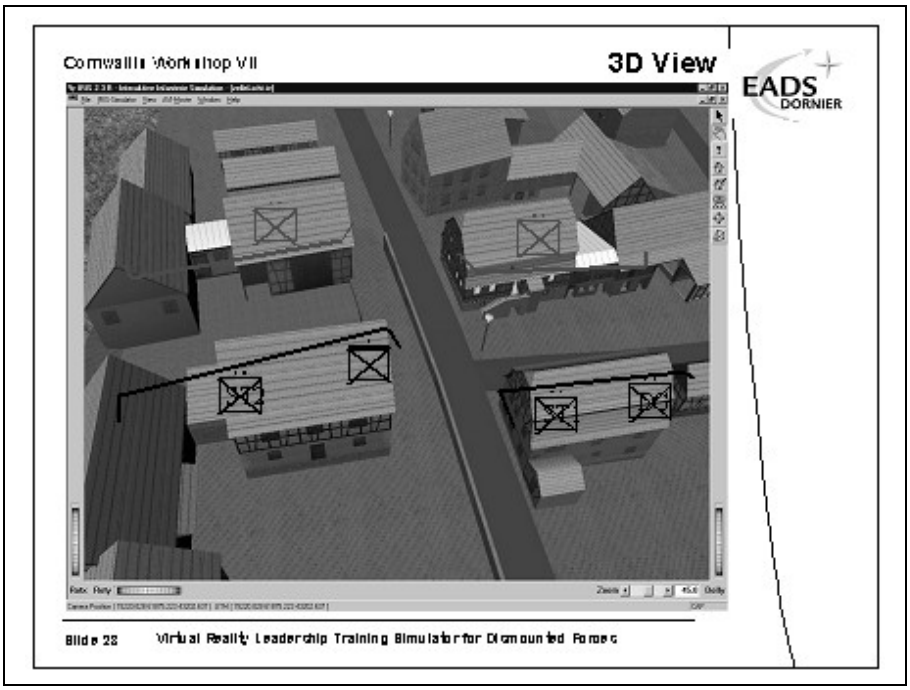

Figure 7: Three-dimensional view of the military situation

In order to call up a number of different scenarios, requires that information about the digital terrain cell is stored in a database. Additional information about lighting effects are also to be stored in a separate database. Different databases are also kept for the different objects. Very important for the trainer is a number of standard scenarios where the exercise can be started from. The virtual world of the virtual training village called Bonnland is shown in Figure 8.

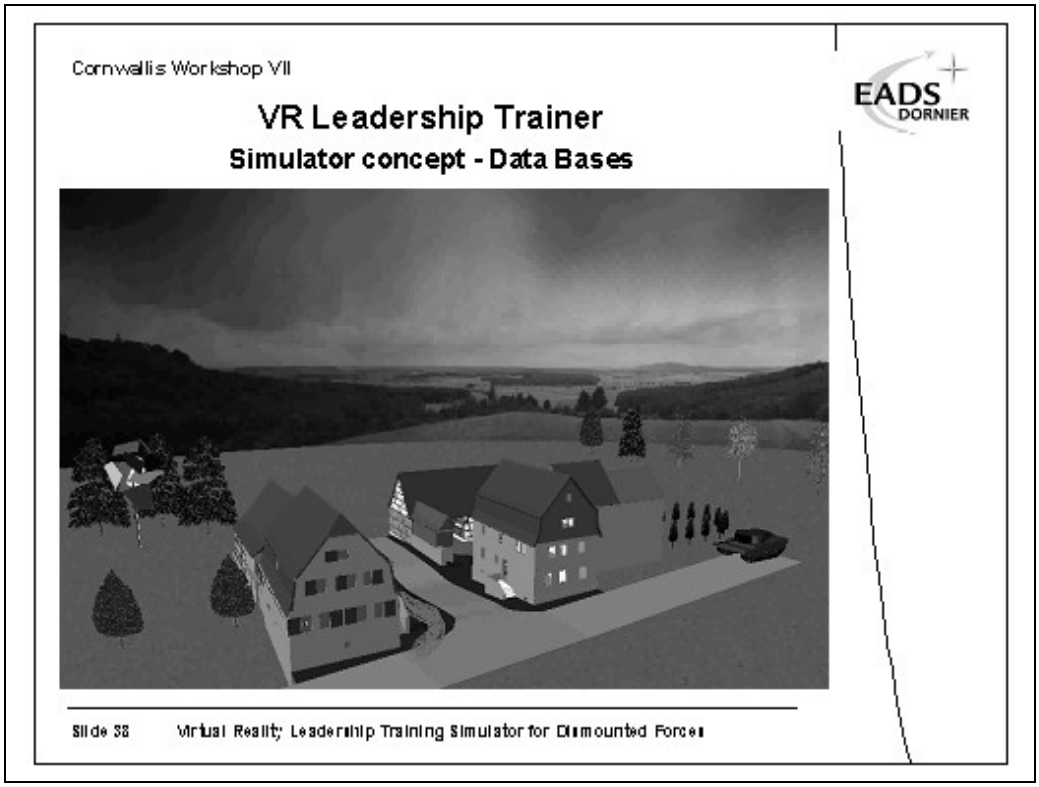

Figure 8: German Infantry Combat Training Center "Bonnland."

