

Habitability and Human Factors: Lessons Learned From The International Space Station

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Introduction:

- NASA HF experts have collected, analyzed, & applied post-Expedition crew debrief data & lessons learned to meet the crewmembers' needs to live & work safely & productively in space





Data Collection Process:

- The first modules of the International Space Station were launched in 2000
 - Have allowed 17 international crews to experience long duration space habitation
 - Each Expedition crew stays 3-6 months
 - 6-crew are expected on-board in May of 2009
 - Returning crew are debriefed in the U.S. and Russia
 - 21 U.S. crew debriefed to-date
 - 23 international crew debriefed



Data Collection Process:

- Data is collected from all ISS debriefs (25-30 per crewmember) and maintained in a confidential database to support identification, tracking and trending of ISS Lessons Learned
 - ~20,000+ crew comments
 - Sorted into Key Habitability Categories including:

Architecture	Planning
Communication	Restraints & Mobility Aids
Environment	Stowage
Human Computer Interaction	Training
Habitability	Transfer
Labels	Procedures
Hardware & Maintenance	



Analysis & Research:

- Multiple internal products are generated from the collected crew data
 - Expedition Summaries (presented to the ISS Program)
 - Expedition-specific summaries detailing the main issues and successes during a 6 month Expedition
 - Lessons Learned (presented to the ISS Program)
 - Identification of the top habitability issues and proposed resolutions pertaining to each Expedition
 - Special Topics (requested via Data Request Form)
 - A detailed, historical compilation of data summarizing key findings collected over lifetime of ISS on specific topics e.g., acoustics, lighting, dining, etc.
 - Trending Analyses (presented to the ISS Program)
 - Captures and tracks top habitability concerns and monitors them as reported across all Expeditions



Application of Data Collected:

- ISS Lessons Learned & trending analyses guide the development of hardware & system requirements and designs
 - Requirements development and application
 - Concept design and user analysis
 - Development of mockups, prototypes & training protocols





Application of Data Collected:

- ISS Lessons Learned data have identified several critical issues in terms of on-orbit habitability & operational safety
 - Procedures
 - Caution & Warning Desensitization
 - Stowage
 - Inadequate Volume
 - Manifesting Issues
 - Labeling
 - Confusing, Missing, Acronyms
 - Training





Identified Issues: Desensitization to Caution & Warnings in Procedures

- Expedition 1-15 crews have repeatedly commented on the overuse of C&W blocks within on-orbit procedures
 - Desensitization to C&Ws due to denoting every hazard, regardless of severity level
 - Tendency to ignore C&Ws due to excessive number
- Human Factors and Safety were tasked with resolution of this potential hazard





Identified Issues:

Desensitization to Caution & Warnings in Procedures (con't)

Process:

A review team was formed under Human Factors and Safety guidance

- A broad data evaluation was conducted
 - All crew debrief data reviewed and analyzed against:
 - Sample set of procedures analyzed
 - NASA Standards reviewed (dictate procedure development)
 - Industry Standards researched (for applicability to caution and warning standards for on-orbit)
- The data analysis led to a crew usability evaluation
 - Determined procedure content usability and “intuitiveness” of caution & warnings within the procedures



Identified Issues:

Desensitization to Caution & Warnings in Procedures (con't)

Results:

- NASA documentation governing the on-orbit crew procedures was clarified and updated based on user evaluation results
 - Improved consistency in procedure development processes
 - Removed redundant, intuitive and low-level cautions and warnings from procedures



Identified Issues: Excessive Stowage

Poor Stowage Management

- Over manifestation of items
- Costly Up/Down mass concerns

Inadequate stowage volume

- Exacerbated by use of packing materials that require disposal
- Obsolete equipment on-board
- Safety constraints violated when fire ports and/or critical equipment are blocked
- Increased crew time required to find equipment or to manipulate stowage





Identified Issues: Excessive Stowage (con't)

Process:

- Team of experts assembled (Operations, Habitability, Safety, various working groups)

- Manifest process analyzed
 - Survey of all existing and planned cargo

- Stowage allocations for cargo established
 - Coordination with Manifesting Boards

- Obsolete/excess on-board equipment identified
 - Coordination with Hardware Providers and Operations



Identified Issues: Excessive Stowage (con't)

Results:

- Requests to manifest cargo reviewed against stowage allocations
- Stowage limits monitored for compliance to cargo allocations through continuous review of ground tracking records
- Periodic on-orbit audits performed by the crew on all items
- Process developed to dispose of excess or obsolete on-board equipment
- Packing materials reduced



Identified Issues: Inconsistent Labeling Practices

- Label requirements have been confusing and hard to apply
- Multi-cultural labeling issues
 - standardization of design and terminology
- Overuse of acronyms on labels
 - Acronyms not intuitive, especially for international crewmembers
- Many items flown with no label, missing labels or inconsistent labeling
- Flight Hazard labeling not clear to ground



Identified Issues: Inconsistent Labeling Practices

Process:

- Reviewed current label processes
- Proposed changes to involved parties
- Captured a standard process in a document
- Presented document to ISS Program for approval and implementation



Identified Issues: Inconsistent Labeling Practices

Results:

- Standardization of ISS Program labeling requirements and processes
 - Alleviated inconsistencies in label application on hardware and systems
 - Increased conformance to operational nomenclature requirements

- Increased efficiency of existing label processes
 - Pre-flight label reviews more thorough



Identified Issues: Training Philosophies

- Focus on task-based rather than skills-based
 - Task-based training may not prepare crewmembers for all necessary operational skills
- Intensive preflight training for daily operations & mission roles & responsibilities
 - Mission objectives change
 - Excessive travel required (ESA, JAXA, RSA crew)
 - Over-trained for tasks that may not be performed (Payloads)
- Inadequate training resources
 - Fidelity of sims and mock-ups
 - Not always "flight-like"
 - Difficult to model all aspects of 0-g, no true floor and ceiling



Identified Issues: Training Philosophies

Process and Results:

- Integration with the ISS training program is still in progress, however initial efforts have begun to resolve the training concerns:
 - Human Factors personnel assessment of current training methods
 - Analysis of individual crew training flows, and subsequent comparison to collected crew training comments



Conclusions

- Human Factors has been instrumental in preventing potential on-orbit hazards and increasing overall crew safety
 - Poor performance & operational learning curves on-orbit are mitigated
 - Human-centered design is applied to optimize design and minimize potentially hazardous conditions, especially with larger crew sizes and habitat constraints
 - Lunar and Mars requirements and design developments are enhanced, based on ISS Lessons Learned



Questions?

