TNO Human Factors – The Netherlands

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1.0 AREAS OF INTEREST

TNO Human Factors distinguishes the following areas of interest as regards augmented, mixed, and virtual environments for intuitive human-system interaction: mixed and virtual environment operations, tele-operations, command & control, and wearable augmented technology.

2.0 CURRENT RESEARCH PROJECTS

2.1 Mixed and Virtual Environment Operations

The goal of the projects in this area is realistic simulation and training of flying, driving, and dismounted soldier team operations (MOUT), and virtual prototyping of various designs, i.e., digital models of ship bridges, vehicles, offices, etc. Various projects are currently carried out in this area, using the facilities and technologies shown in Figures 1-5. Special attention is given to research into the determinants of presence and performance in mixed and virtual environments, focussing on team operations in urban terrain and using ‘agent’ and ‘avatar’ digital human models.

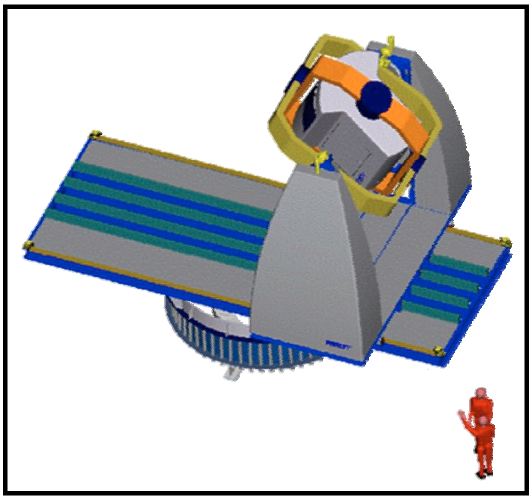

Figure 1: Desdemona, a 6DoF Next Generation Motion Platform for Spatial Disorientation Training and for Driving and Flight Simulation with Sustained G Capabilities.

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14. ABSTRACT

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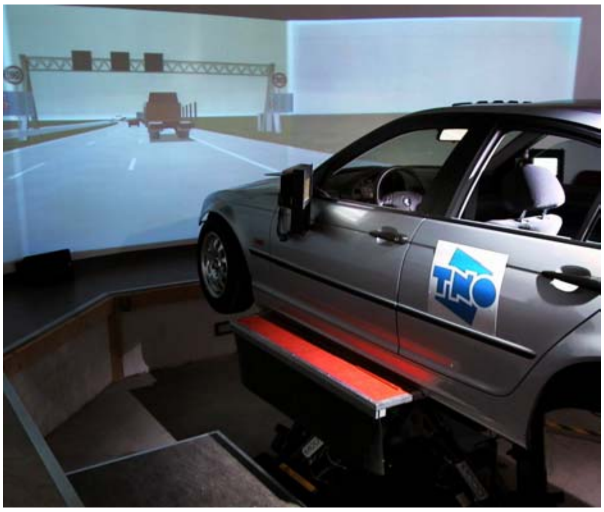

Figure 2: Moving-Base Driving Simulator.

Figure 3: Military Operations in Urban Terrain –
Subject immersed through head-mounted display.

Figure 4: Ship Bridge Virtual Prototyping.

Figure 5: Manipulation of Objects.

2.2 Tele-Operations

The goal of the projects in this area is intuitive control of remote ground and air vehicles (for tele-consultation: interaction of distributed subjects). Various projects are currently carried out in this area, using the facilities and technologies shown in Figures 6-10. Special attention is given to research into the determinants of presence and performance, focussing on the remote ground vehicle (‘The General’, Figure 6).

Figure 6: ‘The General’ Tele-Presence Enabled Unmanned Ground Vehicle (indoor version; at the left) and the Ground Control Station (at the right).

Figure 7: Unmanned Aerial Vehicle (UAV) Flying.

