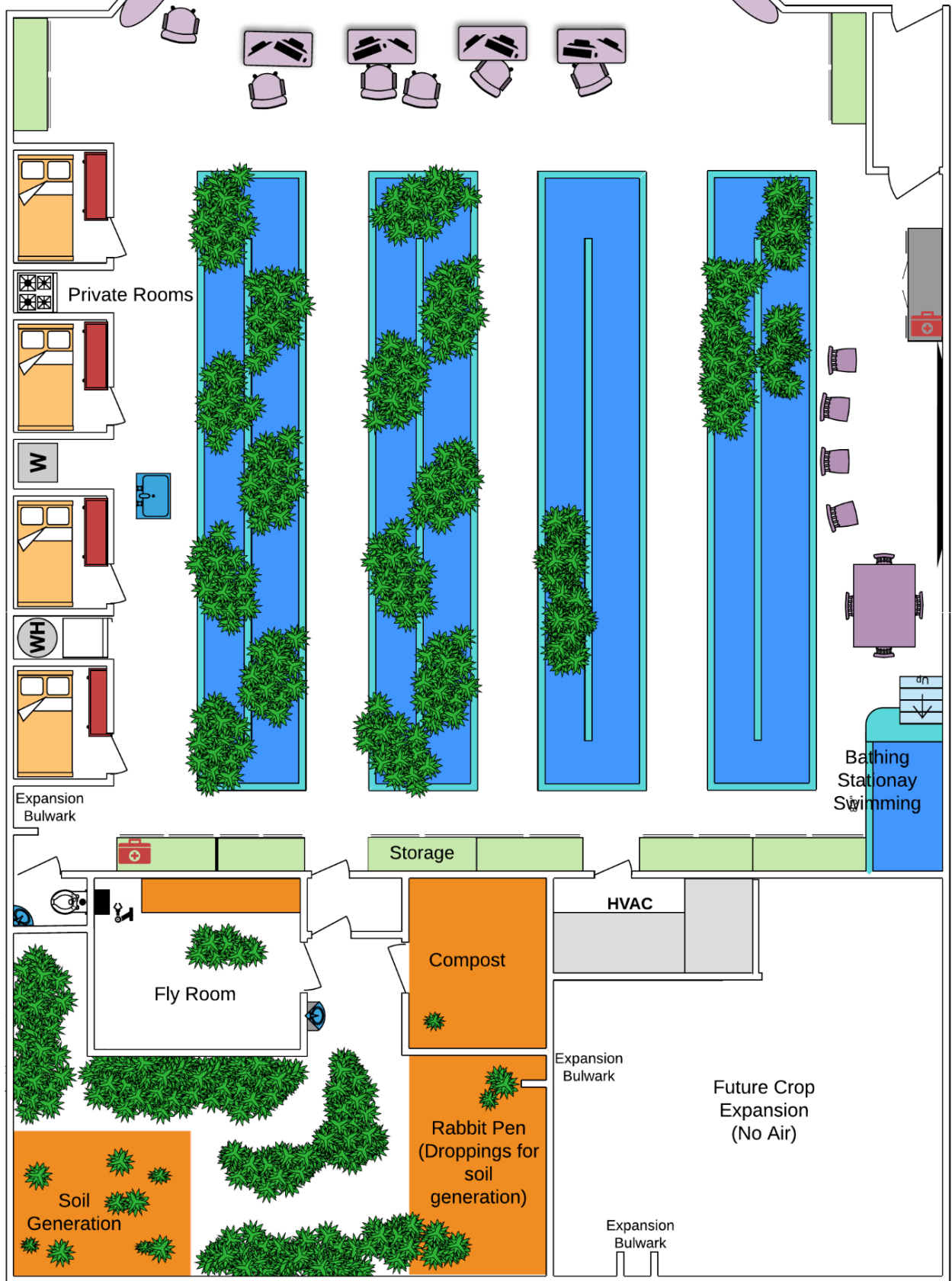


# Bio-Generator Prototype

April 2, 2021

**Legend**

- Soil Generation
- Water



This document is in the brainstorming phase. Please add your ideas and scenarios to further the dialogue.

