Annual Review of Cybertherapy and Telemedicine

Volume 3 Year 2005 ISSN: 1554-8716

Interactive Media in Training and Therapeutic Intervention

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Virtual Technologies for Extreme Environment Effect Mitigation

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Abstract: *This paper examines the demands of a manned system operating in an extreme environment, where there is the need to enhance or at least maintain crew health, team spirit and cohesion, and how nouvelles techniques based on Virtual Reality technologies can provide some answers. A typical example is a manned mission to Mars with a crew of 4-8 astronauts where it is mandatory to maintain their psychological health for a mission that is envisaged to last from two to three years. They will have to work and live in an artificial environment with limited resources (for example communication capability with ground, due to the distances involved, cannot be a direct two way system) and living volumes. The paper proposes some possible fields of investigation. It will also consider the fact of how these innovative technologies based on Virtual Reality will have to be developed and tested.*

INTRODUCTION

In the next 25 years we can expect to see two things. First human beings will be installed in various extreme environments of which one can be the Moon or even Mars. On the other hand many new Virtual Reality (VR) applications will be available to augment our capabilities in various areas from entertainment to medicine and engineering, but it is also possible to envisage that VR or AR (Augmented Reality) may be especially employed where the human being is facing highly demanding challenges. In this paper what might be used in future manned space missions is discussed with a special emphasis on the possible utilisation of VR/AR to support the maintenance of on-board crew well-being.

IDENTIFICATION OF THE PROBLEM

The future Moon and Mars exploration missions foresee, after some pilot missions to the Moon, a series of long missions with human permanence on board. These range from permanence on the Moon surface of one year (the trip of 3-4 days to the Moon is negligible compared to the permanence) to a mission to Mars of three years of which up to one may be spent in travelling to and fro. The envisaged size of the crew ranges from 4 to 8 people, each of whom is highly motivated and knowledgeable. The crew will certainly be specifically selected and highly trained. In addition, they will receive all possible support, and it is expected that VR/AR techniques will be widely employed to provide this support, augmenting crew capability in controlling the overall system, robots and handling communications. It would not be surprising, for example, if VR/AR based training techniques were employed both on ground in preparing the mission and in orbit to handle the unexpected. But there is another area where VR/AR may be employed, that is in the maintenance of the crew's psychical well-being and in maintaining the team's positive attitude and cohesion.

TYPICAL MISSION: EXPLORATION SPIRAL 3/LUNAR BASE AND MARS TESTBED

From NASA Requirements Document "ESMD-RQ-0013". "Exploration Spiral 3 will establish the capability to conduct routine human long-duration missions at a lunar base to test out technologies and operational techniques for expanding the human presence to Mars and beyond. Missions in Spiral 3 will extend up to several months in duration at the lunar poles or equatorial region in order to serve as an operational analog of future Mars missions. Spiral 3 will require the development and deployment of habitats and surface power systems. … Once the surface systems are in place, successively longer missions will be conducted to increase

the understanding of system technical performance (including health and human systems), and to provide increasing levels of operational autonomy capabilities that will be necessary for future human Mars exploration missions."

Related Main Mission Characteristics:

- Crew: 4 Astronauts.
- Gravity: 1/6 of the gravity of the Earth
- Mission Duration:
  - 6 days travel from Earth to Moon;
  - 42 to 600 days permanence on the surface;
  - 7.5 days from Moon back to Earth.
- Habitation Facilities:
  - Transportation phases Crew Exploration Vehicle (CEV) plus Mission Module approx. 14 m^3 volume available for the crew;
  - Up to 200 m^3 gross volume available for the crew for habitability and working areas. This volume may be increased with an additional logistic cargo module that can be connected to the main habitation and laboratory module.
- Surface Crew working and related Activities:
  - It is expected that in one year there will be more than 200 Extra Vehicular Sorties with two people in each one;
  - Control the extensive utilization of robots and automated Rovers for exploration
  - Other activities foreseen are system maintenance and performance of experiments to prepare for Mars missions.
- Surface Crew off-duty and related Activities:
  - Housekeeping
  - Exercise & health maintenance
  - Eating, sleeping and hygiene

Free time.

