Institutes in the UK Undertaking Research into Augmented, Mixed and Virtual Environments (AMVE) for Military Applications of Virtual Reality

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DSTL

1.0 INTRODUCTION

This report describes information gathered about institutes in the UK undertaking research into Augmented, Mixed and Virtual Environments (AMVE) for military applications of Virtual Reality. It also includes information on activities being undertaken in the civil sector that might be relevant to the military.

The information is described under three heading: UK Defence (Dstl/QinetiQ work), UK Academic Institutions, and UK Commercial Companies.

2.0 UK DEFENCE – SOME CURRENT PROGRAMMES

2.1 UK Mission Training via Distributed Simulation

Under the sponsorship of MoD a programme of applied research has been undertaken to explore the benefits to be gained from using networks of simulator, or Virtual Training Environments (VTEs), for aircrew collective mission training[1]. Use of networked simulation in this context has become known as Mission Training through Distributed Simulation (MTDS).

The original research remit was to investigate the technical issues associated with linking legacy and new generation military training simulators, to assess the potential for conducting aircrew collective training. The primary hypothesis was that training simulators could be connected together to provide a common synthetic battlespace capable of supporting the collective training needs of front-line combat ready aircrew.

MoD's research needs were founded in a growing interest in the potential of VE for training purposes. The big assumption was that by transferring certain tasks from the live training environment into the STE, the same level of operational effectiveness could be maintained but at less cost. Today this premise is as hotly debated as in the early 1990's. A balance between live and synthetic training has still to be determined. This is not surprising, as an optimal balance may not exist across the complete spectrum of operational training. It is a complex issue and the debate is likely to continue for some time yet. However some notional indication of the balance is undoubtedly a requirement when procuring any military equipment that requires a synthetic training component.

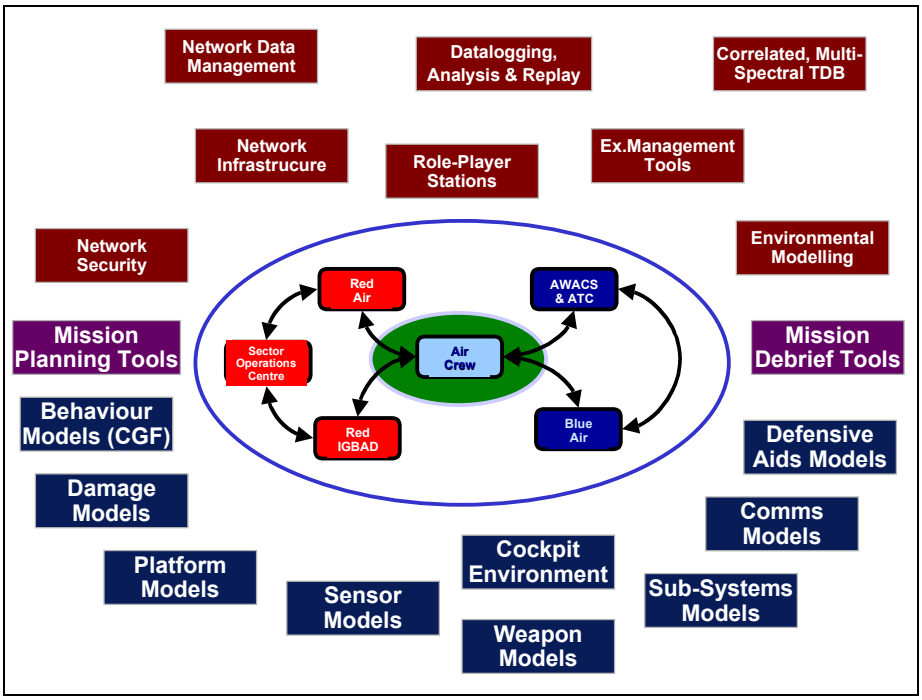
Despite the growing interest in STEs and the perceived potential for mission training via distributed simulation, a proven SE capable of providing collective training for front-line aircrew did not exist. Thus whilst this research activity had been structured in such a way as to enable some very focused technical studies to take place, it became increasingly obvious that the general hypothesis must be tested via empirical research methods. The research team therefore designed a series of practical experiments (trials), conducted under the banner heading of RAPTORS (Research into Aircrew Performance and Training

[1] 'Collective mission training' is defined as two or more teams training to interoperate in an environment defined by a common set of collective mission training objectives, where each team fulfils a different military role. NATO SAS-013 Study.

using Operationally Realistic Scenarios). To ensure that data obtained from these experiments was assessing genuine military training potential, the experimental subjects comprised front-line aircrew. A bespoke synthetic COMAO test-bed[2] was developed specifically to support the RAPTORS series of trials and comprised:

- A large package of aircraft (≈ 40) comprising
- Eight manned simulators flown by front-line aircrew
- A manned E3-D fighter-controller station
- Other friendly platforms represented by role players & computer generated forces (CGF)
- Hostile forces represented by two man-in-the-loop simulators, CGF & role players
- Complex tactical scenario, closely based on a real-world theatre
- Geo-specific location, targets, procedures, etc.
- Dynamically controllable threat environment
  - e.g. In-mission re-tasking of CGF
- War operations room and Exercise Management suite
- Planning, briefing and debriefing complex

The test-bed provided a comprehensive trainee-centric STE created over a secure simulation network that supported exercise, technical and tactical management of the scenario. The complexity of the RAPTORS COMAO environment is depicted below.