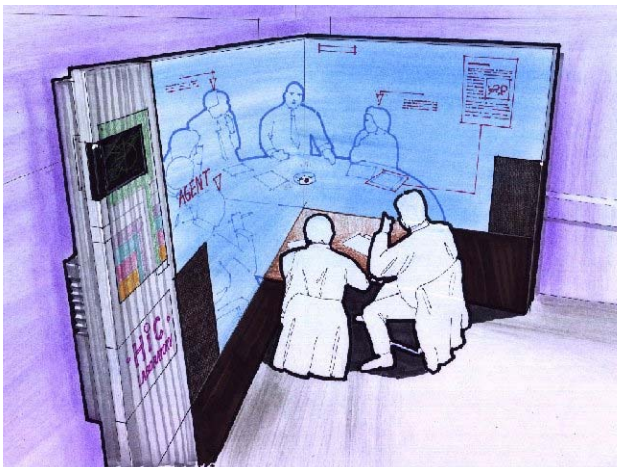

Figure 8: Tele-Conferencing – VIRTUE (Virtual Team User Environment).

Figure 9: Tele-Maintenance. At the left: a mechanic at work, providing a picture to the expert with a hand-held camera. At the right: an expert guiding the mechanic at a distance, communicating with video and duplex audio.

Figure 10: Tele-Medicine Body-Mounted Equipment.

2.3 Command & Control

The goal of the projects in this area is to develop and test new concepts of team organisation, human-system task integration and intelligent interfaces for efficient and effective command and control (example: Figure 11). Starting with a set of missions and tasks, the trade-off between task distribution, personnel qualifications and support concepts is analyzed. Modeling and simulation tools are used to analyze concepts and to monitor how workload is distributed over the personnel during a scenario.

Figure 11: Mock-up for the Landing Platform Dock 2 (Common Operational Picture).

Research on intelligent interfaces focuses on situation and operator state dependent adaptive interface concepts with integrated tools for information management and decision support. Concepts are implemented and tested in a new command & control workstation set-up called the Basic-T (Figure 12). It incorporates 3D perspective and stereo images of the tactical picture.

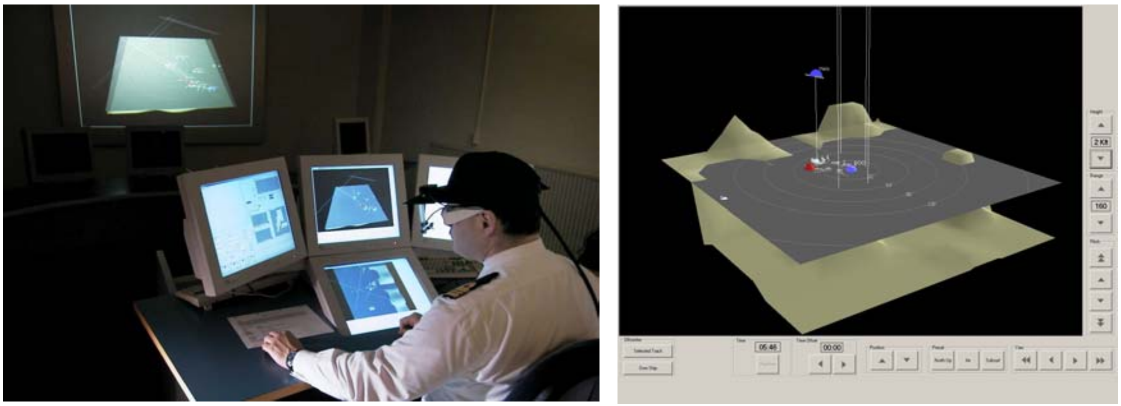

Figure 12: Basic-T (3D Tactical Picture).

2.4 Wearable Augmented Technology

The goal of the projects in this area is to provide situation awareness, communication and navigation for military and rescue services in the field. The deliverables are technology demonstrators, such as the tactile suit (Figure 13), prototype products, such as integrated headwear (Figure 14), and specifications (technical requirements enlightening human factors choices).

