

Kyle Kesling Taylor Phillips-Hungerford Jan. 10, 2017



HESTIA: A Centralized Trunk Earth based analog for a 90 day Mars mission for a crew of 4

Assumptions:

- ECLSS system is equivalent in volume to 4 racks
- Designs to be constrained by current structure
- Designs to be constrained for Earth habitat analog
- Secondary structure to support all interior structures
- Emphasis on subsystems integration
- 90 day mission with NO EVA
- Single, small airlock for non "mission" activities
- Current HVAC and fire suppression systems to be integrated into design (providing ELCSS functionality)

A Centralized Trunk: This HESTIA concept aims to reduce the complexity of the systems by creating a single "systems trunk" though the center of the habitat. This allows for more unique spacial separation, pulling the major systems off the periphery and placing them into a centralized group. This grouping limits the overall length of individual utilities, providing a combined trunk rather than having them spread along a wall. The utilities are centered and based in the ECLSS on the first floor. This allows for the shortest access for water return systems, tanks, air pressure and power to all of the major end uses. The result dictates that the major systems are stacked, creating hubs on each floor, centralizing the workflow and providing dual means of egress on all floors.

Systems running through the trunk:

- Potable water
- Sewage
- Electricity
- Data
- Compressed Air

Secondary Structure: The secondary structure is composed of 80/20 columns anchored to the floor and ceiling by a leveling ring of 80/20. This removes the need for several custom structures and unifies the amount of structural support delivered by the columns. The columns are spaced 20 degrees apart, this allows for a useful chord length (roughly 1 meter) while maintaining flexibility in accommodating built in obstacles on the chamber wall. Per Contra, the main purpose of the secondary structure in this design is to support a soft, modular storage solution as the central trunk feeds all the systems of the habitat. The bags are a 0.5 by 0.5 by 0.5 meter volume that hook onto the screen panels that are fastened to the columns.

Down and Dirty: The ground floor is set up around the ECLSS structure, creating a large volume in the center of the space. In order to maximize the volume closest to the water and power, a hygiene compartment, aeroponics, and sink are molded into the structure. Sandwiching this construction are two 1,100 liter water tanks, supplying direct access to the systems that require on-demand water. This aids in keeping the two most massive elements at the lowest point in the habitat, aiding in EDL by enabling a lower center of gravity. Roughly 50% of the perimeter is allocated to the sciences, providing ample work surfaces for labs, long term experiments, tool storage, controlled environments, sample return clean room options and maintenance. The remainder of the perimeter allow for the stowage of deployable gym equipment, suit spares, and waste containment envelopes. The airlock provides the only egress into the chamber, however,

once inside all floors have two modes of emergency egress provided by the main ladder and the emergency rungs installed on the secondary structure over the cargo access.

NASA requires each crew member to maintain a 2.5 hour a day gym routine, thus the allocation of a significant portion of the available floor space. The first floor accommodates this by separating the primary science/work surfaces and the gym/hygiene/human research area with the ECLSS monolith. The structure creates a large visual barrier as well as providing a high level of white noise to wash out some of the ambient noise that comes from a treadmill and a die grinder (fed from compressed air tapped off the central ECLSS structure).

Food and Fun: The second floor holds very few of the utility heavy systems. Thus the volumes can be reduced while still providing utility for the crew. The second floor supplies the galley, pantry, long term food storage, med-bay, cold storage, wardroom, command control, and RMS station. There are centralized sinks, allowing water to be run, independently to the galley and the med-bay. The slender forms that divide the galley and wardroom space from the medical area yield a reduction of mass. To take advantage of this, the walls, ceiling and floor are to be outfitted with roughly 5,100kg of 5 cm thick radiation bricks to provide shielding. This allows the entire floor to be protected during a solar particle event, giving the crew access to food, water, entertainment, and medical, while the reduced footprint of utilities provides ample floor space for sleeping if the event lasts for more than a rotation. The daily consumables are crushed in a galley mounted waste get stored in the floor of the dust porch or in cargo bags stacked against the exterior wall of the habitat. The wardroom table can be configured in either a small, cafe style surface or deployed out, providing room for four.

The focus is on open space. The first floor, where the crew spends the majority of their working hours, is cramped due to the triple duty of laboratory, gym and maintenance. The second floor, while providing several of the key mission capabilities, caters to R&R with relatively large open floors, a large window and "open plan" style kitchen. Medical privacy is supplied by a deployable curtain to separate crew and patient during exams or treatment. The command and control center is situated on the opposite side of the habitat from the wardroom and galley with no line of site. This separates the functions and creates a work zone that is differentiated from the community area, dining table, and the command center by breaking up the line of sight with the medical area.