Schematic of the RAPTORS COMAO Environment.

[2] The test-bed was developed by DERA at the Bedford site. It is now a QinetiQ facility, although a limited number of components are customer owned.

To date the RAPTORS series of trials has comprised of Ebb and Flow (Feb 2000), SyCOE (Jan 2001), VirtEgo (Nov 2001) and SyCLONE (Feb 2003). Each trial has looked at different aspects of collective training from a technology and human factors perspective[3]. The current UK MTDS programme was initiated due to the success of these trials.

2.2 War Fighting Experiment (WFE)/Synthetic Environment (SE) Demonstrator and Training Strategy

The aim of this work is to create and demonstrate the tools and techniques to capture capability gaps and evaluate the effectiveness of Indirect Battlefield Engagement (IBE) equipment in realistic joint experimental settings. The core of the first year's work comprises two elements. The first of these is a training strategy study, which will address the overall collective training required across IBE. The second is the development of integrated live/virtual simulation techniques ("augmented reality") enabling a number of simulated attack helicopters to take part in a live exercise, for force evaluation and experimentation purposes. The second year is focused on developing an enduring live/virtual capability, by linking Synthetic Environments (SEs) with Area Weapons Effects Simulator (AWES), and broadening the extent of the IBE SE representation by bringing in a future ground-based indirect fire element.

2.3 Human Effectiveness (C2)

It is recognised that the challenge over the next decade will be to assist Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) mission specialists in exploiting the total range of data that will be made available to them whilst at the same time preventing them from becoming swamped with unmanageable information. The MoD customer requires a focus for the development of human factors policy for the use and exploitation of ISTAR assets, including the capture and promulgation of best practices on Human Computer Interaction (HCI) interface design and workload reduction. A primary objective is to determine the benefits of using: multimedia HCIs in Intelligence Databases and Image Product Libraries; touch screens and pressure sensitive pens in the exploitation task; speech recognition technology in populating intelligence reports and retrieving intelligence information; fusing intelligence products to increase the effectiveness of the exploitation task.

2.4 Improving the Representation of Human Variability in CGF

The aim of this research activity is to enhance the representation of Human Variability in Computer Generated Forces (CGF), taking factors such as stress, fatigue, cold, heat, night or day operations etc into account; thus making SEs more credible for users. The outcome of this work will be UK MOD's principal contribution to the development of the US OneSAF.

2.5 Realistic Synthetic Environments for Secure Command Information Service

This work aims to determine and demonstrate how an SE can be constructed to provide an intuitive environment for users to easily specify, develop and exercise, through the stimulation of a secure command system.

2.6 Automatic Extraction of 3D Information from Geospatial Data

Building on previous work, this study aims to automate, and reduce the time taken to extract (satellite) imagery data and create a new rapid and cost effective Synthetic Natural Environment (SNE) terrain

[3] The UK MTDS Capability Working Group was instigated after Trial VirtEgo. Trials Ebb and Flow and SyCOE were funded solely by the ARP. VirtEgo and SyCLONE were part funded by Headquarters Strike Command (HQSTC) and were designed to support both research and training objectives.

database generation, containing representations of true 3D features such as buildings and mountains. The work will open up the potential for using better SE for Mission Rehearsal.

2.7 Dismounted Infantry Virtual Environment (DIVE)

This work set out to exploit current and future modified games technology to develop a low cost, networked PC based system for supporting dismounted urban operations operational analysis. AS part of this research programme a training effectiveness trial was undertaken. The virtual environment was provided using a modification of the commercial PC-game HalfLife®. The aim of this trial was to investigate the utility of the DIVE environment as a training tool using an example of Urban Operations Training at Team and Section level.

This was assessed using a mix of subjective (questionnaire) self-assessment and Subject Matter Expert (SME) observation of comparable tasks executed in the live and virtual domain. Training transfer effect was observed in two groups of two teams who followed different progressions of live and DIVE training. A second comparison was made at Section level.

Overall, the trial achieved its aims in demonstrating that Synthetic Environments (SE) such as DIVE have a role to play in training some Dismounted Infantry roles. The following key results are of note:

- Additional evidence of close correlation of team performance, mission timings and outcomes in live and DIVE environments.
- No significant performance differences between teams following different DIVE and live training progressions at fireteam level.
- Indications of benefit of using DIVE to train at Section level.
- Strong subjective support from trial participants for the use of DIVE-type systems low-level command training applications and the benefit of playback-type After Action Reviews (AAR) enabled by DIVE.

