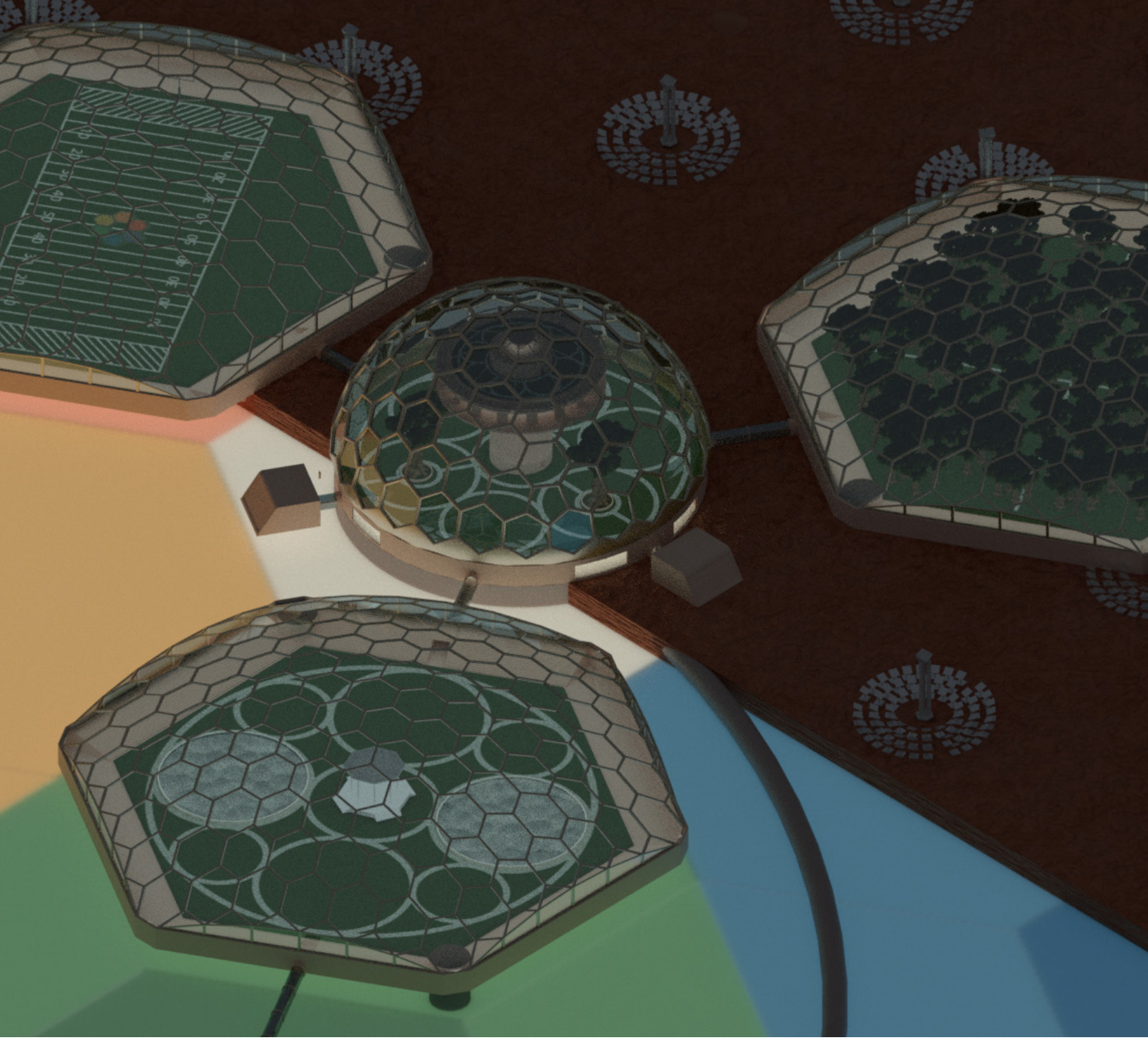

The Chromatopolis

—

A Martian city design concept prepared by

Diane Turnshek, Dean Mougianis & Matt Finlay

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THE CHROMATOPOLIS

(Alternative names: Rainbow Machine, Color Wheel City)
Matthew Finlay, Dean Mougianis, Diane Turnshek

We want to design a city for Mars that revolutionizes how cities are viewed on Earth. Technological solutions that make a sustainable Martian city cannot help but solve some of Earth's problems as well. The first step to making colonization of Mars a reality, to allow the idea of it to enter global thought, is for people to be able to picture a Martian city. Learning is enhanced through active processing strategies like visualization, summarization and designing maps and 3D renderings. Our team has outlined the design process from its conception, so that others will appreciate the nuanced need for meaningful architectural design related to the environment, whether an extreme environment like Mars or somewhere in the town next door. As we learn more about Mars, these ideas will be developed and refined. Stories and pictures that people can identify with will propel humans to colonize Mars.

The construction process of the Chromatopolis presumes a certain amount of pre-existing infrastructure and manpower on Mars from previous and more rudimentary settlements. In other words, this is not necessarily a design suited to be humankind's very *first* fledgling Martian settlement. It is intended as an evolutionary step towards a semi-permanent settlement including civilian colonists, scientists, and families, an attempt to fulfill the basic needs and desires of a small-town-sized population, and the beginnings of a market-based colonial economy.

The design of the Chromatopolis is based on a color wheel, so residents can have residences of equal size and shape, yet not get disoriented or lost. The lighting changes throughout the city further differentiates spaces. The play of light and shadow changes over time in order to suppress the feeling of stagnation in the limited space.

For protection, the disk-shaped city is mostly underground. It is set in a 1-2 kilometer-wide crater in the Utopia Planitia region, in the northern hemisphere of Mars. Several meters of regolith from the crater walls are pushed over the city to shield the colonists from UV light and harsh cosmic radiation. The color wheel concept is simple from a user experience perspective when navigating the internal structure of the colony; a colored stripe around the walls allows the colonists to know where they are at all times. The colors spread around like a rainbow: red, orange, yellow, green, blue, indigo, violet, circling back to red. The darkest colors lie towards the outer edge and pastels towards the center.

A clear geodesic dome lets natural light into the gardens, parks and recreation areas near the center of the city. Natural light also comes in through solar periscope towers. On the surface, mirrors redirect sunlight into the periscope tops that reflect the light down into the city. The tower tubes are in partial vacuum with a high R value – they are not releasing heat onto the planet's surface. From the surface, the solar periscopes look like flower towers.

Solar panels bring electricity down into the city to power LEDs and other equipment. Both the solar mirrors and the solar panels have to be on stilts, so windblown surface sand does not cover them. For maintenance, they run an electrostatic charge and tilt, which will slide fine sand grains off their slick surfaces.

On the surface of Mars, the sunlight is about as bright as a cloudy day on earth – Mars has about 40% the light level that we have on Earth. The solar panels and the solar towers are good enough for normal daily conditions, but have to be augmented. Batteries are necessary for the occasional weeks of sandstorms. Nuclear generators form another back-up system — redundancy of energy sources is key.

Astronomical research will be conducted from the surface of Mars with six telescopes equally spaced around the city. On Earth, The Sloan Digital Sky Survey Telescope (SDSS) in New Mexico uses this creative concept: at the focal plane of the telescope sits a metal plate with holes drilled into it and fiber optic cables plugged in to redirect the light from targeted celestial objects into photometers. SDSS uses a dedicated 2.5-m f/5 modified Ritchey-Chrétien altitude-azimuth telescope. A

1.08-m secondary mirror and two corrector lenses result in a 3° distortion-free field of view. The telescope is described in detail in a paper by Gunn et al. (2006). Bundles of fiber optic cables pass through a metal platen made to match the positions of objects to be studied in the night sky. This instrument can be removed and replaced by others designed to look at different areas of the sky. [1]

We can use that same concept. At night in Chromatopolis, six telescopes with 36-inch mirrors redirect the light into fiber optic cables for research purposes, but, during the day, another instrument swings into the focal plane that redirects the sunlight from the fiber optic cables directly into the city. A bundle of cables that come from the telescope can be split up and divided out so that all the places in the city can have a little bit of sunlight. Alternatively, a beam splitter could be used to redirect the light. The telescopes magnify the sun and track it across the sky during the day. At noon, the sun is the brightest, but as sunrise and sunset, when the sun is on the horizon, the light levels are lower. Colonists would get a feeling of rising sun and setting sun throughout the course of the day and their Circadian rhythms would adjust to the slightly longer day/night cycle.

Aquaponics can produce ten times the amount of produce on the same amount of land and uses ninety percent less water than conventional methods. It combines fish and plant life, so that the waste materials feed each other in a closed loop. Innovations in permaculture (the philosophy of working with nature, valuing plant diversity, integration over segregation, and self-regulation) and aeroponics (growing plants in air or mist) can be added to form a self-sustaining, high-yield, organic, vertical farm in the lower gravity of Mars.

As a backup, an independent method of lighting the city is needed. Earth has bioluminescent creatures: fungi, algae, fireflies and animals that live deep in the ocean. They use a bioluminescent signature to attract prey or for camouflage. We have taken some of the bioluminescence from the animals and plants and put it into other plants, so we have now plants that glow. A forest of bioluminescent plants could light the city. In warm-water oceans of the Earth, the algae only glow when agitated. In parks and recreation districts where people gather, we've designed a waterfall with glowing algae for light. If we understand that lower levels of light at night will suffice, then bioluminescence becomes a possible lighting solution.

On Earth for the last hundred years, we're over-lighting the planet. We get to design this city on Mars from the ground up (and down) and we have the opportunity to *not* over-light it. Human eyes are adaptable. Our irises expand and contract. Our pupils get large enough to take in a lot of light as long as there aren't glaring lights, like headlights while driving or unshielded streetlights.

This Martian city would have subtle lighting that would allow colonists' eyes to adapt to lower light levels. Most humans would be satisfied under 25% of the light levels of Earth. A Martian city wouldn't be wasting light like we do on Earth, sending it up into the sky. We spend billions of dollars with light that is scattered up and out, causing light pollution (unwanted, unnecessary artificial light at night). On Mars, we would use just the light we need for the areas we need it. Architects will use lower light levels as an integral part of the design.

Another part of the design is powered by the fact that Mars has 38% the gravity of Earth. Room design could incorporate more vertical, higher, usable areas. Reaching, jumping and climbing will be easier, so the city design reflects that.

Our rapid transit system is a hyperloop with magnetic levitation and propulsion in a pair of tubes in a near vacuum. The pods travel in opposite directions in their own tube. The tracks are kept level over flat terrain, which is important for best performance. This concept actually would perform better under the chill temperatures of Mars than it would on Earth. Elon Musk's has written a 58-page brief about the design.[2]

The double ring of the hyperloop goes around the whole city and loops through the central dome, so passengers can get into a pod and go whichever way they want. The control panel for the hyperloop is a color wheel, so travelers can dial in their destination. Alternative controls are posted for people who have a difficult time seeing color.

The running, biking, walking and golf cart track goes all around the outside near the hyperloop entrances and will also be a great way for people to get exercise. In lower gravitational fields, bone density, muscle atrophy and other medical issues have come to light in astronauts with long stays in space who did not vigorously exercise enough. Resistance wear will become a fashion norm, providing a small amount of extra resistance to normal everyday activities to counteract the impact of the lower gravitational force of Mars.

Natural light will be redistributed from the central dome to the residential chambers that surround the agricultural zone. Residences will have a window onto the greenery. Around the residences come the services: schools, research facilities, critical services, resource generation. The hyperloop track runs around the very outside along with the running track. Each hex inside the city has their own waste generation facilities, distributed, so that each area takes care of their own composting. The distributed nature of those individual cells provides back-ups if necessary.

Exits are positioned near the telescope facilities. This allows another way of bringing light to the outer regions of the city. The Martian red dust is going to be a problem. It is dealt with by using sonic showers, giant fans when vehicles enter the city to blow the dust away and a Mars version of the Roomba (floor cleaning robot).

