AIAA LA/LV
LUNAR VIRTUAL SYMPOSIUM
22 AUG 2020

SPACE COOPERATIVE

LUNAR DAYTIME

BEHAVIORAL EXPERIMENTS IN A SPACE ANALOG LIVING AND WORKING ENVIRONMENT

MARC M. COHEN, PABLO DE LEON, SHERYL BISHOP, DON BARKER, SUZANA BIANCO, SANDRA HAUEPLIK-MEUSEBUGER, RON GENTILE

marc@space.coop +1 650 218-8119 http://space.coop

2020 ICES Lunar Daytime paper:

https://ttu-ir.tdl.org/bitstream/handle/2346/86410/ICES-2020-11.pdf

THE LIMITATIONS OF HABITAT ANALOG BEHAVIORAL RESEARCH

- **The great challenge** to environmental behavioral scientists and architectural researchers in conducting research in space habitats or habitat analogs is to **produce scientifically valid results.**
- **Historically,** habitability researchers have been **limited** largely **to qualitative surveys.**
- Instead, ***Lunar Daytime*** will demonstrate the efficacy of a **modifiable environmental analog** as a **behavioral laboratory** capable of **producing** empirical, measurable, and **quantitative data sets**.
- To measure effects in crew behavioral responses in relation to environmental settings, **researchers must be able to make and control changes to desired independent variables in the physical living and working environment.**

LUNAR DAYTIME: PURPOSE

- ***Lunar Daytime*** will **overcome** the historical **limitations** of analogs.
- It will demonstrate the efficacy of a **modifiable habitat analog** as a **behavioral laboratory producing** empirical, measurable, and **quantitative data sets**.
- To measure effects in crew behavioral responses to environmental settings, researchers must be able to **make and control changes** in the physical environment **as the independent variable.**
- **The effects on crew behavior,** mood, and performance constitute **the Dependent Variables.**

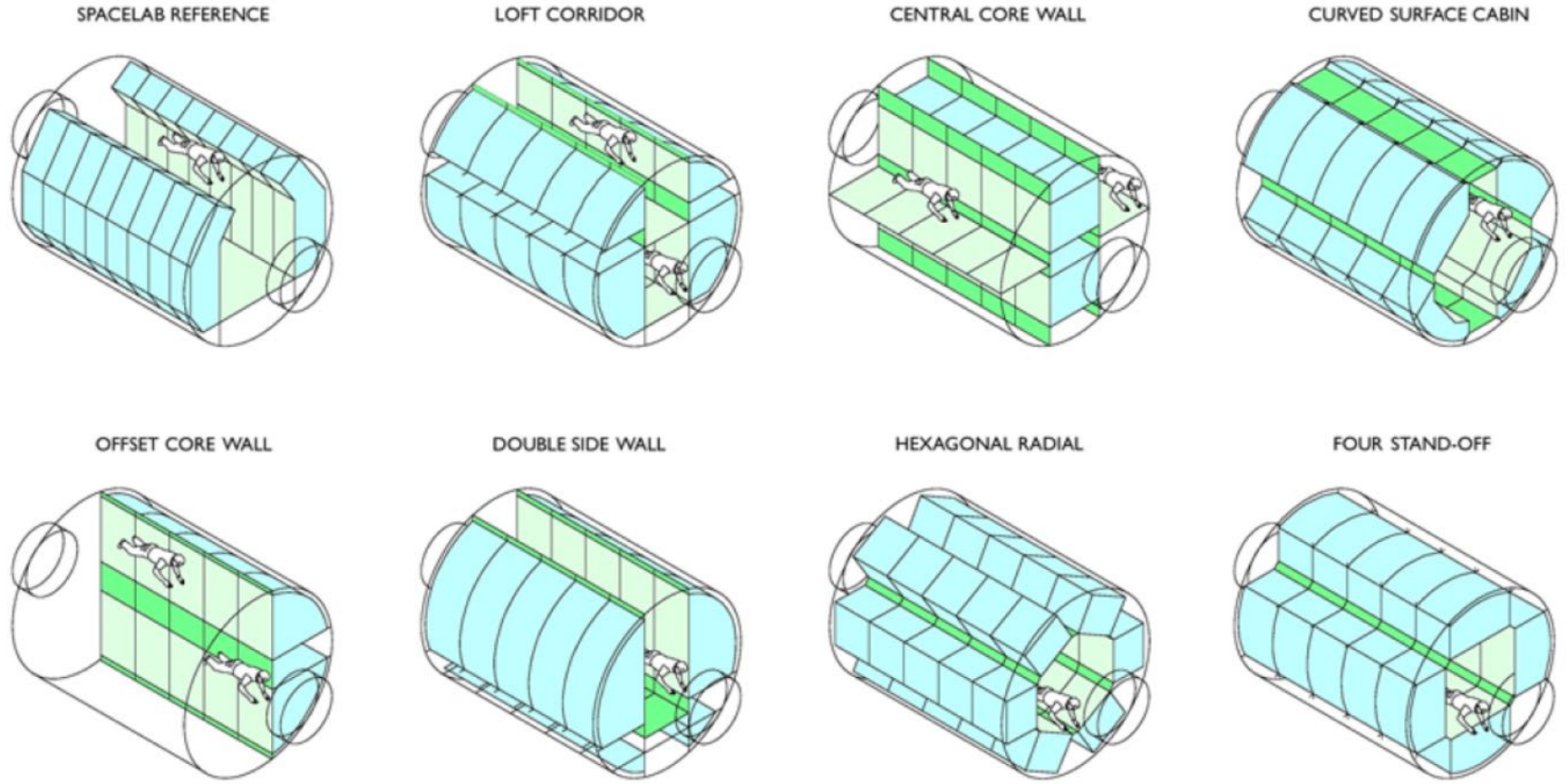
LUNAR DAYTIME: WHY 14 DAYS?