2.8 Using SE in Support of Department of State Activities

This work focuses on the (short and long-term) application of SE tools and techniques to the MOD Department of State function in Military Assistance to Civil Authorities (MACA). The formulation and execution of effective policy in times of crisis is difficult due to the complex interplay between political and socio-economic factors. The tools to be developed and demonstrated would aid the formulation and execution of crisis management policy and offer a SE training tool for those involved in such crisis management.

The aims of this research are twofold:

- To identify areas where existing SE tools can be used for modelling MACA activities, identify where there is a gap in SE capability, or where SE technology is immature for MACA applications;
- Where SEs have utility, this programme will aim to devise a tool framework with appropriate interfaces to assist government departments in the formulation and execution of policy and planning in the MACA domain and research the underpinning architecture required to implement an appropriate set of training tools. The benefit of using SEs for MACA activities include the ability to explore alternative command structures, organisations and processes, support multi-agency training through distributed means with more effective AAR and provide decision support tools which can monitor crisis development as well as assist in resource and action planning.

2.9 Avatar Mobile Instructor

This work is investigating the Military use of Commercial Avatars (the embodiment of a human form within a SE) in the context of pre-deployment training. It aims to determine whether Avatars could provide effective training with the minimum demand for qualified manpower (training staff). This could allow for increased currency of information by taking training material content from a centralised data source. The programme will culminate in a demonstration of an Avatar based system providing a (re)configurable system in appearance and functionality terms.

3.0 UK DEFENCE RESEARCH FACILITIES

3.1 Human Factors Integration Defence Technology Centre[4]

Aerosystems International (AeI) has been awarded a contract by the MoD to establish the Defence Technology Centre (DTC) for Human Factors Integration (HFI). AeI will lead a consortium formed from leading industrial and academic groups which include MBDA Missile Systems, Lockheed Martin UK Ltd Integrated Systems, systems and software house SEA, VP Defence and the Universities of Birmingham, Brunel and Cranfield. The consortium will use virtual enterprise technology to link consortium members and a shared data environment to allow all HFI DTC Stakeholders access to the results of the programme.

3.2 The Applied Research Technology Demonstrator (ARTD)

The Applied Research Technology Demonstrator (ARTD) has been constructed to test and evaluate new, emerging technologies in an enclosed, simulated battle environment. Essentially it is a 'plug-in-and-play' unit, where armed forces, MOD representatives and their industry suppliers can test new technologies by seeing how well they perform in real scenarios, played out in a computer simulated environment.

The facility itself is a series of rooms that can be linked to one another, partitioned to create separate working areas, or opened up to create virtual battle spaces. Units can be added or omitted as desired. State-of-the-art computers can stage any given scenario and even newly designed systems can be added to the simulation mix.

As a member of the Combined Federated Battle Laboratory (CFBL), a consortium, developed between the US, NATO, Australia, Canada, New Zealand and the UK, ARTD is now part of a wide network of similar facilities in friendly countries. It can operate 24 hours a day if necessary, linking with these other nations' facilities over secure links, broadening the scope of research now available to the UK MOD.

3.3 Battlespace Management Evaluation Centre (BMEC) – British Aerospace

The joint MoD/Industry partnership known as NITEworks (Network Integration Test and Experimentation works) will use the BMEC as a hub for linking other MoD and industry battlelabs together to explore network centric warfare. Other industry battlelabs include those at Dstl (the ARTD) and QinetiQ. Other companies have also been asked to identify facilities that could potentially link to the overall NITEworks programme.

4.0 UK ACADEMIC INSTITUTIONS

Many UK Universities are involved with research into Virtual Reality and Augmented Environments. The main universities carrying out work of interest are:

- Cardiff University

[4] http://www.hfidtc.com/hfidtc/index.htm

- Hull University
- Loughborough University
- Nottingham University
- Royal Military College of Science (Shrivenham and Cranfield University)

4.1 Cardiff University

4.1.1 C-HIVE – Cardiff Human Interfaces and Virtual Environments Laboratory[5]

Researchers in the C-HIVE focus on two primary areas of virtual environments (VEs; virtual reality worlds): (a) experimental investigations of the interface between people and VE systems (human-computer interaction), and (b) the use of VEs to investigate other, real-world problems. All of the research is multi-disciplinary.

4.1.2 Published Literature

Ruddle, R.A., Huddart, S.A., and Jones, D.M. (1999). *Interaction in Immersive Virtual Environments: Rotating Objects with an Instrumented Prop.* Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting, pp. 1214-1218.

Ruddle, R.A., Payne, S.J., and Jones, D.M. (1999). *The Effects of Maps on Navigation and Search Strategies in Very-Large-Scale Virtual Environments.* Journal of Experimental Psychology: Applied, 5, pp. 54-75.

Ruddle, R.A., Payne, S.J., and Jones, D.M. (1999). *Navigating Large-Scale Virtual Environments: What Differences Occur Between Helmet-Mounted and Desk-Top Displays?* Presence: Teleoperators and Virtual Environments, 8, pp. 157-168.