Rinse and Repeat: The third floor is reserved for crew quarters and hygiene. The second toilet is centrally co-located with the shower, divorced with a divider and separate entrances. As this is in the middle of the habitat, providing means of egress and maintaining four individual compartments of equal proportions proved impractical. The rooms are of equal net volume, however, the bed structures and overall room layouts vary in pairs. To maximize living space, the beds are arranged as bunks with an asymmetrical divider that separates the rooms. The top bunk's divider is curved over the bed creating more visual volume for the crewmate on the other side of the wall. The hygiene area is recessed into one pair of rooms, while the passageway protrudes into the second pair of rooms. This evens out the reduction of habitable space in the private quarters and increases the corridor, providing almost a direct line of sight to either of the egress points, or to see if someone is using the lavatory. The rooms are provided with power and light, allowing space for sanctioned personal experiments, personal down time and a place to sleep. Through analysis of "A day in the life," crew members spend between 33-59% of a given 24hr day, activities ranging from sleeping, down time, logs, and hygiene. This has been a driving factor in the provision of such substantial volume for the crew quarters.

HESTIA: A Centralized Trunk



January 10th, 2017

Kyle Kesling

Taylor Phillips-Hungerford



Major Systems Trunk





Secondary Structure: Good Ol' 80/20



- 212 (0.50 x 0.50 x 0.50) m bags
- ~ 4 bags equivalent in galley and medical area
- 2 x 1100 kg water tanks
- <u>Minimum Volume</u>: ~ 27 m^3

Multi-colored Woven Polyethylene



1st Floor: Down and Dirty

Cargo bags color-coated as denoted in bubble diagram





1st Floor: Down and Dirty



1st Floor: Down and Dirty

Translucent Water Tanks



Red Carbon Fiber Black Carbon Fiber Door Handles Door Panels

Structure

White Carbon Fiber Tan Synthetic Cork Blue Carbon Fiber Work Floor Surface



2nd Floor: Food and Fun

Cargo bags color-coated as denoted in bubble diagram





2nd Floor: Food and Fun



2nd Floor: Food and Fun

Window-Analog Computer Screen

Computer Screen





Light Orange Walnut Dining Table White Carbon Fiber Kitchen Work Surface

Black Carbon Fiber Structure Tan Synthetic Cork Floor



3rd Floor: Rinse and Repeat

Cargo bags color-coated as denoted in bubble diagram





3rd Floor: Rinse and Repeat



3rd Floor: Rinse and Repeat





Blue Memory Foam Mattress Glossy Carbon Fiber Structure

Tan Synthetic Cork Floor



Cheers!



Kyle Kesling is a native Texan who has been fascinated with space travel ever since his first visit to NASA as a child. He was always looking up at airplanes in awe as giant pieces of metal flew across the sky. This fascination led Kyle to join rocketry in high school and pursue a bachelor's degree in Aerospace Engineering from the University of Texas at Austin. While receiving his undergraduate degree, Kyle was a part of the Mars Research Group, which furthered his interest in space travel. Kyle Kesling is currently pursuing his master's degree in Space Architecture from the University of Houston. As a thesis, Kyle plans on designing a transit vehicle that will one day be used to travel to Mars. Kyle is currently employed as a contractor with Intuitive Machines working with Axiom Space in designing their future commercial space station. After graduate school, Kyle plans on getting a job that will still allow him to look up in the sky in awe, but this time not at airplanes, but at a creation of his own that was used to send the first humans to Mars.

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Taylor Phillips-Hungerford is currently enrolled in the Sasakawa International Center for Space Architecture master's program at the University of Houston. He was classically trained in the trade of design, from a very technical course at WIT in Boston to a very conceptual course at CSM in London. He was also classically trained in vocational labor from construction to landscaping, from laying water pipes in early winter to changing fan belts in the dead of winter. His design aesthetic stems from the virtues of honest form follows function practiced by I. M. Pei and Dieter Rames, and the day to day hands on vocational upbringing. This has led to a collaborative project fleshing out Buzz Aldrin and Larry Bell's Mars cycler and permanent settlement concept as well as a Space Architect Contractor position at Axiom Space and Wyle Laboratories, INC. designing for human centric space crafts.