- ***Lunar Daytime*** = the half of the **Moon's 28-day diurnal cycle** that receives **sunlight.**
- Without a nuclear power reactor on the Moon, **human visits will be limited to the daylight period.**
- ***Lunar Daytime*** addresses the **intensive two week period** that will become the standard of a **lunar surface Mission**.
- **14 day simulations** will allow researchers to conduct **more missions**, providing **larger samples** resulting in more **robust statistical analyses**.

ESA Lunar Workshop Habitat Concept

VARIATIONS IN POTENTIAL SPACE MODULE INTERIOR ARCHITECTURE

Courtesy of David Nixon, Architect



(http://www.metropolismag.com/wp-content/uploads/2018/04/Module-interior-architecture-options.jpg)

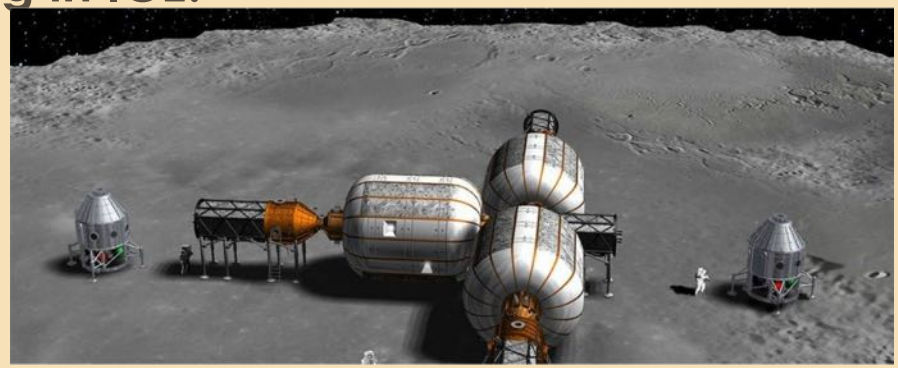
LUNAR DAYTIME: TWO MAJOR OBJECTIVES

- None of the existing analogs allow for the modification necessary to experimentally address the critical issues surrounding the optimal habitat for **isolated, confined environments (ICE).**
- **Objectives:**

1) Create a space habitat analog research facility, specifically designed to accommodate experimental modifications in the physical and perceptual living and working environment, and

2) Demonstrate the ability of such an environmental behavioral laboratory to investigate and address critical factors that we believe play important roles in human health and well-being in ICE.