4.2 Hull University

4.2.1 Hull Immersive Visualization Environment (HIVE)[6]

HIVE provides state-of-the-art visualization, interaction and computing technology and related support for both University departments and industry, and is dedicated to helping researchers and industry make effective use of emergent technologies.

HIVE Facilities:

- Stereoscopic vision (using immersive workwall or desktop PC's)
- Virtual and augmented reality
- Virtual prototyping
- Collaborative design reviews
- Development of virtual environment trainers
- Simulation of urban development and terrain
- Scientific and medical visualization

[5] http://www.cf.ac.uk/psych/ruddle/C-HIVE/

[6] http://www.hull.ac.uk/hive/index.htm

- Scene capture and reverse engineering using stereo cameras, motion tracking, CMM
- Haptic interaction with visualizations
- High performance computing

Computer Science Staff around the VisionStation.

4.3 Loughborough University

4.3.1 AVRRC – Advanced VR Research Centre[7]

The Advanced VR Research Centre undertakes research in the area of immersive and pervasive computing environments. Specific applications for the research involve engineering and scientific visualisation. The multi-disciplinary research undertaken by the Centre is underpinned by in-depth investigations involving the associated human factors issues. For example: Development of intuitive GRID working environments and Improving remote visualisation across GRID architectures.

The AVRRC employs a range of specialised facilities including:

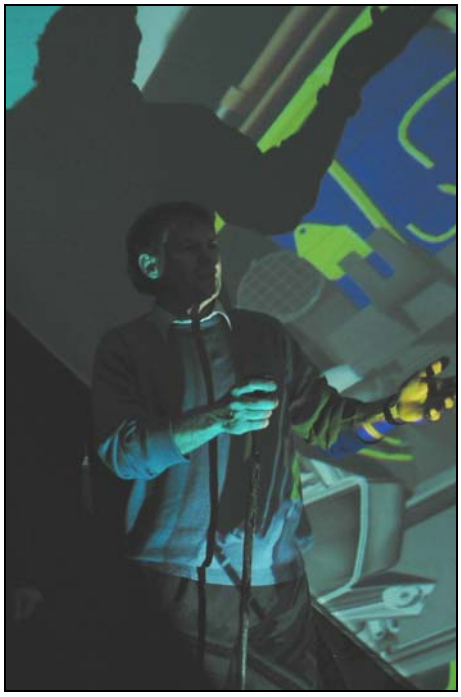
- Panoramic Reality Centre
- 5M Vision Dome®[8]. Thus is a fully immersive multi-user, single projection Virtual Reality environment for interactive space development. Upon entering the VisionDome, users are completely drawn into a fully immersive 180 degree hemispheric screen. The tilted screen is positioned so as to fill the users' field-of-view, creating an incredible sense of immersion. Users experience vivid images that take on depth via the unique optical system. The VisionDome is further enhanced by an environmental sound system. Users of the VisionDome do not have to wear head mounted displays, stereo glasses, or other restrictive devices. The VisionDome can be used for multi-user, multi-sensory display for simulation, training, design, engineering, product display, energy exploration & production, education, medical services and entertainment. A second slightly smaller Vision Dome is also available and can run in conjunction with the 5M Vision Dome.

[7] http://www.avrrc.lboro.ac.uk/

[8] http://www.avrrc.lboro.ac.uk/Visiondome_facility.html

- Immersive Wall
- SmartSpace
- AccessGrid – currently undergoing testing
- Wearable Computing Environments

Inside the VisionDome.



Loughborough University is also undertaking an extensive research programme which is focussing on developing an understanding of the complex human factors issues behind augmenting the real world with virtual information. This work links with their research on wearable computing systems and the University has been conducting extensive research in the field of Augmented Reality as a means of improving the cognitive performance. Much of this work is funded by the UK Ministry of Defence.

4.3.2 Recently Published Literature

Stedmon, W., Kalawsky, R.S., Moore, P.M., Aung, M., Purcell, J., Reeh, C., and York, T., *"It's not what you wear, it's how you wear it: Human Factors of Wearable Computers"*, Centre for Human Sciences, Defence Evaluation and Research Agency, UK, IFC Research Group, Advanced VR Research Centre, Loughborough University, UK.

Stedmon, A.W., Kalawsky, R.S., Hill, K., and Cook, C.A., *"Old Theories, New Technologies Developing Guidelines for the Cognitive Ergonomics of Augmented Reality",* Paper accepted for presentation at the IEA 2000/HFES 2000 Congress. July 30th- August 4th, 2000, San Diego, California.

JTAP Project 305, *Human-Computer aspects of Virtual Design Environments*[9].

Sony Glasstron Augmented Reality Head Mounted Display.

