Immersive Technology Supporting Individual and Collective Training

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ABSTRACT

"The level of complexity in the coalition environment demands a rehearsal framework in pre-deployment training" (US CENTCOM CCJ6-P). To extend the Afghan Mission Network Training, Staging and Mission networks model, the authors propose an approach to support the process of training and preparing transitioning forces during the pre-deployment phase. This approach exploits Modelling and Simulation (M&S) within a web-based training framework and it is designed to suit a Future Mission Network (FMN).
The proposed concept is based on state-of-the-art immersive devices coupled with web-based virtual simulators, serious games and virtual worlds making them accessible through social learning technology to support individual and collective training for Commanders, staff and dismounted soldiers. The framework is suitable to be used to conduct remote distributed training and rapid prototyping activities in a web-based networked environment. Furthermore, it is suitable to be implemented in a Joint Enterprise Information environment like the NATO Training and Education Network (NTEN) fitting the NATO Future Mission Network initiative.

1.0 BE TRAINED "AS WE PARTNER"

"Train as we partner" is one of the pillars defining pre-deployment training requirements for NATO [19]. It requires common access to NATO training resources and the achievement of interoperability between personnel from different countries and organizations. This access includes sharing resources, experiences and information. These education and training processes, along with the use of exercises and new technologies, are the foundations of the NATO Connected Force Initiative [8].

"*M&S technology and networks are already available to the Alliance for distributed training and exercises where the training audience may be located in home bases... Currently modelling and simulation*

technological advances seem to provide applicable promise to NATO's training needs. As such, the excursion into virtual worlds is closely monitored... what should the military expect from this technology? Can we incorporate into the virtual world's "briefing room" the blended learning subject material already developed? How can one train as one fights, instead of "keyboarding" in the virtual world? How then can we elevate the subject matter on the strategic or even the political/military levels? Other than virtual worlds what other M+S advances can assist NATO training to achieve its aim?" [30]

Due to wide-spread financial constraints, budget cuts are affecting training and force preparedness.

Virtual immersive simulation is one of the possible solutions to maintain force readiness reducing as much as possible live training exercises. There is a growing opinion that virtual simulation is one of the most viable solutions to conducting training under the austerity of sequestration [8, 10, 18]. Virtual simulation is now used to replace a significant portion of pilots' live training sessions. For soldiers, high fidelity and high resolution simulators coupled with high definition (HD) immersive interfaces may soon enable most live training objectives to be achieved through virtual simulation.

What is needed is the right balance between the level of realism and the level of immersion. Authors define immersion as the feeling of involvement stimulating human perception through most of the senses [5].

There are promising next generation web and M&S technologies, the authors recognize that virtual simulation and serious games are enabling development and deployment of innovative training solutions at both the individual and collective level. There is an emerging opportunity to utilize innovative immersive Human Computer Interfaces (HCI) and the M&S as a Service (M&SaaS) business model. Leveraging these technologies and services will help maintain NATO's forces readiness and combat effectiveness. The key factor is a web-based networked environment enabling expanded training and increasing exercise opportunities.

Major issues in developing HCIs at the soldier level include the human being himself and the complex ground environment that soldiers are immersed and interact within, because the soldier is the weapon system platform itself.

1.1. Web Based Simulation Training Challenges

Main challenges and key factors to provide individual and collective training solutions for ground forces using virtual simulation and immersive devices in a web-based networked environment are:

- Availability of a new generation of affordable high fidelity immersive devices
- Mature web based virtual simulators within a M&SaaS business model
- Internet, intranet and private networks availability to provide fast, secure and reliable web access within a proofed training, staging and mission network model

To enable a "Train as we partner" pre-deployment training capability supported by new generation M&S technology requires the definition of suitable training objectives. Virtual or Constructive Simulations are not a training panacea for all training purposes. Authors believe that a networked web environment could provide the opportunity to remotely train personnel at the individual and collective level according to specific operational requirements. This research assumes that new generation M&S technology is available to provide remotely distributed training capabilities for Commander and Staff working in a Command Post or Head Quarter and for the Dismounted Soldier; enabling at the same time home station training capabilities [1].