## Intro Bio-Generator & Sheltering

**The ultimate goal** is permanent, autonomous, expansion throughout the home solar system and for use on Earth by family sized bio-generators for a water and air system free of toxins and growing pollution.

So many visionaries are talking about **end products** like colonizing Mars and living in spinning cylinders. **The bio-generator is the first product.** When looking at the endless requirements it becomes clear this is a colossal undertaking. Action must be purposeful and immediate upon realizing the centuries it will take to achieve expansion. Humanity must have full permanent bio-generator habitats. The expansion is the insurance we will have the time and arena to develop the interstellar grade technology to **reverse engineer Earth.** This simple lack of expansion may be the answer to the Interstellar Question.

The first Lunar bio-generator **must be an international project like the ISS.** It is unknown how much water and other resources are attainable from the Moon. Expandability must be part of the design so other nations can add on to the expandability of the bio-generator.

If a sealed habitat can't be developed here on Earth then it will never happen. There is big talk about colonizing Mars and the Moon. **There is zero action to make bio-generators.** The diagram above will be the first lay out for the experimental self sustaining closed habitat as far as recycled biological materials with the aim to continually produce more soil by adding carbonaceous dirt. (carbonaceous being used here as a catch-all term)

### **Project Bio-Generator**

**Part 1 Bio-Generator - Moon Mars Architecture**

**Part 2 Bio-Generator - Solar System Expansion**

**Part 3 Bio-Generator - First Prototype**

**Part 4 Bio-Generator - Soil Generation**

### **Project Sheltering**

## **Project Bio-Generator**

### **Bio-generator Terms**

- **Oxygen Cycle** - most basic need is ability to turn carbon dioxide into oxygen (while also harvesting food)
- **Aeroponics** - raising plants by mist
- **Hydroponics** - raising plants without soil
- **Aquaponics** - circulates water and fish waste through the roots of plants
- **Aquaculture** - raising fish
- **Vertical Farming** - Borrowed term to produce the most in the space available
- **Dirt** - no life giving nutrients or plant raising ability other than holding of water
- **Soil** - processed dirt until the medium has the bacteria and worms to breakdown further

**Why aquaponics?** Because soil is not available until a biological system can generate the soil. The Black Soldier Fly process enables soil generation by way of human feces and produces larvae for fish and that process generates plant food. Will the humans eat the grubs? Nope.

## **Part 1 Bio-Generator - Moon Mars Architecture**

### **The First Lunar Based Bio-Generator Supports 4 Requirements:**

- **Expansion System** - Expansion from Moon to Mars (Lunar South Pole for first version of bio-generator then as aqua sphere at Lunar Gateway and for Mars transit, and then bio-generators placed on Mars and/or Mars moons and asteroids (25,500 known NEAs) parked in Earth and Moon orbits. The system continually increases the mass of air, soil, food.
  - Assume the first Lunar Station will have all the ingredients for full sheltering.
  - Bio-Generator should be the primary design of the first habitat.
  - At the least, the equipment used to build first sheltering will continue on building secondary sheltering for bio-generator and bio-generator expansion by building adjacent structures sharing the same wall and then knock out new doors between as expanding.
  - If shelter printing is a slow process (slow gaining of ideal material?) then the bio-generator may need a more modular/compartments design with just living quarters first and then add features.

- Once a bio-generator is running then sheltering can expand on all sides to more compartments. So the number and size of aquaponics tanks built into the bio-generator should be big enough to max out as needed over time. This strategy could be reversed to just having one tank in the first structure and expansion structures add one tank as needed within their own structure. Lunar scenario primary requirement is enough greenery for the carbon oxygen cycle to support the number of inhabitants.
- **Give Life** - Aquaponics to filter air, water, oxygen CO2 cycle, give fresh food. To keep the precious resources cycling so they don't have to be replaced. Expansion instead of regression. Will expand the volume of available soil and air (gas as a compost and human product) to expand into more compartments.
- **Aqua Spheres** at Lunar Gateway and Mars transit for full radiation protection. Several projects with large inflatable habitats to add to the Gateway are in progress. Could be a double walled version processing waste products in the outer opaque layer and the inner fish layer with see-through wall for the life giving movement of fish and bubbles.
- **Integrate Bio-Generator** into the user's life. By living in the system, the system will do more than supplement the meals. This lends to the simplicity of gardening. KISS
  - Aesthetics of greenery towering over the space and intermittent across the space and moving in the air current
  - A cleaner one vat system can be used for stationary swimming and bathing.