4.4 University of Nottingham

4.4.1 COllaborative Virtual ENvironments – COVEN[10]

COVEN was a four-year project (1995-1999) focusing on the development of a computational service for teleworking and virtual presence. The overall objective of the project is to provide the facilities needed to support future cooperative teleworking systems. The project is a unique endeavour that brings together expertise on communications infrastructures; computer supported cooperative work; virtual reality (VR) and animation to provide support for a European wide distributed virtual environment (VE). This virtual environment will enable groups of geographically disparate users to work together by inhabiting common information spaces. Partners in this work were:

- Arax, Division Ltd.

[9] http://www.avrrc.lboro.ac.uk/JTAP305introd.html

[10] http://www.crg.cs.nott.ac.uk/research/projects/Coven/

- EPFL – Swiss Federal Institute of Technology
- Integrated Information Systems Ltd.
- KPN Research
- Lancaster University
- Swedish Institute of Computer Science
- Thomson-CSF – Laboratoire Central de Recherches
- TNO Physics and Electronics
- University College London
- University of Geneva – Mira Lab
- University of Nottingham

4.4.2 Structured Evaluation of Training in Virtual Environments (STRIVE)[11]

A review of existing case-studies on VE training applications (VETs) was carried out to: examine the type of training applications and VR systems being considered; the state of development of these applications; and results of any evaluation studies. From this review it was seen that the type of VETs being explored involved the training of navigation skills or psycho-motor skills. However generally these applications had been 'proof-of-concepts' and little evaluation had been performed. Of the evaluation studies that existed, generally usability issues with the systems had confounded the results. Therefore it was felt that desktop VR would be the most appropriate system to focus on, as it has fewer of the side effects associated with other systems. Furthermore desktop VR has been highlighted as the most popular VR system because it requires very little initial investment.

In order to perform a structured evaluation, existing theories of training and evaluation were reviewed. It was clear that evaluation was inter-linked with the development process of a training application, therefore using these theories, a framework for developing VETs was suggested. This framework examined the stages of proposing, specifying, building and evaluating VETs. Then using this framework, two VETs were developed to be examined. There were a number of conclusions that were drawn from these experiments. In particular this work highlighted the many areas in the development process of an effective VET that still need addressing. There are still tools to be developed for evaluating VETs and much more evaluation studies required from academia and industry to input information back into the development process. Therefore VEs are still in their early stages but it is possible to recognize the gaps in the development process that need to be addressed before implementation.

4.4.3 Recently Published Literature

Stedmon, A.W. and Stone, R.J. *Re-viewing Reality: Human Factors of Synthetic Training Environments,* International Journal of Human-Computer Studies Vol. 55, No. 4: 675-98, October 2001.

4.5 Royal Military College of Science at Cranfield University

4.5.1 Flight Deck Officer Training[12]

Currently the British Royal Navy Flight Deck Officers (FDO) are trained at RNAS Culdrose, Cornwall, England. Although their training is shore-based, they make extensive use of real simulation, learning to

[11] http://www.virart.nottingham.ac.uk/Projects_STRIVE.htm

[12] http://www.rmcs.cranfield.ac.uk/ssel/train.htm

direct real helicopters onto a landing area. If, however, the weather conditions restrict aircraft flights or aircraft are unavailable, then the training makes use of a virtual simulation system. The current FDO training simulator at RNAS Culdrose requires another person, typically the instructor, to fly the helicopter, in response to the signals given by the trainee.

The FDO Training Simulator.

This RMCS project was an investigation into the use of virtual reality to improve the current simulator. It was envisaged that in such a system the trainee will be wearing a head mounted display (HMD) through which he is presented with the view as seen on the flight deck of a sea-going vessel (e.g. frigate). Using two three-dimensional trackers the hand movements of the trainee were monitored and computer software determined the signal that the user is giving. Once the type of signal had been determined it was fed directly into the dynamics model of the helicopter, which would then respond. Thus if the move left signal was given the helicopter would move to the left. This would remove the instructor from actually flying the helicopter and allow him to concentrate on his main task of instructing. In addition such a system would allow for more than one trainee to be trained at a time and would allow all of the benefits of computer-based training to be applied.

4.5.2 Parachute Training

The Parachute Training Simulator allows a trainee parachutist to gain experience in the handling of a parachute while immersed in a virtual world. The current application runs on a PC, running Microsoft Windows. It was built using Superscape's VRT product. Using a head-mounted display (HMD), the trainee is presented with a view of the world as they descend from an altitude of 3000ft. The use of the HMD allows the user to look in any direction thus giving a complete field of view that would not be possible, or too costly, with a monitor or projection system. The brake toggles used by a parachutist to control their descent are modelled by means of two joysticks that are interfaced to the serial ports on a PC. These inputs control the dynamics model of the parachute.

The Parachute Training Simulator – 1.

It is the aim of the trainee to manoeuvre themselves, using the brake toggles to traverse a course of control gates that an instructor has placed in the virtual world and to land at a specified location.

The Parachute Training Simulator – 2.

