2012 Habitable Volume Workshop Summary Presentation

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Outline

- Background and participants
- Workshop Products
  - Process Flow
  - Task List
  - Metrics and Tools Lists
- Forward Work
- Conclusion
- Acknowledgements

Background

- NASA's Human Research Program (HRP) seeks to mitigate risks to human health and performance during spaceflight
  - Risk of Incompatible Vehicle/Habitat Design
    - What is the minimum volume crewmembers need in a vehicle/habitat?
- Space Human Factors Engineering teamed up with Behavioral Health and Performance
  - Produce concrete products that can aid in the design and assessment of habitable volume of space vehicles and habitats for long-duration missions
  - Identify research and technology development gaps in the area of habitability design and assessment
- HRP hosted the Habitable Volume Workshop in Houston during July 2012
  - Document existing habitability assessment practices used by NASA as well as adjacent industries
- Set of products are intended for use by human factors engineers, habitat designers, and integrators:
  - Process Flow
  - Task List
  - Metrics and Tools Lists

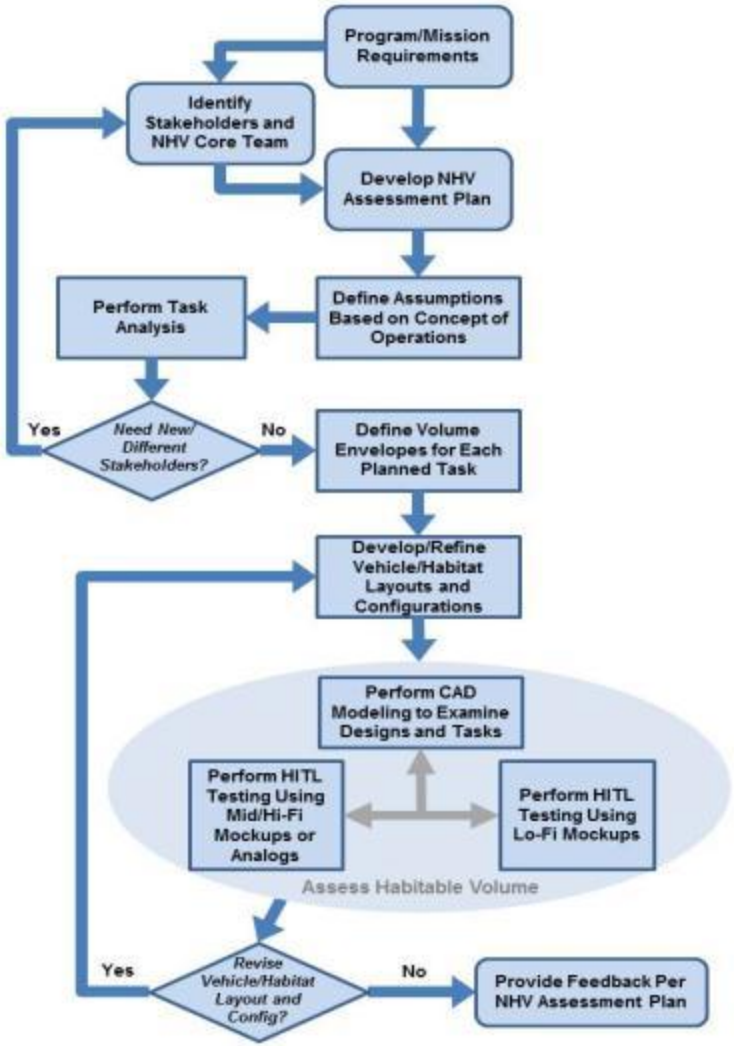
Workshop Participants

- NASA participants represented:
  - Space Human Factors Engineering (SHFE)
  - Behavioral Health and Performance (BHP)
  - Human factors and standards experts
  - International Space Station Internal Vehicle Configuration Working Group (ISS IVC WG)
  - Flight Crew Integration (FCI)
  - Habitability Design Center (HDC)
  - Advanced Exploration Systems (AES)
  - Astronaut Office
- Industry participants represented:
  - Oil and gas
  - Submersibles
  - Maritime shipping
  - Mining
  - United States Navy
  - Lamar University
  - Thomas Jefferson University
  - University of Pennsylvania

Process Flow for Assessing Habitable Volume

- Developed based on existing NASA processes and inputs from workshop attendees, with emphasis on considerations for long-duration missions.
- Users may step through the process to plan out and execute an assessment of habitable volume.
- Intent is to provide high-level guidance; emphasis is on iterative nature of a habitable volume assessment.
- The Process Flow also indicates where the other workshop products can be applied in a design and assessment cycle.
- Caveats:
  - Not intended to replace system-level Human Systems Integration (HSI) plan- considered to be part of HSI approach
  - Does not result in a "pass or fail" judgment

Process flow



Task List

- Developed based on existing NASA documentation with inputs from workshop attendees
  - Emphasis on volume-driving tasks for long-duration missions
  - Captures key information that can inform design
- Post-workshop, the team provided example-volumes required for each task
- The Task List is intended for use in the Perform Task Analysis step of the Process Flow
- Caveats:
  - Example volumes provided are not comprehensive nor are they validated. They help designers intuit the size of a space.