Previous constructive and virtual simulators supported CPX CAX (Command Post Exercise Computer Assisted Exercise), whereas the current generation are moving to web technology. This has been an ongoing direction for at least a decade [31]. While the technical challenges of web-based simulation have essentially been solved, bandwidth, security and network access ubiquity are still issues of concern. Another constraint on wider adoption is the complexity of sharing across classified environments that is required by these kinds of eXercises.

Since the NNEC study (NATO Network Enabled Capability), NATO has begun many initiatives with the aim of creating the culture and infrastructure to support the use of networks for Education, Training and Operations Support. The NATO Training and Education Network (NTEN) concept [28] powered by the CFBL Net to provide the Future Mission Network (FMN) initiative [22] with the training, staging and mission networks environment as a primary milestone. Decision makers face a real challenge to balance security meanwhile facilitating access to on-line training and education resources in unclassified web environments [23].

Author's approach investigated for the development and integration of web-based virtual immersive simulation framework to cope with specific individual and collective pre-deployment training requirements and objectives:

- Command Post (CP) individual and collective personnel training, regarding: CP layout and systems familiarization; collective training for Commander and staff focusing on cross functional/operational planning teams collaboration and team building; CP mission rehearsal and personnel pre-handover/rotation tasks and activities.
- Dismounted soldier and pilot individual and collective training, regarding Tactical Techniques, Tactics and Procedures (TTPs).

The framework could be also used for CP rapid prototyping activities and for CD&E activities regarding the study, development test and experimentation of CP immersive decision support tools to support operations.

2.0 GET IMMERSED WITHIN VIRTUAL WORLDS AND SERIOUS GAMES

To enable virtual immersive solutions reducing as much as possible live training sessions it is needed to provide ad-hoc technology matching the requirement to achieve related training objectives. Common features are: usability (easy to be operated and to be accessed), mobility [26], deployment [20], high resolution and high fidelity immersive devices coupled with virtual simulation systems suitable to provide real immersive experiences.

Regarding Immersive Training for Command Post personnel and dismounted soldiers the system should mitigate as much as possible the following critical challenges: simulating locomotion; tracking weapons and body positions; creating realistic performance of computer-controlled dismounted friendly and enemy Soldiers; simulation of night equipment and sensor images; making terrain and structures dynamic; developing appropriate training strategies and methods; assessing individual and unit performance; and determining transfer of training from virtual to live environments. [18].

One of the major constrain is that live training cannot be completely substituted by virtual immersive training simulation technology at the moment and for the next future. The only way to immerse trainees in a virtual world/simulation is to try to involve as much senses as possible using haptics interfaces reducing the use of non natural HCI like keyboard, joysticks and so on. Furthermore being aware of physics interaction limits.

2.1. Immersive Devices

What is an experience? Only a perception of our brain. Therefore, during training sessions the level of involvement of our senses should be improved in order to boost the learning/experience process. Low cost effective hardware must become the distributed tool in order to boost the experience at a collective level. Immersive devices and the experience of immersive media are hardly new. Latest headset devices and other HCI hap tics technology like brain-machine interfaces, virtual gloves, spatial sensors and so on... are moving fast forward and companies are developing innovative and cheap solutions targeting the consumers market (Oculus Rift, Leap Motion, Microsoft Kinetic, Razer Hydra and so on...) (Figures 1-3) . One of the biggest obstacles to the adoption of this kind of Immersive was mainly related to their cost, low quality, lack of ergonomics and poor applications support. Now technological, social and industrial success of a headset seems to be out of the developer phase. It is foreseeable that these innovative devices like Oculus Rift will be adopted on a large scale and not only for the consumer market [14]. Quality and innovation of these items

make them possible to be utilized broadly for professional training purposes.

Figure 1: Oculus Rift HMD
Source: http://www.edge-online.com/features/oculus-vr-wants-to-release-its-headset-for-free/

Figure 2: Razer Hydra 2 prototype
Source: http://www.roadtovr.com/2013/06/27/sixense-wireless-motion-tracking-development-kit-hydra-2-6824

Figure 3: Leap Motion gesture-based controller
Source: http://www.gsmnation.com/blog/2013/07/24/leap-motion-controller-first-impressions/