The simulator allows for a variety of malfunctions in the operation of the parachute:

- Line twists
- Line bunched together
- End cells closed (slider up or down)

- Streamer
- Canopy damaged
- Canopy distortion

This allows the trainee to become familiar with the recognition of good and bad canopies and the procedures that should be followed in the event of a malfunction.

The trainee's control inputs and flight path are recorded for review after landing, giving the instructor the option to explain any incorrect actions taken.

Initial testing of the simulator by experienced and student parachutists has shown that it offers potential benefits for parachute training.

It is hoped that the future work will:

- Extend the modelling to allow for different canopy types.
- Improve the visual sub-system allowing for greater depth perception, weather effects and day/ night capability.
- The ability to use real-world terrain.
- Improve the input device mechanism so as to have greater range of movement.
- Incorporate the simulator into a network to give the ability for team training.

4.5.3 Recently Published Literature

Smith, J. and Steel, J., *"The Use of Virtual Simulation for Dismounted Infantry Training",* NATO Modelling & Simulation Conference, Royal Military College of Science, Shrivenham (RMCS), England, October 2000.

Sastry, V., Trott, E., and Steel, J., *"A Virtual Environment for Naval Flight Deck Operations Training",* NATO Research & Technology Organisation Meeting Proceedings: MP-058, March 2001.

Hollis, Dr. J.E.L., Meinertzhagen, Maj. R.D., and Lai, Maj. N., *"Application of Virtual Reality Technologies to Communications",* IEE Conf. Pub., 1997, IPA97.

Brent, Maj. P., *'Networked Virtual Reality for Dismounted Infantry,'* RMCS July 1998.

Ourston, D. and Reece, D., *'Issues Involved with Integrating Live and Artificial Virtual Individual Combatants'*, SAIC Stricom.

Hutchinson, Maj. N., *'The Simulation of Dismounted Infantry'*, RMCS, 2000.

Clarkson, Maj. M., *'Low Cost, 3D, Interactive Networked Training'* RMCS 1998.

Jones, Maj. I., *'Desktop Dismounted Infantry Trainer A Proof of Concept Demonstrator'*, RMCS 1999.

Percival, Maj. A.E., *'Distance Estimation in Virtual Environments'*, RMCS 2001.

Bosher, Maj. P. *'Training Transfer in Environmental Awareness from Virtual Environments',* RMCS 2001.

4.6 University of Surrey

4.6.1 Synthesising Human Motion for Virtual Performance

Recent research has achieved automatic reconstruction of realistic 3D models from surface measurements of static objects and environments. Currently captured object models are represented as dense unstructured polygonal meshes. Direct application of unstructured meshes for computer generated imagery is prohibitively expensive. The proposed research addresses the automatic reconstruction of functional models that are optimised according to the requirements of a particular application. Functional requirements include realistic and efficient representation of the development of techniques to enable automatic reconstruction of functional models of real objects suitable for realistic computer generated imagery. Applications include realistic object modelling for virtual environment, animation and Internet transmission. In particular application of this research will be based on existing expertise in capturing 3D models of complex organic objects and internal environments.

4.7 School of Computer Science Information Technology

4.7.1 The Realisation and Utility of Persistence in Collaborative Virtual Environments

The design and authoring of a collaborative virtual environment is normally distinct from its activation and use. For example, completed virtual worlds are made available as fixed definitions (e.g. world description files) which are used repeatedly to create distinct instantiations of active virtual worlds. This project will investigate the implementation and utility of collaborative virtual environments for which design, creation, publishing and use are not differentiated and are available to all participants. This builds on the proposer's PhD work in the area of large-scale collaborative virtual environments, which include the implementation and ongoing testing of the MASSIVE-1 and MASSIVE2 CVE systems. From a distributed systems' perspective, the project will identify and employ system and programming facilities to implement persistent virtual worlds. These will be integrated with an existing virtual reality system or tool kit. From a human factors perspective the project will make one or more such worlds.

