
SPACE ARBOR
HESTIA

DESIGN TEAM

ARC451B - FALL 2016 - NASA Studio
Instructor: Andrea Bertassi

ERNESTO ENCINAS

Ernesto is a 5th year architecture student at the University of Arizona. His architectural focus is on urban and public design. Other interests are investigation of materiality, light use and human connection to new and existing conditions. Ernesto's contribution to the project is the development of the 'tree' core and other various structure in the design. Ernesto can be reached at: www.linkedin.com/in/ernesto-encinas-98654463

CIARA GUNTER

Ciara is a 5th year architecture student at the University of Arizona. Her contribution to the project initially focused on individual research of human comfort and essential qualities for human happiness which was integrated into the design upon group collaboration for the living quarters on the third floor. Ciara can be found at the following links: www.ciaragunter.com www.linkedin.com/in/ciara-gunter-0838a436

NORDEAN MOUSSALEM

Nordean is an aspiring 5th year architecture student at the University of Arizona. He has an interest in architecture driven by sustainability and environmental research. His contribution to the project include the concept of the design, scheduling and understanding of the programmatic elements, and incorporation of the hydroponic wall. For work samples, Nordean can be reached at: nordean92@hotmail.com

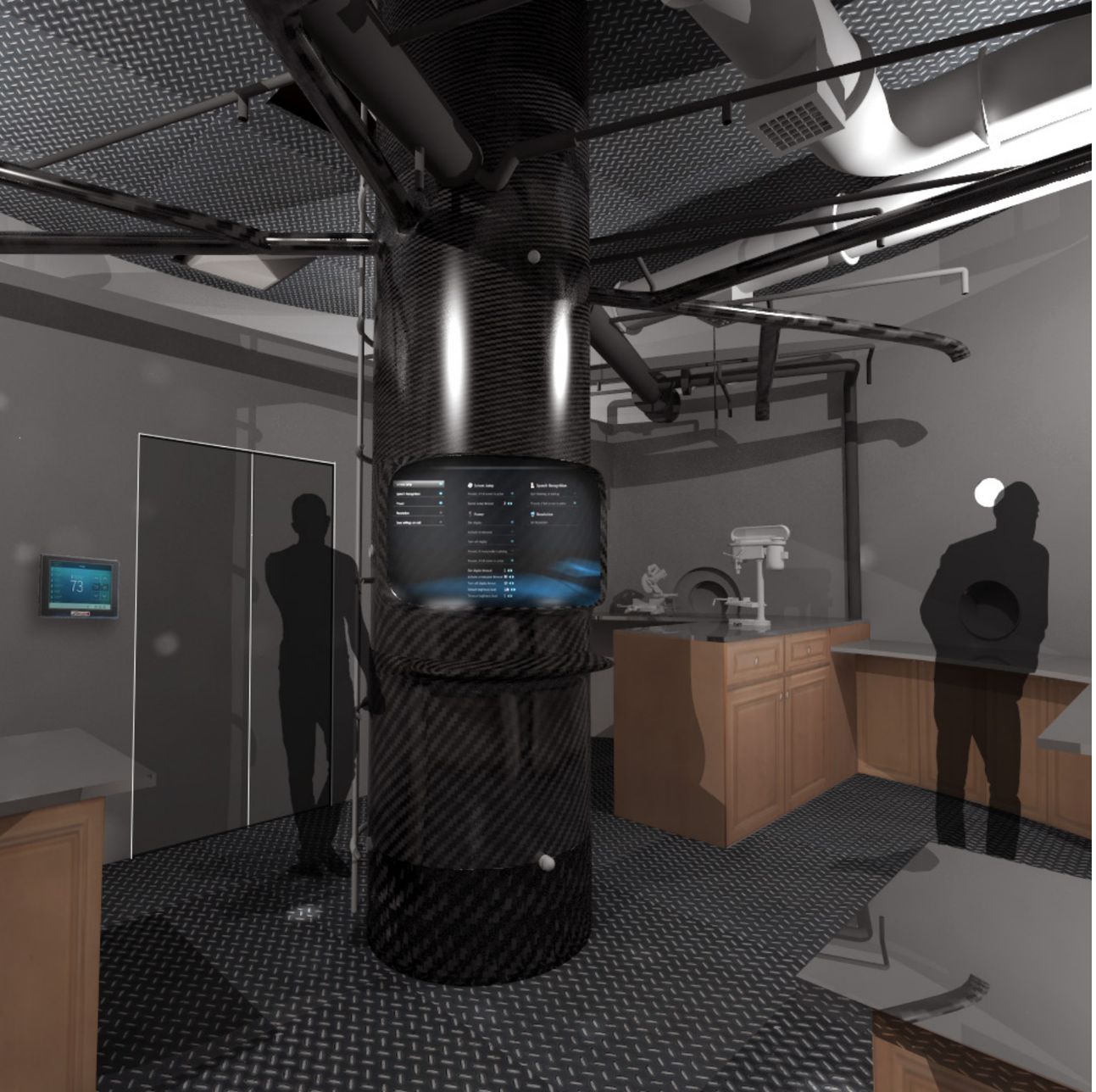
CRAIG SHELDON

Craig is a 5th year architecture student at the University of Arizona. He is interested in hospitality architecture that incorporates nature and blends with the surrounding context, designed with elegance in simplicity. His contributions to the project include the overall design layout, compilation of the design documentation, and the lighting and materiality. Craig can be reached at: www.linkedin.com/in/craig-sheldon-572703128

YU WANG

Wang is a 5th year architecture student at the University of Arizona. His contribution to the project include the design of the bedrooms and bathrooms, and overseer of the digital model and rendering.

Special Thanks to Canaan Martin (NASA)



1 INTRODUCTION

The Habitat Design Center has begun an interdisciplinary project on the campus of Johnson Space Center in Houston, Texas, which involves multiple engineering and science teams. The Human Exploration Spacecraft Testbed for Integration and Advancement (HESTIA) is to become a host for a ground analog for a Mars habitat capable of sustaining four astronauts for 90 days. The goal of this project will be to design the internal architectural outfitting of this chamber including all the elements and stations required for human habitation.

2

ANALOG PRECEDENTS

An analog mission is a field activity set in a remote location with extreme characteristics that resemble the challenges of a space mission. NASA has used this approach since the Apollo days, when they tested roving, space walking, and research techniques to prepare for Apollo missions in meteor craters and volcanic fields in Arizona and Hawaii. Today, NASA conducts analog missions in extreme environments around the globe to help plan and guide the future direction of human exploration of the solar system.[1]

Tests include: new technologies, robotic equipment, vehicles, habitats, communications, power generation, mobility, infrastructure, and storage. As well as behavioral effects including isolation and confinement, team dynamics, menu fatigue, and others.

Analogs provide NASA with data about strengths, limitations, and the validity of planned human-robotic exploration operations. Analogs also help define ways to combine human and robotic efforts to enhance scientific exploration. Test locations include the Antarctic, oceans, deserts, arctic, and volcanic environments.[2]

WHAT IS AN ANALOG?

analog missions are field tests in locations that have physical similarities to the extreme space environements[2]

DESCRIPTION

Analog missions prepare astronauts for near-future exploration to asteroids, Mars, and the Moon. Analogs play a significant role in problem solving for spaceflight research.

DESCRIPTION

Countermeasures can be tested in analogs before trying them in space. Those that do not work in analogs will not be flown in space.

DESCRIPTION

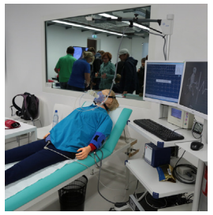
Not all experiments can be done in space -- there is not enough time, money, equipment, and manpower.

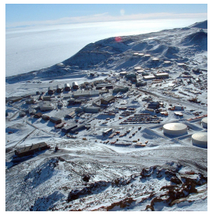
DESCRIPTION

Ground-based analog studies are completed more quickly and less expensively.

TYPES OF ANALOGS

an overview of the fifteen various analogs in use at nasa[3]

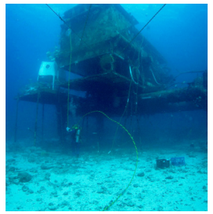




01	02	03	04	05
Human Exploration Research Analog (HERA)	NASA Space Radiation Lab (NSRL)	Human Exploration Spacecraft Testbed for Integration and Advancement (HESTIA)	:envihab	Antarctic Stations - National Science Foundation (NSF)

TYPES OF ANALOGS

an overview of the fifteen various analogs in use at nasa



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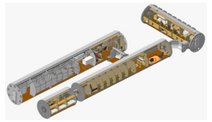
Aquarius; NASA Extreme Environment Mission Operations (NEEMO)

07

Parabolic Flight



08

IBMP Ground-based Experimental Complex (NEK)

09

Human-Rated Altitude Chamber Complex (ACC)

10

Concordia

TYPES OF ANALOGS

an overview of the fifteen various analogs in use at nasa

11

Desert Research and Technology Studies (Desert RATS)

12

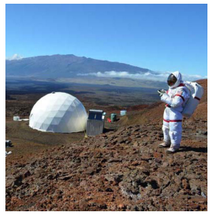
Pavilion Lake Research Project (PLRP)

13

Haughton Mars Project (HMP)

14

In-Situ Resource Utilization (ISRU)



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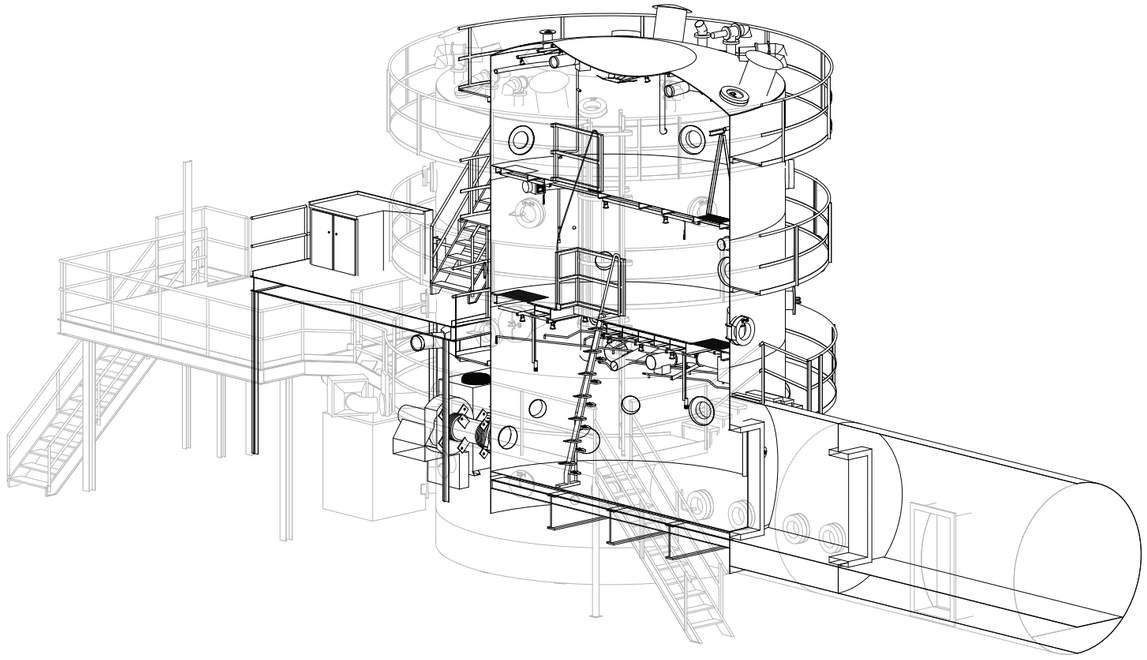
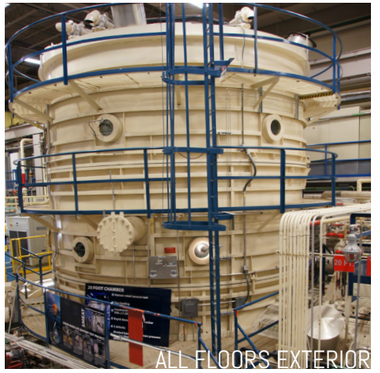
Hawaii Space Exploration Analog and Simulation (HI-SEAS)

HESTIA EXISTING CONDITIONS

an overview of the current conditions of the hestia chamber[4]




ALL FLOORS EXTERIOR


FIRST FLOOR INTERIOR


SECOND FLOOR INTERIOR


THIRD FLOOR INTERIOR

DESCRIPTION

The 20-foot Chamber is a human-rated, 3-story, hypobaric research test facility with a 20-foot inside diameter with an internal volume of approximately 229 m3 (8,090 ft3). Located in Building 7, the 20-foot Chamber Facility was used to support Gemini, Apollo, and SkyLab Missions. More recently, it was used to conduct 30-, 60-, and 90-day human ECLSS closed-loop testing in the 1990s to support the International Space Station and life support technology development.

LOCATION:

Johnson Space Center, Houston, Texas

ENVIRONMENT:

Simulated Pressure

HAZARDS TESTED:

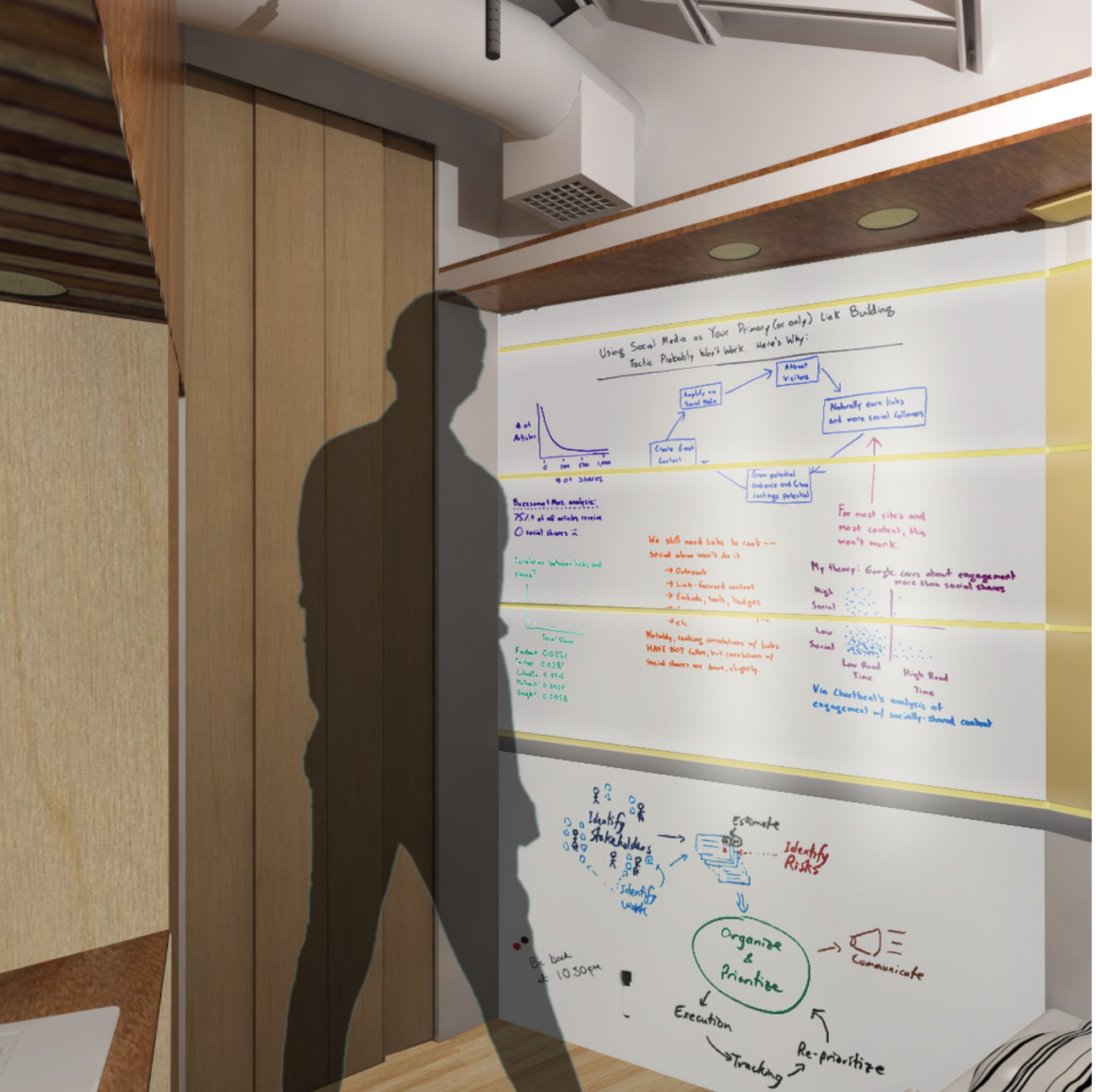
Gravity

RESEARCH GOALS:

The goal is to develop a high-fidelity Mars / Lunar surface analog to conduct research needed in support of next generation NASA Deep-Space Missions in the areas of Environmental Control and Life Support, Human Habitation, and Human Health and Performance

COLLABORATIONS:

Environmental Control and Life Support System (ECLSS), Habitation Systems, Human Health and Performance, Human Research Program (HRP)



3

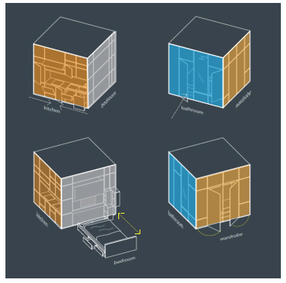
INDIVIDUAL RESEARCH

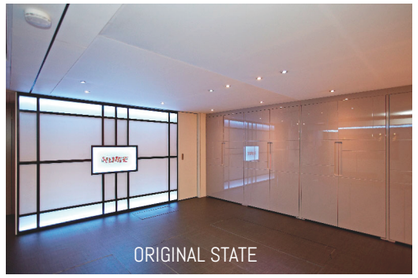
At the beginnings of the semester, prior to design, the team thoroughly researched various topics that were deemed interesting to them, and followed each topic into the final design as appropriate.