### **The Objectives and Surface Details of the First Lunar Bio-Generator**

A bio-generator **generates** food, oxygen (oxygen-carbon cycling), and filters air and water. Built into the architecture of the structure so aquaponic lanes divide up the user living space. The **aquaponics** vats are a linear system (of water movement in racetracks) across the living space. Vats are part of the sheltering construction and the water holding surfaces will need to be processed (glassing). The vats are pools of water and fish alternating with the crop growing sections (where water is moved over shallows). So the surface of the water is the same height through the system with alternating fish pools, filter compartments and greenery shallows. The filter compartments will most likely be shallow to control movement throughout the filtering area to prevent dead areas. The system is not likely to be as intense and high output as a commercial system and more subdued for stability and toxins processing of the air for the closed habitat. A more intense system may not have the best air?

A **livability** system incorporating the food process into the living/sleeping area for morale and the carbon oxygen cycle. These can run through the living space to give greenery and

movement of water for audible aesthetics, along with air movement through the greenery. This will also break up the space for more organic living and separation of the first Lunies. The height of the vats at waist high? The crops can grow to the ceiling. Imagine pea flowers and vines climbing to the ceiling and maybe across some of the ceiling? One system will be separated from the rest for bathing and stationary swimming.

System is regulated by measurements of algae, fish waste, oysters, fish to curb any one factor of system bio-overload and to provide materials for soil generation and greater nutrition to the plants and thus humans.

### **The Objectives and Surface Details of the Aqua Sphere(s)**

- Quasi aquaculture/aquaponics and radiation protection for the users.
- Support and stocking of spheres comes from the Lunar bio-generator.
- Spheres for use at Gateway and Mars transit. One could be sent off to Mars as the other is coming back.
- Ideally as part of a tether system for artificial gravity, specially for Mars transit.
- Having 2 sets allows regenerating one back to optimal levels after Mars transit.
- The passenger needs the tending of their foodstuff and fish.
- Swimming fish give visual aesthetics. Robotic system to clear the algae off the inner shell or only clear some of the surface to allow more algae growth for an overstocked system.

### **Aqua Sphere for Mars Circuit**

- Overstock sphere with fish from Lunar stock for Mars transit.
- Fish population recovers in Mars orbit.
- Algae blocks from the Lunar bio-generator to feed fish/snails etc. in the initial overstock phase.
- Snails eat fish waste. Fish eat snails and algae.
- Shrimp versus fish versus fresh water oysters for this ultra packed and closed system?
- An automated system tracks the fish and algae/waste/nitrogen content of the water to ensure only enough fry develop to maturity.

### **Food Container Shipping**

- Container system for transporting Moon production to Gateway and Mars.
- Detachable ion rockets to move containers ahead of user missions to Mars.
- Containers can travel back to Gateway with Martian samples and/or ice harvested from...
- Food wrapped in water for keeping maximum nutrition?
- Capture by automated Mars Moon storage/orbit.

## Part 2 Bio-Generator - Solar System Expansion

### Earth Development - Meeting Off-Planet Expansion Permanence/Performance Criteria

- Each establishment is a producer for more expansion seeding and duplicate facilities for emergency and biological failure backup.
- Printed expansion compartments are added adjacent -- sharing the wall to a functioning habitat/generator. When a new compartment is fully aired and functioning then drill out the wall of the old habitat to finish the doors between.
- Evolution plan for the first bio-generator to achieve highest human interaction and usable space for morale and physical health (eventual exercise and swimming in aquaponics).
- Multiple copies of different size generators for proving stability and re-seeding process.
- Medium and large habitats to test stability of bio-generator. Some facilities for constant re-seeding exercises. The scrubbing of some copies sterile and see if they are repeatable and how quickly established from seeding from the compact seeding generators.
- Compact non-habitat bio-generators for repeat reseeded to evolve the seeding process. Seed facilities need to evolve to the smallest possible for stable transfer of base organics to start up newly built human habitation bio-generators.
- Compact seeding generators evolve toward self maintaining and self transporting (small asteroids?).
- Long term testing of the largest facilities for durability and self maintenance. Some must see how long they can go and how to eradicate and add micro-organisms