Regarding immersive devices authors agreed that main requirements for a cost/effective professional training system are: the image generator hardware, based on Helmet Mounted Display technology, that should offer a sufficient field of view (FOV from 46° to 96°), with a low latency and a Full HD 1080i resolution in 2D and 3D. The ergonomics of the system should be imported from the military application of Night Vision Goggles for aviators. In particular, the Out of the Window (OTW) image is obtained looking inside the NVG

and the interaction with cockpits, instruments and equipments is obtained looking under the goggles. Similarly, the immersive HMD should deliver the capability to work in the virtual world using real equipment from the real world (interacting under the HMD), based on the "Fly what you see concept": Spatially, the trainee will refer to what he sees within the virtual environment, always maintaining the awareness of real positioning in space and equipment interaction (reading a map for instance). In order to complete the experience, real complex systems (weapons, binoculars and so on…) should be used with virtual manipulation gloves, maintaining their real weight and ergonomics, saving costs for expensive mock up (Figure 4).. The zero need for a prepared infrastructure, delivers the immersive package an unlimited usability potential, being able to be used when, where, and how it is needed.

Figure 4: Latest generation professional wireless HMD and haptics

2.2. Virtual Worlds, Serious Games and the Social Dimension

Virtual Worlds (VW) had their hype peaked in 2007. Many research experiments and products have been developed since then but only few were largely adopted because most of them didn't pass the "*mom test*" [15]. Second Life, the most widely used VW platform, has been used for research activities also by NATO [7] and the US DoD [29] (i.e. the Naval Air Warfare Center) exploiting new technology for training and collaboration purposes. Today's most dangerous issue in using Social MMO (Mass Multiplayer On-line) platforms like Second Life is that, after their hype, they could vanish in the flip of a server switch [33]

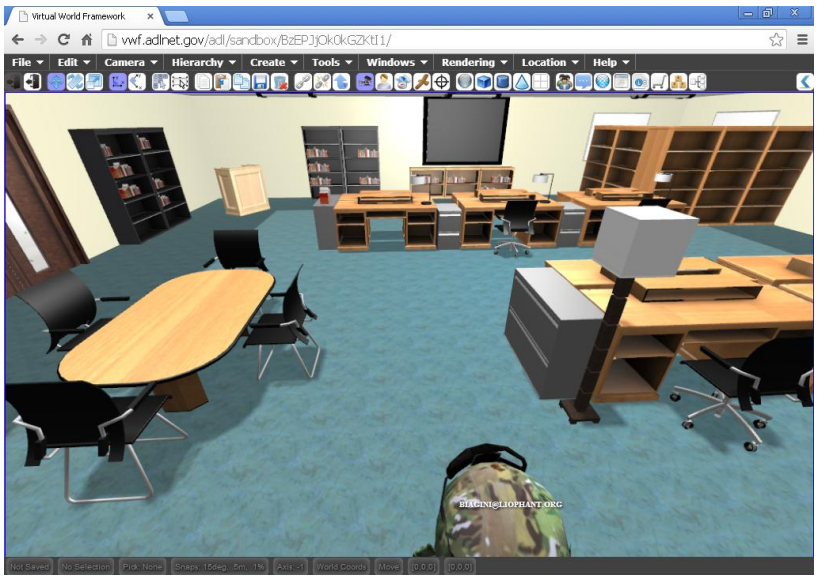

Figure 5: ADSL's VWF sandbox demo
Source: http://vwf.adlnet.gov/adl/sandbox/BzEPJjOk0kGZKtI1/

Regarding Virtual Worlds the latest promising initiative that make VW suitable to survive is the Virtual World Framework [27]. It is a fast, light-weight, web-based architecture for creating and distributing, scalable, collaborative, and component-based virtual spaces. The ADL (Advanced Distributed Learning) has developed an interesting application based on this framework, the VWF Sandbox (Figure 5). It allows users creating and editing their own virtual environments in an easy way.

One of the latest important initiatives in adopting a virtual world experience using a VW platform different from Second Life is the US Air Force Virtual Campus project (Figure 6). The platform has been developed on the basis of one of the most powerful, versatile and widely adopted gaming engine: Unity 3D. This multi platform game engine has for sure passed the mom test and now it is going to be adopted for serious games and simulation projects for professional training in several sectors.