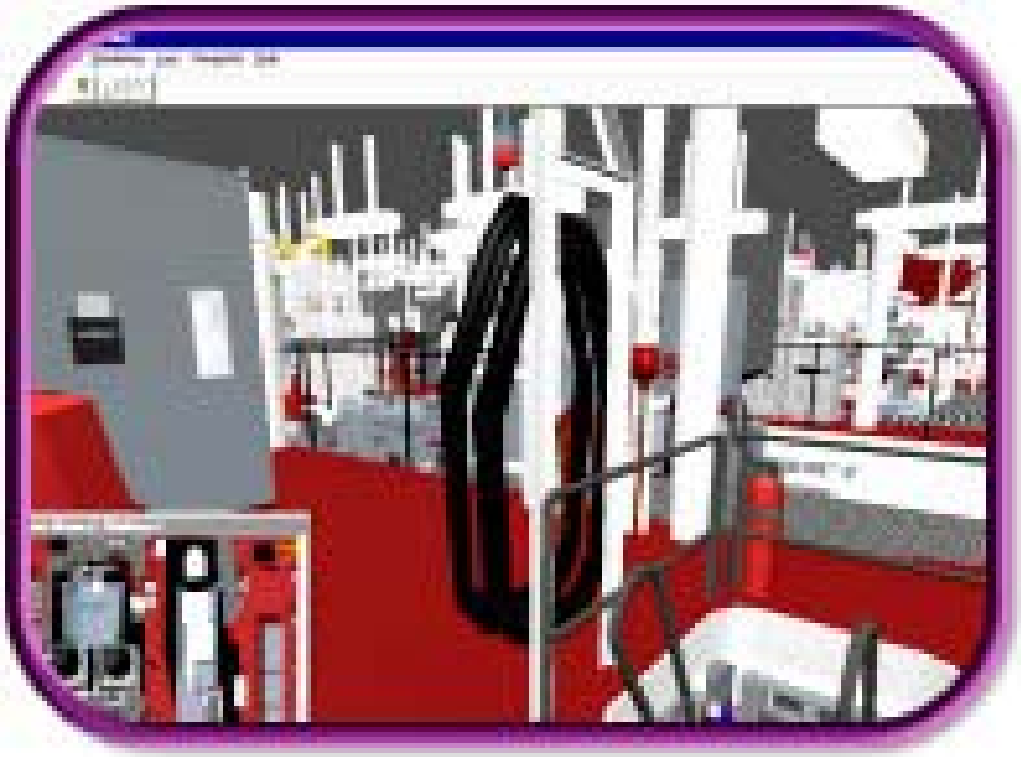
5.0 UK COMMERCIAL COMPANIES

5.1 Facit – A Division of TWG Ltd.[13]

Facit are developers of Sense8 virtual reality authoring software, building commercial visualisation applications for a wide range of industries including retail, education, construction and engineering. Augmented Reality (AR) is a growing area in their virtual research. Augmented Reality can be integrated into a number of different industries as a turnkey solution. Current AR users include Academics, Medical, Entertainment, Military Training, Engineering Design, Robotics and Telerobotics, Manufacturing and Consumer design. Facit aim to bring a solution to industries looking at the implementation of Augmented Reality into their current research projects. They have had success in supplying AR Head Mounted Displays and also the solution of constructing personalised AR unit from products currently available within the IT market.

In addition they supply simulators for the defence market which includes large-scale operations planning and mission rehearsal to part-task training, using a blend of VR and multimedia. Multiple students can familiarise themselves simultaneously with complex systems, vessel or craft layout, maintenance tasks, fault-finding, repair and refit.

[13] http://www.facit-vr.co.uk/defence_simulation.htm



Augmented Reality for Familiarisation of Vessel Layout.

5.2 Advanced Interactive Solutions Ltd.[14]

AIS work in partnership with large system integrators and strategic partners to deliver comprehensive training solutions. AIS integration of simulation technology and readiness certification through advanced information systems is ideally suited for readiness assurance for military forces. In April 2003 AIS announced the sale of a new computerised training simulator to the UK MoD. The UK MOD has purchased an AIS P3000 Live Fire PRISim™ System. The system will be used for close-quarter battle training and counter-terrorist training and provides highly realistic use-of-force training that develops the skills required for personnel armed with both lethal and non-lethal weapons. Flexible deployment options allow training to be delivered at fixed facilities or at any off-site location.

The PRISim™ platform produces exceptionally realistic video-based environments for all aspects of firearms handling including marksmanship, decision-making, and tactical strategies and uses broadcast-quality DVD technology.

[14] http://www.ais-sim.com/casestudies_military.htm

Firearms Training Handler.
(http://www.ais-sim.com/news_press_releases_060703.htm)

Sim Room.

5.3 Inition Ltd.[15]

Inition deliver bespoke solutions to clients, having years of experience working with the following technologies:

- Virtual Reality
- Stereo Visualisation
- Interactive Art & Visuals
- Systems Integration
- Web 3D, Bespoke Application Development

5.4 Maelstrom Virtual Productions Ltd.[16]

Virtual Reality training and simulation environments have been built in the fields of medicine, energy, architecture, and Military.

5.5 Virtual Reality Centre at Teesside Ltd.[17]

The company is involved in image generation, visualisation and training simulations. It creates PC-based and internet off-line visualisation and training packages for various industries. Their products include:

The Hemispherium® – a 6m dome using 7 projectors to give a full 180° field of view and driven by a 3 pipe Silicon Graphics IR2.

The Hemisperium®.

The Auditorium – a 7m wide Cylindrical Display using 3 Projectors to give a 140° x 45° Field of View.

[15] http://www.inition.co.uk/

[16] http://www.maelstrom.com/military.htm

[17] http://www.vr-centre.com/

The Auditorium.