### Development Phases

- Prove basic bio-generator
- Prove human operation for use in first permanently occupied lunar or asteroid sheltering
- Prove robotic maintenance
- Prove robotic construction - see AI and robotics project document
- Prove robotic mining and processing of materials - see AI and Robotics PDF and Mining and Processing PDF.
- Prove expansion seeding of bio-generators - see AI and robotics project document

### Long Term Development of Automated Solar System Expansion Criteria

- First usable packages to parked asteroids will be different from later automated seed packages for solar system expansion.
- Smallest possible bio-generator package for transportation off planet and seeding of full sized facilities throughout the solar system.
- Off-planet stability is established by having several bio-generators in proximity.

- Permanent stability established by several redundant facilities.
- Maintenance drones.
- Maintenance of the seeding unit.
- First permanent populations inserted.
- See AI and Robotics project PDF. Measurement is a technology in itself in this project. Measurables constantly assessed so events can be analyzed for efficiency and stability.

### **Computer Simulations for Specialized Bio-Generator Robotics Development**

- Simulations of all operations and systems including crops and recycling
- In all levels of development identify technical choke points where there is a weakness of testing the biological systems and processes that are skipped over in real world development of a system such as a bio-generator.
- Phases and criteria for when each phase of development of the real world prototypes need to go to the next **development phase**.
- Every Robotic trait and component of every unit must be modeled for simulation so the traits can be treated as variables. Variables will become base data for self evolving robotics fed into simulation based AI. See SimAI and Robotics PDF.

## **Part 3 Bio-Generator - First Prototype - The Cinder House**

### **Basic Goals**

- A self sustaining system processing air, water, food, and waste.
- Controls toxins with the natural filtering and breakdown of the bio-generator processes.
- Continually adds more organic mass (air, soil, food production). Size is stability, quality of living, and more toxin processing.
- Prove a closed air system an rural/urban family can live within to have pure clean air and water.
- Eventually rural family model the aquaponic racetrack will be 3d printed for a natural garden/park aesthetic and of course 3D printed is the Lunar product
- Aesthetic design may be seen by some as a “soft” issue/feature but it will be the predominant feature for making this happen.
- Part of the aesthetic is racetrack circular flow of aquaponic water so research and experience will be gained in same level aquaponics with repeating stages. For instance 3 sets of fish pool-filter-greenery, repeat. This will have its own advantages and energy efficiency. But such an open system within a closed environment will have its own challenges.

**The Cinder House** - The cheapest first prototype will be a cinder block construction on cement slab. It will be a closed system for materials and somewhat locked down to exterior air. For multiple purpose use once it has served its function, it might have a glass roof since this prototype is also promoting a family use bio-generator and might be built as a promise to be a civilian greenhouse or teaching environment later on. The first prototypes can be incorporated into the household by fan works if the household and “garden” are kept separate. If the first Cinder House happens and proves out then a 2nd prototype will be vindicated and move to the next proving with a roof that does not allow exterior air and sun. All prototypes can be incorporated into family living by at the least doing fan works to circulate the “closed” air system from the bio-generator structure through the shared walls of the family living area. Simplest control of humidity for some seasons may be pushing air to the living quarters by fans low in the structure instead of taking higher humidity air above.

#### **Air Lockdown Phases of Cinder House**

- Phase 1 - Prove materially closed without consideration of air mixing from exterior when doors used. Doors could be left open as needed until air quality (smell and humidity) is maintainable.
- Phase 2 - Dual door access. Doors are only opened for access to prove the closed system phase to this point
- Phase 3 - Robotic operation. Completely closed
- Phase 4 - Human lockdown. 4 users in place to measure air quality and more fully test the system. Periods as short as needed for this stage of the development.

