



# Usability Testing and Analysis Facility (UTAF)

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**Habitability & Human Factors Branch (SF3)**  
**NASA Johnson Space Center**





# UTAF Overview



- **One of the Space Human Factors Laboratories in the Habitability and Human Factors Branch (SF3) at NASA Johnson Space Center**
- **Primary focus: Human factors evaluation and usability testing of crew / vehicle interfaces**
- **Staff**
  - **NASA Technical Monitor: Doug Wong**
  - **Contractor Lead: Kritina Holden**
  - **Current number of staff members: 10**



# UTAF Expertise and Capabilities



- **Unique mix of backgrounds**
  - Human factors and usability
  - Engineering psychology
  - Human-computer interaction
  - Industrial engineering
  - Biomedical engineering
  - Visual and auditory perception
  - Attention and memory
  - Learning and decision making
  - Aviation psychology





# UTAF

## Processes / Methodologies



### Human Factors

- Human-Centered Design
- Human-system integration requirements development and interpretation
- Observational/Ethnographic studies
- Task analysis and function allocation
- Scenario and script development
- Information architecture and interaction design
- Human factors assessment
- Heuristic evaluation
- Cognitive walkthrough
- User testing/Human-in-the-loop testing
- User interface design and testing (e.g., websites, software displays, hardware panels and controls, and procedures)
- Applied human factors research
- Human performance modeling
- Error analysis
- Link analysis
- Workload and situational awareness

### General

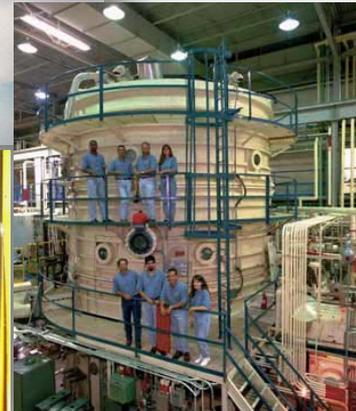
- Questionnaire and survey design
- Research methods and experimental design
- Parametric, non-parametric, and multivariate statistical analysis
- Proposal development
- Technical writing



# UTAF Equipment



- **UTAF consists of:**
  - Isolated subject and control rooms
  - Video recording, editing, and analysis equipment
  - Eye- and head-trackers
  - Hardware and software tools
    - Flight-like computers
    - User interface prototyping tools
    - Specialized statistical analysis software
    - Survey software
    - User testing and recording tools with remote site testing capability
    - Multi-media, web-based, and statistical tools
- **Access to analog environments:**
  - Reduced gravity aircraft (C9, zero-g plane)
  - ISS, Shuttle, Orion mock-ups
  - Neutral Buoyancy Laboratory
  - Testbed Facilities (chamber, NEEMO)

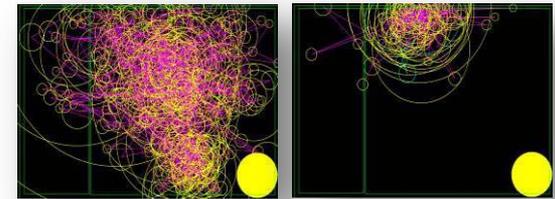




# Key Functions and Products



- **Key Functions**
  - Human factors consultant/team member
  - Advocate for crew
  - Facilitate Human-Centered Design
  - Evaluate user interface designs through heuristic and established usability evaluation methods
  - Space human factors research
  
- **Products**
  - Human engineering requirements
  - User interface development
  - Displays and controls
  - Workstation systems
  - Work environments
  - Task procedures