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APPENDIX

TIME	CM1 - Biologist	CM2 - Physician	CM3 - Geologist	CM4 - Mechanic/Engineer	
6:00 - 6:30 AM	CQ	CQ	CQ	CQ	
6:30 - 7:00 AM	CQ - records questions	CQ - records questions	Medical blood test	Uses Toilet	
7:00 - 7:30 AM	Brookfast	Proakfact	Proakfast	Breakfast	
7:30 - 8:00 AM	DIEdkidst	DIEdKIdSt	DIEdkidst		
8:00 - 8:30 AM	Listens to NASA's response	Listens to NASA's response	Sets up soil samples		
8:30 - 9:00 AM		Sets up rover # 1 for sample return	Repairs hardware on re	Repairs hardware on rover #2	
9:00 - 9:30 AM	Performs soil sample analysis	Resistive workout	Performs soil sample analysis		
9:30 - 10:00 AM	Performs son sample analysis			Cardia warkaut	
10:00 AM - 10:30 AM			Writes up soil analysis report		
10:30 - 11:00 AM	Writes up soil analysis report	Private Medical Call		Runs software analysis	
11:00 - 11:30 AM	writes up soil analysis report		Medical - eye and bp tests	on rover # 2	
11:30 AM - 12:00 PM	Cardio workout	Panairs Trunk Leak/Clean Trunk		Repairs Trunk Leak/Clean Trunk	
12:00 - 12:30 PM			Resistive workout		
12:30 - 1:00 PM	Cleans 1st floor wet room				
1:00 - 1:30 PM	Lunch	Lunch	Lunch	Lunch	
1:30 - 2:00 PM	Lunch	Editeri	Lunch	Lunch	
2:00 - 2:30 PM	Checks plant growth	Replaces pantry with food	Rover # 1, sample return	Writes report on trunk repair	
2:30 - 3:00 PM		Cleans 3rd floor		writes report on trunk repair	
3:00 - 3:30 PM		shower and toilet		Runs diagnostics/ performs final testing	
3:30 - 4:00 PM	Resistive workout	Cardio workout		on rover # 2 for tomorrow's sample return	
4:00 - 4:30 PM					
4:30 - 5:00 PM	Cleans up/ Changes Clothes	Cleans up/ Changes Clothes	Cardio workout	Writes report on rover # 2's repairs	
5:00 - 5:30 PM	Sets up soil samples	Sets up soil samples			
5:30 - 6:00 PM	Receives minor cut on arm	Treats crew member with minor cut	Cleans up/ Changes Clothes	Resistive workout	
6:00 - 6:30 PM	Begins soil sample analysis from	Cleans area/Writes un injury report	Begins soil sample analysis from		
6:30 - 7:00 PM	rover # 1		rover # 1	Cleans up/ Changes Clothes	
7:00 - 7:30 PM	Dinner	Dinner	Dinner	Dinner	
7:30 - 8:00 PM	Dimiter		Dimer		
8:00 - 8:30 PM					
8:30 - 9:00 PM	Game Night	Game Night	Game Night	Game Night	
9:00 - 9:30 PM					
9:30 - 10:00 PM	Personal Time	Personal Time	Personal Time	Personal Time	
10:00 PM - 6:00 AM	SLEEP	SLEEP	SLEEP	SLEEP	



AVERAGE TIME SPENT ON EACH FLOOR OVER THE COURSE OF 16 HOURS

Reminder: Not all crew functions require dedicated workstations - some can be combined and some are accomplished with equipment items, while others may require multiple workstations and/or facilities. Mission duration and mission objectives drive degree Yellow – include Gold – don't preclude