#### **Startup Practices for the Aquaponics**

- To simulate Lunar startup and just as easily for the rural model
- Each separate racetrack tank should be started up as if it is the first for the practice
- 1st - get the nitrification process going in the aquaponics
  - Human bathing and then peeing in the pool
  - Start the feces and Black Fly process
- 2nd - add baby fish and feed minced larvae from the fly process
- 3rd add seedlings to the aquaponic system

**The bio-generator for all! A solution aimed at Earth’s growing threat of food plight. A note on aquaponics in space versus commercial Earth efforts versus personal home use.** This project does not prove aquaponics. It is already proven. It will prove the ability for humans to live



within the system and recycle all of the biological materials and air and water, oxygen-carbon cycle for constant cycling of air, and soil generation to use all human biological waste for animal and/or human feed . Aquaponics is fascinating and draws many fans who try to make a commercial enterprise of the system.

Results are mixed on the commercial level and still evolving. But a mass produced system for the family on Earth (incorporated into 3D printed homes?) can take advantage of the inherent popularity of aquaponics as a year round hobby that could fully support users at the family level. Living in this space will be a sanctuary away from pollution and the accelerating wildfire smoke that now affects most areas for half a year, every year. This is the basis for the first live in bio-generator. And as a technology demonstrated on the Moon it can bring aquaponics into the homes of millions. Aquaponics has reached the stage where it is exciting for a family to live within instead of a separate open air project. We can bring it into the home and live in a swirl of fish and greenery. Glass walls between living areas and the garden that last a century to show off the fish and the garden. Permanent bio-generators.

The first prototypes may even have a glass roof and sunk halfway into the ground as per the Earth-bound family of 4 personal home use. Could be built immediately adjacent to a house for later incorporation. The family design and the lunar design may not diverge until the bio-generator is proven for self sufficiency before making it a completely closed system and simulating underground conditions at university level research.

If prototypes get momentum for rural family models then one communal garden/bio-generator could feed and provide clean air to several households. Each would have their own aquaponic racetrack since each family is fueling their own fly process.

### **Earth based development**

- Development now, for something needed in a few years is always overlooked.
- Cheapest to develop now instead of the typical as we go, as we need, behavior. And in the case of the (long term development) bio-generator it will never happen with the usual approach.
- Relationships with vertical farms, hydroponics, and aquaponics industries.
- Evolve for decades until meeting off-planet criteria.
- Habitats and communities that are self sustaining and control exterior toxins.
- Side product -- develop a closed systems industry for use on Earth to accelerate the technology for off-planet use.

- When robotics can construct the sheltering and bio-generator underground on Earth, then it is ready for the robotics that have been preparing materials on the Moon, Mars, and asteroids - see AI and Robotics PDF.
- Strategic decisions on sheltering in artificial gravity of asteroids versus zero gravity and the “partial” gravity of the Moon and double that on Mars.
- Animal inhabitants constantly tested for toxin buildup and general health. AI monitoring of behavior to detect changes in behavior. An academic sub project?
- Humans as inhabitants are not required until the first stability criteria are achieved. Though one system should have continual experiments with real habitation for quality of livability studies.
- Prove with humans inserted. First phase can be a family and air doesn't have to be a closed system for first phases - compartmentalized for control of humidity and moisture.
- Earth based development needs multiple systems so that some are human driven to speed up development. The human element must be involved at all levels to keep the overall project motivated by the weakest link.
- Robotics Only Testing - To test automated maintenance some habitats in the development phase must exclude any human internal interaction.
- No humans in the biome period – only animals so that only robots operate within.
- Development Criteria - If habitat is stable without humans in it... an easy way to reach stability before using the most difficult cog of the system. And probably stable with the human element? So can do decades of closed work.