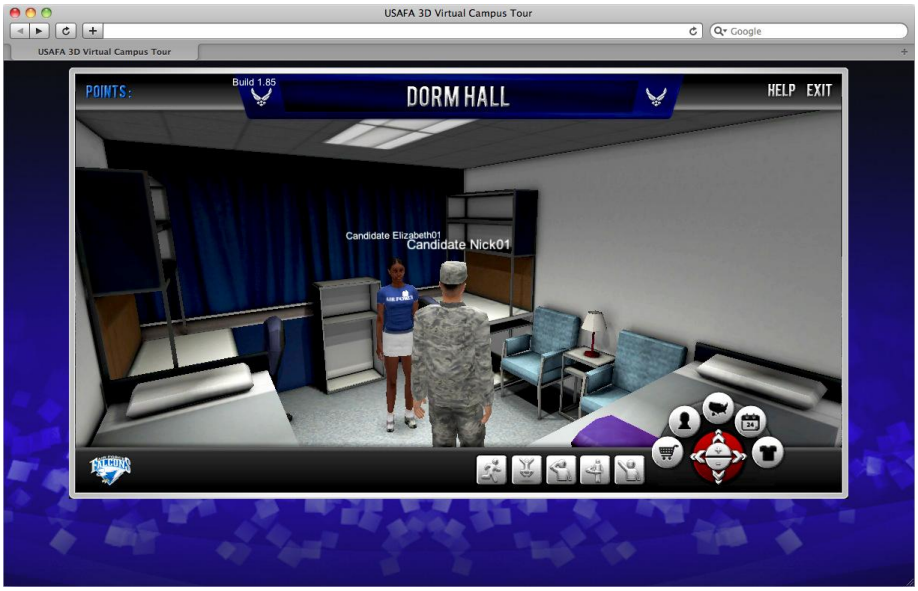

Figure 6: Virtual World platform based on Unity 3D technology
Source: http://www.designingdigitally.com/portfolio/virtual-worlds/united-states-air-force-academy-browser-based-3d-virtual-campus-tour

Regarding the social dimension authors enforce the concept that one of the most important chance provided by a web based training simulation environment is the opportunity to integrate M&S training and education resources within a social network environment enabling real home base training capability. Furthermore developing trainer and trainees communities of practice. Communities of practice for their nature enable exchange of information, practices and experiences between their members facilitating the communication. The opportunity to create communities of practice within the e-NATO training and Education initiative supported by the NTEN and the other initiatives will push the involvement of personnel from allied nations and others NATO partnering countries. It will create the opportunities to plan and conduct training sessions, enabling a real "train as we partner" opportunity pooling personnel being harmonised under common training resources and requirements.

Social network technology provides collaboration and communication tools integrated with web geo mapping tools, audio, video technology and so on (Figure 7). One way to integrate social network technology with a Virtual Worlds environment and creating interaction is via the Immersive Media Mark up Language (IMML).

Figure 7: Web Based Training Capabilities and Social Network technology

Worlds built with IMML are like building blocks, the glue is made of simple compact metadata describes time and space based on XML schema technology. By this technology worlds connect using simple URL requests that can be generated before or during runtime. Worlds can be connected inside worlds as widgets subject to physics, etc..via various connection types. These connections include geometric connections, tele-connections, and embedded connections (widgets). IMML technology provides distributed independent world servers capability enabling users to continue their experience if a server fails "walking around and entering other worlds without any handover of game state information between servers (Figure 8).