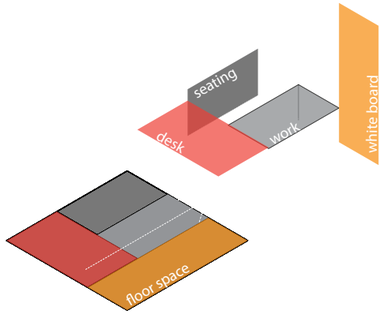
ASPECTS OF COMPACT DESIGN

a look into characteristics and restrictions provided from compact design

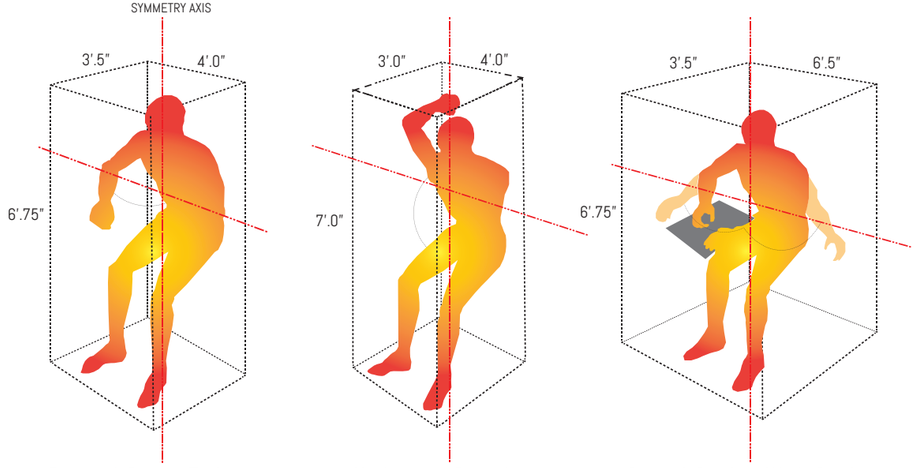
TRANSFORMATIVE SPACES







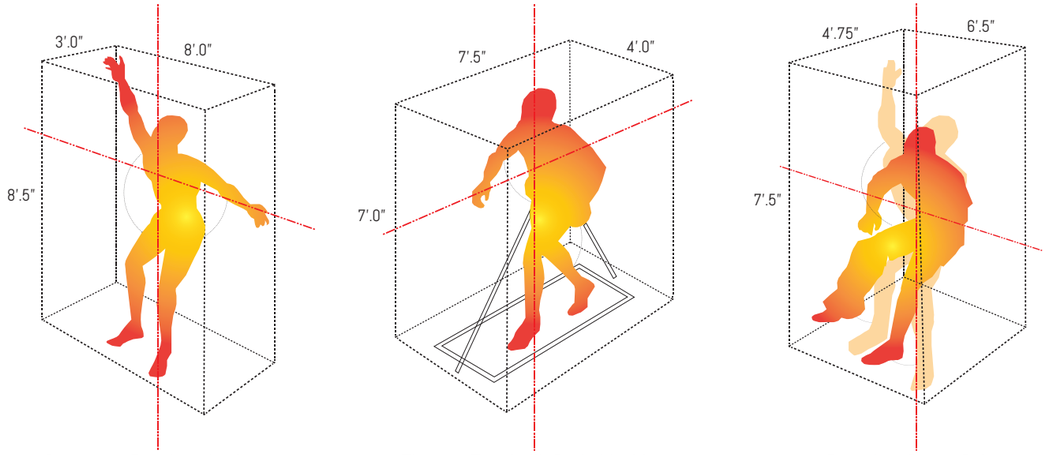
MOBILITY WITHIN SPACES



Personal Space, Eating, Sleeping, At Rest

Hygiene, Grooming, Shaving, Oral

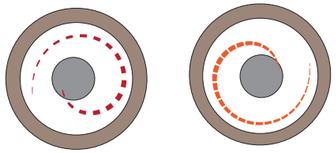
General Station, Work Station, Food Prep, Housekeeping



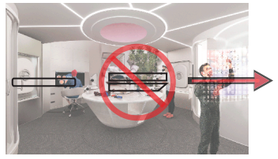
Storage Reach, Lockers, Food, Office

Fitness, Treadmill, Cycle Machine

Dressing, Space Suit



FREE SPACE MOBILITY CIRCULATION



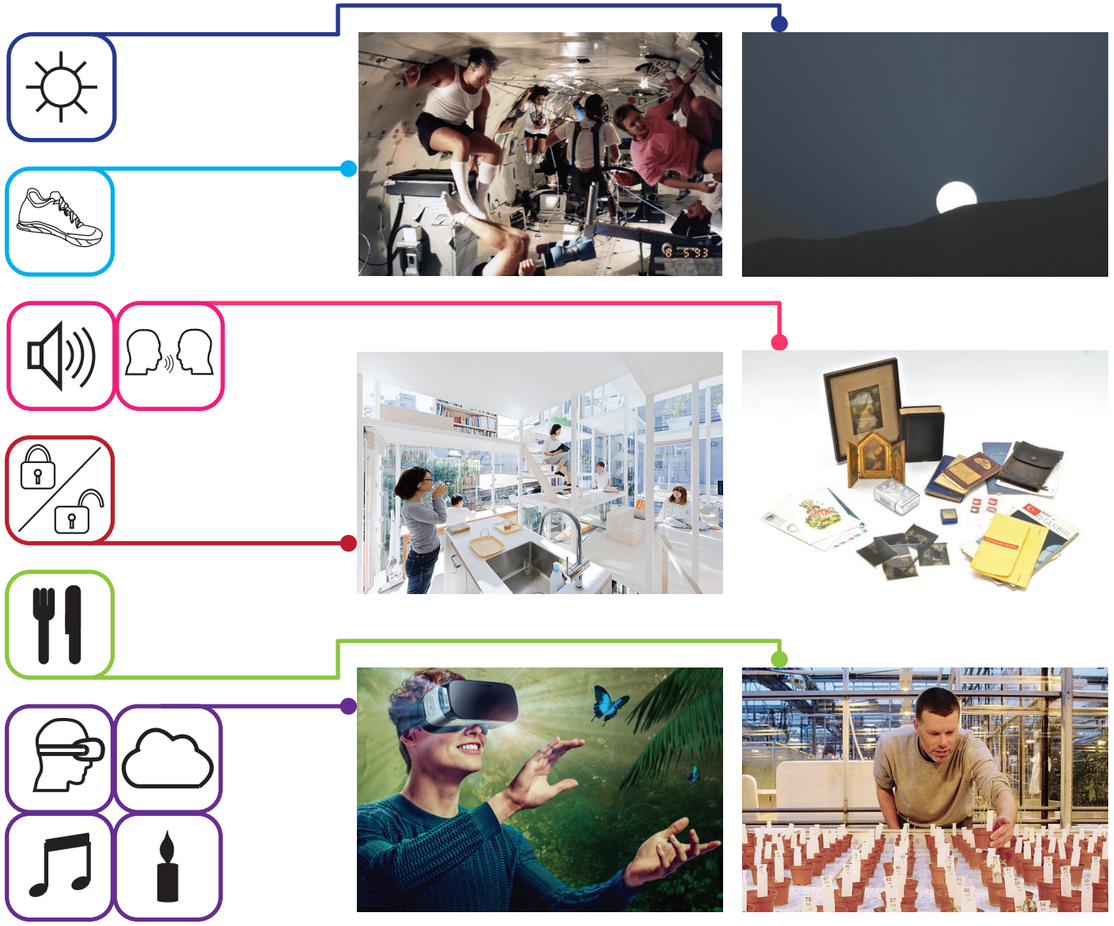
INTERIOR EDGES

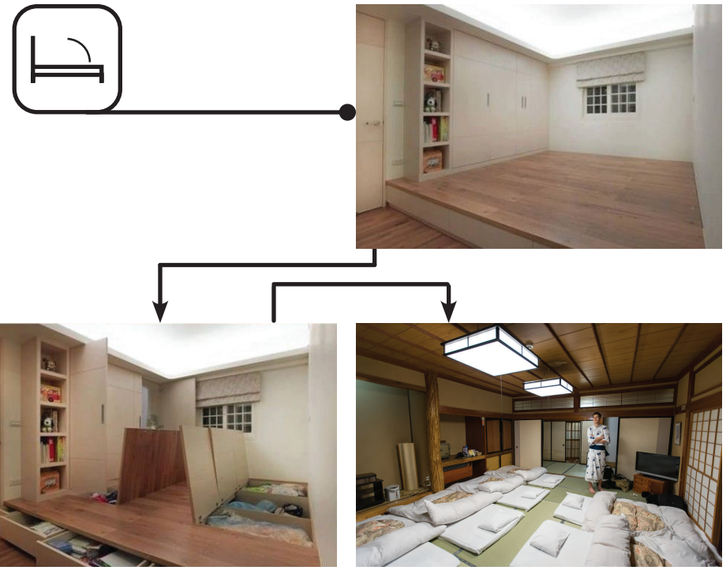
POTENTIAL CAUSES

SAFETY = HAPPY ASTRONAUTS

ESSENTIALS OF LIFE

a look into the quality of life that should be maintained by astronauts





ORIENTATION:

Customizable furniture - multipurpose rooms with hidden storage, the use of mixed material to warm/liven up interior space.

Adapting to the notion of living on Mars is adapting to another culture. Condensed spaces lends for creative use of space and new ways of approaching daily routines.

Maintenance will be crucial to ensure long-term functionality of all systems and must be checked regularly. The astronaut's lives depend on the technology present in the settlement.

NATURAL LIGHT:

Mars receives just 40% of the light we experience on earth, meaning the sky appears much darker the closer it gets to the horizon.[1]

PHYSICAL ACTIVITY:

Astronauts need to work out for 2 hours every day to maintain bone density.[2]

COMMUNICATION:

Bringing personal items can help lessen the feeling of isolation.

PRIVATE/PUBLIC SPACE:

A defined space for each individual promotes happier interactions long term.[3]

QUALITY/QUANTITY OF FOOD:

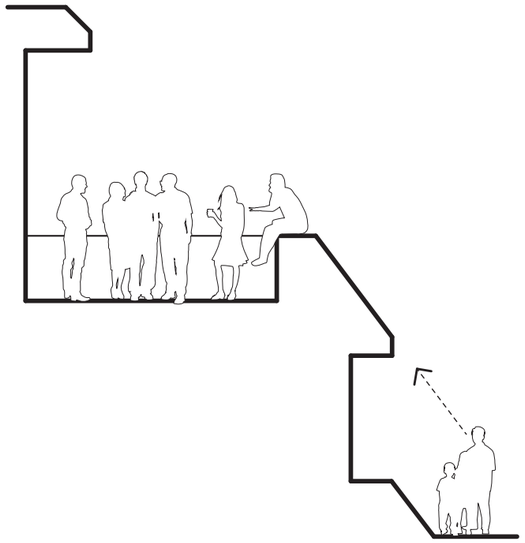
Crops grown in soil simulating that found on mars are safe to eat.

CONNECTION TO ENVIRONMENT:

The use of virtual reality simulations can activate the senses through aspects of earth.

BEHAVIOR IN ARCHITECTURE

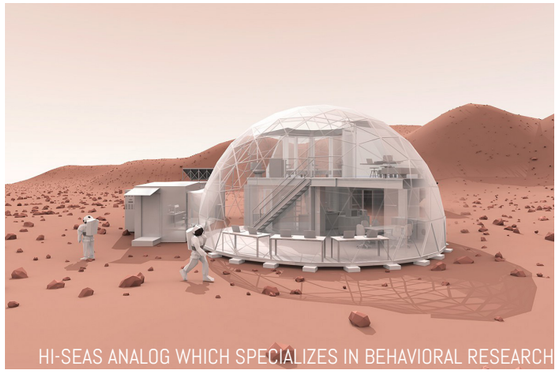
an understanding of the relationship between human behavior, and the natural and built environment



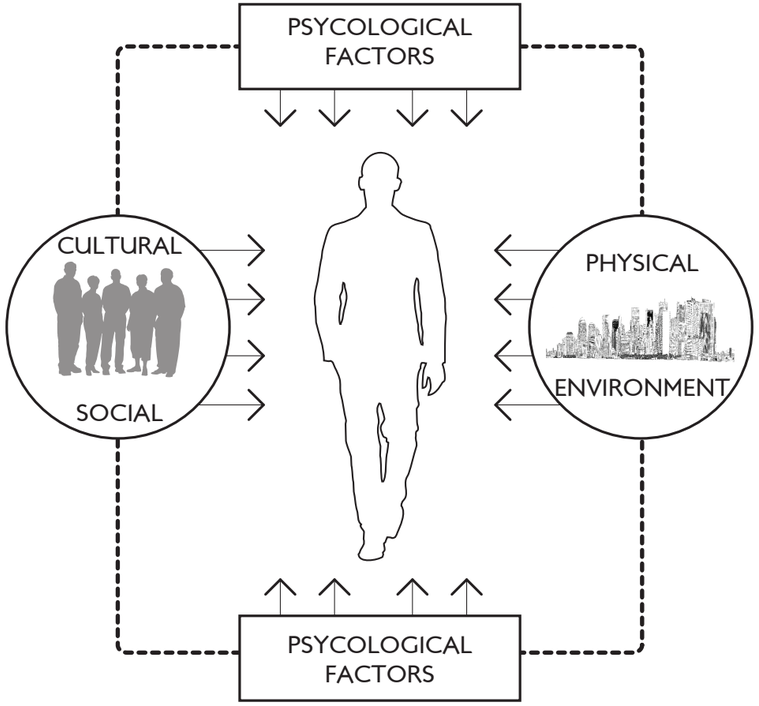
ARCHITECTURAL DETERMINISM

This term, coined in the 1960s, describes the assertion that designs of buildings can change human behavior in a positive way. This lead to a large amount of big name architects, including Frank Lloyd Wright and Le Corbusier, to make all sorts of claims about the field. After a string of failures and the demolition of the Pruitt-Igoe housing complex, the term has fallen to the shadows.

