Virtual reality

Technology

IntroductionThis proposal will compare and evaluate two ways of producing virtual reality, and of measuring their effectiveness in preparing astronauts for EVA. We propose to evaluate the effectiveness of using Immersion Virtual Reality (IVR) technology in place of Neutral Buoyancy Simulation (NBS) for training NASA astronauts to perform extravehicular Activities (EVAs) in order to reduce training costs and safety risks as well as to improve astronaut performance. The first portion of this proposal will deal with measuring how well tasks are performed using the previously-accepted standard of NBS versus a new model of IVR. The second will deal with measuring the astronauts' perception of the effectiveness, benefit, and capability of IVR and NBS training. Primary Measurements of Training Effectiveness NASA's mandate is to address three elements before introducing a new training modality: reduce training costs, improve safety and improve astronaut performance. Any new technique needs to demonstrate superiority in at least one of these parameters. It is important to note that there is a significant ' S-curve' effect in adopting any new methodology: lots of effort going in, then significant payback as the new methodology is adopted and demonstrates greater productivity. One can look at NBS as a ' perfected' technology, one in which a lot more effort will not improve the methodology very much. If, on the other hand, IVR can be shown to be superior at present, the ' S-Curve' effect dictates a greater improvement in the future. Measuring and Comparing IVR and NBS NBS has been established since the 1960's to help train astronauts on EVA. There is therefore a substantial record of learning times on specific tasks, which can then be correlated using real spacewalk experience. With over 30 astronauts who have gone through the NBS training, then the actual EVA experience, we therefore have a database to establish four elements:

- Time to learn specific tasks
- Degree of effectiveness performing those tasks
- Relationship of NBS results to actual EVA results
- Variability between astronaut trainees along important variables
    - Time to learn tasks
    - Effectiveness performing tasks

Two elements: cost to train and effectiveness, can be measured on NBS in a fairly straightforward way. Safety, however, can only be subjectively addressed. This is because there have been no significant safety problems that have led to the loss of an astronaut or a hazard that has stopped an entire mission. In this case, a ‘ score sheet’ for NBS would look as follows: On the groundIn spaceCost per trained astronaut$/astronautN/ATasks performed effectively% of tasks performed effectively% of tasks performed effectivelyTasks performed safelySubjective rating (1-10)Subjective rating (1-10) By comparing on-the-ground NBS scores with in-space actual scores, we can therefore ‘ normalize’ the NBS effectiveness and safety results to correlate them with in-space EVA results. Each of the tasks judged to be important can be thus scored, and a complete score for all NBS tasks for eventual EVA tasks can be evaluated and scored, as follows, one score sheet each for effectiveness and safety: Effectiveness Score Sheet (example) GroundSpace% achievedWeighting 1-10Activity 195%85%85/95= 89%9Activity 299%98%98/99= 99%6. . .   By weighting each task in regards to its importance to the mission, NASA can come up with an overall weighted score which allows for establishing the effectiveness of the training, and how much additional improvement can be made per task, and in overall EVA tasks performed. The three ways to use this are:

1. Establish the effectiveness of training using NBS on the eventual results.
2. Create a ‘ score’ which normalizes NBS results for use when looking at IVR, and
3. Establish which areas have the greatest potential for improvement, thereby increasing overall scores.

The above scoring approach works for both the safety and effectiveness evaluations. Evaluating cost is also fairly straightforward. We should regard the current facilities costs (pool, mechanicals, etc.) as ‘ sunk’ costs, and move on to evaluate the new techniques using a fair capital expenditure and depreciation model. Since the amount of training and number of astronauts is known, we can assign a ‘ capital factor’ to the facilities and computer costs associated with the IVR alternative. After assigning costs in this way, we can then evaluate the costs of NBR as # of astronauts trained divided into the total cost of running the program. For IVR, we will look at the costs as # of astronauts trained divided into (total operating costs of the program + capital cost per astronaut trained). Measuring the Astronauts’ Perceptions of IVR versus NBSThe astronauts are both consumers and trained observers of training technique. While we can capture costs, we are less sure about how the astronauts will perform in EVA’s over an extended period of time. We also have a cadre of astronauts who have participated in EVA in the past. They will be helpful in three areas:

1. Comparing the ‘ reality’ of the IVR techniques to those of NBS
2. Evaluating the relevance of IVR to eventual EVA activities, and
3. Improving the IVR experience by providing ‘ expert’ input—helping to fine-tune the expert systems behind the IVR experience.

It is therefore important not only to measure astronauts’ progress using objective measurement techniques, but also to probe the astronauts about their opinion of the training. Fortunately for this program, many astronauts are pilots who have spent hundreds of hours in IVR-type simulators. They therefore have developed the internal comparators of simulator versus reality performance. Although EVA occurs in a very different environment (heavy suit, no air resistance, no gravity), astronauts are familiar with the differences in sensation performing actual flight maneuvers. It is therefore important to poll each astronaut during and after IVR activities to test their perceptions of the reality of their session, and to relate it to their expected experiences once in space. Specifics Related to IVR Design and TestingSince IVR has been used a good deal in pilot training, many elements are already known about correlating trainer experience against real-world action and response. The sensory elements related to the astronauts’ EVA experience will not be close to those that can be duplicated in an IVR experience: weightlessness and lack of purchase (gravity) will be lacking. The primary goal of IVR for EVA training is to therefore train the astronauts’ brains in a conditioning fashion—stimulus produces response—in such a way that when the astronaut arrives in the real-world EVA, he or she is able to call on his/her conditioning to perform the tasks, even though the haptics will be different. We can expect that NBS will better mimic the sensory inputs of weightlessness than IVR. Properly designed, with appropriate physics engines and haptics, and in a similar suit, the IVR experience should prove better than NBS in many other ways.

Bibliography McLellan, H., n. d., Virtual Realities, Ch. 17, McLellan Wyatt Digital.