It's lucky that Mars has about the same length of day and about the same axial tilt that we have on our planet. Colonists will have the same sort of seasonal variation in their climate. There's a lot about Mars that feels like home. One of things that we have since we've evolved on this planet is that we have a set of circadian rhythms, biorhythms where during the day it should be light and at night it should be dark. The darkness allows for melatonin to be processed in our system and that helps protect us against disease. On Mars, the areas where people sleep are dark, because even low levels of light at night make a difference in human melatonin production. As people move through the city, during the day, it is lit up, but the lights are not directed into the resident's eyes. The lights are diffuse and shielded, and so there is no need for as many of them. In the corridors, a glowing stripe along the side of the corridor notes the location identification colors. The colors in the stripe gradually change as you circle the city. As people travel around the city, functionally different areas welcome them with appropriate light levels. Nothing is ever glaring, so their eyes have a chance to naturally to adapt to the different light levels.

Each residential unit is the same size and shape -- that insures that all is fair and no one's unit is any better than anyone else's. To be able to locate yourself in this circular repeating pattern, colored panels will light the way. No one can ever get lost. The residential units are spaced around in a ring, so that people can live near where they work and play. Parkour is encouraged by the design of the vertical spaces.

The Chromatopolis would be more sustainable if the inhabitants follow this life philosophy of low waste. The idea is to not only survive, but to thrive. Designing the lighting systems with efficient LEDs and using the right light level for the job at hand will drive the cultural change we need to spread.

The Chromatopolis is safe from cosmic radiation with its cover of regolith, but with a critically important view of the night sky for scientific research and inspiration. The constant link to the actual day-lit sky connects the city's inhabitants to the cosmos, ameliorating some of the inherent isolation. Due to the extreme distance of the stars, they look the same from Mars as they do from Earth. One sky connects us all. [3]

Three to thirty-three meters below the surface where the city is located, immense water ice deposits exist. They're the size of Nevada with as much water as Lake Superior. The colonists can extract the water from this region for their use.

From Donald Hood (LSU, Dept of Geology and Geophysics):

"After doing a bit of math, I have some estimates for the total energy to get 1 kg of water from all these substances. It takes something like 500 kJ to take ice from -50C to liquid water. The other substances I checked only give lower bounds, since I couldn't find a reliable source for the heat of fusion to remove

the water from them, but you can see it takes about an order of magnitude more energy to get water from Gypsum. This makes sense, since you are heating up a lot of stuff that isn't H2O, wasting energy. I also looked at heating up hydrated glass as an approximation of the "hydrous amorphous" component seen by curiosity and from orbiters. It takes about 5x more energy to dehydrate that material than the gypsum, so it is even less desirable. In general, we come to the conclusion that was the obvious once, melting ice will be much more energy efficient. I don't think acquiring water from minerals and soil components is prohibitively expensive, especially for smaller scales. Planning to land on or near an ice body, though, is going to make things much easier."

From Geoffrey A. Landis (NASA, John Glenn Research):

"We've pretty well convinced ourselves that you can remove all but possibly the first monolayer of dust off of the solar arrays pretty easily, possibly as simply as tilting the arrays, or if not, by electrostatic removal. So we think we might get 10% degradation or so, but not too bad. For solar on Mars, the worst problem is that one year out of three, on the average, there's a global dust storm, which cuts down sunlight a bit. I'm attaching a copy of a graph of Opportunity's solar array performance during the last dust storm (the only one for which we have data from surface solar arrays). Units on the bottom are sols (Mars solar days) since landing. So you either need some big batteries (or fuel cells) to keep going during a story, or a backup power source, or else oversize the power system." [4]

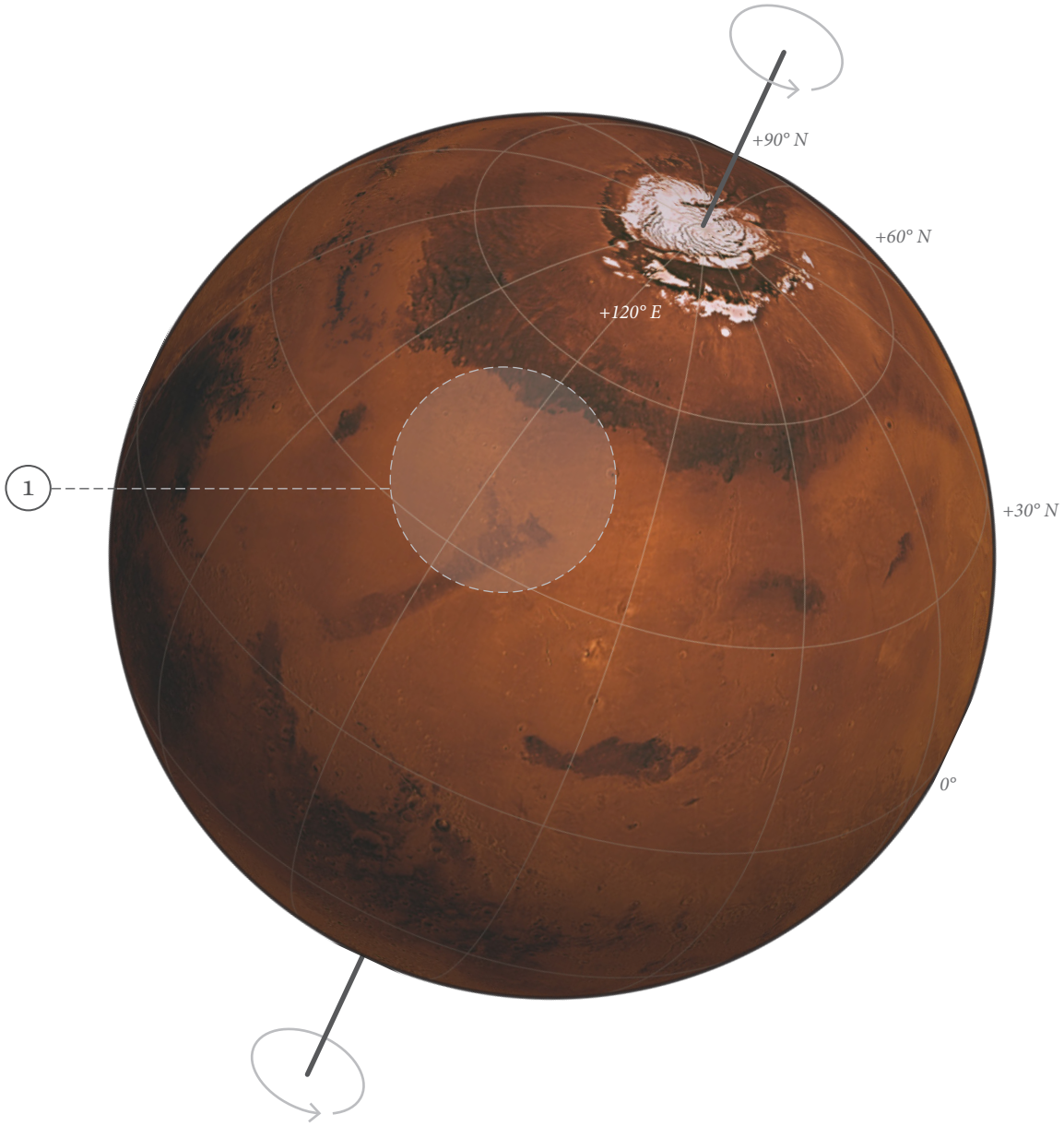
DEAN'S SPACE STORY:

I was in the third grade when Alan Shepard became the first American to venture into space. It was like I was right there with him, both in my spirit and in my right ear. I had "borrowed" - without their consent – my parents' brand new transistor radio, which was the height of 1961 Japanese consumer technology. All that long May afternoon I sat in class, the side of my head resting on my palm, my face composed into what I hoped was a look of rapt attention. I had hidden in that hand the earbud that came with the radio, my palm pressing it into my ear. The wire ran up my shirtsleeve, down the shirtfront and then into the pocket that concealed the radio. I listened intently, through countless delays and holds, until I finally choked down a yelp of joy when the rocket finally took off. I loved NASA and I loved outer space. I wanted nothing more than to be an astronaut. Later, when my seventh-grade homeroom teacher, Mr. Huffman dared to suggest that we could not possibly put a man on the moon by decade's end, as President Kennedy had promised, I took it as a personal affront – and told him so. He suggested we bet on it – to the tune of one dollar, American. I eagerly and defiantly took him up on it.

That summer of 1969, so divisive in so many ways, I sat late into the evening in front of the family black and white Philco, drinking the words of Chris Craft (what a great name for a NASA spokesperson) and Walter Cronkite until that moment when Neil Armstrong stepped off the bottom rung of the lander into our collective historical dream. I couldn't sleep after that, couldn't get enough of it. And when my parents insisted I go to bed, I begged them to let me outside for a while – I wanted to look up at the moon. And they let. I stood on the front lawn, gazing up at the moon in amazement that there were actually people up there now. When I'd finally had enough, I turned to go back inside and saw, up and down front lawns along the street, a dozen or more men and women doing the same thing, looking up at the moon in wonder.It has never left me that this moment was the first time that nearly the entire human race was thinking the same thing at the same time. The real magical moment was actually occurring down here on Earth.

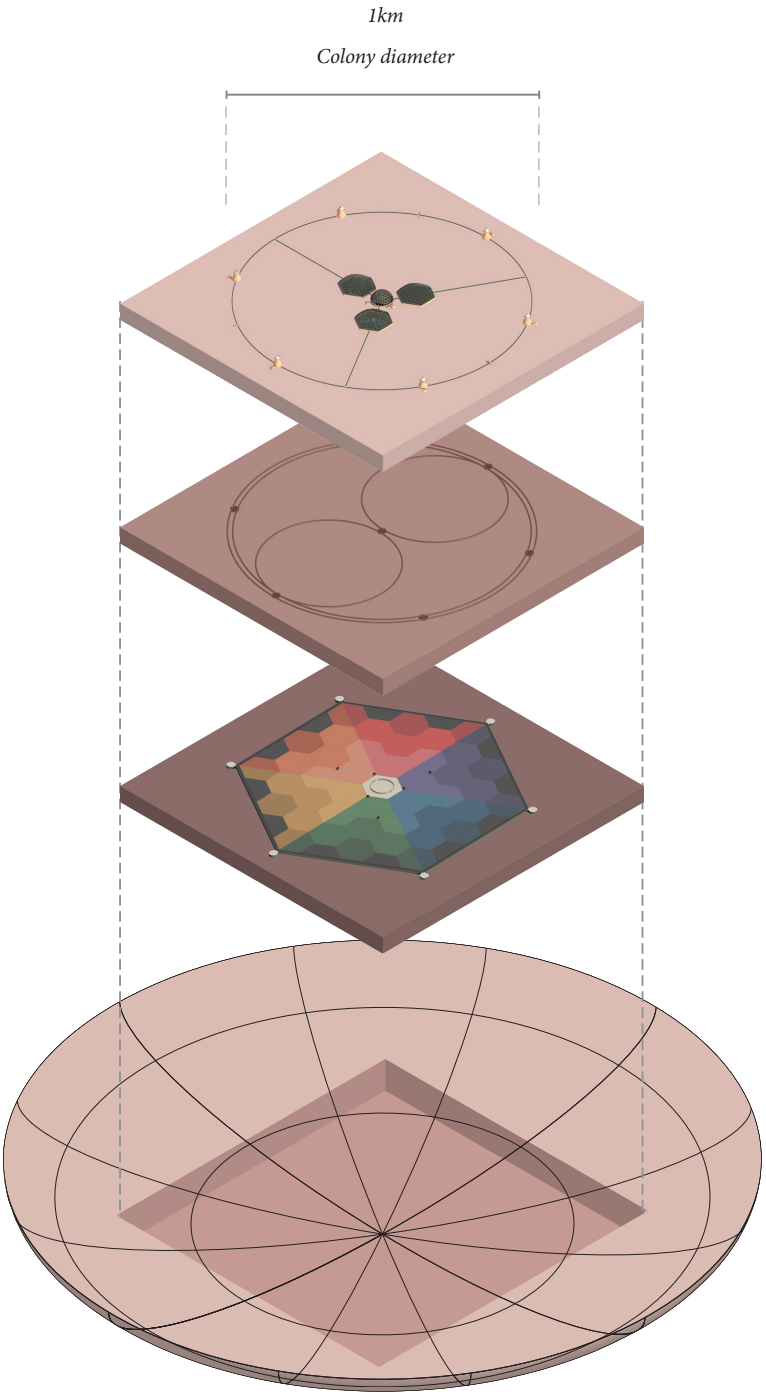
In the fall, the first thing I did when I went back to school was to track down Mr. Huffman and demand my money and my due. To his great credit, he didn't just pull some crinkled bill out his wallet. He made a ceremony of it, setting a place and time, telling teachers and students, and presenting me with a crisp note and nice speech about hope and optimism.