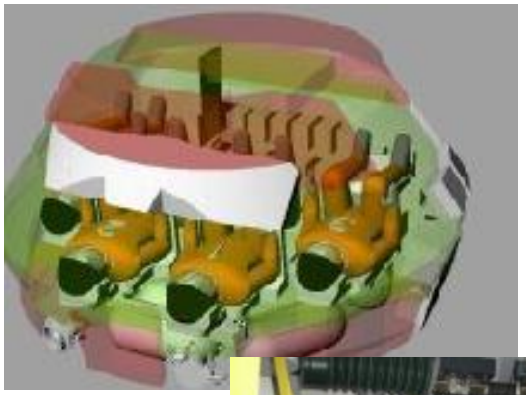
Task List Excerpt

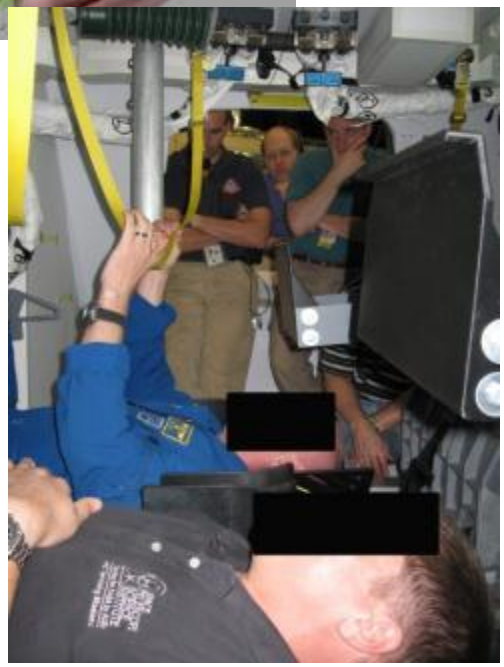
CREW TASK			NOMINAL/ CONTINGENCY	TASK DURATION	TASK FREQUENCY	PRIVACY	REQUIRES MIN / NO RECONFIG OF SPACE? (Dedicated)	POTENTIAL CONCURRENCES	POTENTIAL ADJACENCIES
ID	Main Task	Description							
1	Exercise	-Whole Body Aerobic -Whole Body Resistive	Nominal	Hours	Per Day	Semi-Private	Yes	-Recreation -Crew Heath/Medical (e.g. Monitoring)	-Crew Heath/Medical (e.g. Monitoring) -Whole Body Hygiene -Waste Collection and Management -Stowage

EXAMPLE VOLUMES									
TASK/FUNCTIONAL AREA VOLUME						ADDT'L ANCILLARY VOL			ADDITIONAL NOTES
Source	No. Of Crew	Foot print (ft or ft2)		Height (ft)	Volume (ft3)	HW/Sys	Point-of-Use Stow	Trans-lation	
Heritage	1	5.31	2.89	7.61	116.78	Included	Excluded	Excluded	Exercise in ISS Zvezda Service Module
Human Integration Design Handbook	1	7.78	4.04	6.89	216.56	Excluded	Excluded	Excluded	Body volume for operating Treadmill with Vibration Isolation System (TVIS) (HIDH Table 8.2-1).
	1	4.69	4.04	3.18	60.25	Included	Excluded	Excluded	Body volume for operating Cycle Ergometer with Vibration Isolation System (CEVIS) (HIDH Table 8.2-1)
American Bureau of Shipping (ABS) Guide for Crew Habitability	1	20.00		6.50	130.00	Included	Excluded	Excluded	Volume estimates reference ABS Guide for Crew Habitability on Ships (p.108). Size given is for one physical fitness station. ABS requires stations to permit aerobic, flexibility and strength training capabilities.
Other	1	4.30	3.30	7.30	103.59	6.7	Excluded	Excluded	Volume estimates reference CEV-T-70024 HSIR Rev D, based on anthro dimensions for max standing stature and max sitting height while using rower/cycle ergometer (no arms overhead). HW Vol estimates reference Table 18-5 "Mass and Volume Factors for Crew Accommodations" in "Human Spaceflight Mission Analysis and Design"