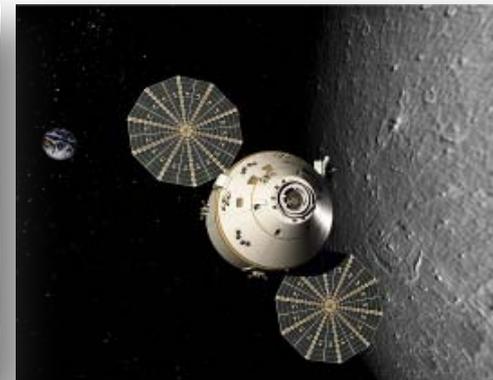




# UTAF Program and Research Support

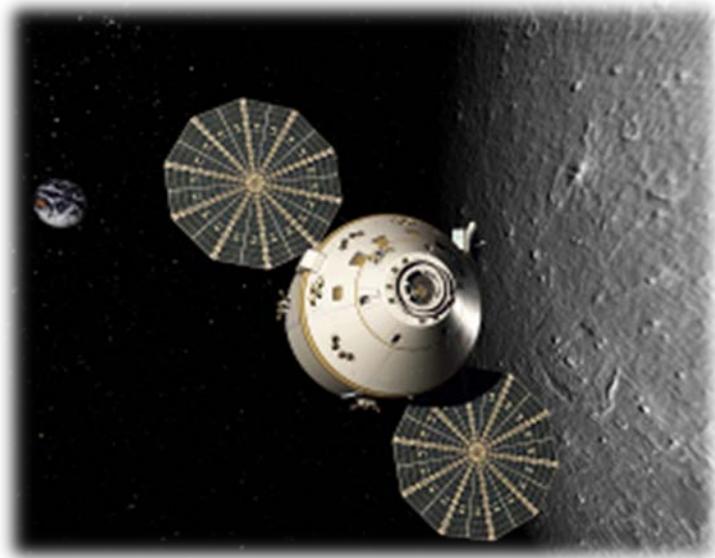


- **Human factors support to major space programs**
  - **Constellation Program (CxP)**
    - Orion Crew Exploration Vehicle, EVA, Altair, and Lunar Habitats
  - **International Space Station**
  - **Commercial Orbital Transportation Services (COTS)**
- **Space human factors research**
  - **Space Human Factors Engineering Directed Research funded by the Human Research Program**
    - Information Presentation, Training, Usability, Human-Robot Interaction
  - **Research projects with external businesses and universities**





# CxP Orion Support

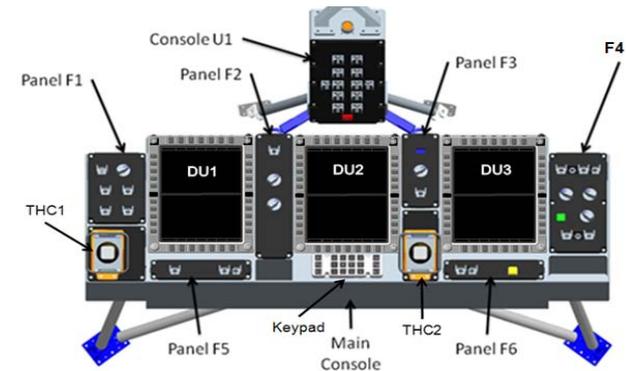




# Orion Human Engineering Activities



- Human-systems requirements development
- Mission-level task analyses
- Practice-oriented evaluations using low-fidelity CEV mock-ups:
  - Crew module internal layout: seats, display & control panels and other systems / sub-systems
  - Window size and location
  - Net Habitable Volume (NHV)
  - Displays and Controls Console Design
  - Software Display Formats



Left Controllers				DAP Pushbuttons		Right Controllers			
Mode Norm				Mode Norm		Mode Norm			
RHC Pwr: On	1	2	3			RHC Pwr: On	1	2	3
Pitch	0	0	0	1 2		Pitch	0	0	0
Yaw	0	0	0	Intl		Yaw	0	0	0
Roll	0	0	0	Free		Roll	0	0	0
CSS	Auto					CSS	Auto		
BFS Eng						BFS Eng			
Fast Stk						Fast Stk			
Abort						Abort			
THC Pwr: On	1	2	3			THC Pwr: On	1	2	3
X	0	0	0			X	0	0	0
Y	0	0	0			Y	0	0	0
Z	0	0	0			Z	0	0	0



	Forward Observer 1	Forward Observer 2	Forward Observer 3	Forward Observer 4	Forward Observer 5
<p>Rating Scale</p> <p>0 - Highly Distasteful</p> <p>1 - Distasteful</p> <p>2 - Unacceptable</p> <p>3 - Highly Unacceptable</p> <p>4 - No Place</p>					
<p>Forward Observer Configuration</p> <p>1. Rate the overall situation based on the situation using the Rating Scale for each window configuration.</p> <p>2. Rank each situation from 1 to 5, the lowest being the most preferred.</p>					
<p>Notes:</p> <p>1. Rate the overall situation based on the situation using the Rating Scale for each window configuration.</p> <p>2. Rank each situation from 1 to 5, the lowest being the most preferred.</p>					
<p>General Forward Observer Comments:</p> <p>1. Rate the overall situation based on the situation using the Rating Scale for each window configuration.</p>					