Red – assumed no room to include				
HESTIA simulation of a Mars surface ha	Ditat	Description	HECTIA Suggestion	Eurotian Location
Functional Category		Description	HESTIA Suggestion	(2'o clock - dust porch
Hygiene Activities	Full Body Cleansing	Washing of the entire body of an individual crew member	Enclosed shower-like volume: separated from toilet volume	SF/C3
	Hand/Face Cleansing	Washing of an individual crew member's hands or face	Traditional sink/faucet mirror arrangement Include surfaces/points for holding washcloth soan etc. May	1F/C2
		washing of an individual erew member 5 hands of face	or may not have privacy enclosure to close off from cabin: should include access doors to full body cleansing	2F/C
			and urination/defecation	3F/C9
	Personal Grooming	Individual personal care tasks such as shaving, brushing teeth.	Co-locate with hand/face cleansing, include counter surface area for grooming materials and stowage area	1F/C2
		combing hair, etc.	for housekeeping and shared items	
				3F/C9
	Urination/Defecation	Discharge and containment of liquid and solid bodlily wastes	Enclosed toilet room with odor control and acoustic insulation: opens to hand/face cleansing and grooming	1F/C8
			volume.	3F/C9
Personal Activities	Sleep	Private environment to allow individual crew member sleep	Place inside a private crew quarters: sleep on horizontal surface, elevated minimum of 2' above floor	
				3F/12&6
	Private Communication	Crew member video and or audio conversation with visual and	Place inside private crew quarters; possible from both sleep and sitting position; requires CQ to have both	
		auditory isolation from other crew	visual and auditory partitions as well as data interfaces	3F/12&6
	Private Recreation/Leisure	Individual crew member unstructured, non-mission, self-directed	Place inside private crew quarters; include both a desk space for seated tasks and sufficient open floor space	
		activity	to move unencumbered in any direction (e.g. Kinnect based video game)	3F/12&6
	Dressing/Undressing	Changing of IVA clothing	Place inside private crew quarters AND inside personal grooming volume; include overhead reach	3F/12&6
	Personal Data Entry/Access	Individual crew member data device access on private (non-mission,	Place inside private crew quarters; implies computer network securitity	
		non-shared) IT devices		3F/12&6
Exercise Countermeasures	Aerobic Exercise	Individual crew member aerobic conditioning	Requires both treadmill and ergometer; additional rower is optional	1F/C6/6
	Resistive Exercise	Individual crew member resistive conditioning	Requires equivalent to ARED	1F/5
	Physical Rehabilitation	Individual crew member recovery from dehibilitated condition	May also include stretch bands	1F/5
	Bone Conditioning	Individual crew member bone loading	Met by combination of ARED equivalent and treadmill	1F/C6/6
				1F/5
	Sensorimotor Conditioning	Individual crew member sensorimotor exercise	Met by presence of treadmill	1F/C6/6
	Exercise Monitoring	Physiological monitoring of individual crew member exercise	Requires appropirate monitoring devices and room to mount in exercise area and/or medical or life science	
		countermeasure effectiveness	area	1F/7
Medical Care	Preventative Medical Care	Routine medical evaluation and intervention	Requires ISS-equivalent or better medical capability	2F/C6
	Medical Monitoring	Physiological monitoring of individual crew member health	Met by above medical equipment	2F/C6
	Emergency Medical Care - don't preclude	Contingency medical intervention due to injury or illness	Requires medical workstation to be a dedicated volume not shared with other tasks and deployable privacy	
			curtains; should also include equipment for transfer of injured crew to other spacecraft	2F/C6
Crew Dining	Meal Prep	Preparation of food items for crew member consumption	Level of capability varies depending on fresh food augmentation; minimal is ISS rehydrator and food	