Bigelow Aerospace Lunar Base Concept



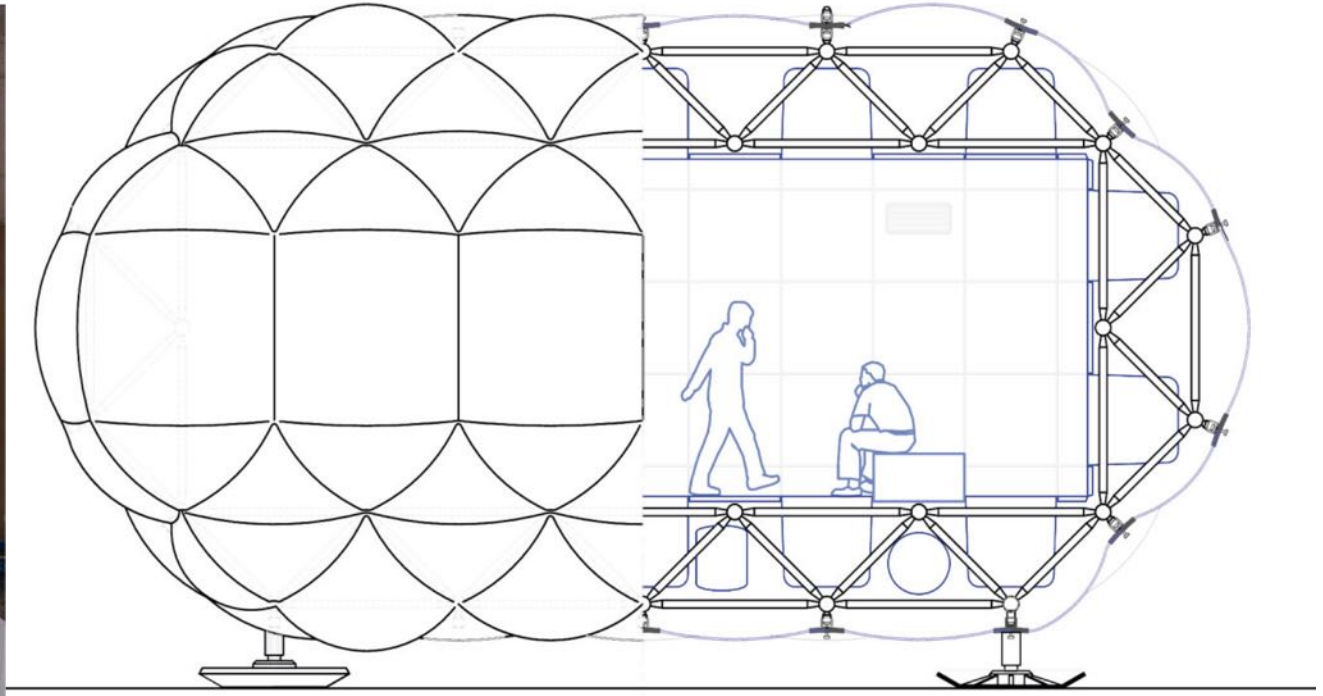
THE SIXTH MODULE

- To that end, the ***LDT*** will build a module for the **Multi-Purpose Research Station (MPRS)** at the **University of North Dakota (UND**) in Grand Forks.
- **MPRS** currently consists of a **five-module** lunar/planetary habitat **analog complex** built from two NASA EPSCoR grants. PI Cohen served as consultant on the first EPSCoR.
- The **expansion** of the existing simulation facility is the **most efficient path** for realizing a **true** space habitat analog **behavioral laboratory.**
- The addition of a **sixth module** will accommodate a wide range of **spatial and visual experimental configurations** addressing various **habitat design and psychosocial factors**.