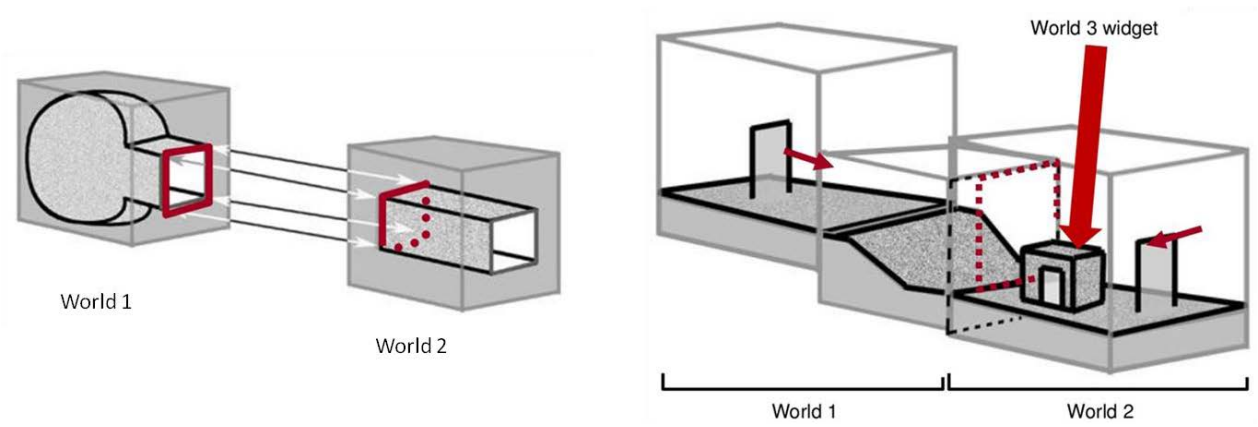

Figure 8. IMML technology concept

Supporting native HTML worlds using Javascript and HTML 4 and 5 is it possible to generate 2D worlds with 3D-like graphics. This technology is almost supported by any devices and browser. It offers fast access to secure collaboration rooms and all remote team members can access with presence and chat through firewalls as standard http traffic. Thanks to IMML specification support this technology will work with 3D worlds soon. The web-based version of IMML could enable a powerful different way to create versatile Immersive Learning Experiences thanks to the development of a JS version and a Unity 3D core coupled with 3D and 2D worlds [15].

Coupling this technology with innovative consumers HMD or virtual goggles and with haptics trainers and trainees could be remotely immersed within what they should "feel as a real world".

3.0 THE IMMERSIVE COMMAND POST

Use of virtual technology to implement a Virtual Command Centre for training, collaboration and operation support opportunities is hardly a new concept. A lot of literature has been written about it since 1998 [11,21] virtual command centre] (Figure 9). Despite several tentative up to now this concept has not been seriously adopted due to some factors and issues [Figure 10, 11]. Wide support to latest technology, security, bandwidth limits, hardware limits, wide installations i.e. Cave [13], ergonomics issues, lack of C4ISTAR digitalized systems and/or presence of legacy systems. Above all the biggest obstacle remains the cultural resilience in using these devices that now are going to be extremely user friendly and widely adopted by the gaming industry for the consumer market.

Technology is doing steps forward and nowadays authors believe there is the opportunity to revitalize this concept introducing innovative technology and devices supporting remotely distributed training capabilities powered by social network technology.

Figure 9: One of the first Virtual Command Centre prototypes
Source http://rubyquest.com/glenn/resume/publications/virtual_command_post_files/image004.jpg

Figure 10: A Virtual Command Centre Demo based on a commercial platform
Source: https://www.saic.com/feature/critical-infrastructure/images/olive2.jpg

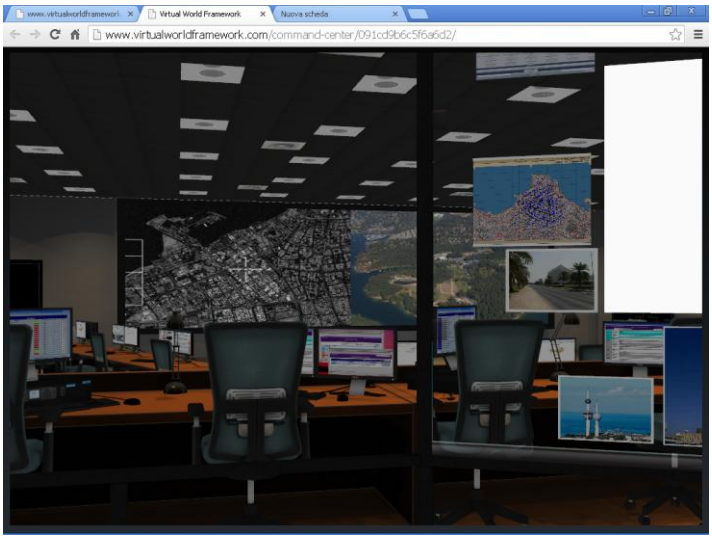

Figure 11: A web based virtual command centre demo developed with the VWF
Source: http://www.virtualworldframework.com/command-center/091cd9b6c5f6a6d2/

The authors' concept is based on Web Based Immersive Technology eliminating any frustration regarding the way to access and to operate within virtual worlds environment applying the desktop metaphor [17] to HMD's devices. To make a more immersive experience, users wearing haptics will be able to access real or emulated desktop computer via virtualization technology.