			warmer; enhanced versions consider how to prepare freshly grown meats and vegetables for immediate	
			consumption; other enhancments include stabilizing fresh food for use in multi-week rover expeditions	
				2F/C9
	Fresh Food Augmentation - don't preclude	Production of fresh food items (e.g. plant or animal growth) to	Minimum solution should include sufficient fruits and vegetables for a weekly crew salad; enhanced	
		supplement prepackaged food items	solutions may increase frequency and/or add additional plants or animals; consider demonstrating a meat	. = / ==
			concept (perhaps tilapia or salmon)	1F/C2
	Eating	Group and individual crew meal consumption	Includes utensils, trays, surfaces, cups, etc. and galley table; Mars location implies need for chairs	2F/2
	Meal Cleanup	Disposal of food waste products and cleaning and stowage of	Stowage for housekeeping / cleaning supplies and trash stowage sized to accommodate 1-3 days worth of	25/00
		reusable meal equipment	meal trash	2F/C9
Group Activities	Group Recreation/Leisure	Group crew member unstructured, non-mission, self-directed	One or more locations in the spacecraft where all four crew can play, inclusive of physical activity, board	25/2
		activity	cames, movie/video watching, cards, conversation, etc.	2F/2
	Crew Meetings	Multi-person crew mission-related meetings	One or more locations in the spacecraft where all four crew can conduct work related meetings without	
			displaying prohibited content in the background; at least one location should be appropriate to each type of	
			mission operational activity (e.g. research, EVA, spacecraft system commanding, etc.)	ar /a
				2F/2
	PAO Events and Multi-Person Video	Multi-person crew video and audio communication with the ground	One or more locations in the spacecraft where multiple crew can communicate with Earth or other space	
	Communication	or other space assets	vehicles without broadcasting prohibited content in the background (e.g. no direct view of medical activity	аг/а
National States in the second			or proprietary research)	27/2
Naintenance, Fabrication, and	Housekeeping	Routine component replacement, cleaning, or adjustment of	finclude pantry stowage for general nousekeeping items as well as point of use stowage near areas requiring	25/04
Repair - now much?	Electrical Maintenance, Densir, and Estrication	spacecraft subsystems	Trequent nousekeeping (e.g. cleaning fluids and rags in galley)	2F/C4
	Electrical Maintenance, Repair, and Fabrication	corrective action to diagnose and restore degraded functionality of	Extensive electronic and electrical capability including PCB fabrication, soldering, circuit testing, etc.	
		electrical components or produce new/replacement items		1F/2
	Machanical Maintenance, Renair, and	Corrective action to diagnose and restore degraded functionality of	Tools fixtures and parts for repair of electric meters, mechanisms, releases, and other mechanical devices	11/2
	Endprication	mochanical components or produce new/replacement items	Tools, includes, and parts for repair of electric motors, mechanisms, releases, and other mechanical devices	
	rauncation	mechanical components or produce new/replacement items		1F/2
	Soft Goods Maintenance, Ronair, and	Corrective action to diagnose and restore degraded functionality of	Miniaturization of EC Soft goods laby thermonlastics canability should be able to fabricate inflatables. flexible	±1/4
	Fabrication	soft goods components or produce new/replacement items	tubes of varying diameters natches seals atc : sawing shon should be able to fabricate unit replacement	
		sore goods components of produce new/replacement items	segments rebuild gloves repair boots fabricate IVA clothes cargo bags curtains ato	
			segments, resulta gioves, repair boots, rasineate tvA clothes, targo bags, turtallis, etc.	1F/2
				,