I will, to my great regret, never live on Mars. But what great fun it is to help imagine a place where people one day will. And they will too. I'll bet you a dollar.



Region

The Chromatopolis will be located in the Utopia Planitia region of Mars (1), the largest recognized impact basin on any body in the Solar System. Large subsurface ice deposits are known to exist in Utopia Planitia[5], facilitating water extraction efforts to service the colony. Areas containing ice, including those found in Utopia Planitia are often indicated by polygonal patterns found on the surface the planet where ice sublimation from the ground has occurred[6]. Approximately 990 craters are known to exist in the Utopia Planitia area (30°N - 60°N and 110°E - 130°E) fitting the characteristics required by the Chromatopolis (1-2km in diam.)[7]



L1. Surface

Includes central domes, solar periscopes & reflectors, Solar panel arrays, upper portions of observatory columns, road structures & garages for surface vehicles.

L2. Subsurface

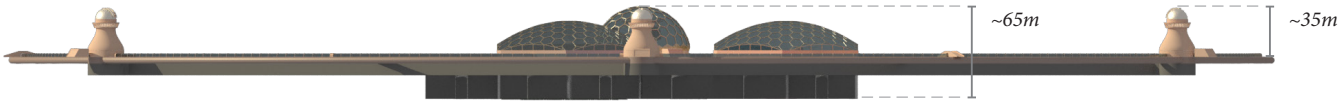
Contains the hyperloop track, outer node stations, and central node station.

L3. Habitation

Contains all infrastructure, living spaces, crucial services, and areas necessary to sustain a colony. Chromatically defined regions with iconographic zoning defining the use of each hexagonal space.

Crater

Pre-existing crater of diameter 1-2 km in the Utopia Planitia region of Mars. Crater floor is leveled using regolith material harvested from the crater rim. L2-L3 portions of colony are buried to protect colony from cosmic and solar radition.

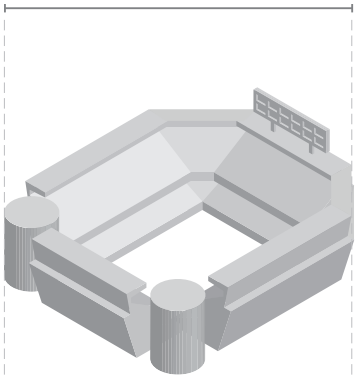


Central Bulge

The Chromatopolis features a much deeper and taller region surrounding its core. This accounts for psychologically necessary open spaces on both L3 and L1, which should reduce any sensation of claustrophobia on the part of permanent residents and provide an escape to more Earth-like biodomes if desired. The L3 spaces also crucially take advantage of the extra vertical space to create dense vertical farms on platter-like structures demonstrated in more detail later on.

~275m

American football stadium (avg)

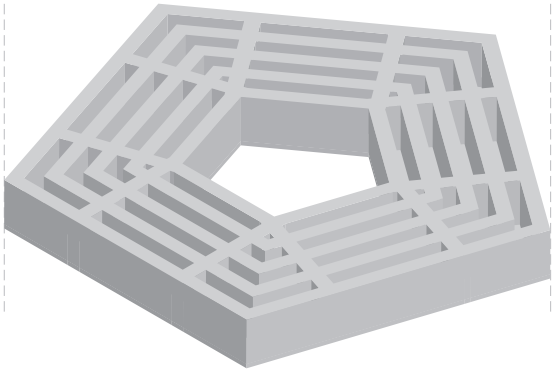


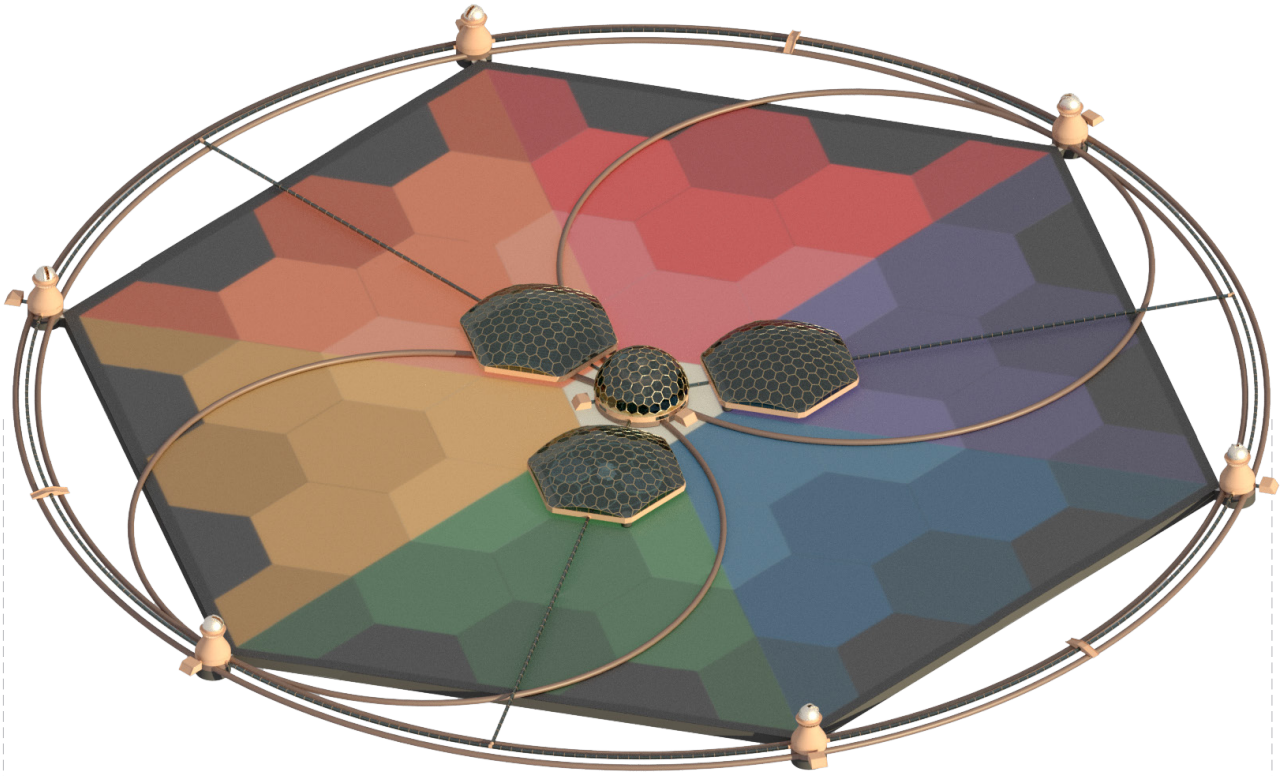
~108.5m

I.S.S.