INTEGRATED HABITAT INTERIOR

Early Integrated Habitat Interior showing hatch, galley and group activity area.

Partial Transverse Section through the inflatable Integrated Habitat Structure



UND EPSCOR 1 INTEGRATED HABITAT

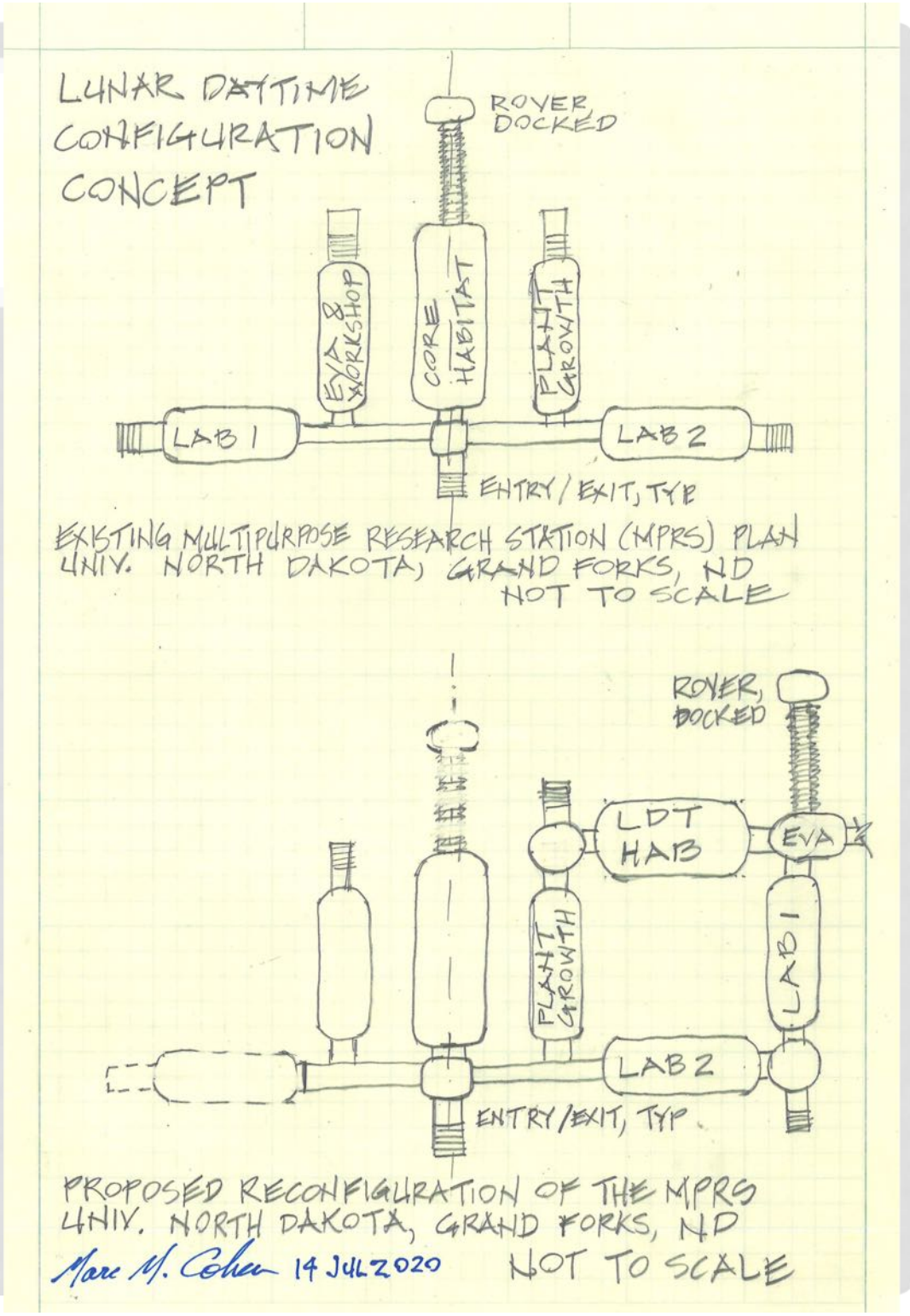
- **Lunar Daylight** P.I. Marc Cohen served as a consultant to Prof. Pablo De Leon on his first EPSCoR grant.
- **Integrated Habitat System** incorporates Spacesuits, Suitports, and Rover Analog.