Metrics and Tools Lists

- Provides a survey of habitability metrics, methods, and tools that have been used to measure and assess habitable spaces or vehicles
  - A snapshot-in-time of the changing research and technology landscape in the domain of habitability design and assessment
- The Metrics and Tools Lists are intended for use in the Assess Habitable Volume step of the Process Flow
- Caveats
  - Minimally necessary database for use by the designer/evaluator when planning an analysis or an assessment activity





Metrics and Tools List Excerpts

Metrics List

METRIC ID	HABITABILITY METRIC			SUB/ OBJECTIVITY	PROS	CONS	APPLICABLE TOOLS (see Tools Tab)	REQUIRED INPUTS	DESIRED OUTCOME	APPLICABLE LIFECYCLE PHASES	APPLICABLE EVAL ENVIRONMENT		POTENTIAL RESEARCH GAPS	REFERENCE
	Title	Description	Units								Model/Sim	Physical/ Operational		
M-1	**Net Habitable Volume/Floor area**	Net habitable volume is the total remaining volume provided for crew living and work functions, after accounting for system/equipment layout and installations, stowage, secondary structures and any unusable volume. The Habitable Floor Area indicates available floor area for crew living and work functions.	m3 m2	Objective	- Good proxy measure of usability of space - Floor area may be a better measure of usable, accessible space for non-zero gravity environments than habitable volume	- Requirements not universally agreed upon.	T-11	Pressure vessel geometry, size and arrangement of interior subsystems	Maximized up to a point; adequate volume to perform tasks effectively	Early Design Phases	Low-Fi CAD		Maps to Human Research Program (HRP) Gap SHFE-HAB-02: What tools can be used to evaluate habitability concepts for on-orbit and planetary missions	Human Integration Design Handbook (HIDH) (NASA/SP-2010-3407) Net Habitable Volume Verification Method (JSC-63557) Report 1: Figure of Merit Criteria for Evaluating and Selecting Lunar Habitat Module Concepts (SICSA, 2008)

Tools List

TOOL ID	HABITABILITY TOOLS			SUB/ OBJECTIVITY	PROS	CONS	REFERENCE
	Title	Description	Measures				
T-1	**iSHORT**	Space Habitability Observation Reporting Tool is an iPad-based tool that allows users to report HF/habitability issues near real-time, using media files to enhance reports.		Subjective	- Allows crewmembers to report data near real-time - Incorporates media files into reports - User-friendly interface - Options to customize app for future use such as ISS deployment	- Requires subjects to take the initiative to use it - Capture only a sampling of HF/hab issues, based on crewmember discretion - Requires use of hardware	Developmental Testing of Habitability and Human Factors Tools and Methods During NEEMO 15 (Thaxton, Litaker, Holden, Adolf, and Morency, 2012).
T-2	**Human-In-The-Loop (HITL) Assessment**	Test conductors design protocols in which participants perform tasks in a mockup or analog environment. HITL assessments typically include the use of additional tools targeted for specific objectives (e.g., participants may be asked to rate perceived physical exertion as they perform a task), and HITL assessments often employ customized questionnaires and/or checklists. It is typical to examine human performance metrics and/or interactions with hardware and software.		Objective/ Subjective	- Provides information about what happens when humans actually perform planned tasks - May also serve as a demonstration of designs to stakeholders such as crewmembers - Depending on necessary fidelity, may provide a low-cost method to test a design	- For more complex tasks or designs, may require high fidelity mockups - In order to achieve statistical results, it may be necessary to test more participants than is typically feasible - Robustness of HITL results is dependent on good assessment design	Habitability and Environmental Factors: The Future of Closed-Environment Tests (Lane and Feeback, 2002)

Forward Work

- Definition of Task Volumes
  - Identify or refine task volumes using a combination of methodologies including task analysis, CAD modeling, and HITL data
- Refinement of Modeling and Simulation Approaches
  - Greater capabilities in physical representation of humans and microgravity applications
  - Development of a habitable volume assessment or estimation tool based on mission parameters and established metrics
- Definition of Behavioral Health and Performance Impacts
  - Quantitative measures of metrics that impact behavioral health and performance: e.g. privacy, isolation, spatial quality, degree of personalization and individual control of the environment
- Collection of In-Flight Data
  - Crew utilization, modification and in-flight behavioral adaptations on the ISS
  - Definition of postures assumed for various tasks in microgravity

Conclusion

- The 2012 Habitable Volume Workshop brought together multiple industries to share expert knowledge on habitability in long-duration missions. This knowledge was streamlined and retooled for practical use.
- Workshop products helped identify several gaps and areas of forward work that may help to shape future research.
- As appropriate, contents of these products will be published
  - SHFE and BHP are updating an integrated HRP research plan
  - Human-Systems Integration Processes document will include input from the Process Flow
  - The workshop summary report will be published as a NASA-TM
  - Paper accepted at Humans in Space conference

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