In the following decades, further research has confirmed that our environments do in fact affect us, whether by design or on accident. The healthier a person, a good environment will impact them more positively while a bad one will have a lesser negative effect. The feeling of awe, induced from architecture or not, has been found to reduce the harmful affects of mood disorders. It is difficult to prove these psychological effects, but that doesn't devalue a building that creates an awe inspiring space. Most focus today on this topic is done on health care design, where these changes literally do have life or death consequences; the same can be said for space design.[4]



HI-SEAS ANALOG WHICH SPECIALIZES IN BEHAVIORAL RESEARCH



DESCRIPTION

Studies on behavior caused by the environment in architecture is a modern approach to traditional purposes of architecture. It places the needs, values, and preferences of the users at the forefront in the design process. The goal of this is the ultimate satisfaction of human needs while eliminating environmentally-induced stress. The ultimate judge of great buildings and good design are how well they adhere to the human existence.[5]

EXAMPLES:

How often is serious attention given to the needs of the user, or behavioral, social, and cultural elements of design, or good design impacting human behavior?

FIRST EXAMPLE:

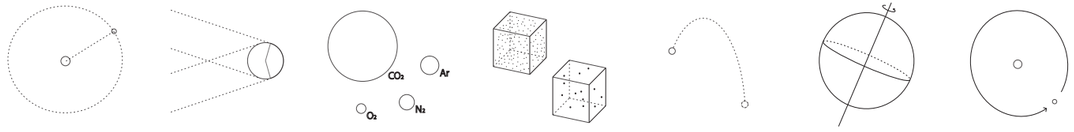
It may sound strange, but designing the environment to be more easily accessible for an elderly person may make them more dependent on such and less self-assured. How can design address this issue of dependency?

SECOND EXAMPLE:

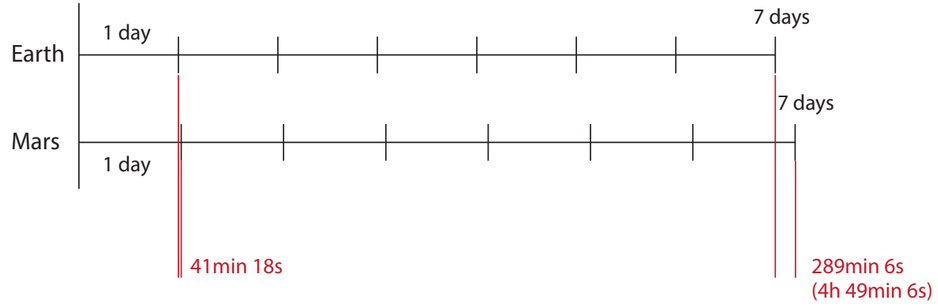
On the other side of age, how can design stimulate and support the growth of children? Despite a child's developmental needs containing physical, social and intellectual aspects, why do most buildings focus on only the physical aspect?

THE NATURAL ELEMENTS OF MARS

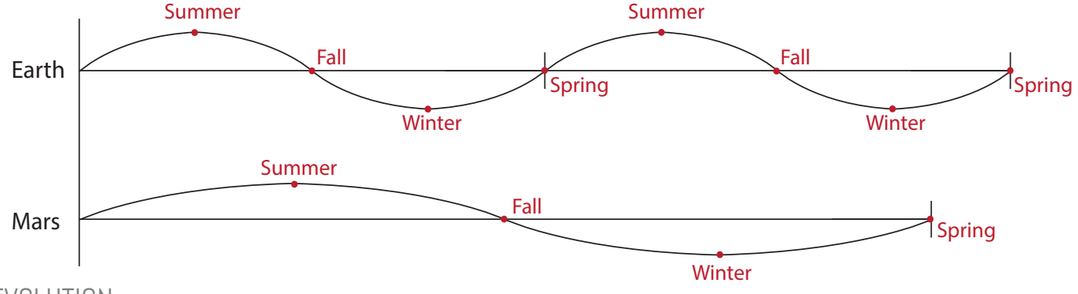
a study of the natural factors associated with mars, and how natural lighting affect design



DISTANCE TO SUN | LIGHTING | COMPOSITION | MASS+VOLUME | GRAVITY | ROTATION | REVOLUTION

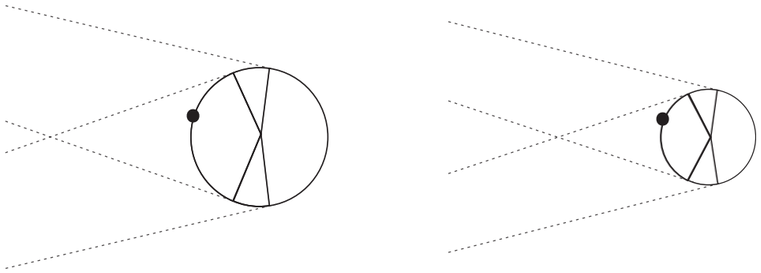


ROTATION

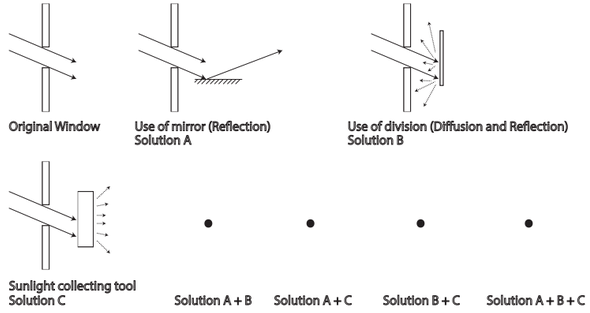


REVOLUTION

NATURAL LIGHT



DESIGN



DESCRIPTION

The brightness of the sun on Mars, were there to be a clear day, is about half the brightness of a similar day here on Earth. Now, just because the apparent brightness is half, that does not necessarily mean that the setting will be half as bright on Mars. Due to Mar's less massive atmosphere, this means less light will be scattered and thus the clear martian sky would not be as blue as here on Earth; and all the scattered light seen on Earth, which makes the sun appear a bit less of a flashlight beam that it is, would all conspire to make the sky on Mars appear darker.

DISTANCE TO SUN:

Aphelion: 249.2 Gm or 1.6660 AU

Perihelion: 206.7 Gm or 1.3814 AU

MEAN RADIUS:

3,389.5 ± .2 km or .533 of Earth

MASS:

64171 x 10^23 kg or .107 of Earth

MEAN DENSITY:

3.934 g/cm^3

SURFACE GRAVITY:

3.711 m/s^2 or .376 g

ESCAPE VELOCITY:

5.027 km/s

AXIAL TILT:

25.19 degrees

PERIOD OF ROTATION:

24h 37min 22s

PERIOD OF REVOLUTION:

687 days to Earth, 668.6 days to Mars

AN ASTRONAUT'S DAY IN SPACE

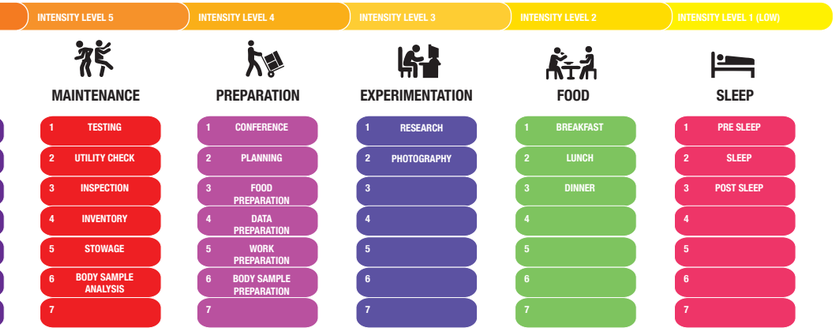
a study of schedule and intensity throughout time

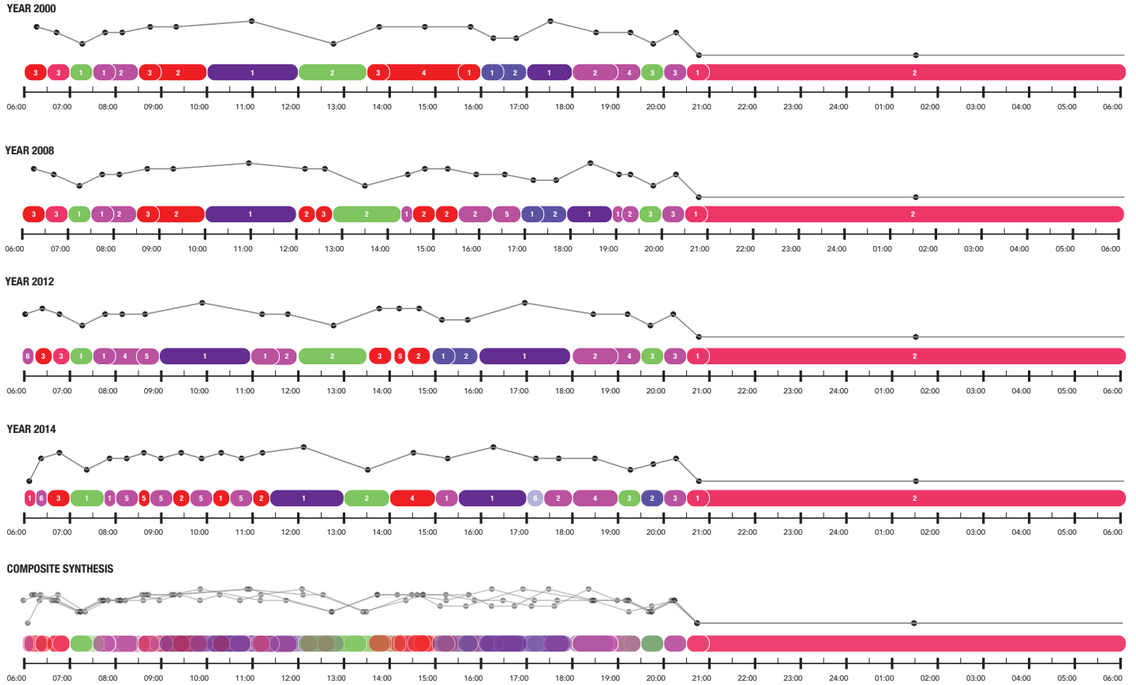
PERSONAL LIVING QUARTERS

ISS SLEEPING QUARTERS INTERIOR

DESCRIPTION

The International Space Station (ISS) is a habitable artificial satellite in low earth orbit since the year 2000. It serves as a space environment research laboratory in which crew members conduct experiments in biology, physics, astronomy, meteorology, and other fields. An astronaut's daily schedule consists of various activities from exercise, maintenance, preparation, experimentation, food, and sleep. Although astronauts operate similarly to a 24-hour routine schedule, it is critical to understand that daily activities require careful scheduling and organization in order to conserve human functions/intensity in the altered conditions of space.[6]





PHOTOGRAPHING A METEOR SHOWER

ISS KITCHEN INTERIOR

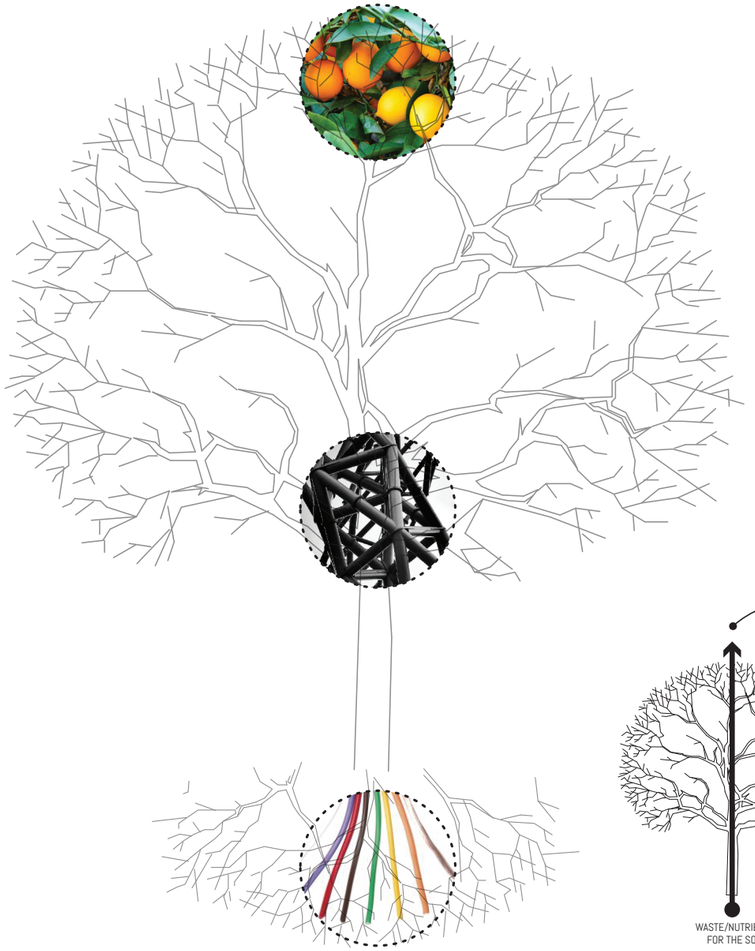
4

SPACE ARBOR

The concept for Space Arbor is derived from the relationship between man and nature, specifically the natural exchange, coexistence, and dependability of man with nature. On Mars, little is known of the resources that are available. In this case, it would be beneficial to reuse and recycle the available nutrients already existing in the HESTIA chamber. Learning from a tree, the concept of having a central core that unifies the available systems and recycles the outputs to regenerate and resupply the astronauts with electricity, clean air, plumbing, agriculture, and structure for movement.

CONCEPT DIAGRAM

a look into what factors are driving the design forward

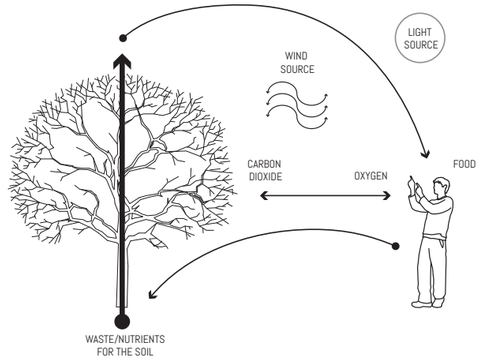


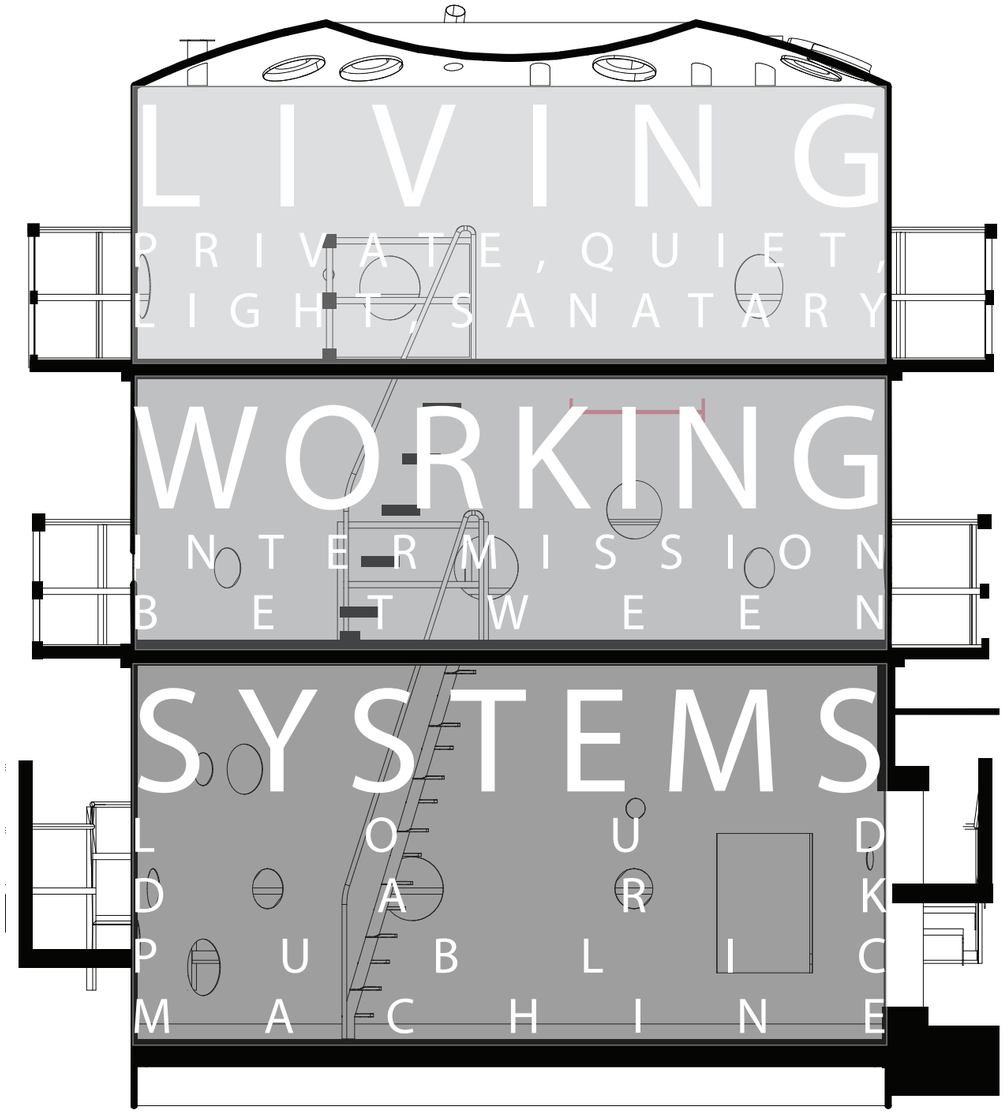
DESCRIPTION

THE HABITAT: Vertical Gardens. As resources are unknown on Mars, it would be beneficial for the HESTIA Chamber to be self sufficient and self-supporting in recycling internal activities and functions for food growth and fresh water.