Lunar Daytime / Space Cooperative

THE MPRS AT UND–GRAND FORKS, JANUARY 2019

- The Wide Central Habitat is the product of the first EPSCoR.
- Lunar Daylight's sixth module will provide the capability for customizations that can address a wide range of experimental inquiries.

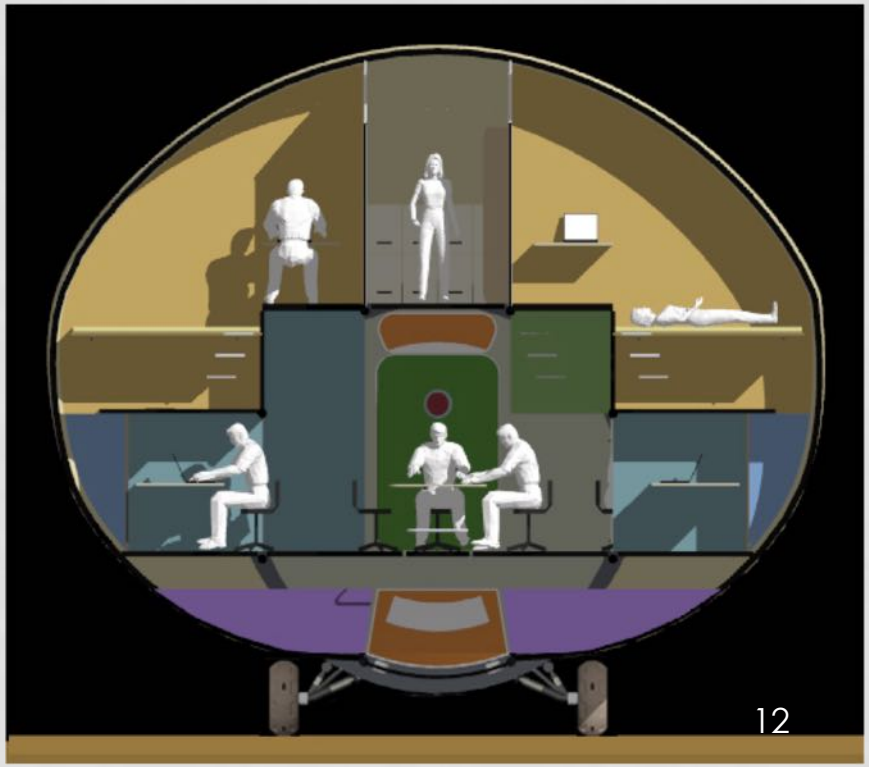
ARCHITECTURAL PLAN



HYPOTHESIS 1: PRIVACY OF SLEEP QUARTERS –

- **Providing individual private quarters will produce better outcomes (e.g., lower stress, reduced interpersonal conflict, higher well-being, more positive moods, more restful sleep) than shared or common sleep quarters. Configurations to be tested include: individual, twin, and all-in-one/common sleeping arrangements.**

- Cross-Section through the inflatable SEIM lunar-planetary habitat module.
- The private sleep compartments appear in the upper left and upper right.
- Courtesy of Constance Adams and Georgi Petrov