~431m

The Pentagon

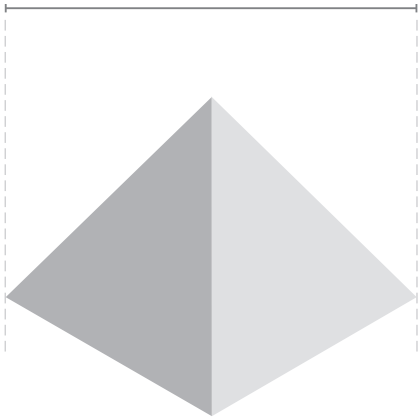




1km – Chromatopolis

~325m

Khufu's Great Pyramid

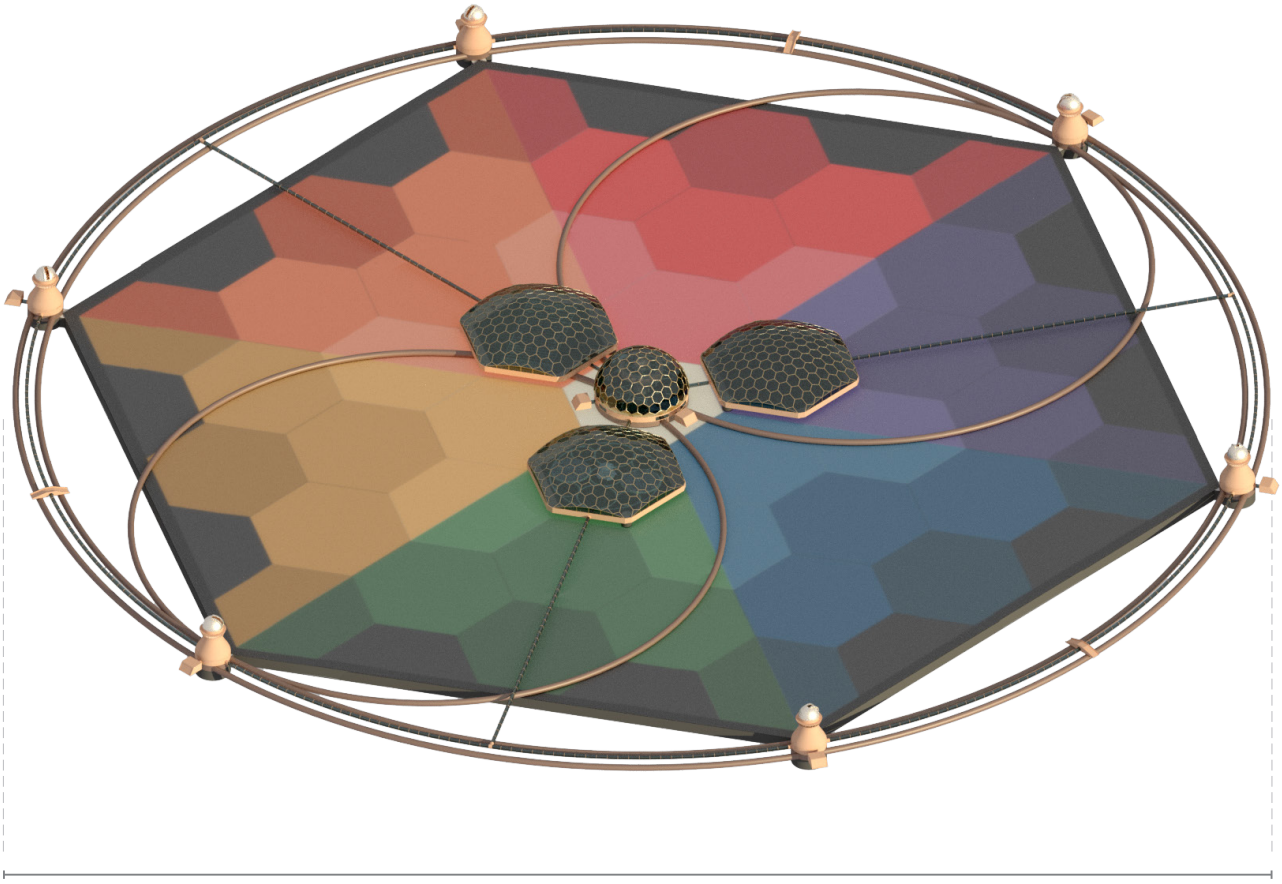


~76.2m

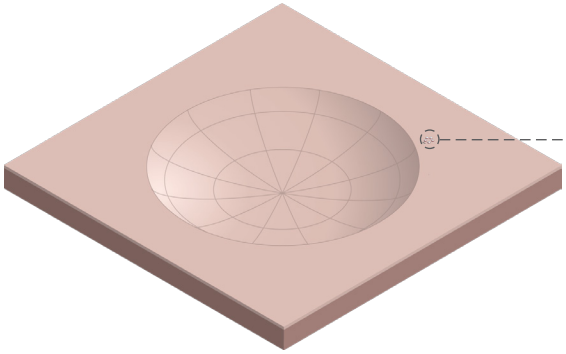
Boeing 747

~245m

LZ 129 Hindenburg

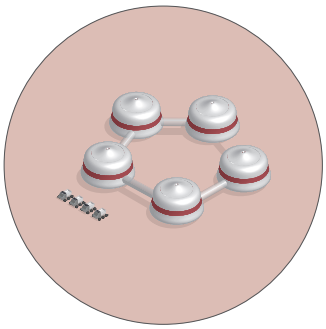


1km – Chromatopolis



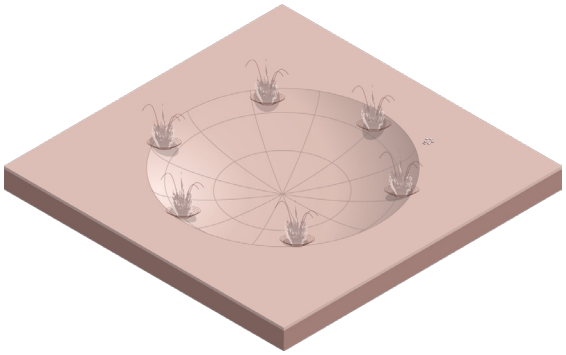
1. LOCATE VIRGIN CRATER

Utopia Planitia region; 1-2km in diameter



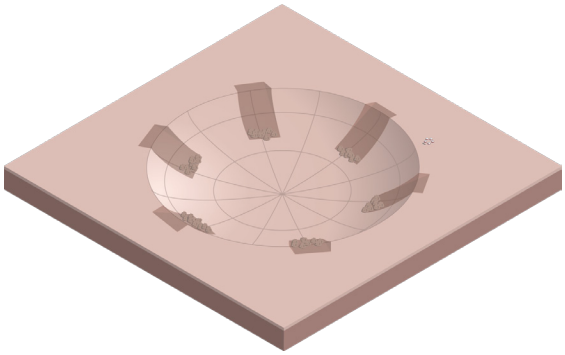
2. PRELIMINARY STRUCTURES

Tent-like temporary construction staging areas



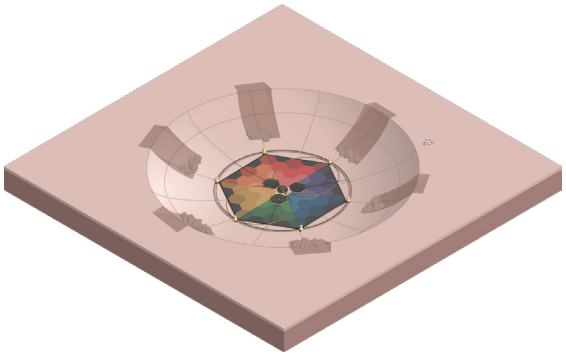
3. PARTIAL DEMOLITION

Pulverize crater walls selectively with explosives



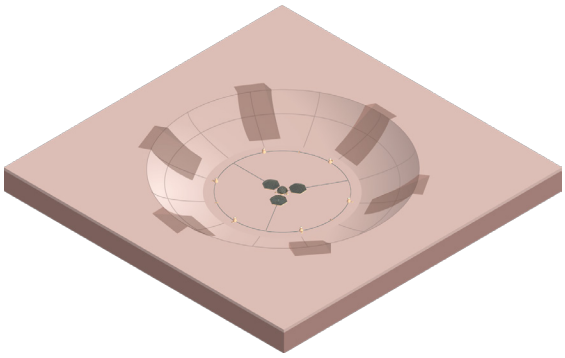
4. DEBRIS CLEARING & RESHAPING

Form ramps into the crater, break down debris



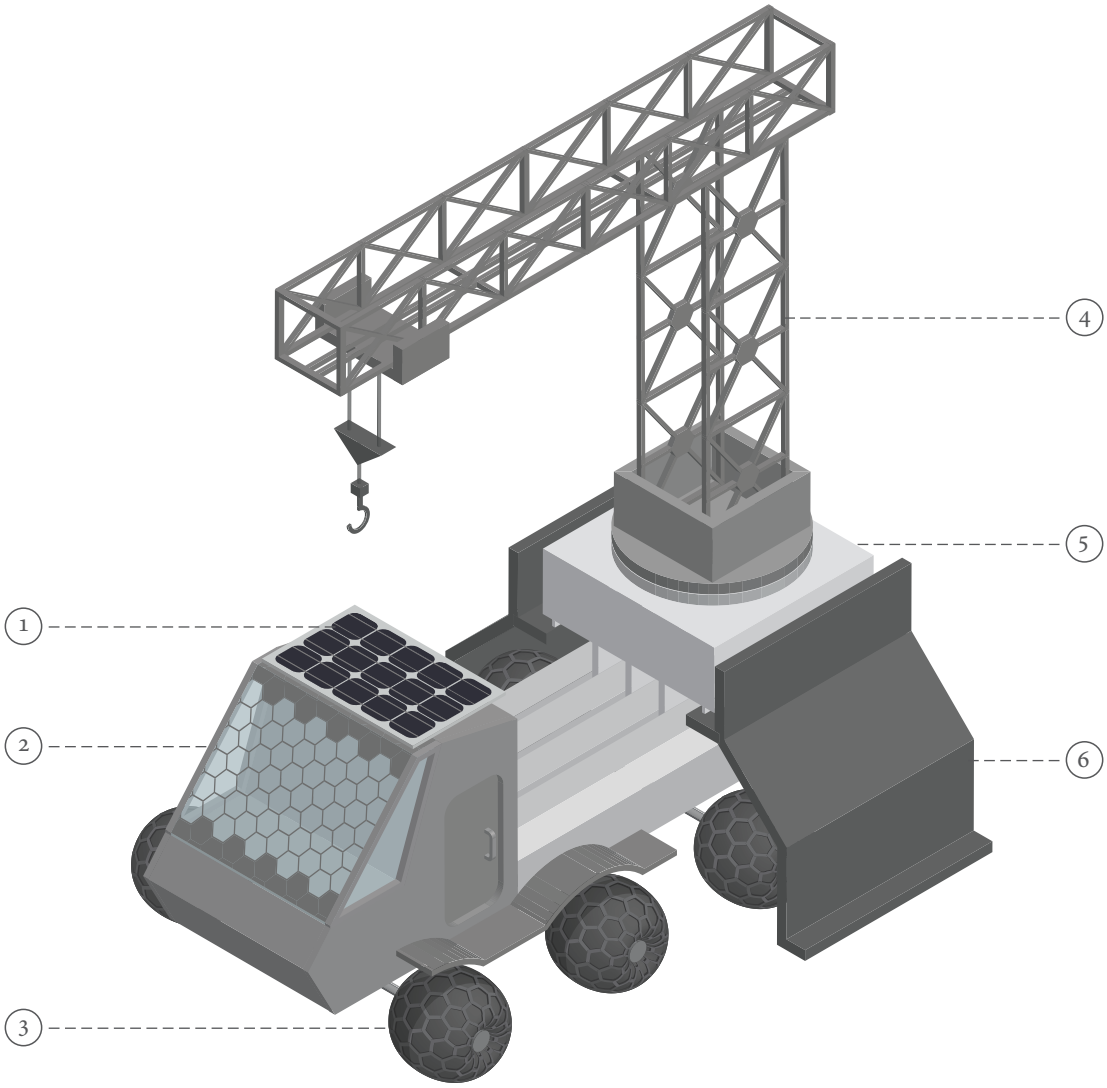
5. BUILD COLONY FRAMEWORK

Use regolith concrete & bricks to construct colony



6. BURY LOWER SECTIONS OF COLONY

Use pulverized regolith loosened during demolition

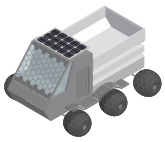


Modular Work Vehicle

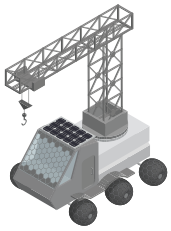
1. *Solar Panels*
2. *Reinforced Windshield*
3. *3D printed Mars-optimized toroidal tires with hex tread*
4. *Interchangeable Vehicle Tool*
5. *Electromagnetic plug/lock system*
6. *Docking station*

EXAMPLE CONFIGURATIONS

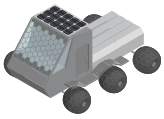
Regolith concrete mixer



Haul/dump

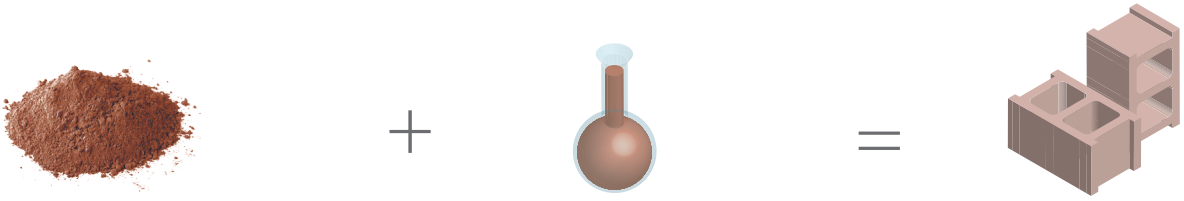


Mini-crane



Standard vehicle base

Martian Regolith Concrete



50% MARTIAN REGOLITH

Pulverized surface dust & rock with max aggregate size of 1mm largely composed of SiO_2 and Al_2O_3 with some Fe_2O_3 and TiO_2

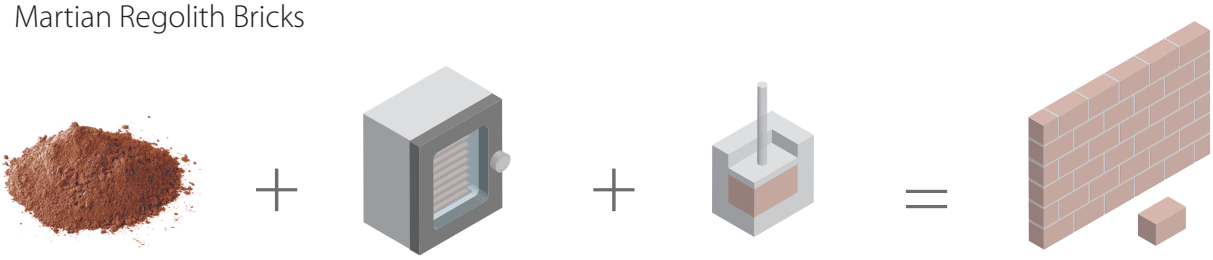
50% MOLTEN SULFUR

Sulfur (abundant on Mars in sulfates, sulfides, and elemental form)[8] heated to 240°C, reaching its liquid phase

REGOLITH CONCRETE

Compressive strength greater than 50 MPa — in excess of stringent building codes on Earth (requiring ≥20 MPa)[9]

Martian Regolith Bricks



100% REGOLITH

surface dust & rock

DEHYDRATION

via Freeze-drying[10]

COMPRESSION

via hydraulic pistons[10]

REGOLITH BRICKS

Standard rectangular bricks

Martian Regolith 3D Printing

70% REGOLITH

surface dust & rock w/ max aggregate size 1mm

30% PLGA

polylactic-co-glycolic acid copolymer[11]