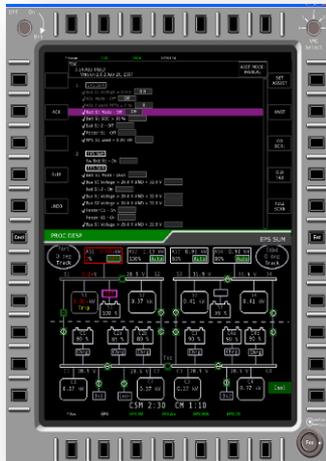


# Orion Displays and Controls



## Displays

- Conduct hierarchical task analysis
- Support ConOps development
- Support display format standards development
- Develop display evaluation process
- Conduct crew evaluations of display prototypes
- Evaluate electronic procedures
- Owner of workload and usability requirements



## Controls

- Conduct crew evaluations of cursor control device concepts



- Test unpressurized and pressurized glovebox usability with representative task scenarios / displays



- Hand controller evaluations



- Edge key and panel ops evaluations
- Effects of vibration on use of controls



# CxP EVA Support

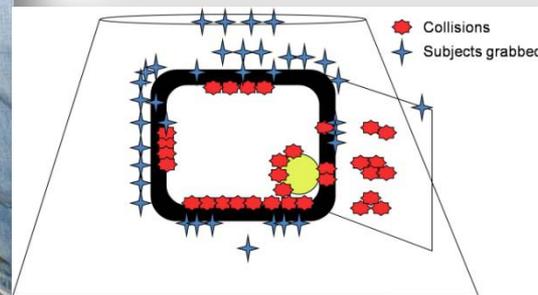


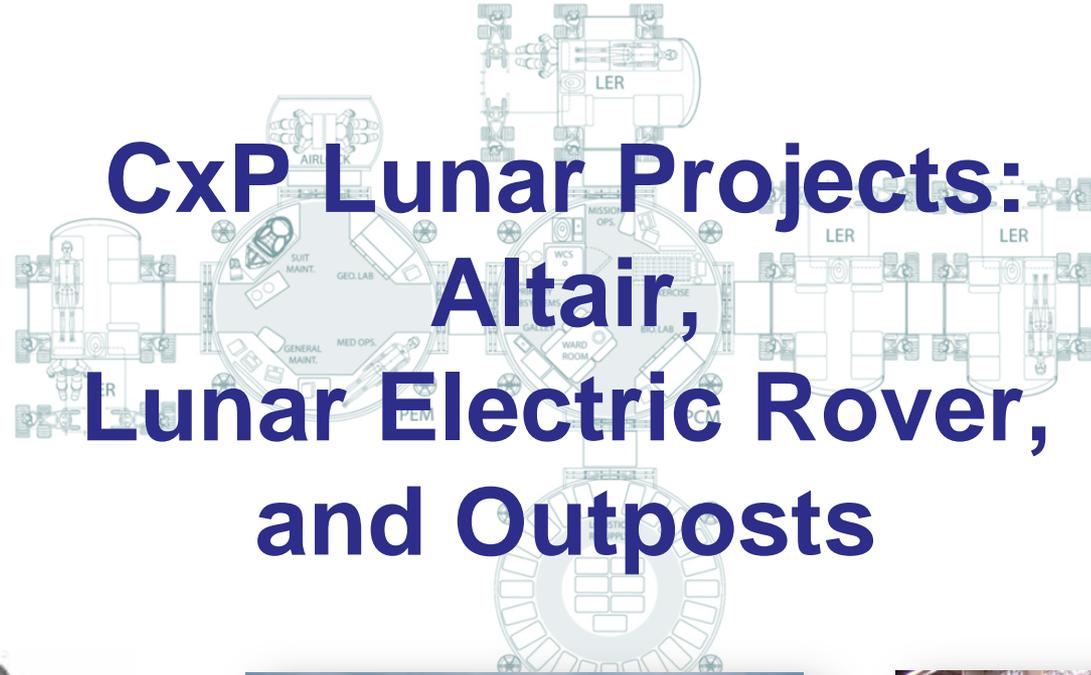


# EVA Integrated Suit Test



## Exploration Task Analyses





# CxP Lunar Projects: Altair, Lunar Electric Rover, and Outposts





# Altair Lunar Lander



- **Evaluate habitable volume, mission operations, overall design**
  - **Suited and unsuited groups performing functional tasks (eating and sleeping, medical events, maintenance, etc.)**
  - **This aids in studying the crew's net habitable volume (NHV)**