VR – DEVEOPMENT OUTLOOK

Figures 9 and 10 show the development steps to build such a VR-Leadership trainer. We will start with our already developed 3D IRIS — core model for dismounted infantry, which we presently use for analysis and add a small number of scenarios each requiring a number of decisions and commands. This expanded form of IRIS could then be used by individuals (officers) to practice their leadership skills in a self study mode.

A further expansion of this system would be achieved by significantly increasing the number of scenarios. These expanded sets of scenarios could then be used for classroom instructions. The systems described here would be three-dimensional systems models but non-immersive.

In a further development step multimedia can be introduced including head-mounted displays for a fully immersive system. The classroom exercise model would still have a number of predefined scenarios. In fully-developed system, a full mission rehearsal could be carried out.

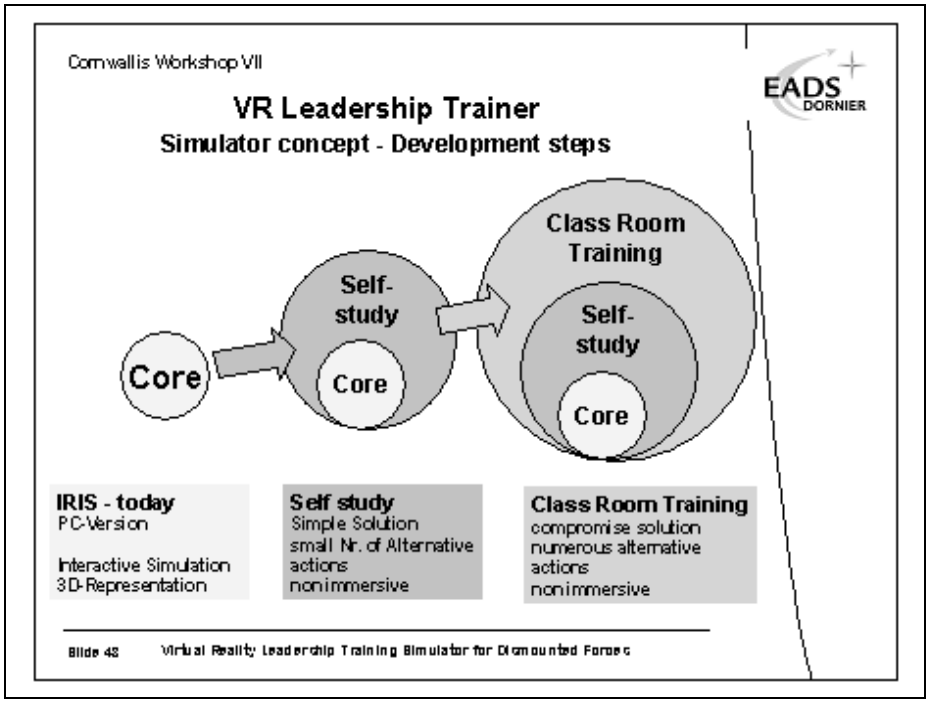

Figure 9: Simulator Concept — initial development steps.

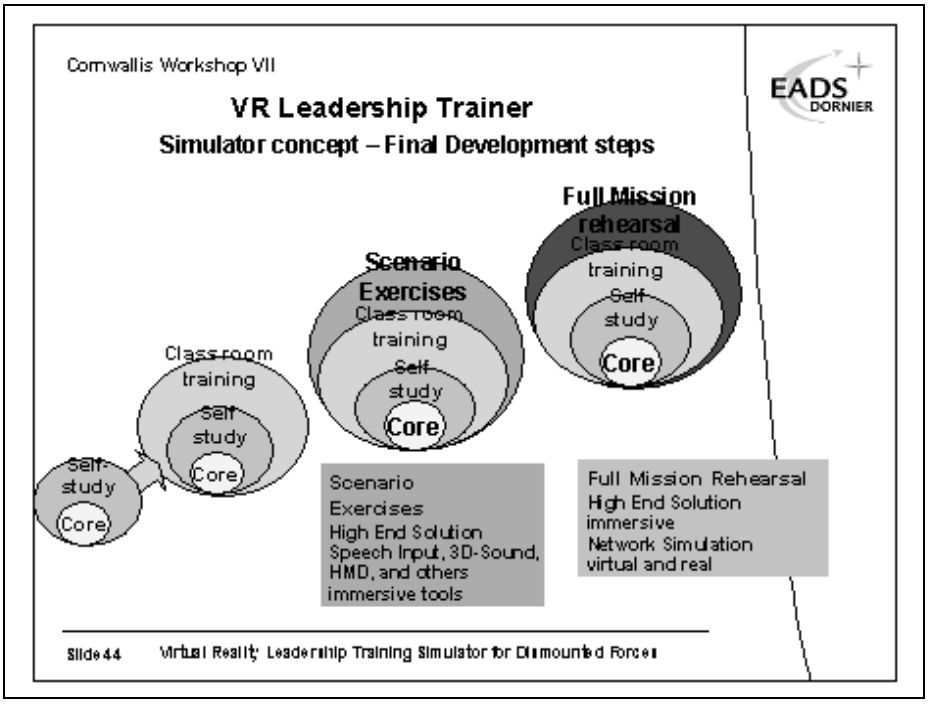

Figure 10: Simulator Concept — final developmental steps