REGOLITH INK

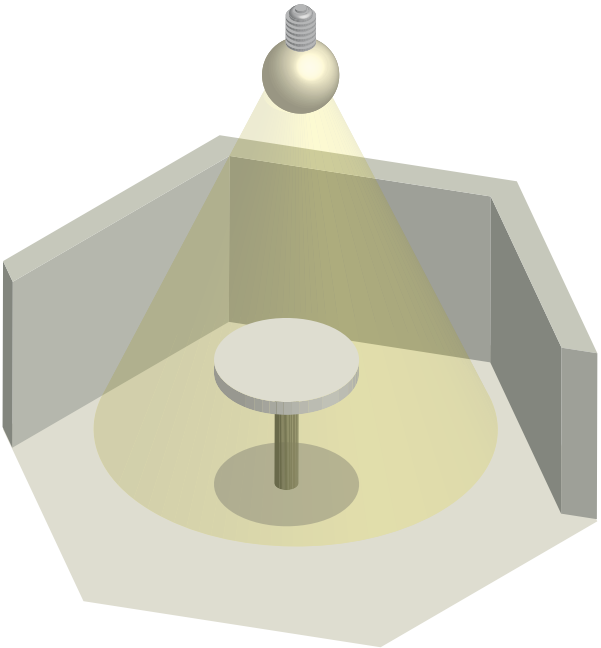
storable in air-tight containers at 4 °C

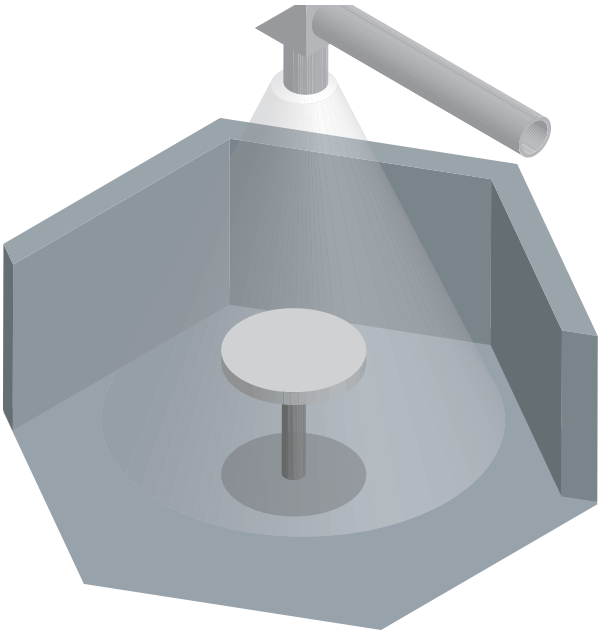
REGOLITH 3D PRINTING

Prints of any shape, size or configuration are possible

Earth int. lighting

On Earth, interior and exterior lighting is often far higher and harsher than is technically necessary for humans to function. Its artificial quality can also induce eye strain and stress and disrupt the body's circadian rhythms.





Colony int. lighting

In this Martian colony, we have the opportunity to teach people how to reduce the amount of light to just what they need — roughly 25% of the intensity of lighting on Earth. This reduces unnecessary energy consumption, allows colonists to grow used to the less intense light conditions that exist on the Martian surface and may lower general strain and stress induced by bright artificial light.

Chromatopolis Seal

Seal of the Chromatopolis — intended for use in formal documents, colony government & legal contexts, ceremonial events, or whenever a decorative logo is required.

Horizontal Logo

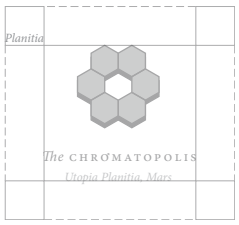
Standard Chromatopolis logo oriented horizontally. Featuring three components: the hex icon, the logotype and the separator. The hex icon may be unpaired and used by itself in certain contexts.

Stacked Logo

Variant of standard Chromatopolis logo oriented vertically as a stack. Featuring two components: the hex icon and the logotype. All logos should be used as lockups without altering proportions.

Logo Clear Space Guidelines

Quick reference guide for the amount of margin/clear space to leave around the outside of a logo in any given context