THE SUBSTRUCTURE: Utility Outreach. Like the branches of a tree, the substructure is a support system that stretches vertically throughout the capsule providing electricity and plumbing to areas in need. This is also where vertical circulation occurs as a unified system of stability.

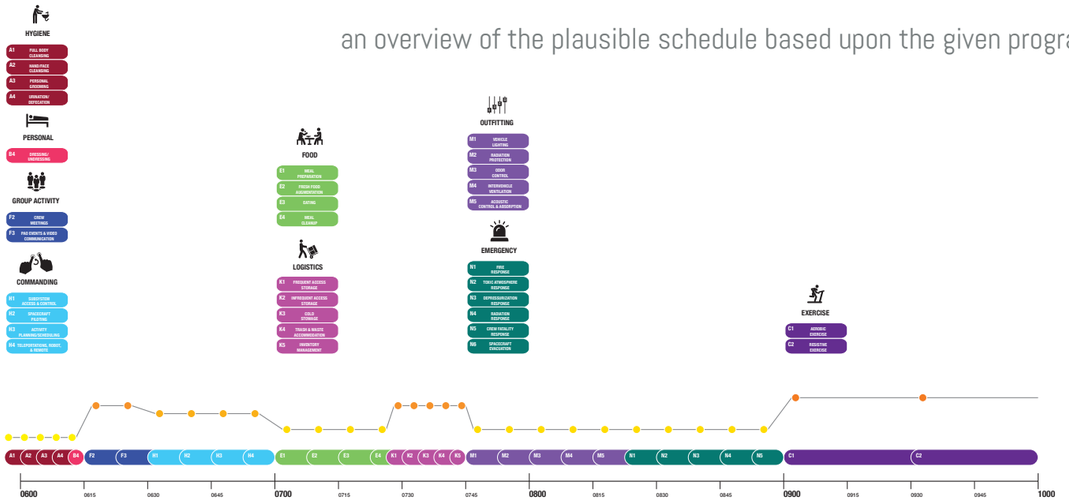
THE SYSTEMS: Grey Water Reuse. With limited and unknown resources, recycling water will be a major aspect and a lifestyle that the astronauts will adopt. This includes water from sinks, showers, and kitchen that can be recycled and stored.

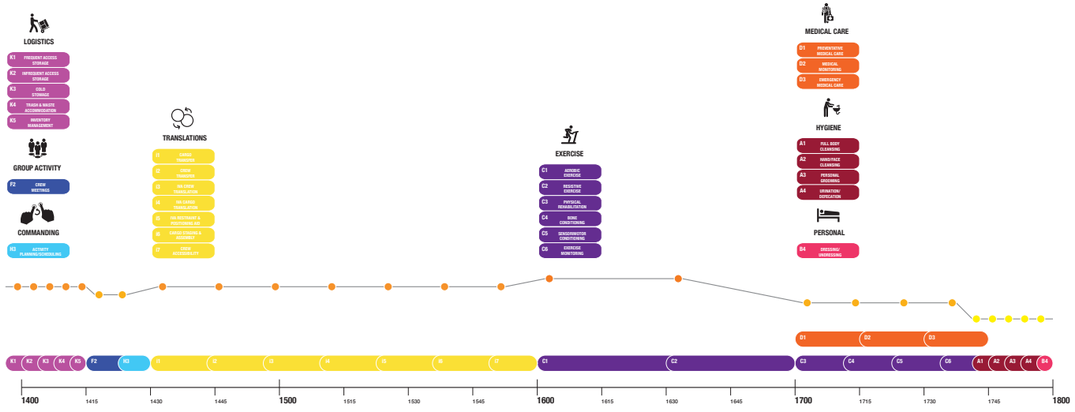


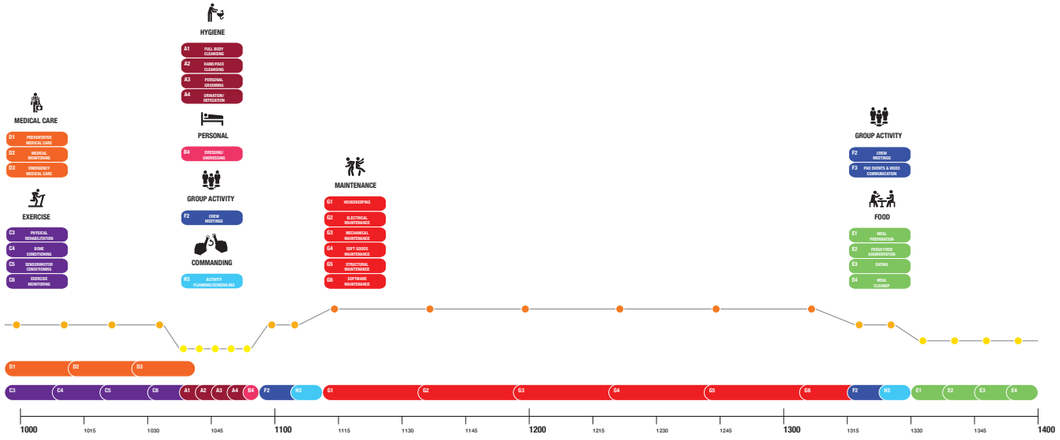


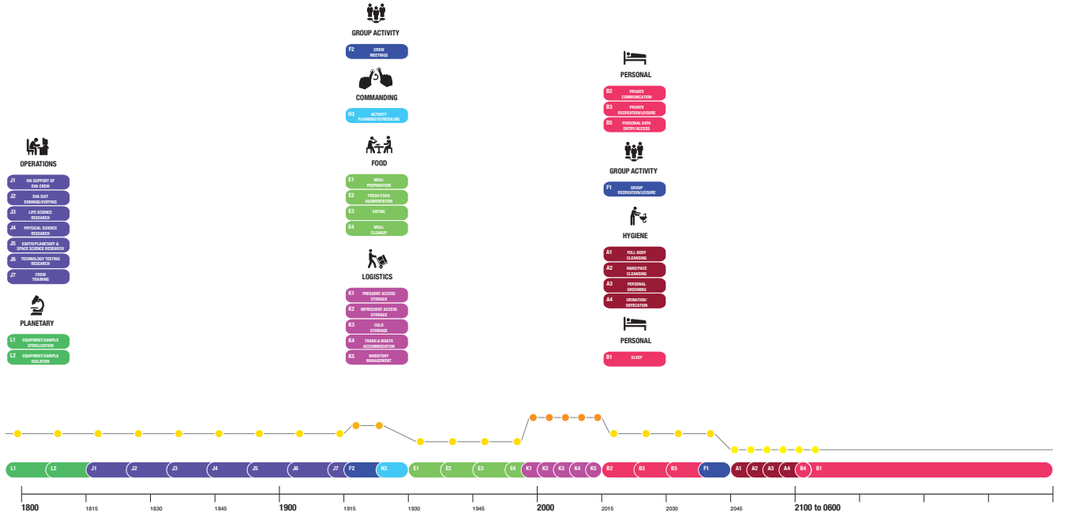
PROGRAMMATIC SCHEDULING

an overview of the plausible schedule based upon the given program



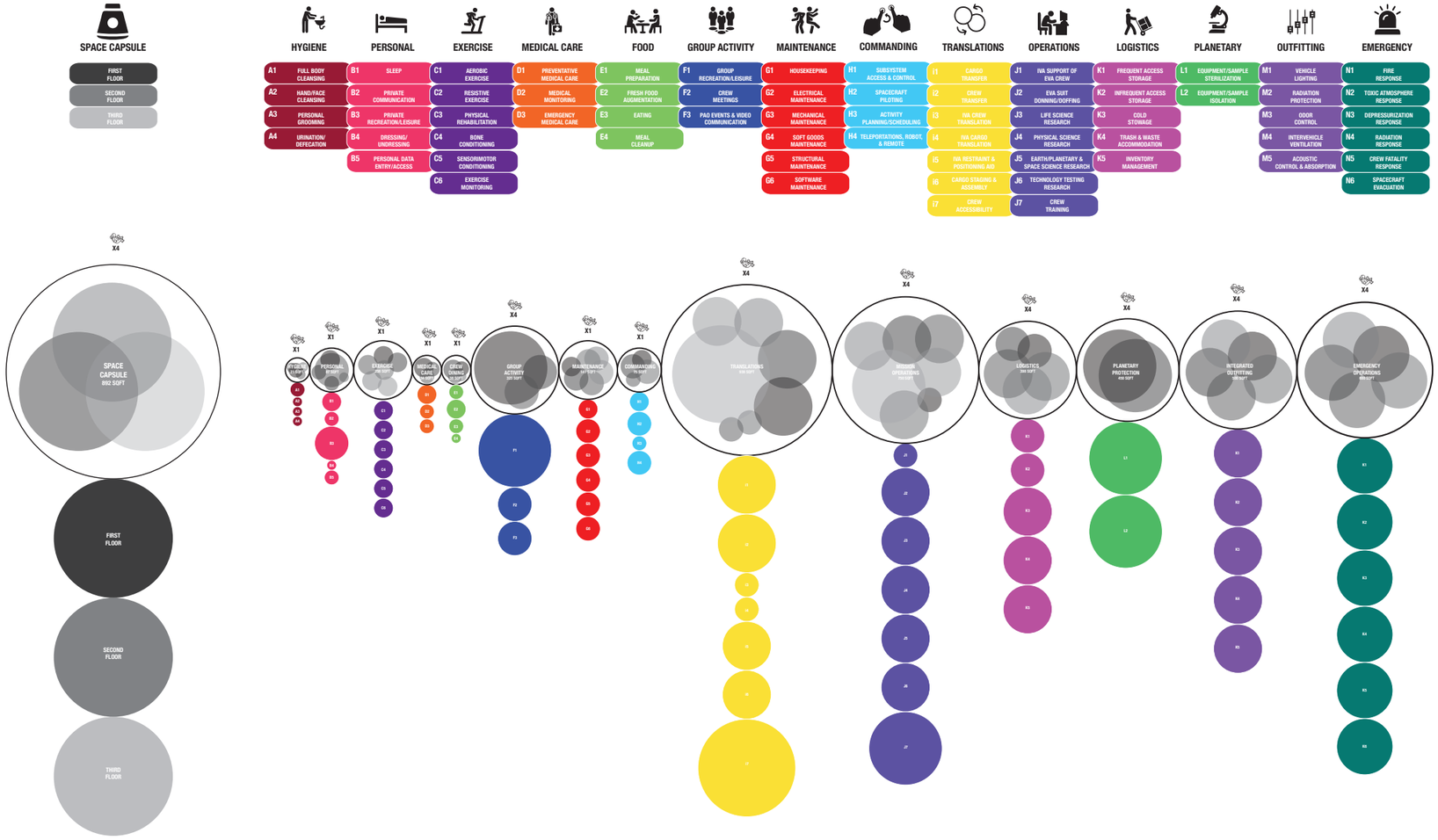




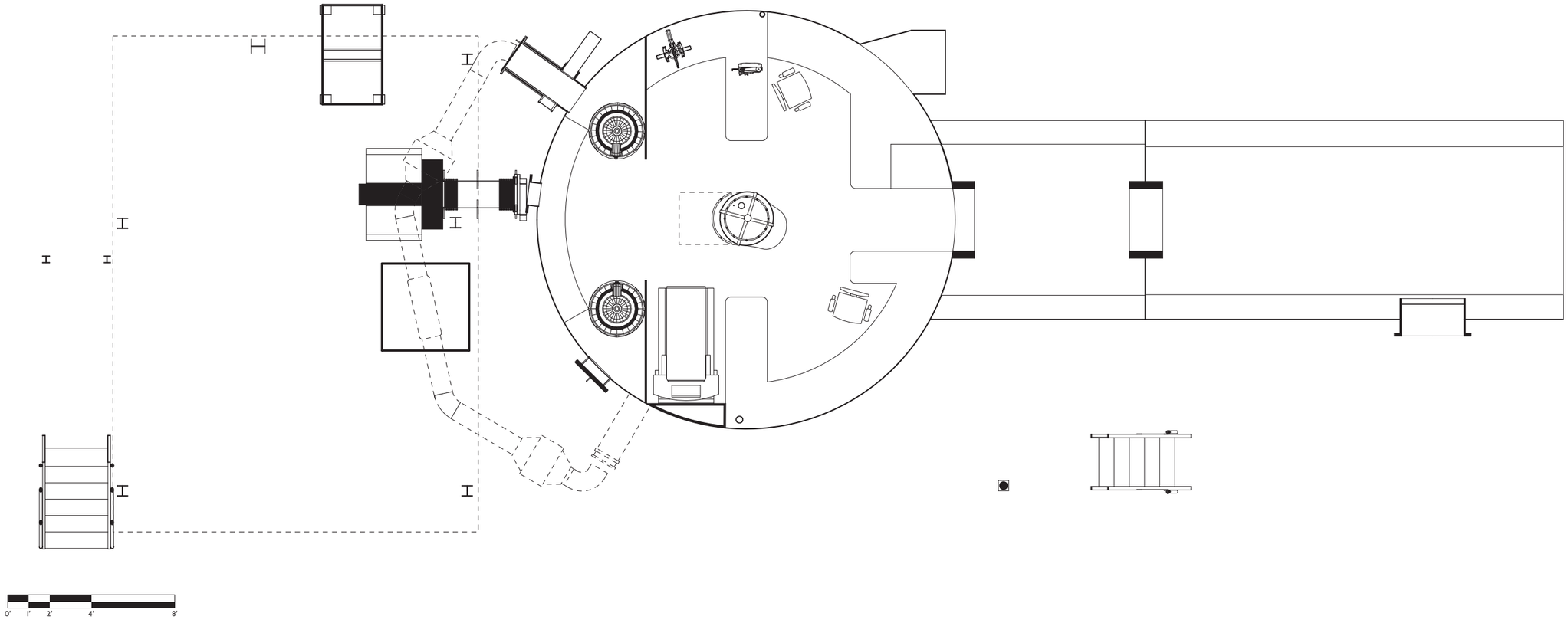


PROGRAMMING UNDERSTANDING

an overview of the programmatic layout of the design



FIRST FLOOR



PROGRAM:

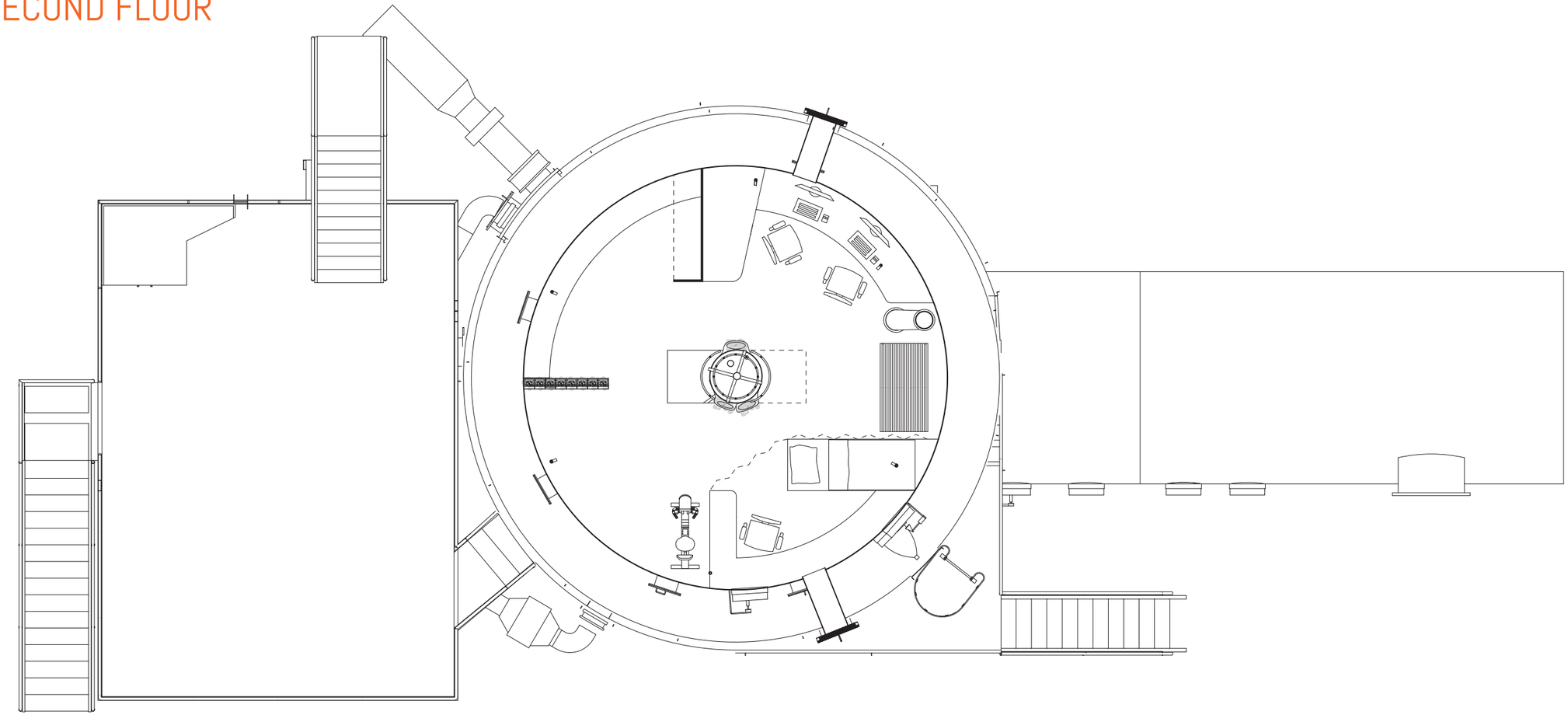
-EXERCISE COUNTERMEASURES

-MAINTENANCE

-MISSION OPERATIONS

-LOGISTICS

SECOND FLOOR



0' 1' 2' 4' 8'

PROGRAM:

-EXERCISE COUNTERMEASURES

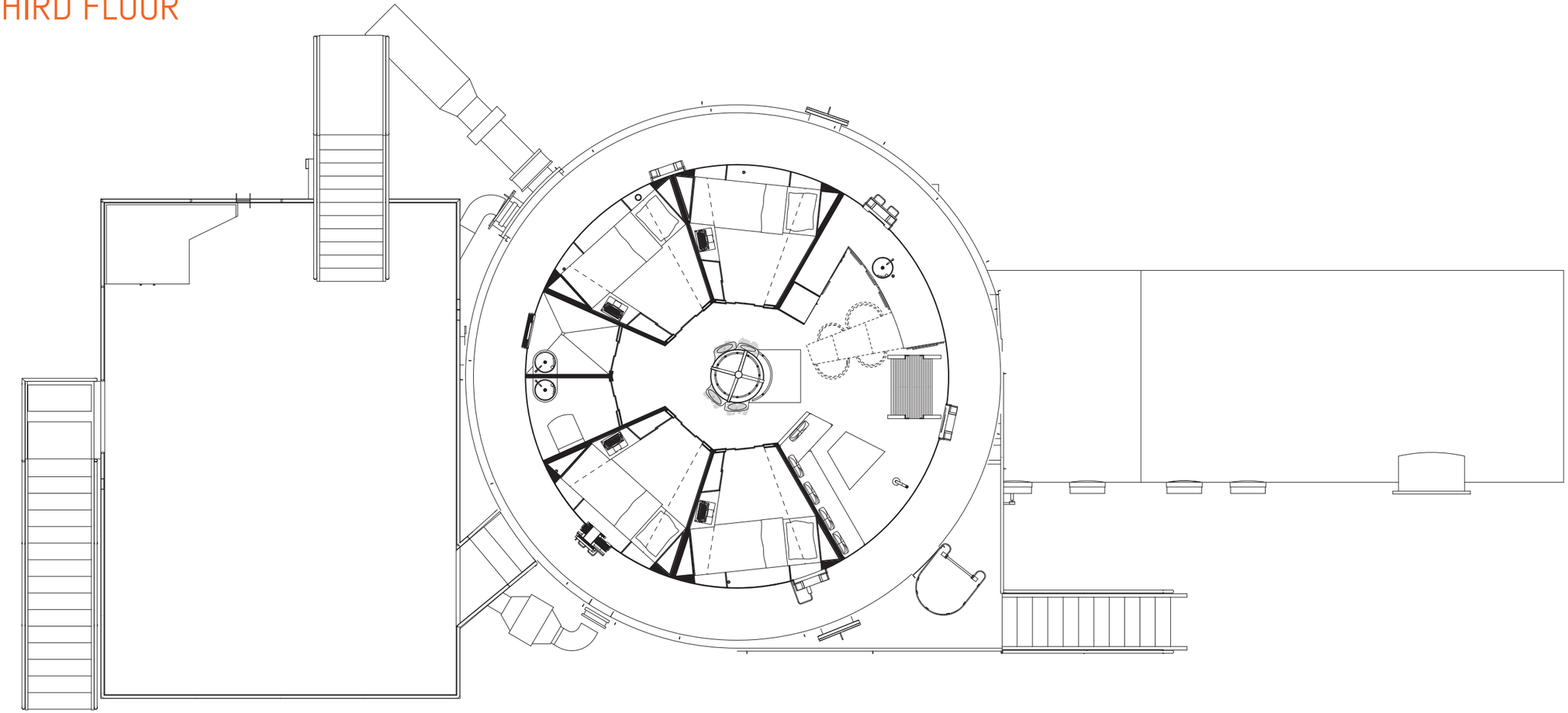
-MEDICAL CARE

-COMMANDING

-MISSION OPERATIONS

-LOGISTICS

THIRD FLOOR



0' 1' 2' 4' 8'

PROGRAM:

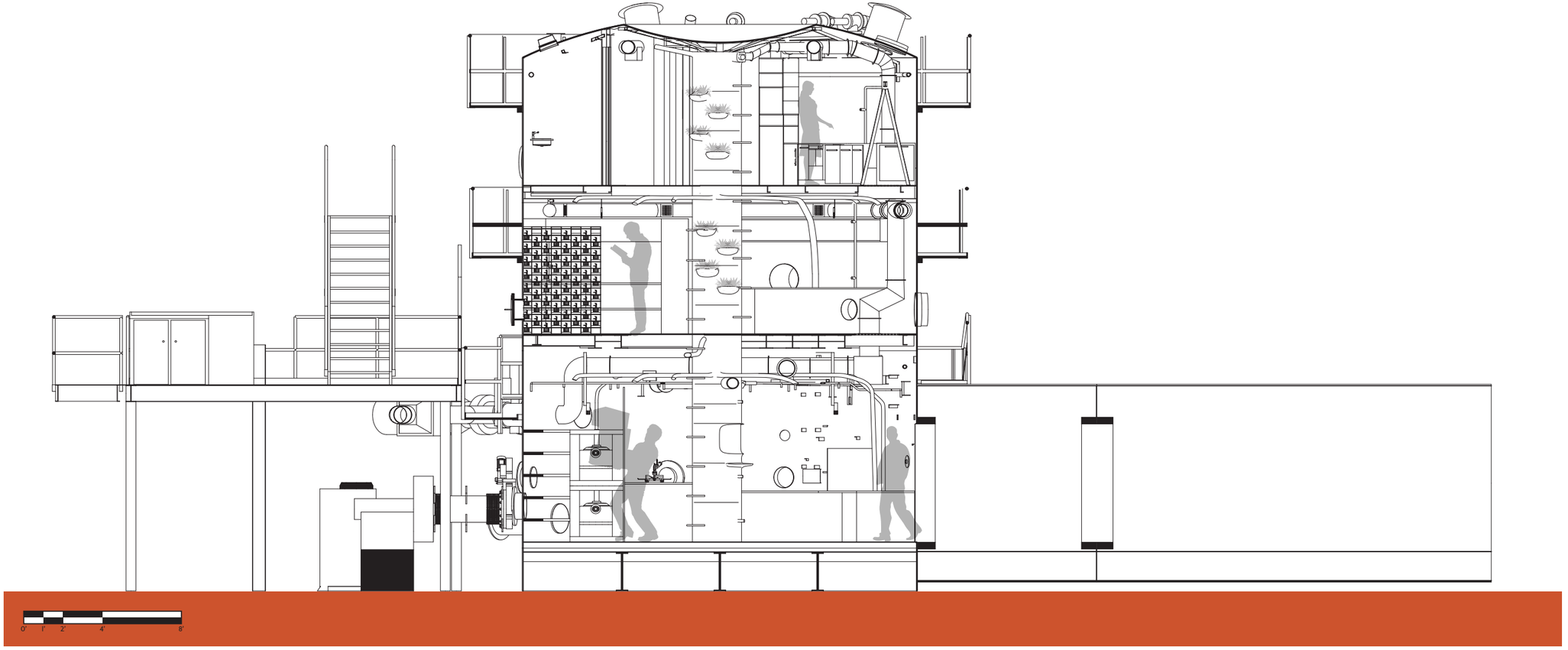
-HYGIENE ACTIVITIES

-PERSONAL ACTIVITIES

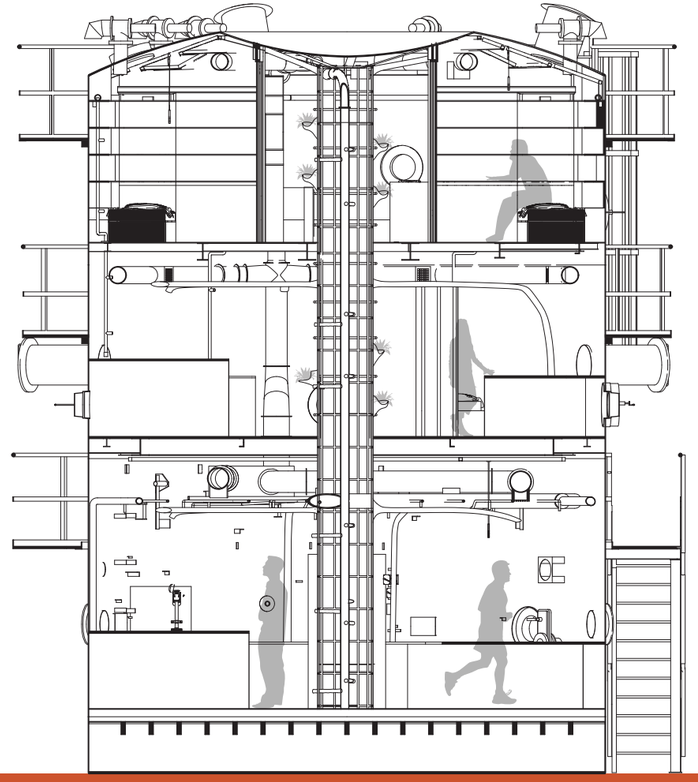
-CREW DINING

-GROUP ACTIVITIES

SECTION A

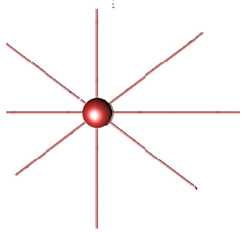


SECTION B



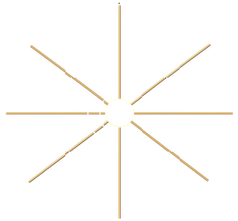
PROCESS

a series of design methods to capture the element of the tree function



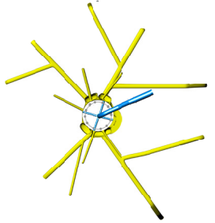
ITERATION 1

Using the current egress opening of the analog as a test to determine coverage of branches



ITERATION 2

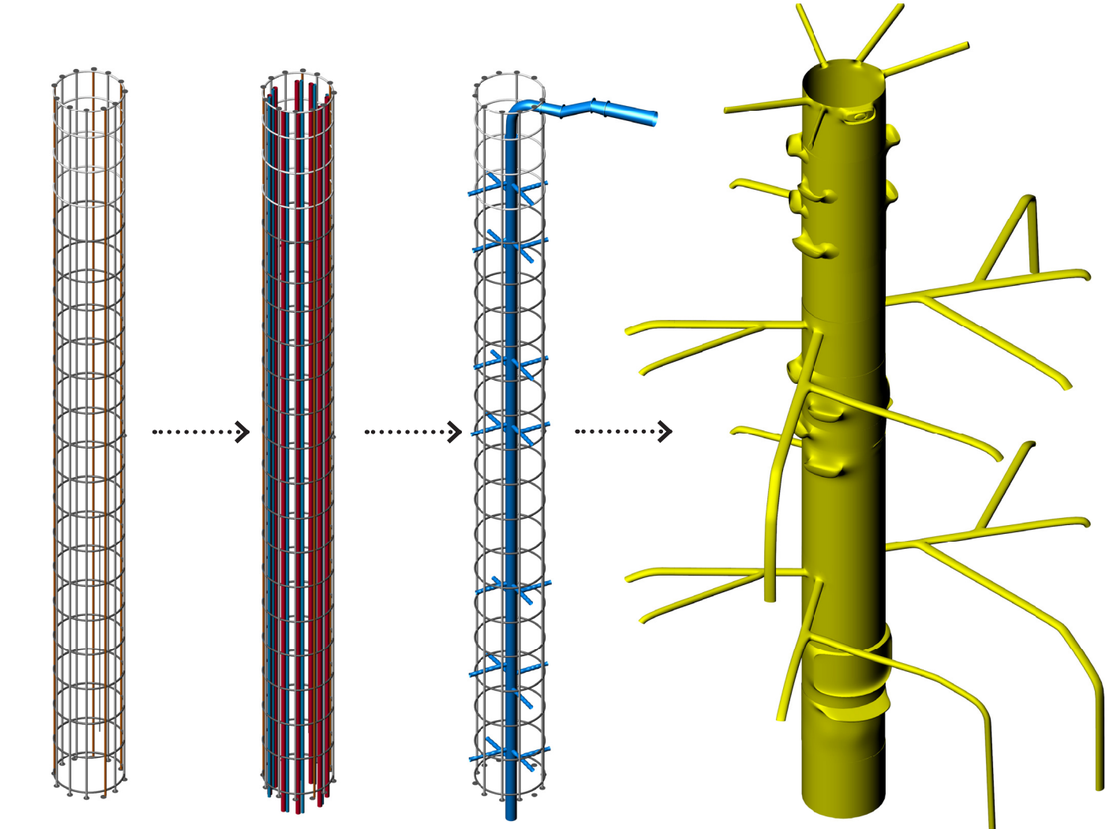
Shifting the core to the middle to have equal distance and attempt increase circulation. This iteration consisted of a steel tube core and branches