### **Sample Lunar Livability Factors (that must be found by experience)**

- Unforeseen problems with Moon Environment
- Aquaponics printed on legs instead of directly to the floor to avoid cold soaking.
- Module has a main living area with rows of aquaponics to visually and physically divide the area into a natural feeling of space and private living areas. 2nd and 3rd areas are air controlled access to lavatory and BSFL production.
- Since the biggest space factor in the main area is the aquaponics, the vats could be 2 sets of “L” shapes in a head to toe configuration.
- Humidity control - keep aquaponics water temperature below the habitat temp
- $\frac{1}{6}$  gravity (compared to Earth) lends to accidents - tall ceilings - fish nets for fish jumping?  
- Sleeping restraints
- Closed compartment Swimming/bathing tank so splashing is not a concern
  - Small oval system just long enough for stationary swimming.
  - Large enough for swimming with alignment leash, the arms and legs don't hit vat surfaces. Sitting area for feet in water and same for cold water systems.

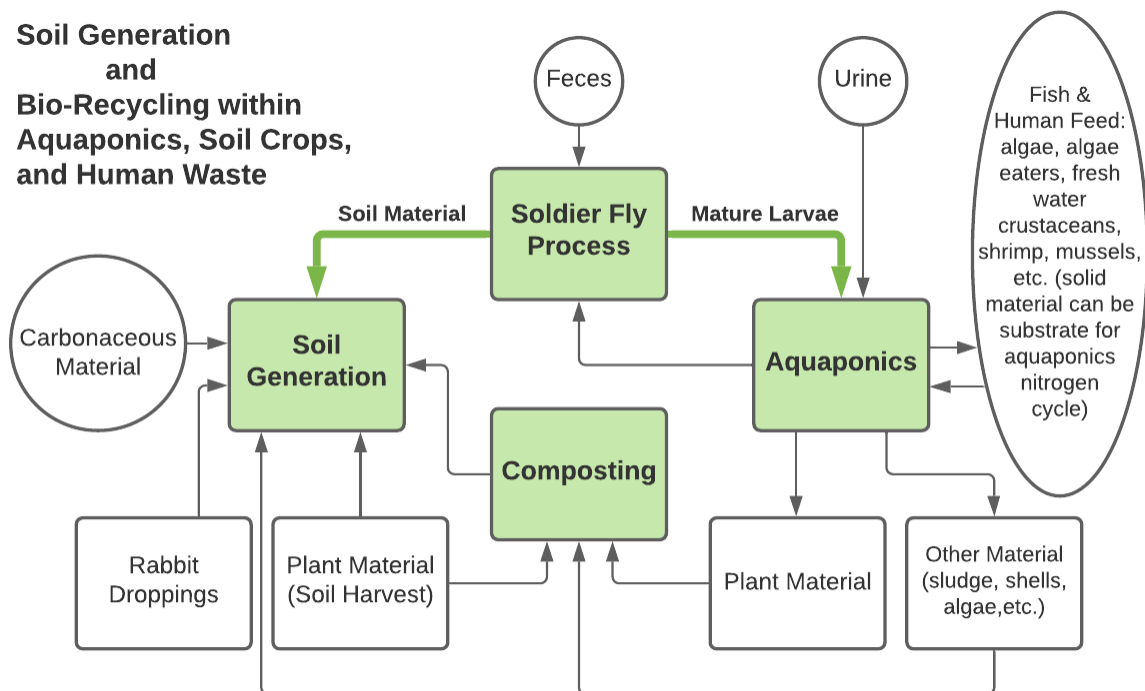
- Large enough for biological scrubbing to breakdown oils and skin cells and keep crystal clear water.
- Lighting will have random dimming or brightening of one part of the space every few seconds. Not really noticeable but gives sense of outdoors to go with the greenery.
- For odor/air control of the soil generation compartment there is a double door compartment between this and the living area and the compost and BSFL system have their own doors.
- Designed to expand so excess can go to Lunar Gateway and Mars transit.
- Food/water containers for transport off the Moon

### Research

- Composting adds gas to the air mix. This extra source of CO2 is turned to oxygen in the plant cycle. This is the key to growth into expansion compartments?
- Humans add gas to the mix?
- Does the water in the aquaponics serve as an oxygen control by staying high in oxygen content?