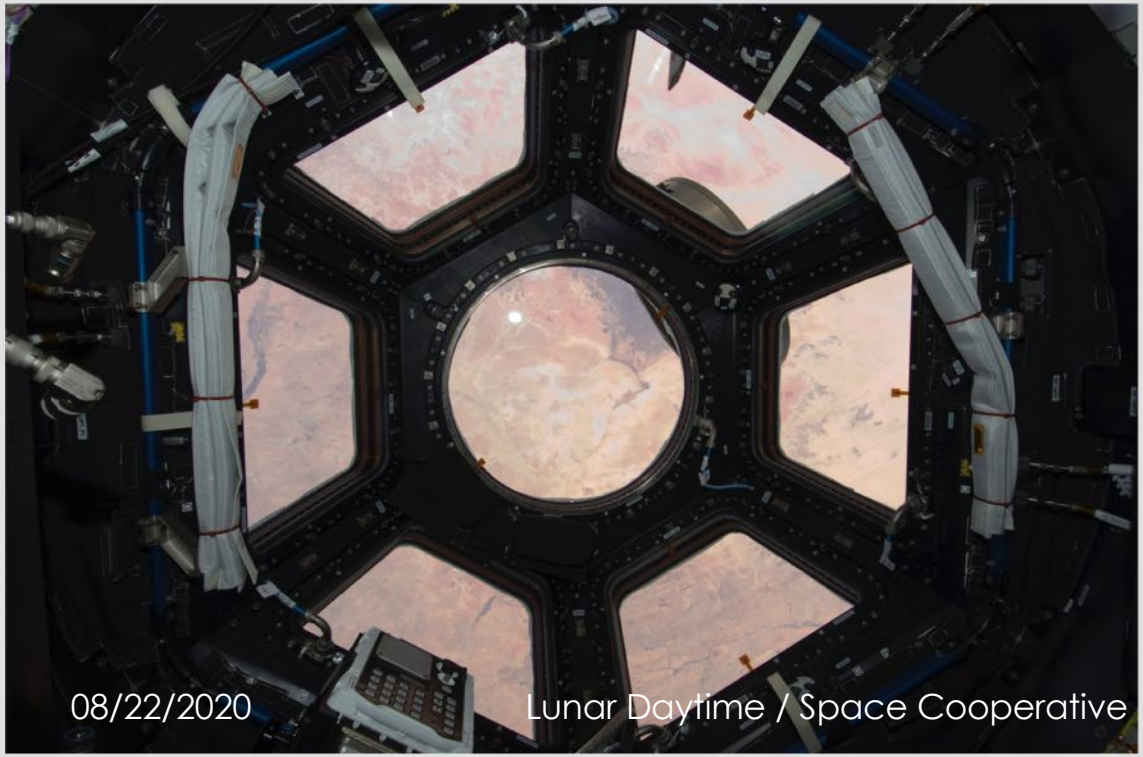


HYPOTHESIS 2: WINDOWS

- **Digital display "windows" will provide reductions in stress and the sense of confinement. Proposed characteristics to be tested include: geometry, size, and location.**