Reminder: Not all crew functions require dedicated workstations - some can be combined and some are accomplished with equipment items, while others may require multiple workstations and/or facilities. Mission duration and mission objectives drive degree Yellow - include

Gold – don't preclude

Red – assumed no room to include

HESTIA simulation of a Mars surfa	ESTIA simulation of a Mars surface habitat				
Functional Category	Crew Function	Description	HESTIA Suggestion	Function Location (3'o clock = dust porch	
	Structural Maintenance, Repair, and Fabrication	Corrective action to diagnose and restore degraded functionality of structural components or produce new/replacement items	Basic metal and plastics machine shop capabilities, including metal bending, rolling, cutting (sheet, bar stock, tube, etc.) grinders, saws.; 3D printing (metal and plastic); lathe and mill; small IVA welding (larger welding capacity EVA)	1F/2	
	Software Maintenance, Repair, and Fabrication (Coding, CAD, Diagnostics, etc.)	Corrective action to diagnose and restore degraded functionality of software modules or produce new/replacement code	High performance CAD and computaitonal analysis workstation; software integrated development environment (IDE), hardware/avionics integration (miniature SAIL-like capability)	1F/2	
Commanding	Subsystems Access and Control	Crew member commanding and monitoring access to spacecraft subsystems	Include dedicated displays and crew interfaces; should facilitate 1 and 2-person operation and allow 4 crew to observe at same time.	2F/6	
	Spacecraft Piloting - don't preclude	Crew member manual or supervisory piloting of mobile spacecraft assets	Should not conflict with robotic asset operation; usage may include Hab control of nearby MMSEV or ATHLETE, or remote checkout of MAV, taxi, or Mars Transfer Vehicle	2F/6	
	Activity Planning/Scheduling Teleoperations, Robotic Supervision, and	Onboard crew planning or scheduling of human or robotic tasks Crew member teleoperated or supervisory control of robotic or	Does not need to be a dedicated station - could pull up from any computer interface Similar to piloting station, but capable of monitoring of swarm robotic assets (e.g. multiple robots in parallel)	2F/2	
Translations	Cargo Transfer to/from Visiting Vehicles or Attached Modules - don't preclude	Cargo Transfer across exterior pressure vessel hatches to/from Visiting Vehicles or Attached Modules, inclusive of hatch size, placement of open hatches, hatch operation, and visibility across	Accommodate 2 docked logistics modules at all times. Hatch size should maximize cargo transfer efficiency - recommend 40x60-inch as minimum hatch size. If connecting tunnel is greater in length than side-step length, tunnel height should be same as cabin deck.	2F/6	
	Crew Transfer to/from Visiting Vehicles or Attached Modules - don't preclude	hatches Crew Transfer across exterior pressure vessel hatches to/from Visiting Vehicles or Attached Modules, inclusive of hatch size, placement of open hatches, hatch operation, and visibility across	Accommodate 2 docked MMSEVs at all times. Hatch size should accommodate pressurized suited crew transfer, including one crew member carrying incapacitated crew member - recommend 40x60-inch as minimum hatch size. If connecting tunnel is greater in length than side-step length, tunnel height should be same as sakin dock.	1F/3	
	IVA Crew Translation	Crew translation from point to point within the pressure vessel, including across interior hatches, between workstations and subsystems, and past other crew members and cargo	Translation space should accommodate suited crew member carrying incapacitated crew member; all interior vertical and horizontal hatches/doorways recommend 40x60-inch as minimum size.	ALL	
	IVA Cargo Translation	Autonomous, teleoperated, and manual cargo translation from point to point within the pressure vessel, including across interior hatches, between workstations and subsystems, and past other cargo and crew	Accommodate transfer of largest IVA inert item (e.g. rack, machinery, pallet, robonaut, etc.); for all interior vertical and horizontal hatches/doorways recommend 40x60-inch as minimum size.	ALL	
	IVA Restraint and Positioning Aid	Rails, tie downs, manipulators, seats, foot straps, thigh bars, enclosures, and other devices to aid in translation, positioning, or restraint of crew or cargo	Mars gravity calls for use of seats for crew; rails, tie downs, manipulators, and other devices may be required for cargo	WINCH INSTALLED	
	Cargo Staging / Configuration / Sorting / Assembly	Temporary positioning of cargo items for sorting, assembly, rearrangement, or preparation to transfer to other locations	Strategically reserve open floor space near key translation points. Airlock, docking hatches, vertical translations are primary examples.	1F/3	
	Crew Access to Workstations/Crew Stations	Physical access to spaceceraft facilities designed for crew use	Reserve operator volume that does NOT protrude into translation paths	1F/9-3 2F/C9 2F/C6 2F/2	
	Crew Access to Subsystems Equipment	Physical access to spacecraft subsystem components	Reserve access volume behind/around equipment for cables and other ducting/plugs as well as access volume to install/remove and inspect subsystems	1F/C3 2F/C6 2F/C12 3F/C3 3F/C9	
	Crew Access to Stowage	Physical access to spacecraft logistics stowage locations	Ensure sufficient room to not only access and remove/replace stowage items, but to also read labels and identify the proper stowage unit	ALL	
	Crew Access to Trash/Waste	Physical access to spacecraft trash or waste containment locations	Consider logical trash locations to store small amounts of trash at point of use (e.g. 1-2 meals worth of trash in galley) and odor-controlled aggregation points for batch relocation of trash to logistics module	2F/C9	

Reminder: Not all crew functions require dedicated workstations - some can be combined and some are accomplished with equipment items, while others may require multiple workstations and/or facilities. Mission duration and mission objectives drive degree Yellow – include Gold – don't preclude