ITERATION 3

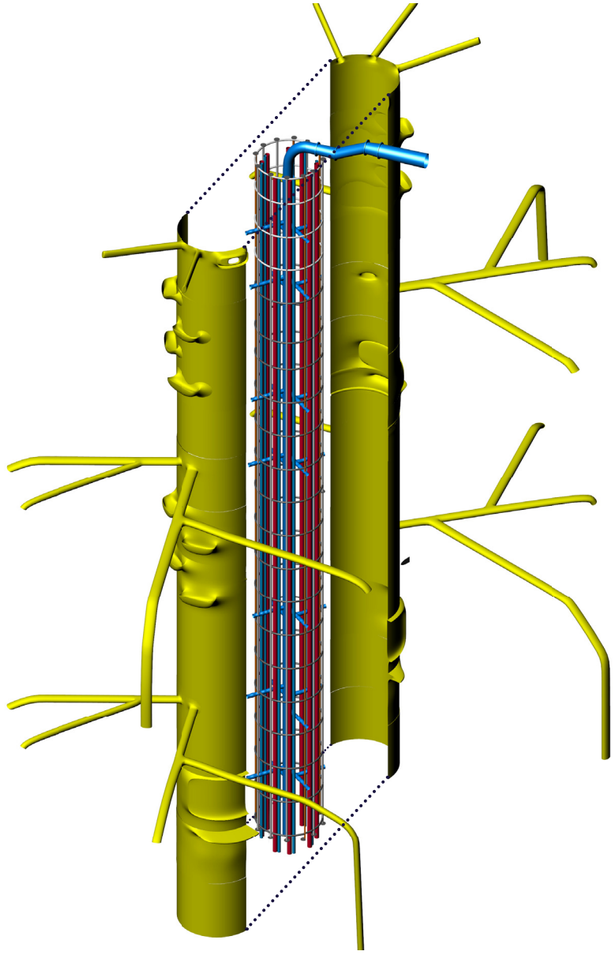
Providing a dynamic by creating workstations and plant life to bring the sense of outdoors and productivity. Material used carbon fiber

TREE ASSEMBLY



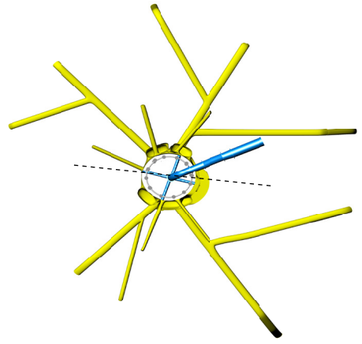
BEHIND THE CORE

a look at the inner working systems within the tree design



DESCRIPTION

The core exterior core is designed with carbon fiber for rigidity and structure, but also for its light weight characteristic to reduce load. The module is based on two foot increments from bottom to top. The core latches onto the supporting structure which then activates the outer core for lighting, work stations, and plant growth. The inner system consists of four components: H20, Energy/Data, Heating/Cooling, and Plumbing Lines.



INTERNAL SYSTEMS

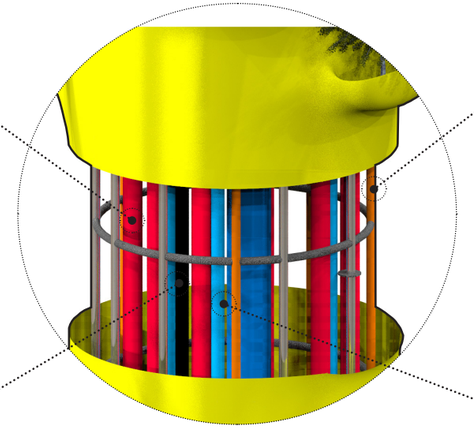
the systems are designed to feed all the needs of the analog

POWER + DATA

All power and data lines are housed in the red tube with then feeds to needed areas and core modules that include: lighting, power supply and patch panels.

WASTE + WATER COLLECTION

The black pipe is used for waste and water collection that is then sent to the ECLSS filtration system located at the 1st level, then recycled to produce usable water.



OXYGEN

There are 4 oxygen lines that run the height of the analog, with emergency masks that eject out of flush comportments of core.

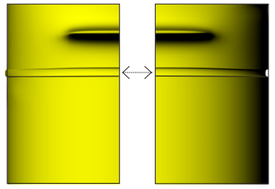
H2O SUPPLY

A series of h2o lines that are used on the 2nd and 3rd levels. The lines are primarily used for hygiene and vegetation growth. h2o is produced by the on board eclss system which cycles throughout the core.

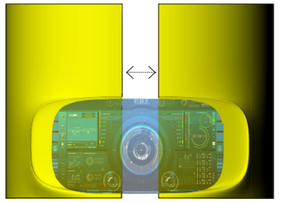
MODULAR CORE

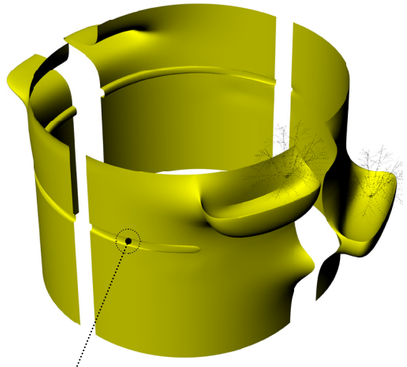
designing the core as a modular system allows for flexibility

keyboard+table



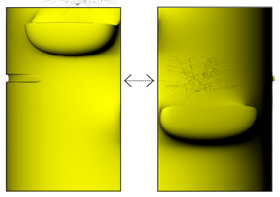
monitor





power and data source

vegetation module

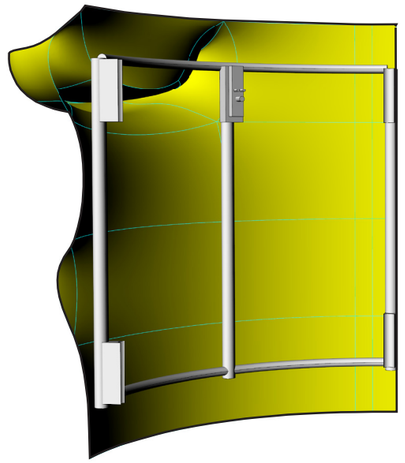


projector

SYSTEM LINK

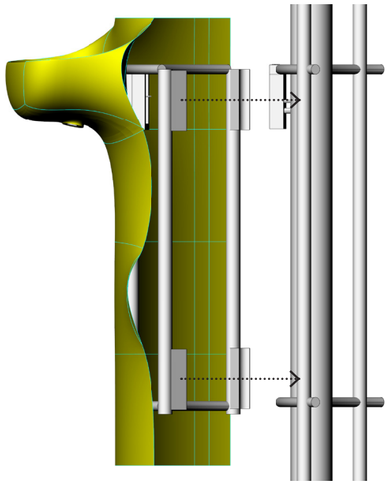
CONNECTION

the idea behind the process of module meeting substructure for systems



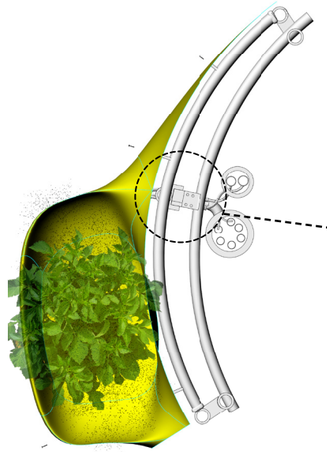
THE MODULE

Each module consists of its own steel framing attached to the carbon fiber molds. All units are pre-wired for their services. There is a series of 6 inter-changeable modules, all based on 2'x 2' grid



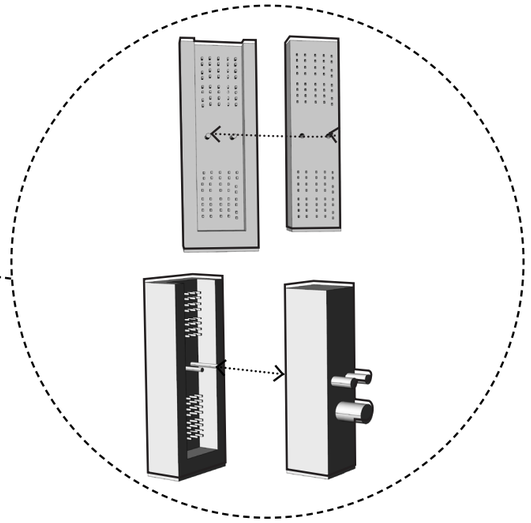
CONNECTION POINT

Each module is attached with a set of magnets that allows ease of connection and transformation through trigger activation.



PLAN VIEW

Displaying the module fully connected to substructure. This module consists of the planter system that hydrates the plant and recycles any overflow of water back into system.



CONNECTION

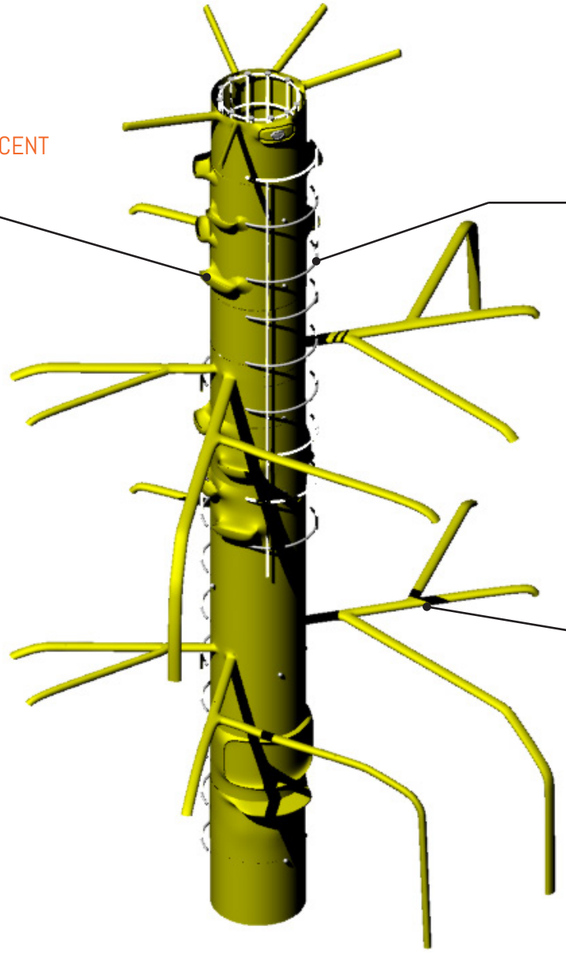
The connection points consist of 3 systems that operate each module. Data lines, power lines, and water with a return. Each has a standard led lighting system that is adequate for work and emergency guidance.

LIGHTING SYSTEMS OF THE TREE

a look into the various lighting schemes incorporated into the tree

FULL-SPECTRUM FLUORESCENT
(FOR PLANTS)

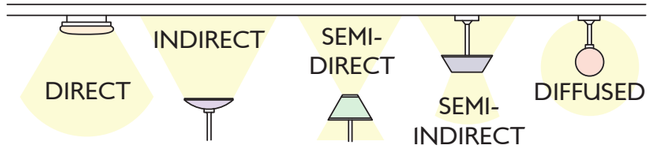
HALOGEN EMERGENCY LIGHT

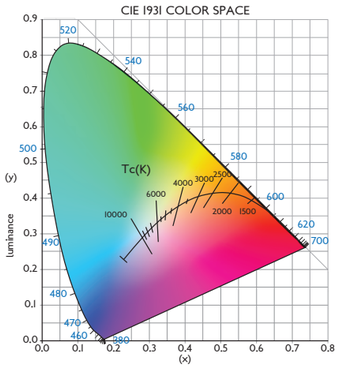


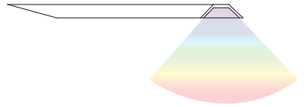
LED RECESSED STRIP LIGHT
(FULL SPECTRUM)

LIGHTING SPECTRUM OF THE ANALOG

a look into a system of a variety of lighting settings to change the atmosphere





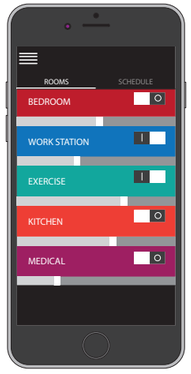


DESCRIPTION

Allowing the user to have access to a multitude of lighting customizations of warm and cool colors, fitting to the person's needs. As a general rule of thumb, warmer colors are more comforting and relaxing while cooler colors may stimulate the senses. Because of this, the general lighting aspect of each floor is the first and second floor evoke cooler colors to stimulate research productivity, while warmer colors are utilized more on the third floor which specializes in human comfort. As these rules are not definite, through the use of app-controlled lighting, the user is able to dynamically change their lighting settings to their preference.