Figure 13: Pilot Wearing a Laboratory Version of the TNO Tactile Torso Display (TTTD), or Tactile Suit (in the back: a RNLAF Chinook Helicopter). This particular version of the TTTD contains twelve columns of five rows of vibro-tactile actuators, plus four more on shoulders and between the upper legs and the seat.

Figure 14: Example of Gen. 3 Integrated Head Based Systems (courtesy TNO).

3.0 RESULTS ACHIEVED TO DATE

Publications on the results achieved to date can be found in the section ‘Literature prepared by researchers’. This section contains brief descriptions as regards the areas distinguished.

3.1 Mixed and Virtual Environment Operations

Basic research has been conducted on spatial orientation, navigation, and glove manipulation by subjects in various virtual spaces with a comparison to the equivalent real space. Virtual prototyping is implemented as a flexible and user-collaborative design method. The method has been applied to various workplaces, such as ship bridges, control rooms, and military vehicles.

Desdemona is under construction and is scheduled to be in operation at the end of 2005.

3.2 Tele-Operations

In the past a range of human factors aspects of unmanned (military) vehicles has been studied. The effort was focused on remote control of cameras, dealing with such issues as transmission delays and bandwidth limitations, situation awareness, and image augmentation. In more recent years, issues worked on have shifted to operator training, operator skills, ground control station design, automation design, human factors guidelines and standards, and manned-unmanned collaborations.

3.2.1 UAV Flying

Various interfaces to assist the operator were developed, and a series of experiments has been conducted. It was shown that the manual control of the camera of an unmanned aerial vehicle (UAV) can be difficult due to several factors such as time delays between steering input and changes of the monitor content, low update rates of the camera images, and lack of situation awareness due to the remote position of the operator and the small field of view of the camera images. Furthermore, if the UAV is controlled from inside an aircraft (moving operator), the operator has to deal with different frames of reference.

3.2.2 Tele-Presence Control Station

A new track is the work on tele-presence control stations. Intuitive (perceptual-motor) control of remote camera and possibly platform will free up the cognitive resources that are needed for performing the task at hand (e.g., acting in the remote environment, decision making, etc.). 'The General' is the first attempt to demonstrate this concept. It currently features immersive head-slaved stereo images and 3D sound, vibration sensations, body control of platform movement, and remote manipulator control. Special attention is given to research into the determinants of presence and performance in tele-operation settings.

3.2.3 Tele-Conferencing

VIRTUE (virtual team user environment) aims to create a multiparty meeting space where virtual and real worlds are seamlessly combined so that participants at different locations can have the impression that they are sitting next to each other and can work co-operatively. Experiments were carried out on the effects of shared background, stereoscopic vision and motion parallax, video and audio delays, and deviations in gaze direction on tele-presence. It turned out that tele-presence was not influenced by these variables. People have a high tolerance toward critical factors such as gaze deviations and delays. However, negative effects may appear under more critical circumstances and with more sensitive and more objective measures.

3.2.4 Tele-Maintenance

When knowledge, required for trouble-shooting at sea, can be supplied real-time but from a distance, problems, such as with the limited availability of specialists, and the high costs of maintenance, may be tackled. An experiment was performed with thirty subjects, in which an on-shore expert and an on-board mechanic fixed technical problems together. The results show that, in principle, the problems could be fixed, both by technical and non-technical mechanics, although it requires more time, communication and effort. Unfortunately, it is less safe.

3.2.5 Tele-Medicine

The tele-medicine project created opportunities to study an on-line mediated workplace involving a medic treating a patient, and a doctor at a remote site giving advice. Clinical experiments showed the effects of equipment and settings used, the mounting of the equipment, and the resulting conversation. A direct feedback tele-viewing system addressed the issues of delays and decreased image quality on telecommunication links.

3.3 Command & Control

Various new command concepts have been created and tested for the Dutch armed forces. With Basic-T as a testbed the different tools for information management and decision support have been tested for future application in the maritime environment.