Identified issues:

- **Communications**: although the distance between the Moon and the Earth is relatively small, communication delay is of approximately 6 seconds each leg. This will require a different concept of control for all used automated systems. Now most of the controls are performed on ground by the flight control personnel. For voice communication it might be only a nuisance but its effects on the crew over a long period are unknown. In case of Mars mission the communication delay can be up to 20 minutes each leg: this will sharply increase the communication problem.

- **Safety & Isolation**: the handling of emergencies during these exploration missions is completely innovative with respect to the approach taken for the Space Station where an injured or ill crew member can be back on the Earth in approximately 12-16 hours. Starting from the Moon surface it would take as a minimum 5-6 days and from Mars up to 6 months to return to Earth, so most of the emergencies must be handled there.

- **Group dynamics and roles of each astronaut:** this is one of the keys to mission success, which means being able to maintain - throughout the mission and despite any problem that may arise - a positive attitude of each single component of the team as well as of the team itself.

POSSIBLE ROLE OF VR

Most probably there will be quite ample applications of VR/AR techniques to improve the quality of the working environment on board during these long exploration missions. These applications can be envisaged in the field of:

- Communications between Moon base and the Earth or between the exploring astronauts and the Moon Base.
- Training (on the job)
- Automatics and Robotics command/control

- Support to procedure implementation,

Leisure i.e. movies and scenery display (some students have conceived a relaxation room with VR)

All these applications are up to now perceived as single pieces of application, each developed to handle a specific need but not linked one to the other. What has been missing up to now is an integrated system that can perform all that has been mentioned before, but beyond that will be able to take care of the maintenance of the psychological well-being of the astronauts both at individual level as well as at team level. This system shall be capable to move from present applications of VR techniques aimed at restoring people's well-being by, for example, treating the fear of flying like the VR technique described in reference[2] to a nouvelle application of monitoring and maintaining the human being's well being.

An integrated system based on VR/AR technique of exchange of information and control with the crew also with the use of nouvelle techniques of Brain Computer Interface (BCI) can be developed. This integrated system can not only give the crew an effective support both in working and non-working activities but, since it can be envisaged that it would be capable of monitoring their health, it can also intervene by taking actions to reduce/control potentially dangerous situations.

DISCUSSION

Clearly a system such as the one proposed is not available in the short term and it will take a well coordinated effort to develop; on the other hand, there are some issues - some simple but some others much more complex involving ethics - that it is better to start discussing now.
The following are the issues to be investigated in order to set the requirements capable to describe a system to be produced that respects the ethics of the human being but on the other hand is capable of guaranteeing the mission success:

- Private experiences vs. common experience (screen vs. helmet or both): How can the group dynamics be supported?
- Communication system: How to overcome the time lag constraint maintaining a level of "quality" and "effectiveness" in communication? - especially if it is used as a keystone for well-being maintenance.
- Psychological Health maintenance: How and when can VR/AR be used to support the Crew's Psychological Health?
- Psychological Health monitoring system: How can the psychological well-being of the singular member and of the group be monitored?
- Training and other VR/AR applications used for Crew support: VR/AR are recognised candidate techniques for training as well as to provide information and control capability to a crew member but can this VR/AR system be exploited to the level required without overloading the human being?
- Human VR interfaces: New interfaces are being developed including the BCI: how can these be used without violating ethical rules?

If such a system can be developed and accepted for utilisation would it be possible to refer to it as VR/AR system or must we use a new word like an enhanced reality system?

CONCLUSION

This paper was not aimed at giving solutions but more at collecting questions and doubts. Nevertheless two positive issues can be gathered from what was presented before:

- First how extreme environments can be used as technological trend identification and then can become valid test beds for research and development of new techniques

How a user centred approach is more and more needed in order not to be overcome by the technological push especially in new areas like VR/AR.

REFERENCES

[1] Exploration Crew Transportation System Requirements Document (Spiral 3) Version Preliminary – Revision D 22 Feb 2005 (ESMD-RQ-0013) - http://exploration.nasa.gov/documents/documents.html

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