QUICK DIMMING

CONTROL FROM SMART PHONE



SET SCHEDULES

NIGHT SHIFT/WAKE-UP LIGHT

LIGHTING SCHEMES

a look into the spaces of the design at various lighting color temperatures

BEDROOM AT 1000K

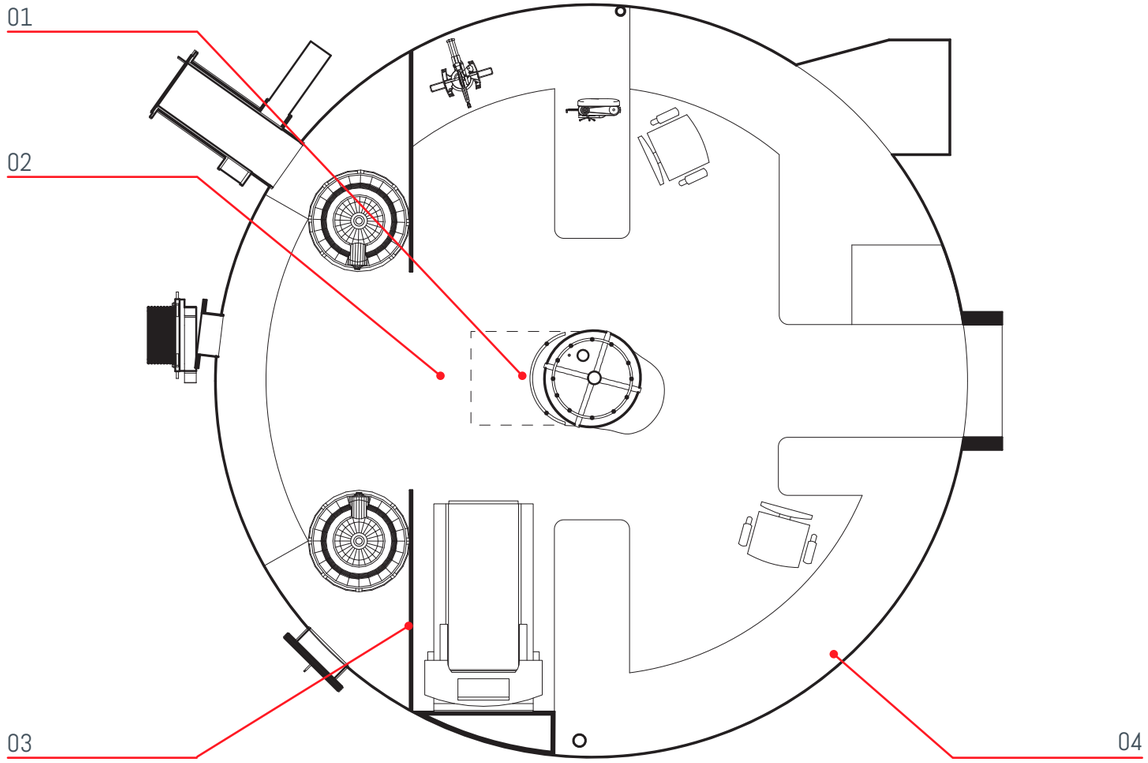
BEDROOM AT 4000K

LIGHTING SCHEMES

a look into the spaces of the design at various lighting color temperatures

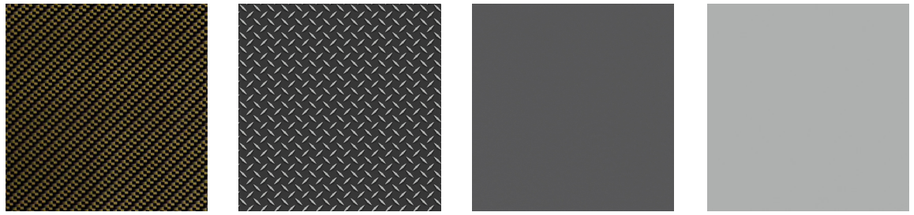
BEDROOM AT 7000K

BEDROOM AT 10,000K

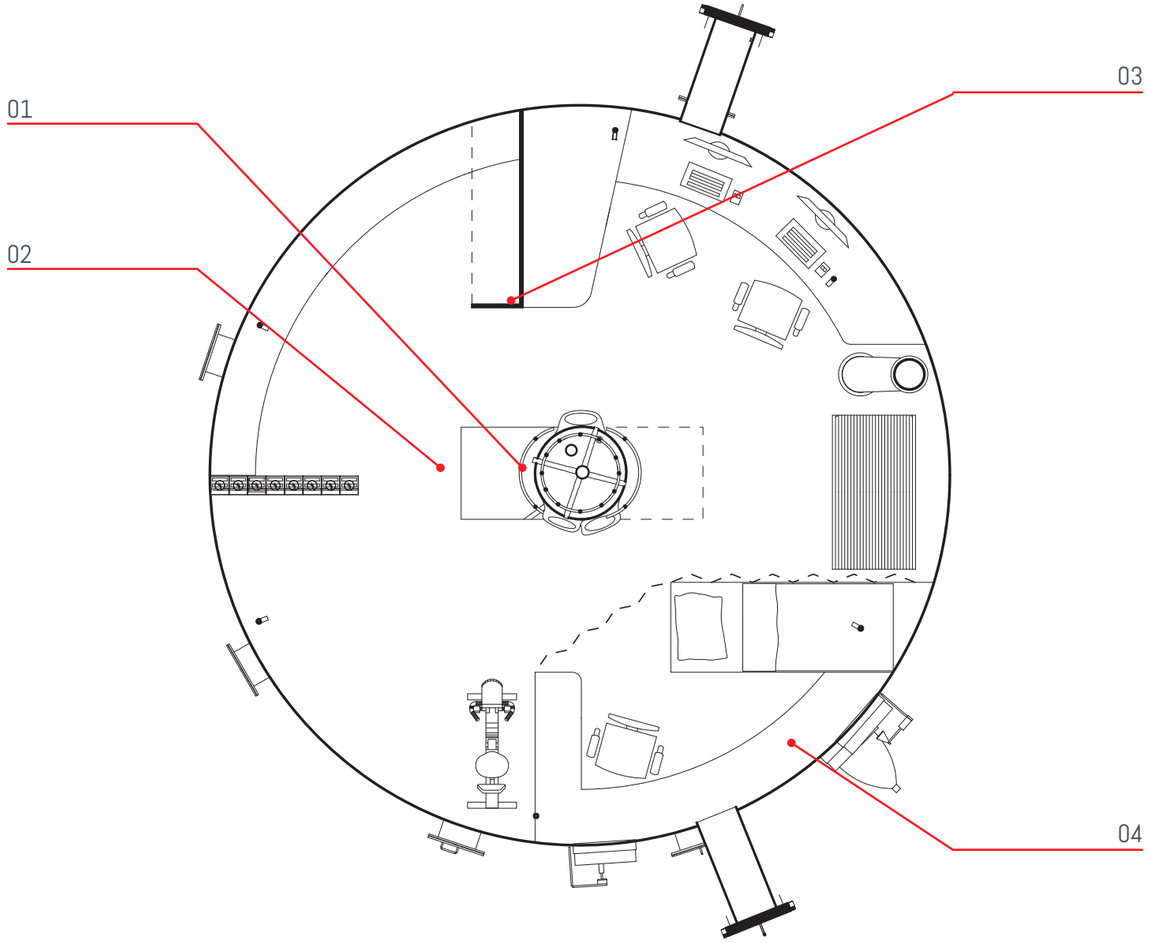


MATERIAL PALETTE

a look into the materials used in the design and their reasons why



01	02	03	04
CARBON FIBER - chosen as a structural component for the 'tree', used for its flexibility and rigid light-weight composure; color used to simulate the appearance of vegetation.	STEEL FLOORING - chosen because the material has the highest strength-to-weight ratio, as well as keeping the analog structurally sound for its eventual mission to Mars.	POWDER COATED STEEL chosen as a means to divide particular sections of each floor, also can act as a pin-up board due to its magnetic properties.	MELAMINE COUNTERTOP chosen for the work station countertops due to its hard surface and the unlikelihood of getting wet or causing odors.



MATERIAL PALETTE

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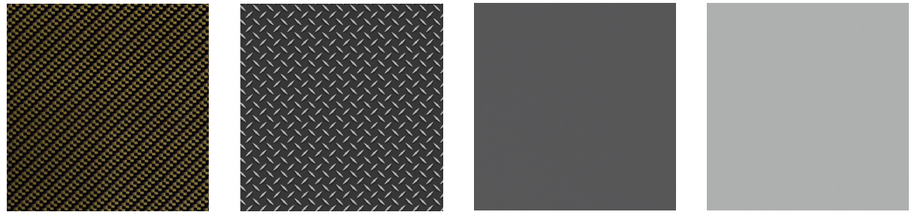

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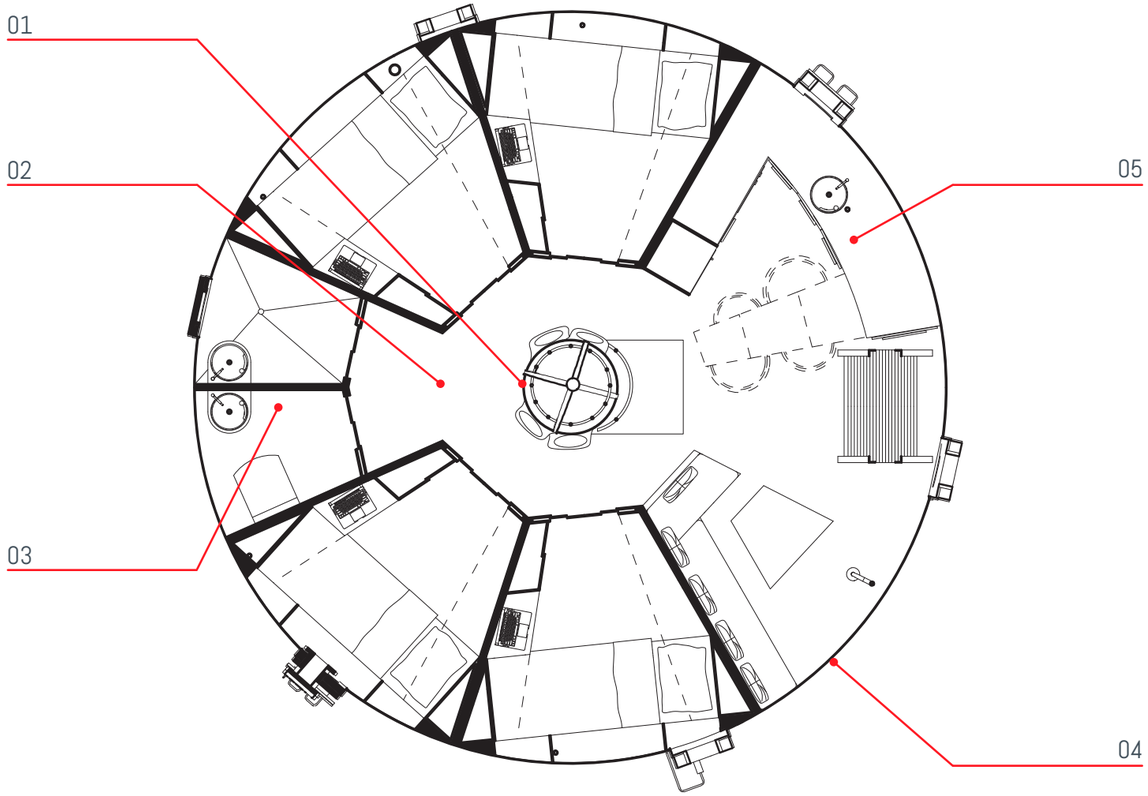

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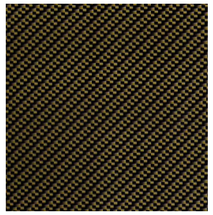
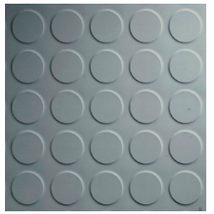
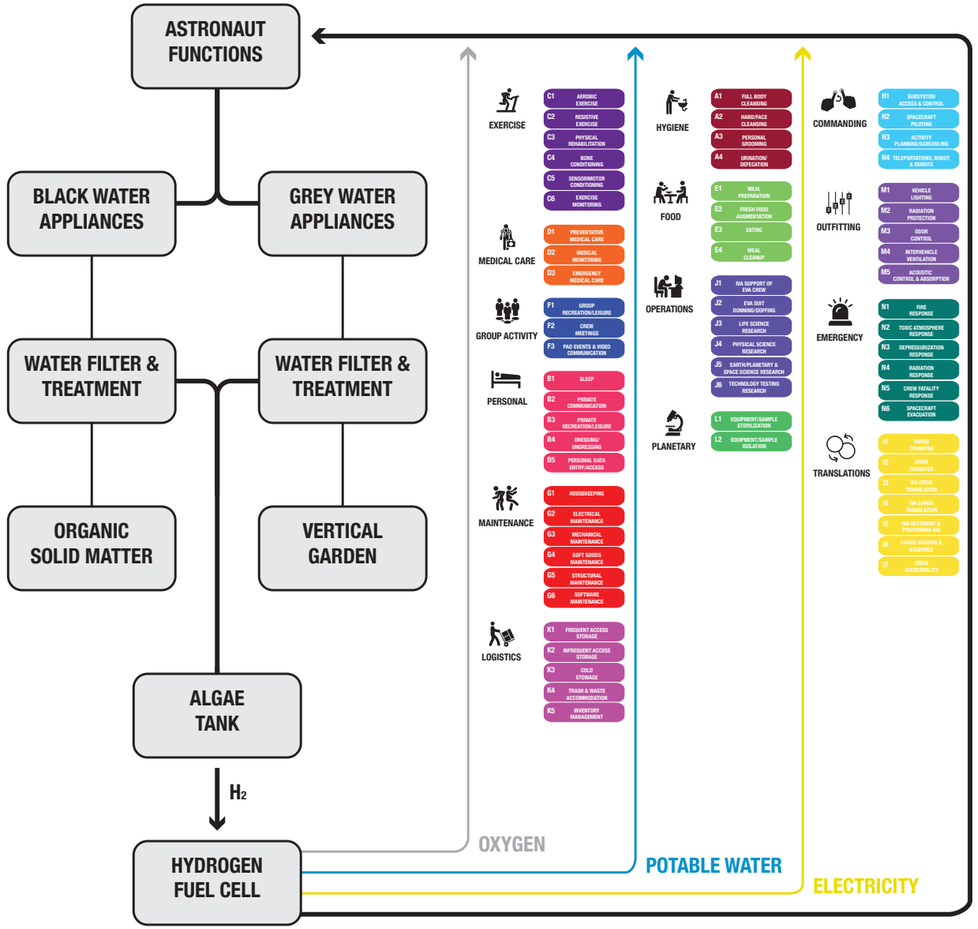


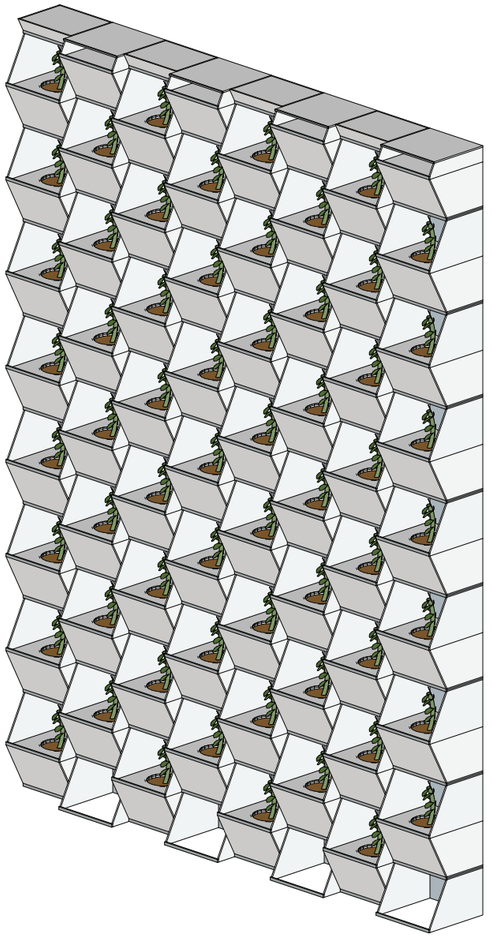


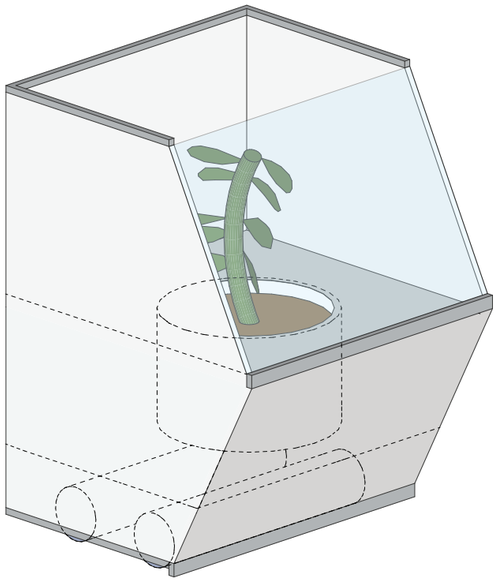
01	02	03	04	05
CARBON FIBER - chosen as a structural component for the 'tree', used for its flexibility and rigid light-weight composure; color used to simulate the appearance of vegetation.	WOOD VENEER - chosen to emphasize a warmer atmosphere on the top floor where the 'living' activities occur.	RUBBER TILING - chosen for the hygiene flooring to aid against slippage during the activity.	DRYWALL VENEER - chosen for the outer walls of the analog to subvert the colder feeling produced by the original grey walls; its color allows its appearance to alter based on lighting to create a particular mood.	POLISHED WOOD - chosen for the various furnishings present on the floor to emulate a 'home-like' level of comfort.