## Part 4 Bio-Generator - Soil generation

### Soil Generation and Bio-Recycling within Aquaponics, Soil Crops, and Human Waste



### **Processing Regolith into Soil Development - Sub Project**

- Initially in the first Lunar bio-generator, the soil generation process recycles all biological products and can continue to add more healthy soil to an expanding system and of course provide a variety of food with better nutrition value.
- The composting room adds air/gas to the volume. This extra production of CO<sub>2</sub> is turned into oxygen. Must insure the compost is constantly turned to keep oxygen in the process to keep from producing methane and keeping out mold and rot.
- Ultimately Soil Generation is the base for an off planet environment with strong healthy systems of microbes on up to humans. For example, where a baby can crawl in the dirt and grow with a strong immune system.
- Processing of raw material into dirt and then into life giving soil. Dirt must be processed into material for the first line of biological breakdown and then that is further processed by more lines of biological processing.
- Sterile dirt material must always be as transitional as possible. Meaning as useful to bio-matter and plants as possible. As a substrate it has little value if it is not a part of the process of becoming soil.
- For prototype purposes we will need a carbonaceous material that can be grinded into dust and then added to the soil generation process.
- Finding multiple sources of raw material off-planet. Starter level compounds and minerals.
- Mechanical processing solid to ground up material for easier chemical, biological processing.
- Mold and fungus dirt breakdown.
- Human waste (not being saved offplanet at this time from the ISS), worms, microbes, water, chicken waste, plant (plant material is mixed into the process) action for breaking down dirt and waste into plant giving soil.
- Waste plant stalks mixed into compost and shredded and mixed into the soil and fed to rabbits.
- Much traffic on the internet about difficulties of growing “plants in space”. All of these refer to zero gravity conditions. The bio-generator scenario is for permanent habitation with gravity of Moon, Mars and the artificial gravity of spinning asteroids.
- SCENARIO: Plants absorb from dirt - Plant eating rodents deposit (clean versus hot fertilizer) waste (find maximum processing plant eater). Eventually soil builds up if plants are provided material to absorb from dirt/regolith. Find the period of time to build up soil enough to support human crops.

- Worms/organisms that can digest heavy material of unprocessed rock after mechanical crushing.
- Dirt processing also through the water and microbial actions in the aquaculture/aquaponics process.
- Before humans arrive is one stage in the life of each soil vat. Once human waste is inserted into the equation then the system may be completely sustainable plus adding more raw dirt for processing into seed packages for the next expansion bio-generator. Animals used to process plant life into soil can be moved on to the next soil processing vat.
- PROJECT: A measured process to see how sterile dirt can be processed with the smallest amount of seed material to start up biological processes on the material. - microbe/worm/plant/animal?
- Chicken products - egg shells, feathers, chicken droppings are all possible dirt to soil processing

#### **Lavatory**

- Directly above or adjacent to the Black Soldier Fly production (BSFL).
- Urine is streamed to the aquaponics and flushed by water from aquaponics.
- Feces are dropped into the collection system for BSFL. The toilet is closed off from the collection for odor control.
- Bidet versus toilet paper

#### **Black soldier Flies (BSFL System)**

- Fly larvae digest human feces.
- Fly vats are carved/printed with ramps for mature larvae to self harvest into catches for feeding aquaponics.
- Larvae is fed to fish and/or chickens.
- The leftovers from the grub processed waste is now lower PH and ready to be processed in the soil generation by red worms.
- Chicken manure can also be a source of nutrients in aquaponics. Current thinking is less pathogens to humans by using other species for sources. Might be a more likely system instead of human feces for Earth family systems.
- Plants will be needed in the BSFL system for fly mating and corrugated plastic boards (where eggs are laid) above the feces processing area.

#### **Hydroponics/Aquaponics, Waste Processing, Soil generation - Sub Project**

- Seeding of a bio-generator will involve **soil generation** which may be incorporated into the aquaponics.

- Human water and waste system feeding into aquaponic/hydroponic plant growth.
- Air system is filtered through the water system for aeration and to propel water movement through the growth system.
- 2 Compartment habitat to control air quality -- to deliver “fresh” air filtered through “cleaner” compartment after processing/filtering of water and air in “dirty” aquaponic systems.