To develop a Web Based Immersive Virtual Command Post concept authors have looked for possible training requirements to proof the concept supporting well defined training objectives for pre-deployment training needs regarding Command Post personnel duties and activities.

3.1. Pre-deployment training needs, requirements and assumptions

Looking at multinational, Joint and combined environments like large Head Quarters (HQ) down to Tactical Command Posts (CP), rotation can happen on the entire personnel basis or periodically involving single or multiple personnel. When arriving for the first time to a large HQ, personnel is usually a little bit disoriented and it takes time to get used to tasks, routines people and places. Sometimes hand over time last few days and personnel rotate without a complete picture about what their predecessors used to do. In few cases this could create also an initial disruption in his job activities due also to his level of experience, training and initial lack of knowledge about the environment and the personnel he has to work or interact with.

Authors' assumptions about a possible adoption of a web based immersive training system are based taking into consideration the Afghan Mission Network model. This model has developed a multi-networks environment for different purposes: training, staging and mission support. It is supposed to use to exchange data between that networks according to their security levels and also it could be used to enable training sessions via web technology. But security and bandwidth are still the major issues to be solved related almost to policy and adoption of latest technology.

Taking into consideration what above illustrated authors have assumed the following training needs and requirements assumptions and related possible training objectives:

- Command Post Familiarization (individual training)
  - Be familiar with the Command Post layout environment
  - Be familiar with workspace, applications, tools and systems

- Be familiar with standard tasks and duty activities related to the assigned job position
- Pre deployment Command Post team building and cross functional team training (individual and collective training)
  - build individual team working skills regarding the job description
  - be able to collaborate and participate to cross functional team building activities (collective)
  - Improving ad hoc cross functional team skill for SME
- Pre-handover familiarization (Individual and Collective)
  - Meet and familiarize with the colleagues personnel has to hand over with (individual)
  - Meet and familiarize with the team it is supposed the personnel will going to work within

Most of the mentioned training objectives should be achieved by participating personnel before Mission Rehearsal CPX CAX's to maximize exercise outcomes.

Regarding requirements not affecting directly training the same technology could be used also to support operations and Concept Development and Experimentation purposes giving the opportunity to leverage a framework to design and test Command Post Layouts and Decision Support Tools capabilities.

3.2. Web Based Virtual Command Post

Author's proposed framework will enable personnel from different locations to access a virtual command post trough a web browser, interacting with the virtual environment by the immersive wireless devices system. The system consist of High Definition HMD, virtual gloves and other sensor and technology based on wireless connections (Figure 4,14).
Architecture provides a server centralization. The web-based application is intended to be used supporting Command Posts rapid prototyping and to train personnel through a Virtual environment. This environment is going to built up around latest virtual worlds, social network and gaming engines technology (Figure 12) integrated via the immersive wireless devices system. Furthermore fits the following training requirements: individual and collective Command Post (CP) layout and systems familiarization; collective training for Commander and staff focusing on cross functional/operational planning teams collaboration and team building; CP mission rehearsal and personnel pre-handover/rotation tasks and activities. More over the framework offers greater training schedule flexibility, lower costs and less travel time with less impact on the environment.

Figure 12: A Web Based Virtual Command Centre prototype integrated with social network technology

Regarding technology the research put in evidence that coupling IMML with Unity 3D gaming engine is currently the best solution to provide a real immersive experience using web technology and immersive tools. IMML can provide certain levels of interoperability in Html 4 and 5 and in JS environments providing high efficiency and easy way to access. Authors have already proofed the concept of a Virtual Command Post framework also for decision support purposes [2,3,16]. Evolving the concept adding immersive capabilities via wireless user friendly immersive devices will enable users to feel a real training experience.