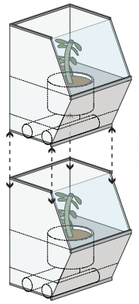
HUMAN COMFORT THROUGH RECYCLING

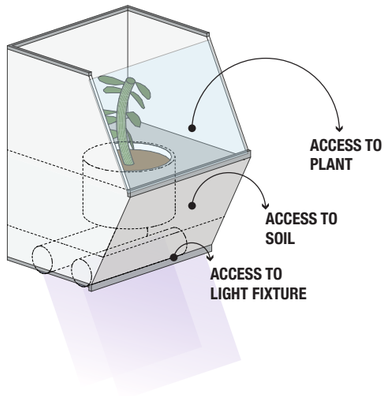
a look into a potable water recycling system through a hydroponic plant wall





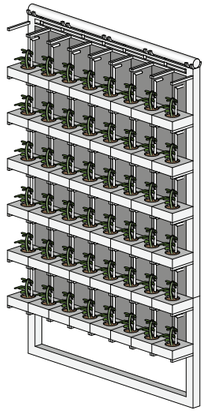




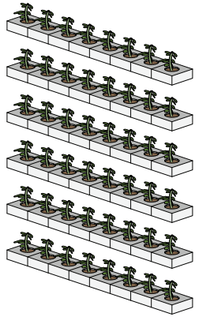


RESEARCH AND LIFE IN SPACE

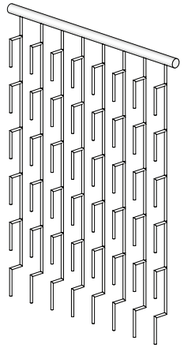
a further look into a wall for life, research, and well being



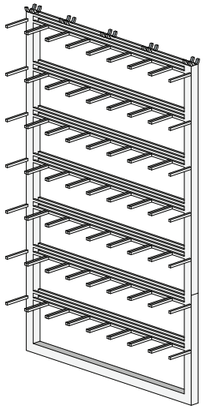
HYDROPONIC WALL ASSEMBLY



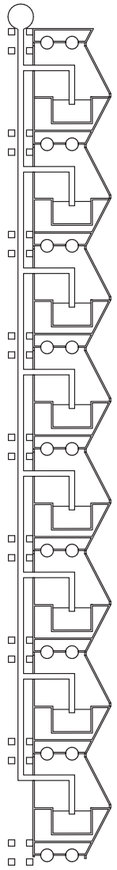
HYDROPONIC BEDS/TRAYS



WATER FEEDS FROM CORE



SAFETY FRAME



WALL SECTION

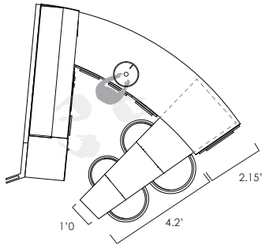
FLEXIBILITY IN DESIGN AND SPACE

HUMAN COMFORT IN ERGONOMICS

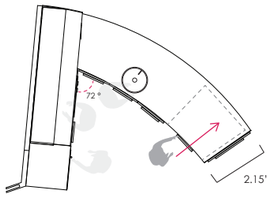
a look into the use of furniture on the third floor through design

COMPACT DINING + TABLE DESIGN

DIAGRAMS OF DINING TABLE IN USE

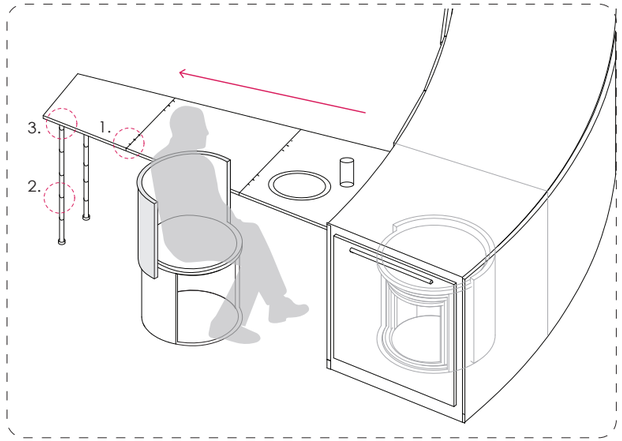


EXTENDED

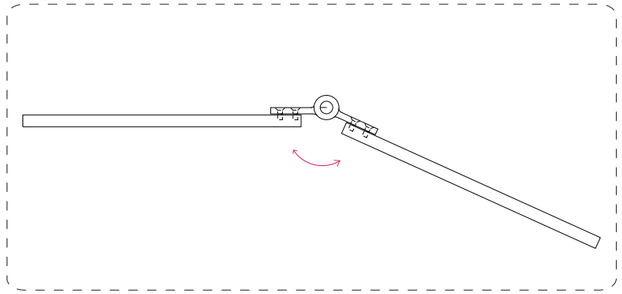


STOWED

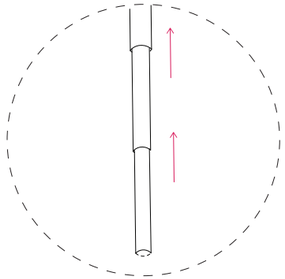
ERGONOMIC ISOMETRIC



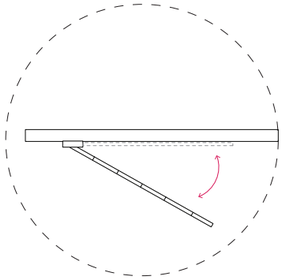
1. CONNECTION DETAIL



2. RETRACTABLE SUPPORT LEGS



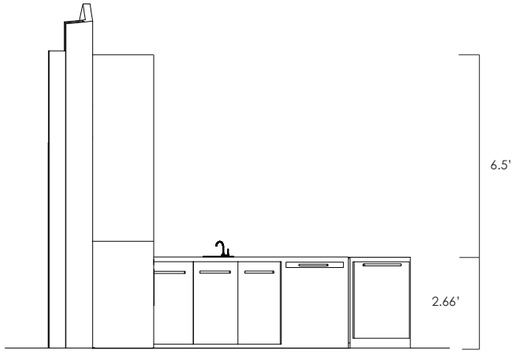
3. LEGS STOW UNDERNEATH



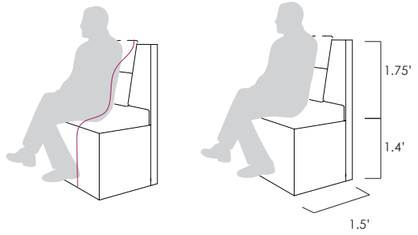
HUMAN COMFORT IN ERGONOMICS

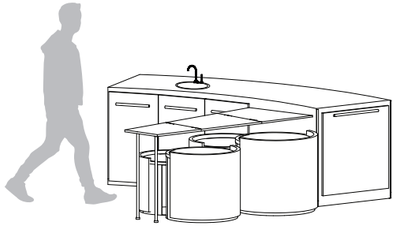
a look into the use of furniture on the third floor through design

ELEVATION OF MEAL PREP

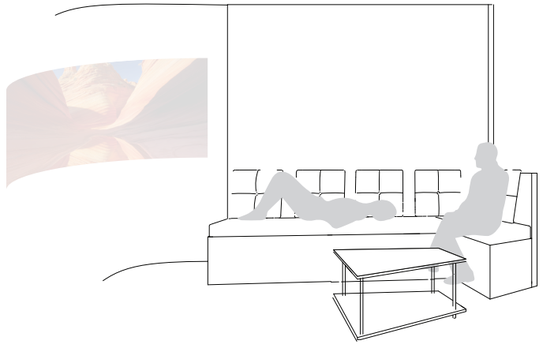


ERGONOMIC DETAILS





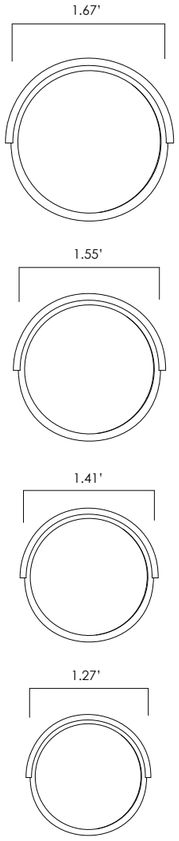
AXON OF FOLDING TABLE FULLY EXTENDED WITH SEATING



GROUP MEETING/LEISURE

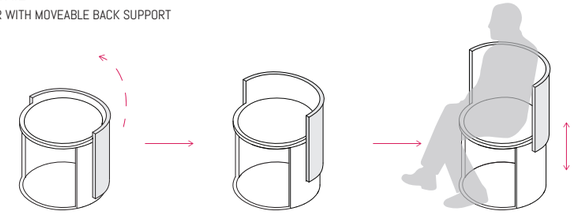
MODULAR COMPACT CHAIR DESIGN

PLANS



DESIGN DETAIL

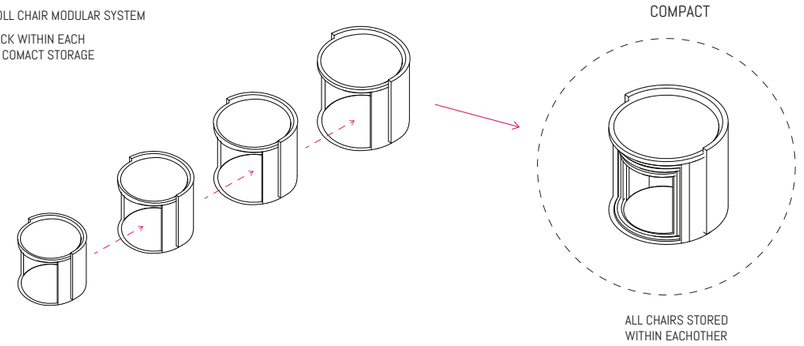
MODULAR CHAIR WITH MOVEABLE BACK SUPPORT



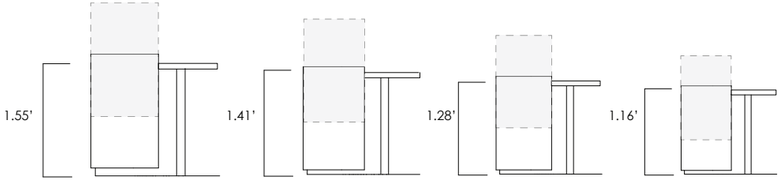
'HOW-TO' STORAGE AXON

RUSSIAN DOLL CHAIR MODULAR SYSTEM

CHAIRS STACK WITHIN EACH OTHER FOR COMACT STORAGE

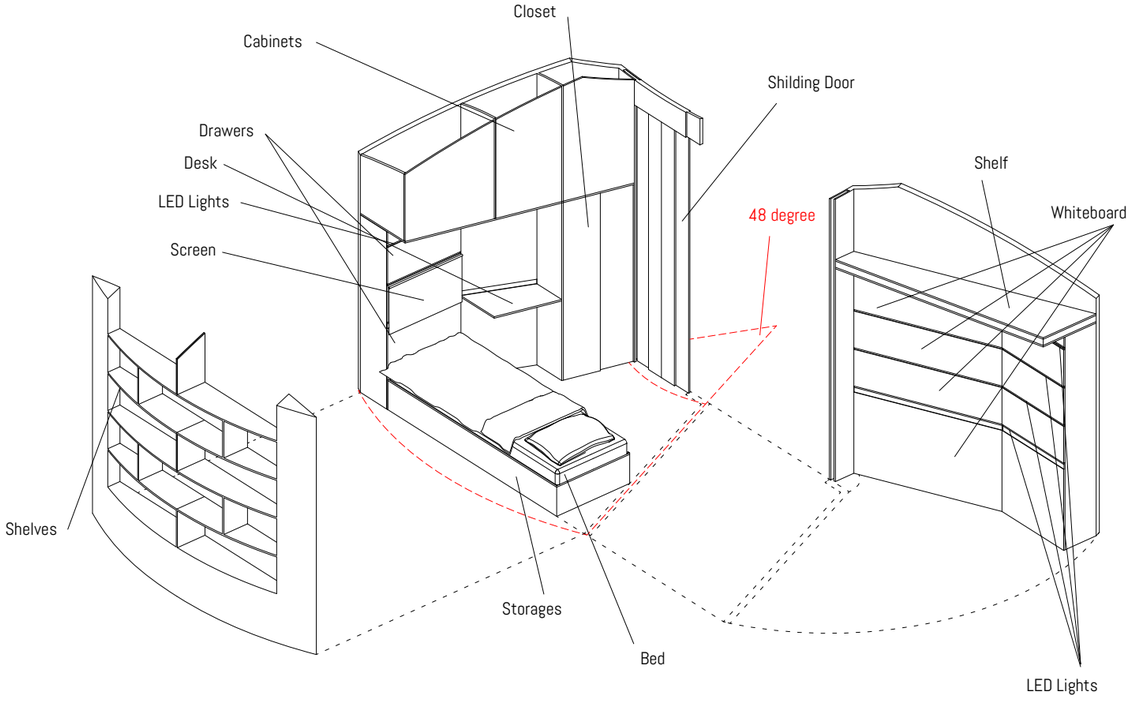


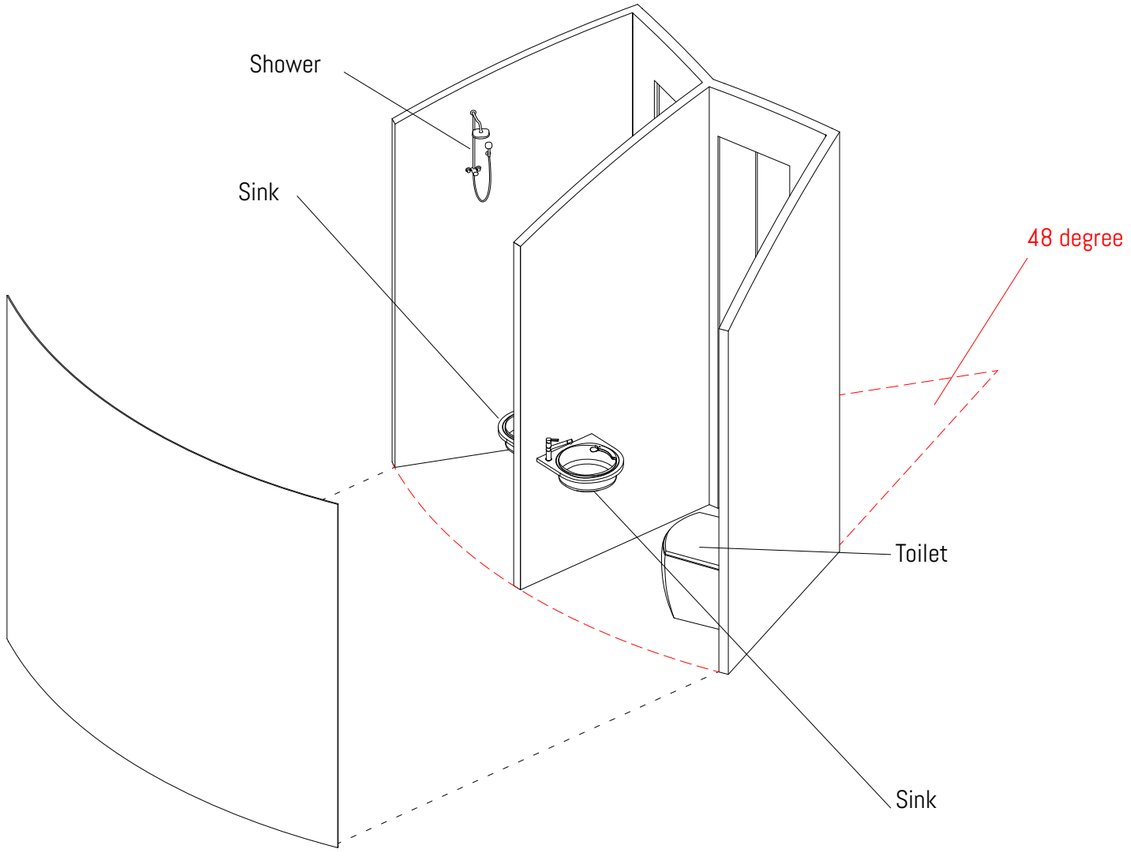
ELEVATIONS



HUMAN COMFORT THROUGH REST

a look into the breakdown of the design of the sleeping quarters and hygienic rooms





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THANK YOU

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