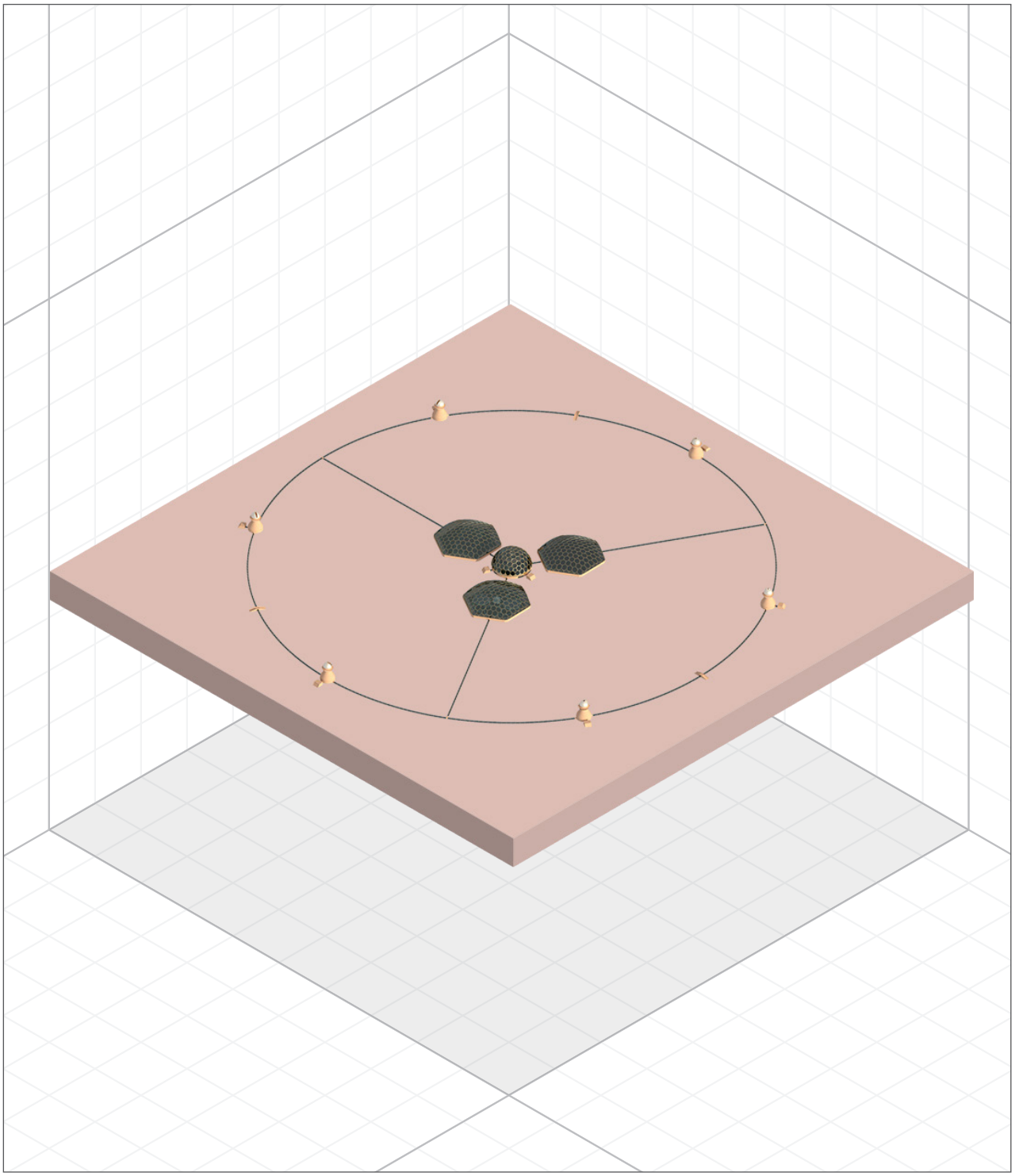


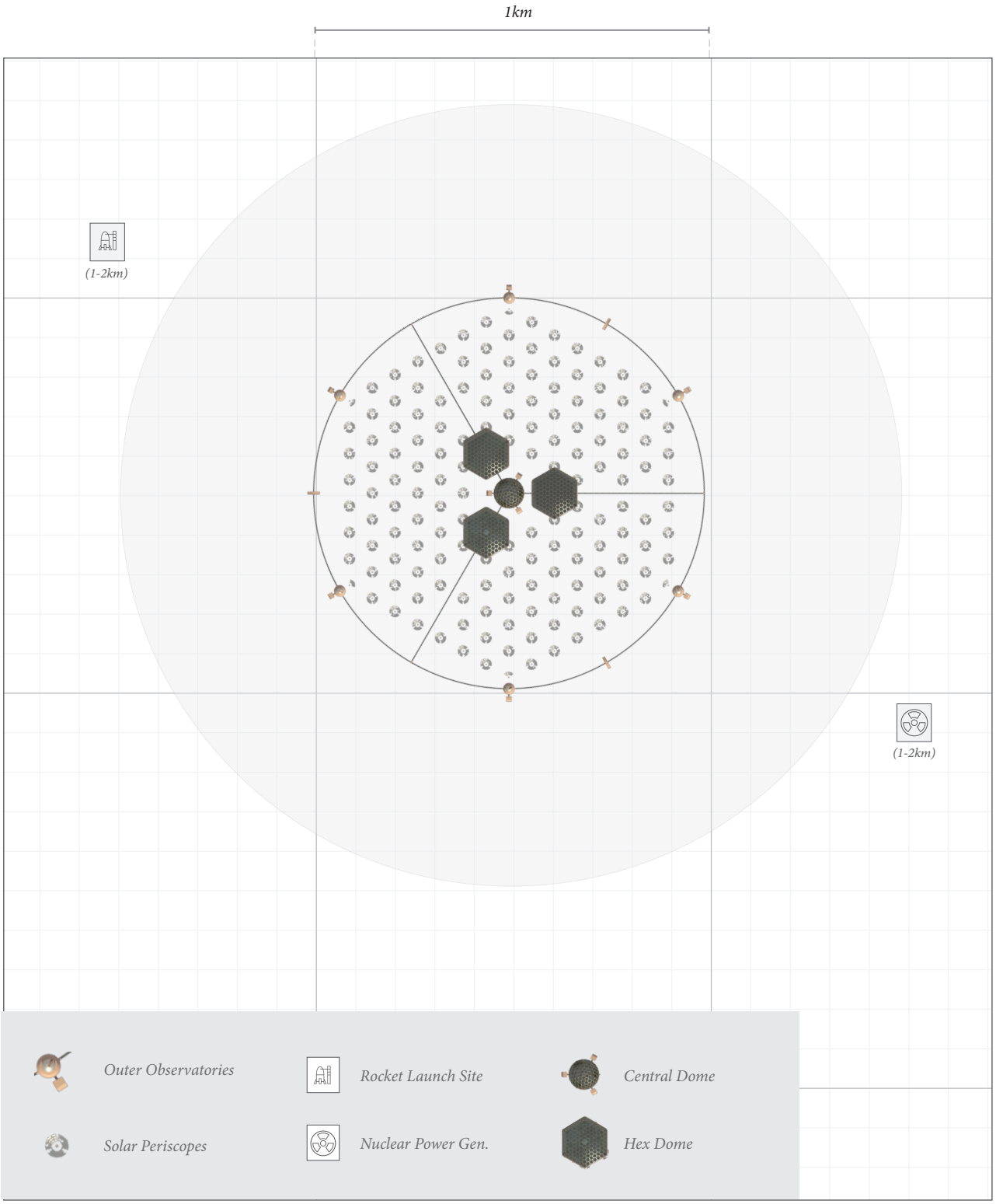
THE CHROMATOPOLIS

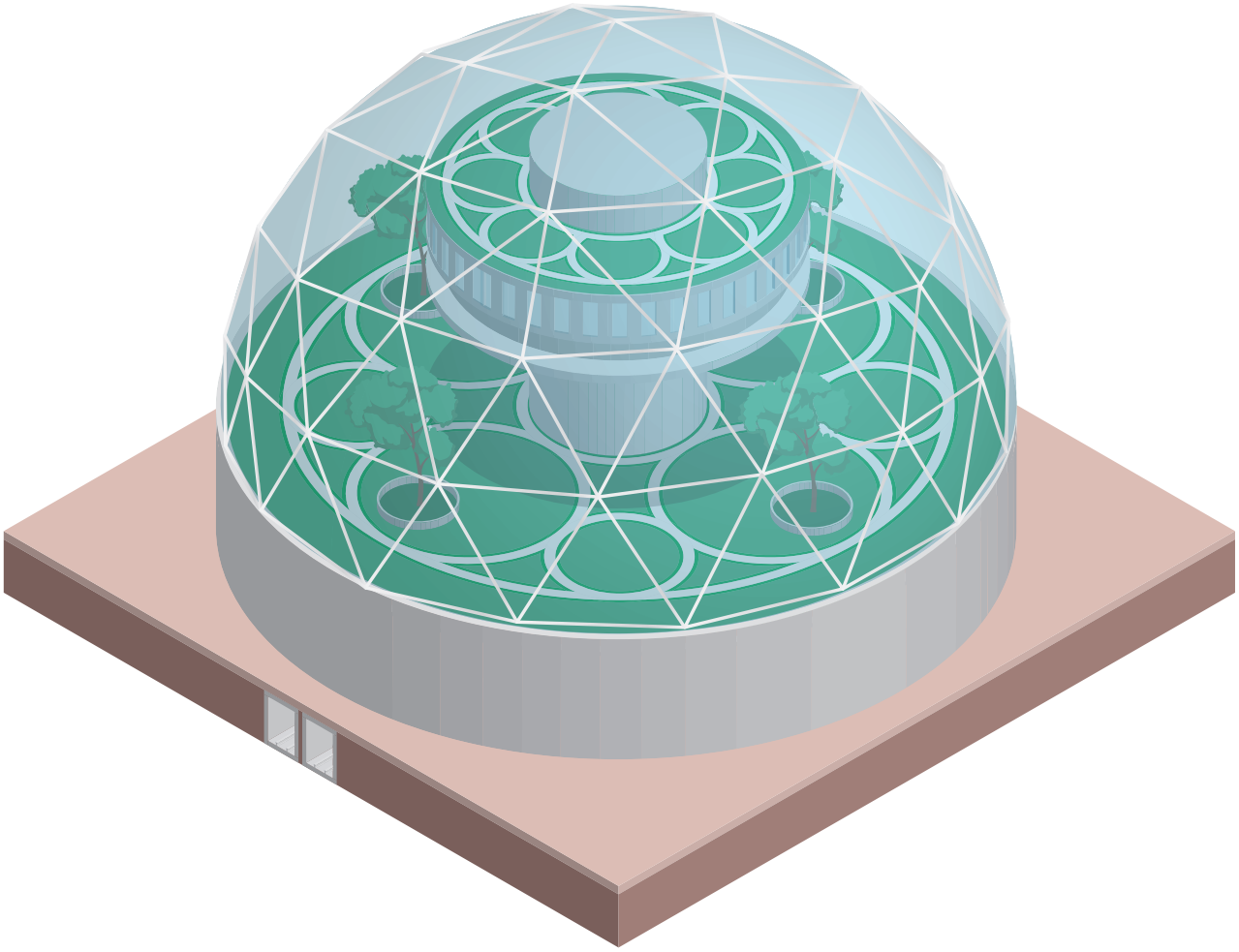
UTOPIA PLANITIA, MARS

L1 Surface

Overview of above-ground colony features (+ 0-20m)

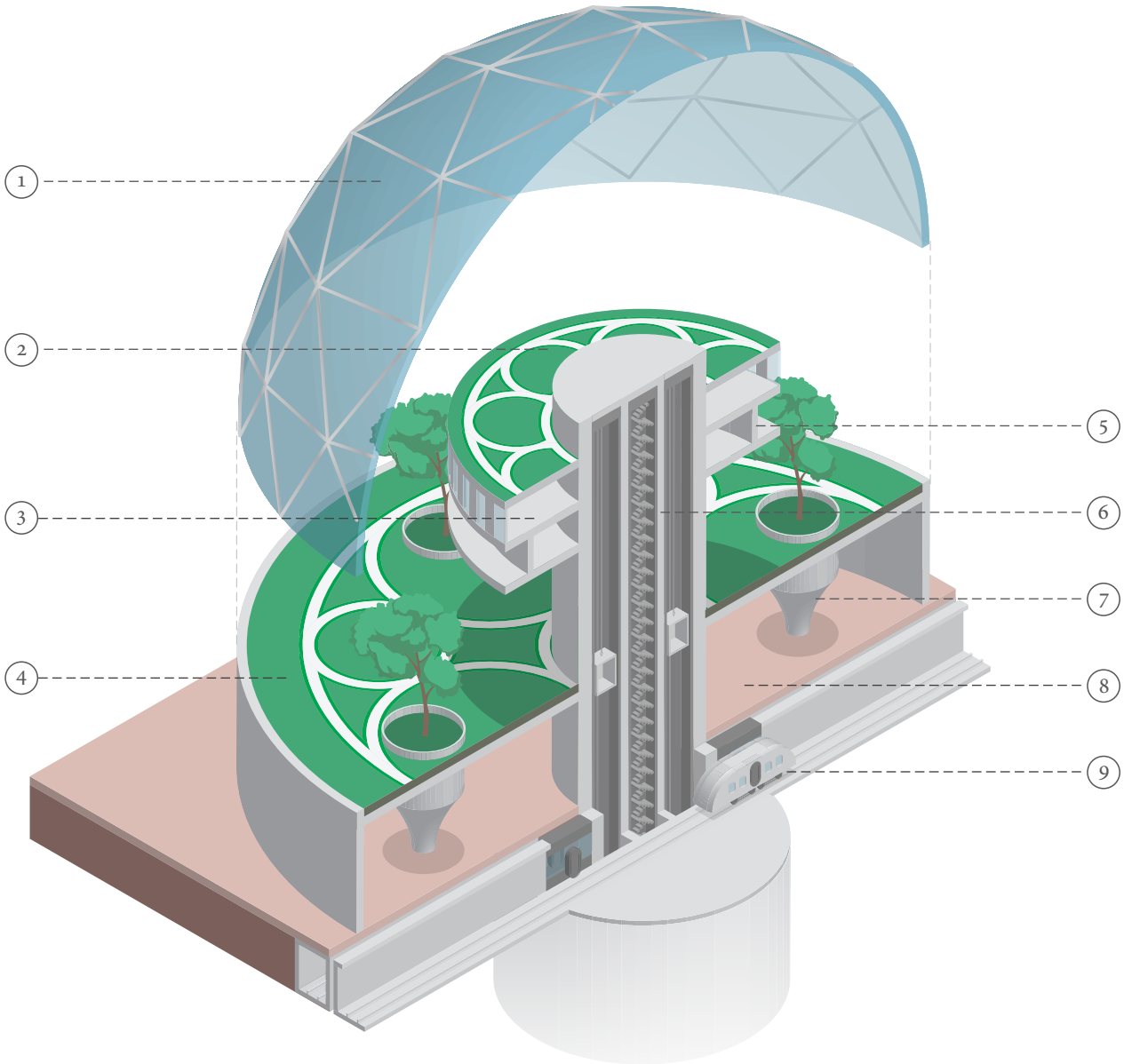



1km
(1-2km)
(1-2km)
Outer Observatories
Rocket Launch Site
Central Dome
Solar Periscopes
Nuclear Power Gen.
Hex Dome



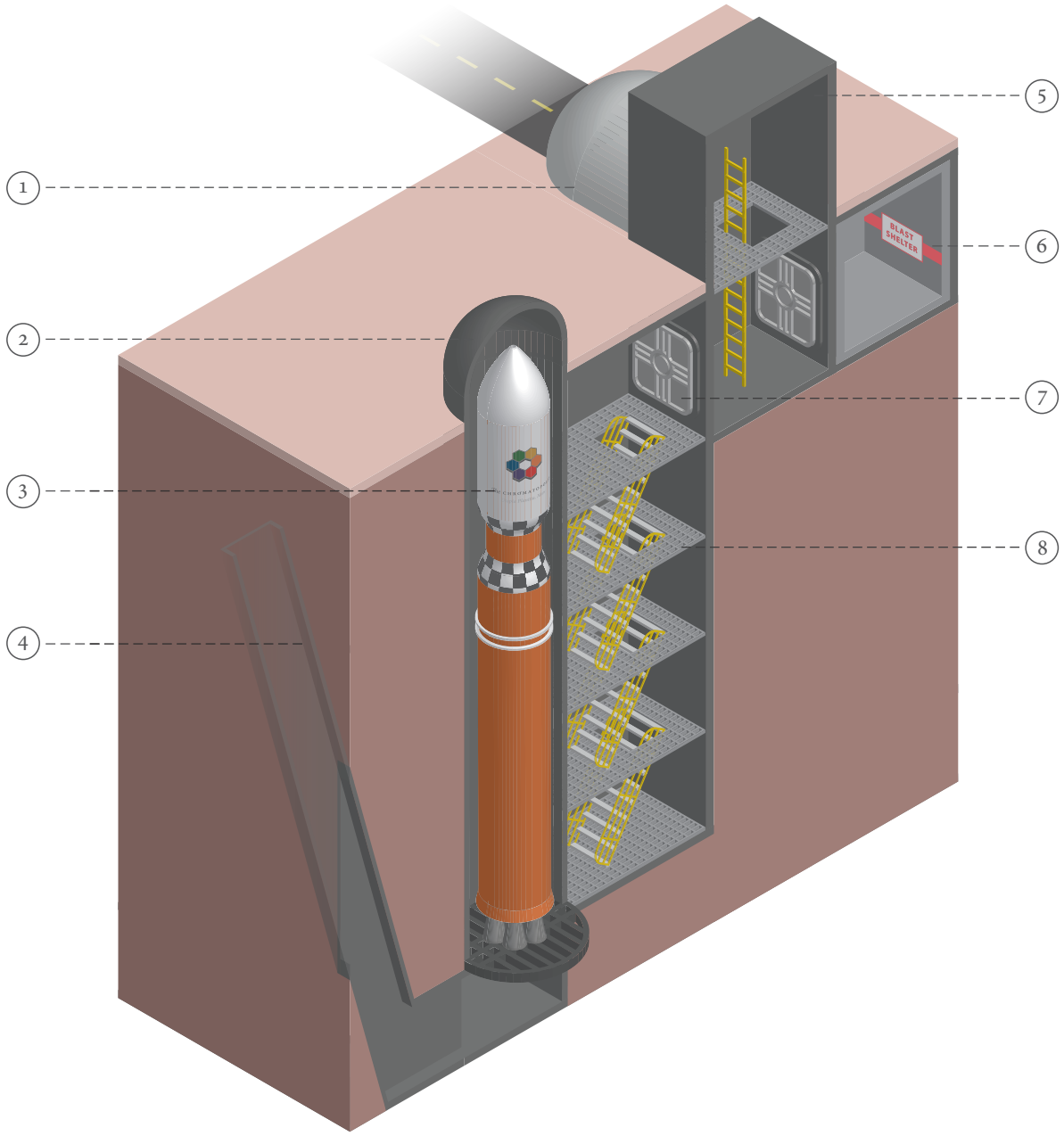
Geodesic Dome

The focal point of the colony's surface level is the Central Dome, a roughly 20m tall structure, towering above the other surface features of the colony. This is a construct both decorative and functional; on the one hand intended to inspire awe, serve as a meditative conservatory for colonists, and allow a stunning 360° vista of the Martian crater landscape, on the other hand to create a staging area for surface expeditions and a limited extension of the colony's commercial hub. The dome is equipped with a multi-level central observation tower allowing for full appreciation of the Martian environment in day or night. While the dome's lower observation deck is stationary, its upper observation deck doubles as a slowly rotating café and gift shop, making one full circuit every sixty minutes to give colonists and tourists a one-of-a-kind aesthetic experience. On top of the observation deck and on the main floor of the dome is a well-maintained garden with winding paths for contemplative strolls. Beneath the gardens at ground level is a more functional multipurpose area that may serve as a staging ground for surface expeditions, a garage for vehicles, or even a limited marketplace. Beneath the dome lies the central Hyperloop station, and beneath the Hyperloop lies the L3 cultural core zone.