5.6 cueSIM (ex-Motionbase)

Originally developed by Motionbase plc at Bristol, production is now by cueSIM at Bedford. QinetiQ acquired Motionbase in 2002 and formed cueSIM. The company has access to the simulation expertise of its owner organisation, the UK company QinetiQ plc that deals in R&D for the UK Ministry of Defence. This may be particularly important in aspects such as multi-player networking and the use of Computer Generated Forces (CGF). Their products include:

- VANguard multi player simulators: VAN stands for Virtual Air Network and this range of devices is designed to be coupled together for mission training exercises. A modular design is employed and types from desktop to motion-based Full Flight Simulators are available. Facilities include DIS, HLA and CGF.
- RTAVS simulation: This stands for Real Time All Vehicle Simulation and includes DIS/HLA compliance and compatibility with many COTS components. RTAVS is essentially a software architecture that allows hardware to be rapidly implemented.
- Motion platform: CueSIM Maxcue 6-DoF electric.
- Explorer dynamic flight simulator: This includes a compact flight simulator cockpit shell mounted on an electric motion platform. The display system comprises three of the company's collimated monitors.

cueSim Dynamic Flight Simulator.

5.7 Pennant Training Systems Limited (PTSL)[18]

5.7.1 Virtual Aircraft Training System (VATS)

This is a computer-based classroom training system for aircrew and maintainers.

Features include interactive training, maintenance and diagnostics, aircraft systems emulation with faults, test equipment and LRU change.

The Virtual Aircraft Training System.

[18] http://www.pennantplc.co.uk

5.7.2 Synthetic Environment Procedural Trainer (SEPT)

The Royal Air Force has adopted the very latest development in Virtual Reality to enable training of recruits in marshalling and ground handling of aircraft. The trainer, known as the Synthetic Environment Procedural Trainer (SEPT) is in service at RAF Cosford where, after classroom instruction on the required skills and safety procedures, students consolidate their learning through practical experience on the SEPT. This is an ideal preparation ground for the real situation where the marshaller must give clear and positive direction to the aircraft pilot.

SEPT is a complete procedural trainer providing high fidelity, real-time, computer generated images of an operational airfield with realistic visual and aural representations of operational aircraft, general airfield activities, buildings and vehicles. Central to the SEPT's capability is the high-fidelity visual system with its wide field of view (FOV). The aircraft visual is integrated into the SEPT computing system that contains an aural-cueing database, synthetic airfield database and Instructor operating facilities.

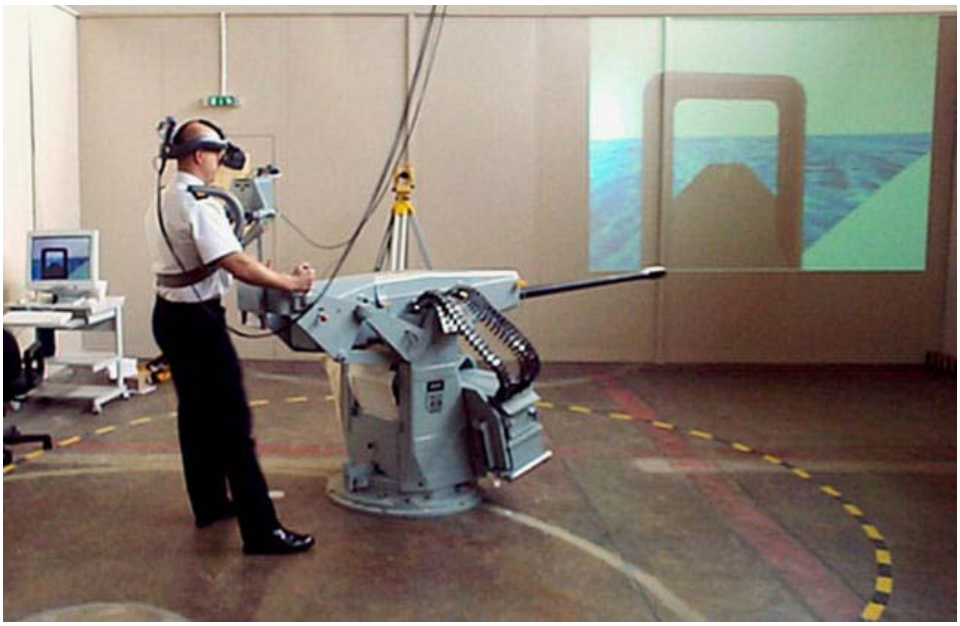
The Ground Marshalling Training Simulator.

The visual database is projected onto a wide-angle screen in front of the trainee who is then able to conduct the Marshalling and Ground Handling of Aircraft, in an immersive environment. This enables the trainee to progress from a theoretical base into the practical environment and instills confidence in undertaking the task for real.

5.8 Virtalis – Naval Virtual Reality Close-Range Gunnery Trainer (CRGT)[19]

Virtalis employs an experienced team of software, hardware, electronics, human factors and design specialists. They form partnerships whatever type of work is needed, be it a short commercial feasibility study, an in-depth technology review, a concept demonstrator or a full-blown visualisation system.

[19] http://www.vrweb.com/



The Virtual Reality Gunnery Trainer.