NUMBER Control of the cont	Red – assumed no room to include					
Image is a problem in the second se	IESTIA simulation of a Mars surface habitat					
Outcome of the set of	Functional Category	Crew Function	Description	HESTIA Suggestion	Function Location	
part of not a size is any set of a size is an an an and a size is any set of a size is an a direct when a size is a direct when a direct when a size is a direct when a direct when a size is a direct when	Mission Operations (Assume EVA	IVA Support of EVA Crew - don't preclude	IVA crew member monitoring and communication with EVA crew	Does not need to be a dedicated station - could pull up from any appropriate computer interface		
Quarkey Real always and problems of order (Quarkey) Balance waves for decay problem (Quarkey) Balance waves for decay problems (Quarkey) Balance waves for	is part of mobile asset or other chamber)		Ğ		1F/12-2	
Number Number of the start of the intervention is a rank of the intervention is a start of the intervention is a st		EVA Suit Donning/Doffing	Physical environment for donning or doffing EVA suits	Dedicated area not inside the actual airlock volume	1F/3	
In the starting section starting with starting section starting section starting with starting section starting secti		EVA Ingress/Egress	Access path and environment for crew member ingress and egress	Could be internal or external airlock; aluminum or inflatable		
Number of the description of			to the exterior space or planetary environment		1F/3	
Numerical set in the interfactor interfacto		Life Science Research (plant, animal, human,	Research related to life science disciplines including plant, animal,	Study needed to determine appropriate number of workstations given crew size; approximately 7 ISPR-		
Number of the sector frame and sequences of the sector frame and sec		cellular, microbiology, etc.) - as required by HRP	human, cellular, microbiology, and related domains	equivalent gives broad range of life science capability	1F/3	
Participant period Product period Pro		Physical Science Research (physics, chemistry,	Research related to physical science disciplines including physics,	Study needed to determine appropriate number of workstations given crew size; approximately 8 ISPR-		
Network Network Network Network Network Network Network Network Inder def values Network		metallurgy, geology, etc.) - don't preclude	chemistry, metallurgy, geology, and other physical domains	equivalent gives broad range of life science capability	1F/11	
Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume Instrume		Earth/Planetary and Space Science Research	Research related to space, earth, an dplanetary science disicplines	Study needed to determine appropriate number of workstations given crew size; approximately 1 ISPR-		
February Training Result Result of end of a photogene indicating space of a photogene indicating space of a photogene indication in the photogene indication indindicatina indication indication indication indication indicatio		(meterology, astronomy, etc.) - don't preclude	including meterology, astronomy, and other related domains	equivalent gives broad range of Earth/space/planetary science capability	OUTSIDE	
Image: space		Technology Testing Research	Research related to testing of technologies including spacecraft	May be able to co-locate with maintenance and repair capability; might require some additional		
Image: space			subsystems, robotic systems, and other engineered devices or	hardware/tools		
Ores Topins, Base of the sector of			locally fabricated items		1F/2	
Light is in the second in the selected of them designed to fail that fiquent cere member accoss Consider logical accose plot of to the second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected of the designed of a figure second in the selected second in the selected of the designed of a figure second in the selected secon		Crew Training	Individual and group crew member training and evaluation activities	Does not need to be a dedicated station, but may require deployable panels (e.g. Orion mockup for crew training)	2F/6	
Interpretation Access Food in the galgyd Food in the galgyd Access Access Interpretation Interpretation Dispersion Considering regressing stowage at stratege/schebecurgs out discussing i.e.g. at dod stowage will a protein stowage at stratege/schebecurgs out and stowage will a protein stowage at stratege/schebecurgs out and stowage out interpretation regressing stowage at stratege/schebecurgs out and stowage out interpretation regressing stowage at stratege/schebecurgs out and stowage out interpretation regressing stowage at stratege/schebecurgs out and stowage out interpretation regressing stowage at stratege/schebecurgs out and stowage out interpretation regressing stratege/schebecurgs out and stowage out interpretation regressing stratege/schebecurgs out at a stratege/schebecurg stratege/schebecurgs out at a stratege/	Logistics	Frequent Access Stowage	Stowage of items designed to facilitate frequent crew member	Consider logical stowage locations to store reasonable amount of supplies at point of use (e.g. 1-2 weeks of		
Integrate Access Soviety Integra	Ŭ	, , , , , , , , , , , , , , , , , , ,	access	food in the galley)	ALL	
Cold Stowage Stowage of Lood, science, or other licens within specified Manneed to store half or more of surface food supply in refigerator to preserve life science and physical science Preserve in the supply science Preserve i		Infrequent Access Stowage	Long term stowage not intended for regular crew member access	Consider larger pantry stowage at strategic/architecturally sound locations (e.g. a food stowage wall in a corridor with 3 months food)	1F/TOP	
Non-basis Importative ranges Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science and physical science Prefigerate or freed tresh food; may need separate system to preserve life science Prefigerate or freed tresh food; may need sep		Cold Stowage	Stowage of food, science, or other items within specified	May need to store half or more of surface food supply in refrigerated or frozen form; may need to		