3.4 Wearable Augmented Technology

3.4.1 Tactile Suit

The tactile suit can be viewed as a cockpit instrument, and ongoing research is establishing its value for navigation, hovering, threat warning, spatial disorientation countermeasures, communication, and other purposes. The same technology is also used for application on land (navigation support and threat warnings for drivers, infantrymen, blind people, etc.), underwater (divers), and in space (astronauts in the ISS).

3.4.2 Integrated Head Based Systems

Future soldiers will wear helmets in various degrees of encapsulation, as an optimization of protection, perception, and usability. Although information presentation is an important aspect (new type of non-obstructive head mounted display, high resolution on the move, restoration of 3D environmental sound while wearing hearing protection), the human factors integration is key to head based systems (design for a stable fit, weight and balance, scalability to head form, anthropometric variety, hearing protection, vision, facial recognition, quick conversion from grim to kind appearance). Head based systems replace a large number of equipment items while being fully compatible with the soldier system. Head based systems are a platform for additional functions such as instrumented vision, antenna's, breathing protection and climatization. Soldiers need for instance a day and night vision capability, that allows them to supervise, acquire targets, aim and shoot. Speed and accuracy compete for priority. Shooting comes in direct and indirect fire, demanding rather different aiming techniques. Though nothing is virtual at this, it is an outstanding example of the need for intuitive human system interaction. Procedures need not be different between day and night, sensor images need to combine so as to require minimal operation for switching. And there must be a smooth transition between searching and aiming, without losing the target. We found a practical solution that is economical and convertible to various military tasks.

4.0 COLLABORATIVE PARTNERS

TNO Human Factors collaborates with a large variety of national and international military and non-military organisations. Refer to www.tno.nl for more information.

5.0 LITERATURE PREPARED BY RESEARCHERS

This section contains a selection of the literature prepared by TNO-HF. Refer to www.tno.nl for more information.

5.1 Mixed and Virtual Environment Operations

5.1.1 Basic Research and Virtual Prototyping

Werkhoven, P.J. and Groen, J. (1998). Manipulation performance in interactive virtual environments. Human Factors, 40 (3), pp. 432-442.

Bakker, N.H. (2001). Spatial Orientation in Virtual Environments. PhD Thesis. Delft, The Netherlands: Delft University Press.

Delleman, N. and Oudenhuijzen, A. (2003). Advances in predicting motor behaviour, comfort and performance for digital human models. Proc. of the XVth Triennial Congress of the International Ergonomics Association “Ergonomics in the Digital Age”, August 24-29, 2003, Seoul.

5.1.2 Desdemona

Bles, W., Hosman, R.J.A.W., and De Graaf, B. (2000). Desdemona: Advanced Disorientation Trainer and (Sustained-G) Flight Simulator. AIAA Modeling and Simulation Technologies Conference. Denver, Co. August 14-17, 2000. AIAA 2000-4176.

Bles, W. (2001). Desdemona: Advanced Disorientation Trainer. HSIAC publication Gateway, SD-edition Fall 2001.

5.2 Tele-Operations

5.2.1 UAV Flying

De Vries, S.C. and Jansen, C. (2002). Situational awareness of UAV operators onboard of moving platforms. Proceedings HCI-Aero 2002, P 024.

Van Erp, J.B.F. and Van Breda, L. (2001). UAV Operations using Virtual Environments. What is essential for virtual reality systems to meet military performance goals? AC/323(HFM-058) TP/30. Neuilly-sur-Seine, France: RTO NATO, 2001, pp. 125-131, 2001 P 054.

Veltman, J.A. and Oving, A.B. (2003). Augmenting Camera Images for Operators of Unmanned Aerial Vehicles. In: The role of Humans in Intelligent and Automated systems. (RTO-MP-088) HFM symposium, Warsaw, Poland, October 2002, pp. 21.1-21.10.

5.2.2 Tele-Conferencing

Van Besouw, N.J.P., Van der Kleij, R., Werkhoven, P.J., and Machin, D.J. (2000). VIRTUE – virtual team user environment requirements specification (Report TM-00-D010). Soesterberg, The Netherlands: TNO Human Factors.