Shuttle Aft Flight Deck

ISS Cupola



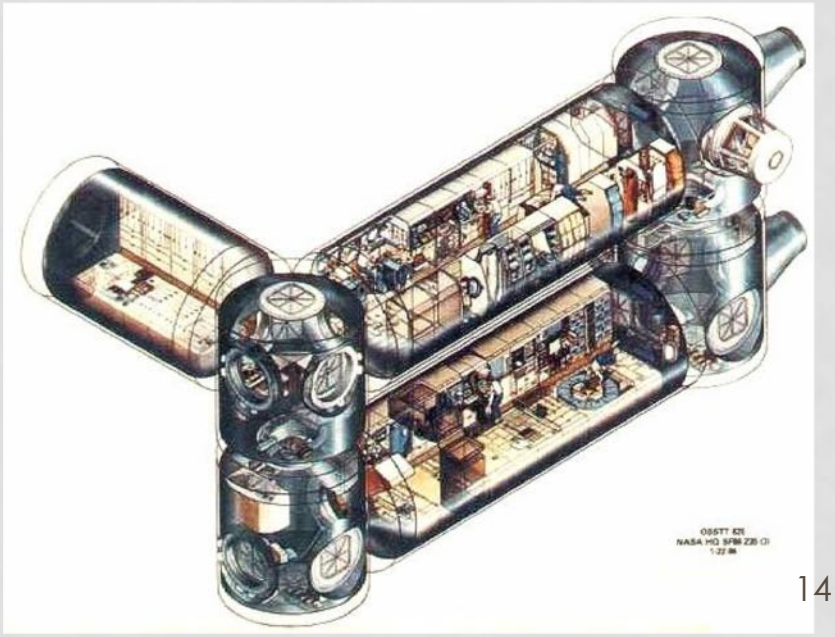
Karen Nyberg, Kibo Window

HYPOTHESIS 3: CIRCULATION PATTERNS

- **A module traffic pattern that creates a circulation loop will elicit functional and crew interaction differences from a non-loop "tree" pattern. These differences include increased social interaction (positive or negative), and efficiency in response to emergency egress and access, and normal operation.**

Mir: Single Path, Dead End "Tree" Pattern

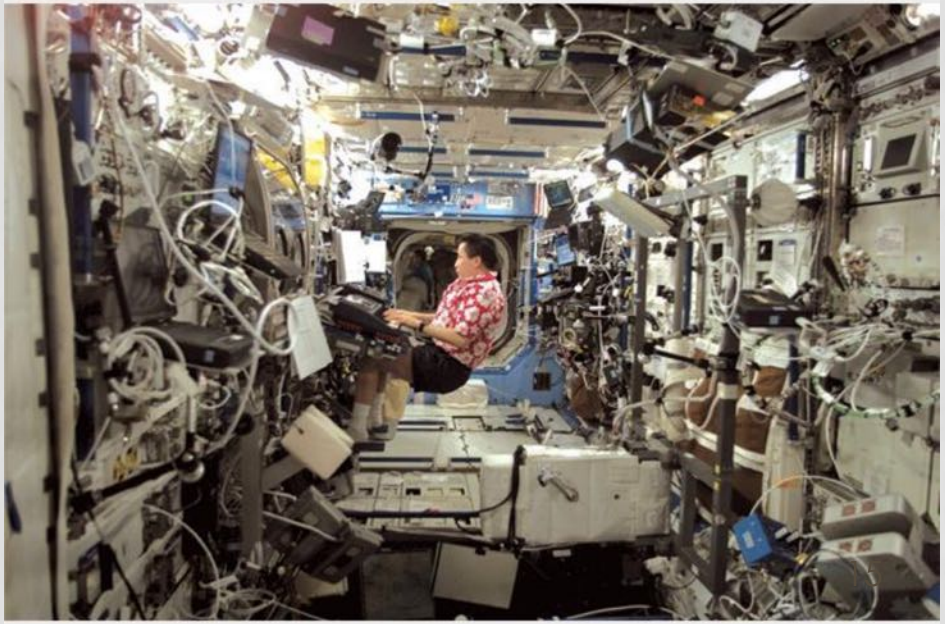
Space Station Freedom circa 1986 "Racetrack" Circulation Loop



HYPOTHESIS 4: PHYSICAL AND PERCEPTUAL ORDER

- **A habitat with physical order and visually clean will increase work output and positive effects in crew function, mood, performance, and productivity.**

Lockheed Martin "NextStep" Cislunar Habitat Mockup for Lunar Gateway



ISS: US "Destiny" Lab, Hawiian Shirt Day. The shirt is the most orderly and visually readable item.

EXPECTED RESULTS FROM LUNAR DAYTIME

- We will validate the fully operational, modifiable space analog behavioral laboratory.
- The series of experiments will demonstrate the utility and flexibility of performing behavioral studies in a modifiable analog facility and begin to set new standards for space analog habitat research and design.
- It will also facilitate a *new paradigm* of behavioral research that moves beyond passive observation and "expert opinions" that have dominated past surveys and quasi-experiments, bridging the results from qualitative and descriptive studies with quantitative ones.
- It will provide a, heretofore, unavailable degree of physical manipulation of the living environment that will lead to more definitive and complex mission simulation research as well as provide for synergies between joint interdisciplinary efforts (e.g., space architects and behavioral researchers from sociology and psychology).