Toph and Wate Accommodation SPCG Toph and Wate Accommodation Slowage frash or wate items Indust control of topically styte item and wate. 27/03 Planciary Protection Slowage frash or wate items in the space-crift. Indust control of topically styte items and wate. 27/03 Planciary Protection Calability to string explanment to food samples items in the informace in the ambient space-crift architecture and account of topical space items in the informace in the ambient space-crift architecture informace in the ambient informace in the ambient informace in the ambient informace i		Ŭ	temperature ranges	refrigerate or freeze fresh food; may need separate system to preserve life science and physical science		
Task and Weste Accommediation Stowage of irasis rowasis items Include trapment of biologically active trash and weste 27/C2 Planetary Yonection Approverty Management Spacerari Spacerarii Spacerariii Spacerariiii Spacerariiii Spacerariiii S				(e.g. ISRU) samples	2F/C6	
Investor Manual and automater tracking of all portable terms in the procession. Include degins (RVID readers, machine vision, on other technologies into the spaceraft and the procession. Non- procession. Planetary Protection Automater tracking all portable terms in the introduction the aminimum spaceraft environment. Incorporte into airdok or which cecterior		Trash and Waste Accommodation	Stowage of trash or waste items	Include treatment for biologically active trash and waste	2F/C9	
Planetary Protection Subpretary Protection Capability to isolate equipment or local samples intended to be introduction into the ambient spaceralt environment integrated Out[Iting neoporate into airlock or vehicle exterior If/3 integrated Out[Iting Capability to isolate equipment or local samples to prevent their introduction into the ambient spaceralt environment integrated Out[Iting Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include transfer devices, bags, glove boxes, or other appropriate provisions Include Intervelower GCR, and radiation emitted by samples or spaceraft equipment Gcapbility blouid exist throughout the spacera		Inventory Management	Manual and automated tracking of all portable items in the spacecraft	Include design of RFID readers, machine vision, or other technologies into the spacecraft architecture	2F/C12	
Introduced into the ambient space of equipment of local samples to preven their introduction into the ambient space of equipment of local samples to preven their introduction into the ambient space of equipment of local samples to preven their introduction into the ambient space of equipment of local samples to preven their introduction into the ambient space of equipment of local samples to preven their introduction into the ambient space of equipment and lask lighting lights. Exterior should also include navigation lights, searchights, and heacons. Introduction into the ambient space of CR, and radiation emitted by samples or space aff equipment cabin environment cabin enviro	Planetary Protection	Equipment / Sample Sterilization	Capability to sterilize equipment or local samples intended to be	Incorporate into airlock or vehicle exterior		
Instance Copability to loads expressed to loads another to prevent their induction in the ambient spaceraft environment Include transfer devices, bags, glove boxes, or other appropriate provisions Pathol Integrated Outfitting Vehicle Lighting Interfor and exterior spaceraft ambient and task lighting lights. Faterior should also include newigation lights, searchights, and becons. ALL Relation Protection - don't preclude Protection from radiation sources, including ambient solar, SPF, CRC, and radiation emitted by samples or spaceraft equipment Maintain keep out zones for lighting; proper lighting intensity and mix of fixed general vs. task vs. portable lights. Faterior should also include newigation lights, searchights, and becons. ALL Odor Control Isolation, containment, or removal of odors from the spaceraft. Capability should exist throughout the spaceraft, not just in trash storage enclosures and hygiene crew station. PRE.INSTALLED Renegrency Operations - ground bacode & some Mars scenable Fire detection and location, fire suppression, personal protective equipment, and post the recovery couperessization and election, leak repair, personal protective equipment, and post the recovery include to coll segrent and rule ability to isolate certain sections of the habitat from primary cabin air loop personsization and election, sheller protective equipment, and post incident incident recovery Recovery may imply ability to isolate certain sections of the habitat from primary cabin air loop personsization and election, sheller protective equipment, deceaderead repair, habots, etc. incident betabing the spaceraft and pob			introduced into the ambient spaceraft environment		1F/3	
introduction into the ambient spacecraft environment Introduction into the ambient spacecraft environment Introduction into the ambient spacecraft environment Interior and exterior spacecraft environment Nalintain keep out zones for lighting; proper lighting intensity and mix of fixed general vs. task vs. portable lights. Exterior should also include navigation lights, searchlights, and beacons. All. Radiation Protection - don't predude Protection from radiation sources, including ambient solar, SPF, concernent May include localized protection within workstations, spacecraft closeouts, and/or surface features/terrain rabin environment All. Odor Control Isolation, containment, or removal of odors from the spacecraft cabin environment Consider vent and ducting design as part of cabin layout Reservers and hygience PRE-INSTALLED Present of the spacecraft environment Free spacecraft recovery Consider vent and ducting design as part of cabin layout Reservers and yingly ability to isolate certain sections of the habitat from primary cabin all loop PRE-INSTALLED Present environment Free description, environment within tolerable levels Look at separation of quiet and noisy activities, acoustic biankets, etc. PRE-INSTALLED Present environment Free description environment within tolerable levels Look at separation of quiet and noisy activities, acoustic biankets, etc. PRE-INSTALLED Present environment Free description environment within tolerable levels Look at separation of quiet and noisy activities, acoustic biankets, etc.		Equipment / Sample Isolation	Capability to isolate eqipment or local samples to prevent their	Include transfer devices, bags, glove boxes, or other appropriate provisions		
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