# UTAF Support for Space Exploration Vehicle (SEV)



- HF plays a major role in designing the vehicle's nose, window placement, and interior functionality
- HF engineers participated in two DRATS habitability studies (3 and 14 days) examining areas like driving, displays & controls, visibility, EVA, daily operations, sleep, and exercise, etc.
- Using lessons learned from the two field tests, some redesign of visibility, software, cabin, storage, and suit ports has been implement to improve the crew's efficiency
- A GEN 2 SEV is in the design phase today

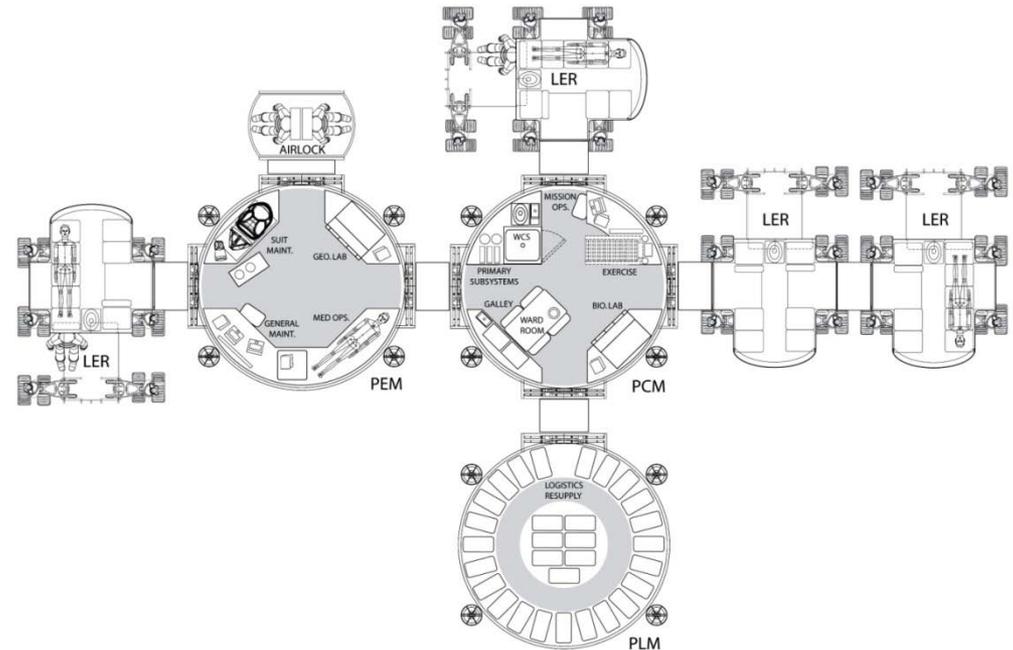
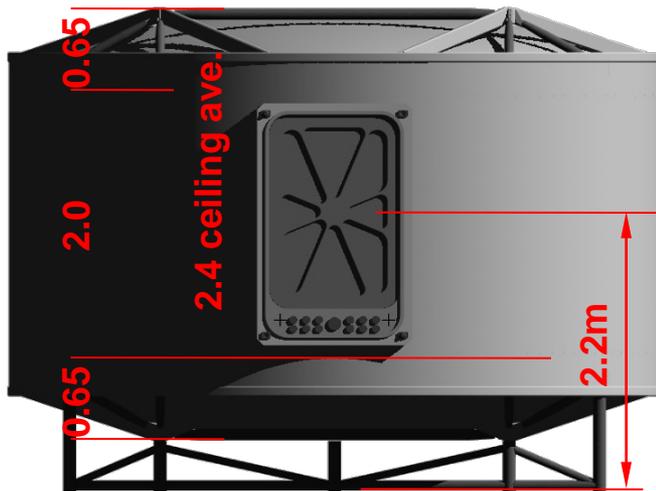




# UTAF Support for the Habitat Demonstration Unit (HDU)



- NASA's Lunar Surface Systems team is constructing the Habitat Demonstration Unit (HDU) to test crew habitability, subsystems, and procedures for lunar missions
- UTAf will support displays and controls development for the HDU as well as testing the NHV





