Why Space Human Factors Advanced Development Project?

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Abstract

The different space agencies, space human factors community, engages in activities that range from basic research through advanced development projects to applications associated with ongoing programs such as the International Space Station and the Shuttle. This panel of human factors specialists will present information relating to advanced development projects aimed at the creation of tools that can be applied to the analysis, design and evaluation of space vehicles and operations, and future space vehicle design concepts.

Key words

Human Space Project, Microgravity, human factors

The Voice of the World

The International Space Station (ISS), NASA, Euro Space have many challenges for human factors and habitability. For long mission, the vehicle must be designed to support work and personal activities. Still another issue is that the space agency is truly international and must support a multi-cultural crew. The modules and nodes are assembled in orbit, and actual operation during a real mission is the first and only integrated performance test, especially for human performance and habitability. The astronauts' or marsonaunts' first mission is most certainly the first exposure that they, the primary individual for space human factors, have to the integrated environment and the demands of actual living and working on space agencies. The task loading includes a variety of operations from construction, maintenance, housekeeping, exercise, public affairs, scientific experiments, to recreation, hygiene and sleep. The actual use of the Space agencies, for a real mission is also the first opportunity for human factors specialists to receive feedback from the individuals. This feedback is an essential part of the human factors design-test-redesign loop. For example, it is critical for human factors designers and mission planners to acquire user feedback on

* Equipment
* Environmental conditions
* Operational context

Crew summary - Extended interviews of the crew members on prescribed topics are the primary source of feedback. A dedicated habitability and human factors debrief has been conducted for each of the space agency's crews to date as well as the previous astronauts or marsonaunt who stayed for 6 months. In these debriefs, crew members answer specific questions designed to elicit descriptive feedback on general habitability characteristics of the agencies, and on specific difficulties. Standard templates of topics and open-ended questions are used for each debrief to facilitate longitudinal analysis. In addition, debrief content is tailored to specific missions by including more focused questions relevant to the mission at hand.

One drawback of the crew debriefs is that the feedback is delayed and therefore potentially inaccurate due to such mechanisms as the halo effect. As the mars missions can last up to six months, accurate recall of low-level details is difficult. To address this issue, a second means of collecting customer feedback is via an electronic in-flight user-initiated anomaly reporting system. On the form, the crew member describes the details of the issue, categorizes it, and submits the feedback immediately to the ground team. The anomaly reports are a reactive means of gathering feedback however, in certain circumstances, there is a need to actively focus the user's attention and gather feedback. For example, one sleep station was developed on an accelerated schedule and therefore received abbreviated evaluation. The functionality of a sleep station for supporting human performance is particularly impacted by the lack of gravity. Therefore, there is a need to assess this important

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piece of habitability hardware or simulated microgravity environments in long-term zero gravity use in order to identify potential design improvements. In these instances, a specific in-situ usability engineering assessment is conducted wherein the crew is requested to perform various actions with the targeted hardware and answer specific questions.

As important as it is to collect feedback from the user on habitability, it is of equal importance that something be done with that feedback. To that end, this program has established a means of identifying and logging habitability issues from ISS missions and the associated corrective actions. The actions include creating or modifying requirements and hardware or operations changes. It is hoped that the increased emphasis on habitability for ISS and the lessons identified will generalize to other long duration human-tended extraterrestrial ventures such as planetary habitats and flight to Mars.

Emergency Medical and Dental Procedures

Work is being carried out to upgrade the emergency medical and dental procedures on board the each space agencies. Emergency medical capabilities currently available were developed over recent years to provide the training and equipment to resuscitate an injured crew member, along with a reference book (called the Medical Checklist) for the crew's use. A space agency's crew member is designated as Crew Medical Officer (CMO) and is trained in these procedures .The human factors investigations are addressing crew training, likely medical and dental emergency scenarios, air to ground communications, and predicted patient outcome on-orbit and ground support), and to recommend solutions that will improve survival chance of crew members in the event of a medical emergency. The initial work includes gathering information on the current practices in analog facilities and environments. In addition, analyses of navigation and layout of the Medical Checklist and algorithms are underway.

Analysis of Scanned Anthropometric Data

There are numerous databases that provide volumes of information collected using traditional anthropometric methods. Unfortunately, these uni-dimension based anthropometric databases are not adequate to generate digital human models that can be applied in a wide range of design applications. This is primarily due to the fact that uni-dimensional anthropometric databases do not include surface contours of body segments and volumetric data. Hence, graphical representations of human figure models have not been accurate. With the advent of laser scanning technologies, it has become possible to gather two and three-dimensional anthropometric data. Three dimensional anthropometric data are capable of providing a better representation of physical attributes in computer-graphics-based human models and may enhance the analytical capabilities for conducting human-work interface evaluations.

Crew Member Activity Scheduling

Short duration shuttle flights are very highly orchestrated with crew member activities being planned in great detail well ahead of a mission. Longer duration missions on the Space Station provide much greater opportunity for temporal variability to creep into the planning and implementation processes. This variability has positive learning components and negative fatigue influences. Furthermore, the local knowledge and inclinations of long duration crew members is such that there is a trend for much greater levels of autonomy. The human factors community is collaborating with colleagues in the Program Office and Mission Operations to improve the data collection of "actual" for comparison with planned timelines. This evidence is being used for the development of models that can be used for planning and real time evaluation of alternative scheduling strategies. The activity is also linked to much longer term questions related to planned and unplanned maintenance and the resource demands for the limited (3 person) crews to perform "payload" work.

The first challenge in crew activity scheduling is to define the time available during each flight day for sustaining activity (sleeping, eating, exercising, hygiene, other personal time) and "work" activity (logistics, research, maintenance, training, planning, housekeeping etc.) The general blocks of time for these

activities are preplanned. The next step is to find ways of obtaining better estimates of the time taken to carry out individual activities and generic activity elements - such as setup, procedure review, actual experimentation, tear down and reporting. Earth based estimates are not always accurate and crew members and ground support personnel are understandably not always enthusiastic about the chore of detailed time data collection. There are also contingencies, such as responses to caution and warning alarms, activities associated with visiting space vehicles and communications with ground personnel that cannot be accurately measured or estimated. Crew members also have weekends. Given the available data, the next task is to create the time based model of activities that is the basis of activity scheduling.

Upgraded Displays for the Space Shuttle Cockpit

During a mission of the Space Shuttle, the crew can view dozens of different display formats on the computer screens in the cockpit. The computer screens in each Space Shuttle orbiter are being upgraded from monochrome cathode ray tubes (CRTs) to color liquid crystal displays, which are part of the Multifunction Electronic Display System. Advantages of the new displays (called Multifunction Display Units, or MDUs) include lighter weight and lower power requirements than the CRTs.

Space Human Factors Engineering Database

The NASA Space Human Factors Engineering (SHFE) Project addresses critical questions that must be answered to enable long duration human space flight missions, including longer stays on the International Space Station and eventual exploration-class missions.

The database consists of six classes of information

- Critical questions identified by Space agencies.
- Information needed to answer the critical questions
- Citations of published research
- contact information for individuals with relevant publication
- draft requirement undergoing review by users and by subject matter experts.
- approved requirements.

Conclusions

Simulated microgravity Development Projects represent some of the ongoing activities of the NASA, Euro Space, ISS Space Human Factors Project. They are based on a "pull" through the experience of the leaders in their day-to-day involvement with NASA operations such as the International Space Station and Shuttle, and a "push" from the human factors research community through involvement in broad based conferences such as the Annual Meeting.

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