### **Plant Selection - Sub Project**

- Much experimentation and research has already been done for the best plants for hydro/aquaponics.
- Hardy for regolith based soil
- Balance of fat, protein, nutrient producing
- 3 Sisters Concept -- Corn, beans, squash is a well known symbiotic combination. Is it viable for a system with little soil?
- Easiest plants to harvest seeds off-planet
- Continuous growth without the need for seeds?
- Permaculture concepts viable in the bio-generator scenario?

### **Aquaponics**

- 3D printed to make an organic circular flow that has rural home aesthetic
- Racetrack/circular flow instead of separate systems connected by pipe. More energy efficient flow to keep the water moving
  - Attractive to family use and 3D print friendly design for off-planet use
- Include algae for more variety of food cycle for the plants and fish (more than just black fly larvae) that feed on algae eaters such as snails and oysters.
- How much need for other filtering by fresh water oysters for example.
- Some of the runs with straight forward aquaponics and some for processing urine and some heavy with algae to feed those critters that can go to fish and humans
- With multiple aquaponics runs one system can lend a hand to balancing another aquaponic tank/run if needed.

### **Project Sheltering - Off-Planet Considerations**

The primary concern is shielding from cosmic radiation, long term micro-meteorite exposure, and toxins and radiation from local materials available. For instance underground may present its own hazards that have to be distanced from the inhabitants. Selection of sites may be most dependent on the single factor of surrounding radioactive and toxic material. Some materials

may have to be mined locally just to line the walls for toxicity and radioactive material distancing. Glassing the walls (floor, ceilings) sufficiently to hold in the habitat atmosphere.

### **General Excavation Sites**

- Solid rock for quality glassing of impermeable shelter surfaces
- Lava tubes - Moon and Mars
- Asteroids - parkable with multiple asteroids on tether and spun for artificial gravity
- Tunnelling - especially viable if produced by resource mining?

### **Excavation - First structure to encapsulate the printed structure**

- Digging would leave columns and side supports for printing stage
- Glassing of walls to control radioactive gasses
- Glassing of columns that will run through the finished habitat

### **Printing - Second Structure Within Excavation**

- Printing of non-radioactive and stable materials for permanent use into the centuries and millennia
- Suspended between all of the excavated walls by short columns and side armature to the outer walls and inner columns

### **Sheltering Requirements**

#### **Cave/Lava Tube Scenario**

- Glassable materials?
- Distancing
- Bubble within a cavity with support arms out to cave walls to support internal pressure of the bio-generator and habitat.
- Shelter is less toxic and radioactive than other choices.
- Materials gathered for printing shelter inside of sheltering so distance is maintained.
- So less radioactive materials are used within and to keep distance

### **Ground Prep**

- Soundings of all sheltering surfaces for solidity

### **Glassing the Walls**

- To eliminate dust and future dust production.
- For complete wall impermeability for air and pressure containment.
- Lazing and or printing material onto walls. Multiple layers.

- Radioactive or toxic materials. Multiple walls. Inner wall is thin to limit exposure. Between walls is pressurized depending on the strength/thinness of the inner wall.
- Drone monitoring and maintenance of sheltering surfaces.
- Some walls could be in endless printer layering if space is big enough

### **Primary Inner Walling**

- Inner walls distanced from outer walls that may be radioactive

### **Entrance**

- Underground walls and floors naturally have more ability to handle holding of pressure versus tunnel nearest surface. Entrance will require thicker wall processing.
- Each section's air is reclaimed to the innermost compartment after passing through doors.
- Doors - triple compartment for dust control. A must to protect the innermost door for high pressure sealing.
- Doors - rolling, sliding or hinged doors? Weight of a door made of local materials may require rolling doors that are then pulled into locking position. Printed from basic materials - fusing rock into doors? Sub project.

### **Compartments**

- Like in a ship or submarine - lesser emergency doors, emergency suits and air.
- Humidity zones for humans and food growth and aquaponics.

To add your input to the first prototype please go to

<https://leapspecies.space/brainstorm-bg-prototype>

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