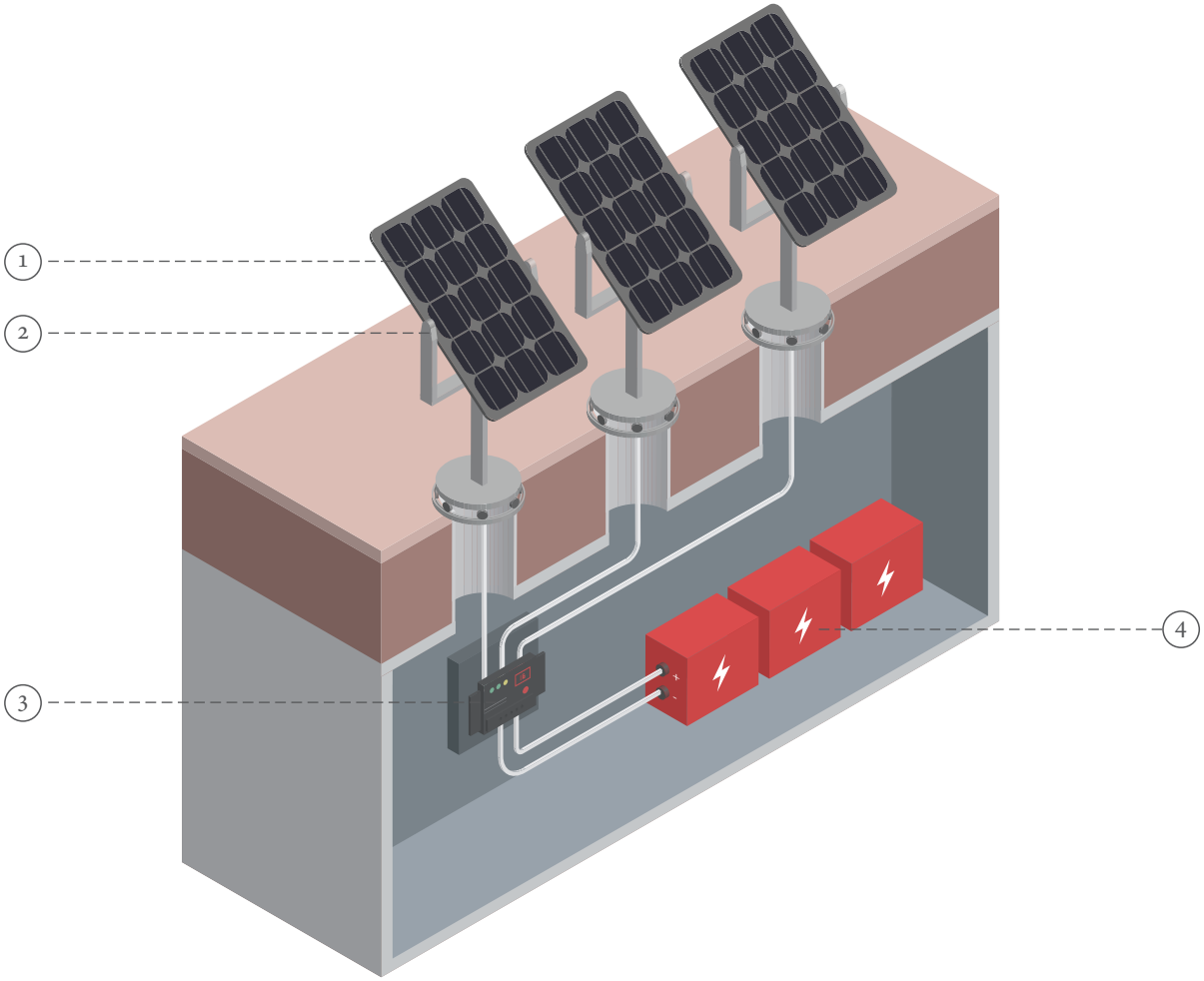
Central Dome Features

1. *Geodesic Lattice*
2. *Rooftop Garden*
3. *Upper Obs. Deck (Rotating café)*
4. *Floor Garden*
5. *Lower Obs. Deck (stationary)*
6. *Elevators/stairway*
7. *Tree root planter*
8. *Garage/Prep/Market area*
9. *Central Hyperloop station & pod*



Silo Structure

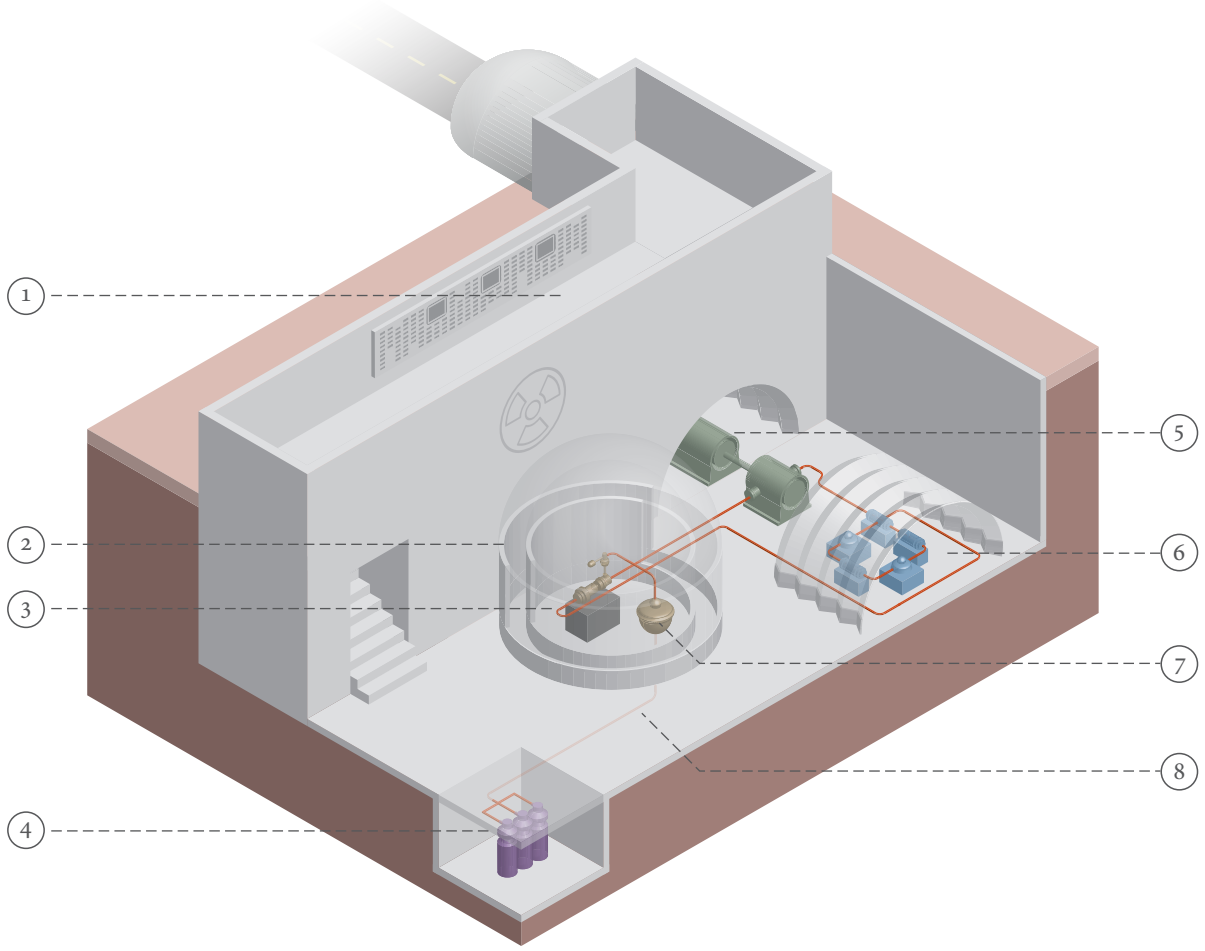
1. *Vehicle Garage/airlock*
2. *Silo with retractable lid*
3. *Multi-stage rocket*
4. *Exhaust channel*
5. *Antechamber*
6. *Blast chamber*
7. *Blast proof doors*
8. *Work & maintenance area*



Photovoltaic Solar Array

The majority of the colony's energy requirements should be met by the implementation of a vast surface solar array using standard photovoltaic solar cells. Due to the potential for Martian dust buildup on solar panels, a swiveling joint will be necessary to physically dump dust occasionally, and the panels are also equipped to perform occasional electrostatic bursts to assist in blowing dust from the surface. Unfortunately, global dust storms occur on Mars approximately once every three years and may last 100 sols (Martian days) or more. Such dust storms may reduce the efficacy of solar arrays by 90%+ at their most intense. Thus, solar power must be used in conjunction with a reliable backup power source not reliant on sunlight (e.g. nuclear power).

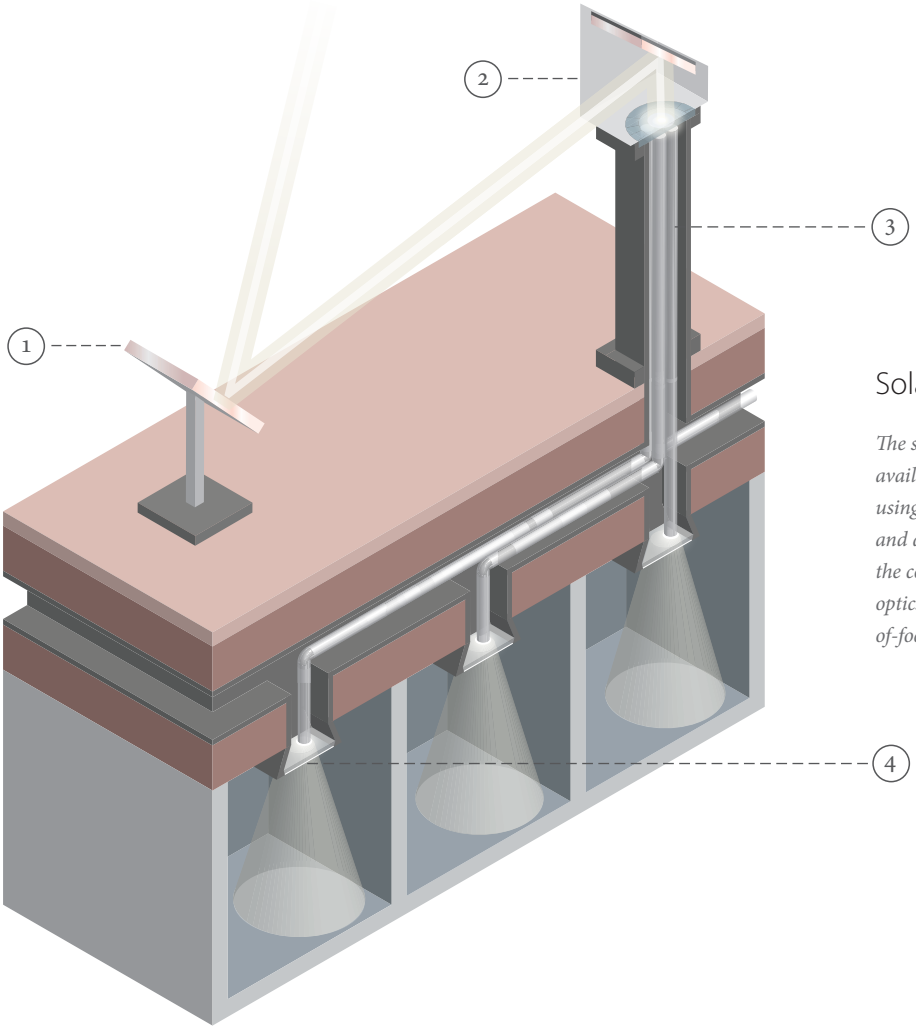
1. *Photovoltaic solar cell equipped with electrostatic burst capability*
2. *Swivel arm for dust dumping*
3. *Charge controller to regulate amount of DC charge from solar cells*
4. *Battery bank (later to be sent through inverter to convert to AC)*