# Commercial Orbital Transportation Services (COTS)



*Orbital*

SPACEX





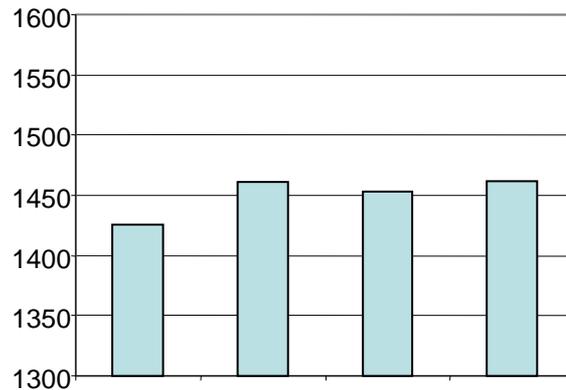
# Commercial Human Systems Integration Requirements Development



- **Development of the Commercial Human Systems Integration Requirements (CHSIR) for the COTS program**
  - **Leveraging CxP experience**
  - **Offering Subject Matter Experts (SMEs) in a number of Human Factors areas**
    - **Crew hardware and software interface design**
    - **Displays and controls**
    - **Electronic procedures**
    - **Net habitable volume**
    - **Usability and workload**



# Human Research Program – Space Human Factors Engineering

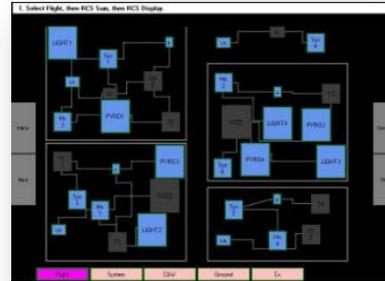




# Information Presentation Research



- **Displays**
  - Label alignment
  - Alarms
  - Multi-monitor interaction
  - Color Coding
  - Head Mounted Displays
- **Controls**
  - Cursor control device design
  - Cursor movement
  - Dual-task performance
  - Pressurized gloved operations
- **Vibration**
  - Readability under vibration
  - Use of cursor control devices under vibration



hub	on
record	left
nominal force	right
rechargeable	54
control panel	43
accelerator	23
pharmaceutical	67
buffer	top
data	open
extravehicular	down
group	up
supplemental	21
cabin	68
heat exchanger	79
pump module	35
cooling unit	in





# Cursor Control Device Studies





# Short Duration Bioastronautics Investigation (SDBI-1904)

## Visual Performance Under Shuttle Launch Vibration



- Objectives
  - Provide operational data to supplement ground-based studies aimed at understanding human performance limits under vibration
  - Provide crew readability data to be used in conjunction with DTO 695, which measures Shuttle seat vibration
  - Assess readability of different font sizes under vibration, using Orion-like display formats
- Task
  - During each ascent phase, scan the placards and determine the smallest readable display



Scan procedure line and graphic in each quadrant. Mark smallest readable quadrant.

Pre-launch (MET -10 sec)

1	3
2	4
NONE	NONE

Max Q (MET -10 sec)

1	3
2	4
NONE	NONE

Launch (MET 1 sec)

1	3
2	4
NONE	NONE

Post Max Q (MET 70 sec)

1	3
2	4
NONE	NONE

1/2 hr in-flight (MET 110 sec)

1	3
2	4
NONE	NONE

Post SRB sep. (MET 131 sec)

1	3
2	4
NONE	NONE

View after SRB Sep. (select during vib. Circle options)

Low	Med	High
Low	Med	High

Blurring

Discorder	Lack of Confidence
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Up/Down

Right/Left	In/Out
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Upper Case text

Difficult	Neutral	Easy
-----------	---------	------

Magnify 10x

Difficult	Neutral	Easy
-----------	---------	------

Green edge keys

Difficult	Neutral	Easy
-----------	---------	------

White flow lines

Difficult	Neutral	Easy
-----------	---------	------

Gray flow lines

Difficult	Neutral	Easy
-----------	---------	------

Red Values

Difficult	Neutral	Easy
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Comments:

1. [Status Bar] [List of parameters] [Schematic]

2. [Status Bar] [List of parameters] [Schematic]

3. [Status Bar] [List of parameters] [Schematic]

4. [Status Bar] [List of parameters] [Schematic]

Mid-deck placards and response card

Placard showing 4 displays/font sizes





# Usability Research



- **Areas of Focus**

- **Usability factors: efficiency, effectiveness, and satisfaction**
- **Errors: metrics, methods, and requirements**
- **Consistency scale development and testing**
- **Legibility methods and requirements**
- **Maneuverability Assessment Scale development and testing**