The web based environment aims to overcome these common barriers and challenges to create a new approach to remote collaboration and network management backed by a platform framework that has embedded training and assessment capabilities. The main novel features of the platform are:

- No software downloads needed to access core web-based collaboration, crowdsourcing and training services
- Integration with immersive wireless HMD, haptics and other innovative sensors
- M&S simulation services that are web-based using a 3D web plug-in
- Intuitive Data representation and Visualization
- Embedded interaction with external remote desktop and virtualization technology. Furthermore to provide real or emulated C2/C4ISTAR systems access within the virtual world environment

Wireless immersive devices state of art is provided adapting the most innovative and cost/effective technology from Dismounted Soldier Simulation Systems.

4.0 THE IMMERSIVE DISMOUNTED SOLDIER

One of the most common Dismounted Soldier Training System limitation affect the soldier locomotion and his manoeuvre capability. Using hand controls to move is worse than unrealistic: It's potentially dangerous. There's such a thing as muscle memory, and a soldier who has repeatedly practiced running for cover by tweaking a mini-joystick may be just a little too slow to use his legs when someone shoots at him for real. Even minor differences between the training environment and real combat can cause big problems. Police departments across the US country, for example, changed their firearms training after they realized that officers were wasting time in real-life firefights by picking up spent brass cases from their revolvers or pocketing empty magazines from their semi-automatic pistols, things they had done over and over and over on the firing range. Any combat training that teaches soldiers to stay in a three-foot circle is deeply problematic.[12]

Figure 13: The US Dismounted Soldier Training System (DSTS).
Source: http://breakingdefense.com/2013/08/09/the-army-gets-unreal-the-pros-cons-of-video-games-for-combat-training/

The proposed concept uses state-of-the-art immersive wireless device coupled with web-based virtual simulators and serious games. These devices can work with web-based virtual simulators, serious games and virtual worlds capable of supporting individual and collective training for Commanders, staff and dismounted soldiers. The out of the window view is obtained employing an high quality cost/effective head mounted display, equipped with high rate full High Definition Stereoscopic (HD) transmitter system, able to guarantee wireless capability. Furthermore, the integrated sensors will deliver a complete freedom of movement for body and manipulation without cameras or others external tracking devices. The resulting system delivers a complete freedom of movement and related manipulation capability within virtual worlds applications.

Based on the Immersive Devices technology (HMD, sensors and gloves), the dismounted soldier package fully leverage all the benefits of this low cost scalable system. The player is able to move within a virtual battlefield with a 30 m/sq capability without any prepared structure. Manipulation will be achieved via an innovative low cost glove system that enables the user to employ real equipment within virtual worlds.

In addition, the modular nature of the package delivers the system the capability to be used by different operators, from dismounted soldiers, to aviators, without any additional system/plug in.

Authors proposed solutions mediate the above inconvenient using passive special, reducing the number of wires to enable soldier to move in a range of 30 meters.

Figure 14: Dismounted Soldier System Version 3.0

5.0 CONCLUSION

The authors' research has shown that state-of-the-art immersive devices like HMDs and haptic devices used with virtual simulators are suitable for individual and collective training in a pre-deployment NATO training environment. Several related initiatives are on-going within NATO. The paper introduced possible approaches and innovative concepts about a training framework. It enables several training and rapid prototyping activities in a web-based networked environment at both the individual and collective level. The cost effective architecture could be suitable to be implemented in a Joint Enterprise Information environment like the NATO Future Mission Network initiative.

Immersive technology for ground forces training in a networked web environment may be suitable for initiatives like the Connected Forces, the e-NATO Training and Education, the NATO Training and

Education Network, the CFBL Net and the Future Mission Network. These initiatives could become the catalyst for the wide-spread introduction of web-based virtual immersive training systems. This is also an opportunity to utilize a social network-like approach to provide, distribute and perform cost-effective training, tailoring the training objectives to the training audience down to individual level.

Next stage for this research is to prove the value of the Command Post training concept for individual and collective pre-deployment training needs and requirements. It may also be suitable for rapid prototyping support. A further step should be to investigate how virtual immersive reality could be used to develop CD&E cycles. In particular, the authors are interested in studying innovative Decision Support Tools and Applications taking advantage of the potentials of VWs including the possibility to overcome real world physical and technology barriers inside a virtual immersive environment. A mix of Virtual and Real environments (the ViReal) [4] could offer to Command Post Operators (Commander, Staff and other specialist) a way to interact with information beyond the availability of current technology and physical limits also supporting operation.

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