Schraagen J.M.C. (ed.) Final research report on human factors experiments (Report TM-02-D006). Soesterberg, The Netherlands: TNO Human Factors.

Van der Kleij, R., Paashuis, R.M., Langefeld, J.J., and Schraagen, J.M.C. (in press). Effects of long-term use of video-communication technologies on the conversational process. Cognition, Technology, and Work.

5.2.3 Tele-Maintenance

Post, W.M., Van den Boogaard, S.A.A., and Rasker, P.C. (2004). Distributed Trouble-Shooting. In: Darses, F., Simone, C. (Eds.) Scenario-based design of Collaborative systems. IOS Press. In press.

5.2.4 Tele-Medicine

Hin, A.J.S. (1998). Camera configuration and communication for on-line tele-consultation. ITEC’98, Medical Simulation Conference.

Hin, A.J.S. and Delleman, N.J. (2000). On-line teleconsultation: a human factors technology. Proceedings of ‘Combat Medicine: the future of military medicine and battlefield support, May 22-23, 2000, The Hatton, London. London, UK: SMI.

5.3 Command & Control

5.3.1 Common Operational Picture

Punte, P.A.J. and Post, W.M. (2004). Design and evaluation Joint Operations Room LPD-2. Soesterberg, The Netherlands: TNO Human Factors. In press.

5.3.2 Basic-T

Van Delft, J.H. and Schraagen, J.M. New MMI concepts for situation assessment and decision making in naval command and control. SCI-129 Symposium on ‘Critical Design Issues for the Human-Machine Interface’, Prague, Czech Republic, 19-21 May 2003.

Van Delft, J.H. and Passenier, P.O. Interface Concepts for Command & Control Tasks. NATO RTA/HFM Symposium on ‘Usability of Information in Battle Management Operations’, Oslo, Norway, 10-13 April 2000.

5.4 Wearable Augmented Technology

5.4.1 Tactile Suit

Van Erp, J.B.F., Veltman, J.A., Van Veen, H.A.H.C., and Oving A.B. (2003). Tactile torso display as countermeasure to reduce night vision goggles induced drift. NATO RTO meeting on ‘spatial disorientation in military vehicles: causes, consequences and cures’ help in Spain, 15-17 April 2002, RTO-MP-086, pp. 49.1-49.8.

Van Veen, H.A.H.C. and Van Erp, J.B.F. (2001). Tactile information presentation in the cockpit. In: Brewster, S., Murray-Smiths, R. (Eds.): Haptic Human-Computer Interaction. Springer Verlag, 2001 (Lecture Notes in Computer Science), pp. 174-181.

5.4.2 Integrated Head Based Systems

NATO Standardization Agreement (STANAG) Head Borne Systems Standards for Dismounted Soldier Systems, first draft 2004, NATO NAAG/TG1. No unclassified references available at this time.

6.0 VR R&D LABORATORY FACILITIES AVAILABLE

Most of the technology used can be found in the new SimLab and the new Desdemona facility (Figure 15). The following facilities and technology are available:

Figure 15: TNO Human Factors SimLab and Desdemona Facility.

6.1 Mixed and Virtual Environment Operations

- Visualisation means (HMD, large screen projection, 3D-glasses)
- Moving base with an instrumented car or truck cabin
- Fixed base flight simulator
- Desdemona, a 6DoF motion platform
- Digital human models (agents and avatars)
- Body tracking (locomotion, gestures, etc.)
- Data glove (manipulation of objects)
- 3D sound

6.2 Tele-Operations

- Ground vehicle operations ('The General')
- Unmanned Aerial Vehicle flying
  Related technology
- Tele-conferencing / virtual team user environments
- Tele-medicine (consultation / tele-knowledge)
- Tele-maintenance (consultation / tele-knowledge)

6.3 Command & Control

- Basic-T
- Common Operational Picture mock-ups

6.4 Wearable Augmented Technology

- Integrated head based systems
- Tactile suit