Th-MSR Power Plant

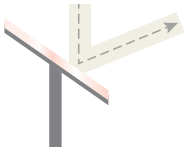
A nuclear power plant is necessary on Mars due to the high likelihood of dust storms occurring on the surface. During non-dust storm times, the nuclear power plant will merely supplement the energy generated by solar arrays. But when dust storms obscure the solar arrays, the nuclear plant will become the primary means of generating power. The above illustration is based on the design for a Thorium-fueled molten-salt reactor (Th-MSR) as presented in 2011 by Thorium Energy alliance and Popular Science[12]. Th-MSR reactors are ideal for Mars because Thorium can be found in abundance in the Martian environment[13], is more efficient than Uranium fuel[14], and the Th-MSR design is safer than other types of nuclear power plants. Liquid fuel in Th-MSR reactors is maintained at lower pressures than in traditional light-water plants, reducing the likelihood of explosions. And if reactor gets too hot or if a power outage occurs, a frozen salt plug within the reactor melts and the liquid salt fuel simply drains into tanks where it cools and stops the fission reaction.[14]

1. *Control room*
2. *Containment vessel*
3. *Fuel loop*
4. *Emergency drain tanks*
5. *Turbine*
6. *Power station (with Brayton Cycle turbines using low-pressure high-density CO_2 to obviate need for cooling towers)*
7. *Thorium Reactor*
8. *Frozen salt plug*



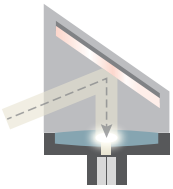
Solar Periscope (type 1)

The solar periscope is a method of gathering available sunlight from the Martian surface using reflectors and then focusing that light and distributing it in the habitation level of the colony. The type 1 periscope uses fiber optics to convey light from its initial point-of-focus to its endpoint in light fixtures.



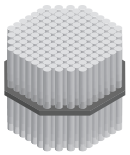
1. PRIMARY MIRROR

A swiveling mirror repositions itself relative to the sun's transit through the Martian sky, redirecting incident light from the Sun toward the secondary reflector.



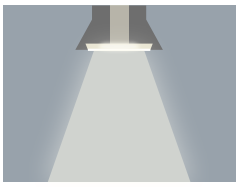
2. FOCUSING BOX

The stationary secondary reflector bounces the incident light from the primary mirror into a lens, sending focused light down into the collection tower.



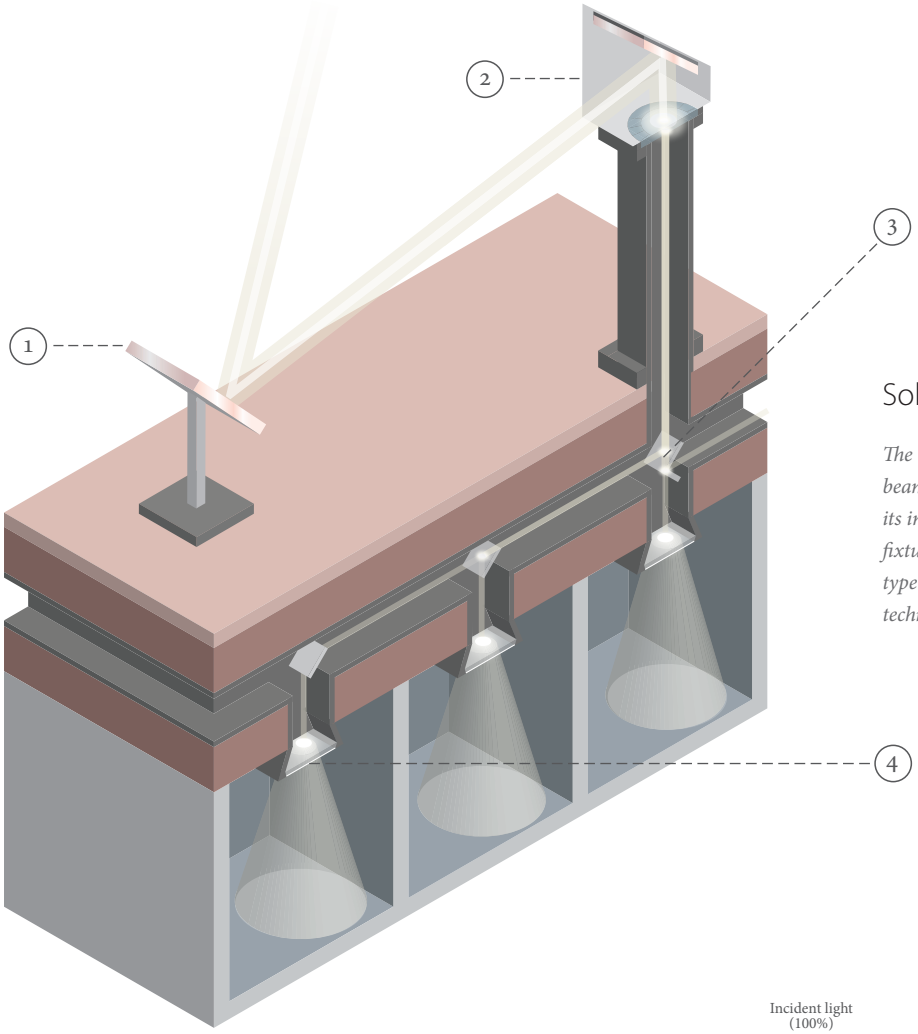
3. FIBER OPTICS

Focused light enters fiber optic bundles (held in place by ferrules) within the collection tower.
The bundles are routed through ductwork to their destinations.



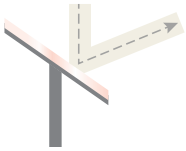
4. DIFFUSER FIXTURES

Having reached its detination, a fiber optic bundles terminates in a light fixture fitted with diffusers to spread and soften light in a given location or room.



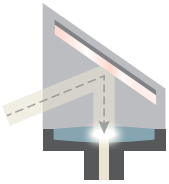
Solar Periscope (type 2)

The type 2 periscope uses precisely-placed 50:50 beam splitters and mirrors to convey light from its initial point-of-focus to its endpoint in light fixtures. The colony may use a combination of type 1 (fiber optic) and type 2 (beam splitter) techniques to distribute available sunlight.



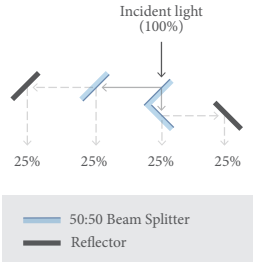
1. PRIMARY MIRROR

A swiveling mirror repositions itself relative to the sun's transit through the Martian sky, redirecting incident light from the Sun toward the secondary reflector.



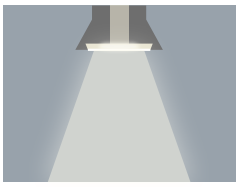
2. FOCUSING BOX

The stationary secondary reflector bounces the incident light from the primary mirror into a lens, sending focused light down into the collection tower.



3. BEAM SPLITTERS

Focused light travels down the collection tower into a complex network of beam splitters & reflectors, dividing the light and passing it to its correct destinations.



4. DIFFUSER FIXTURES

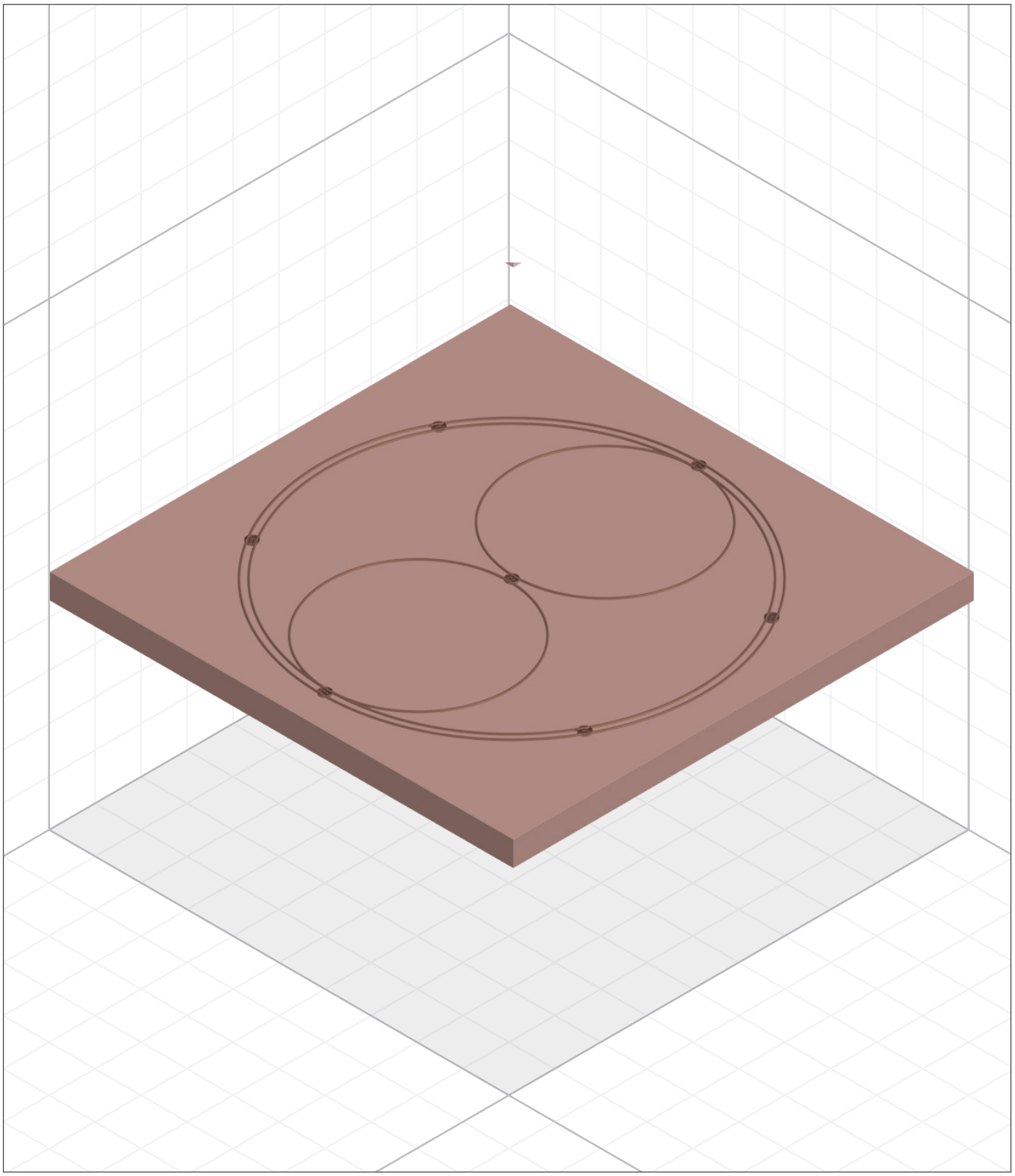
Having reached its detination, a light path terminates in a light fixture fitted with a diffuser to spread and soften light in a given location or room.

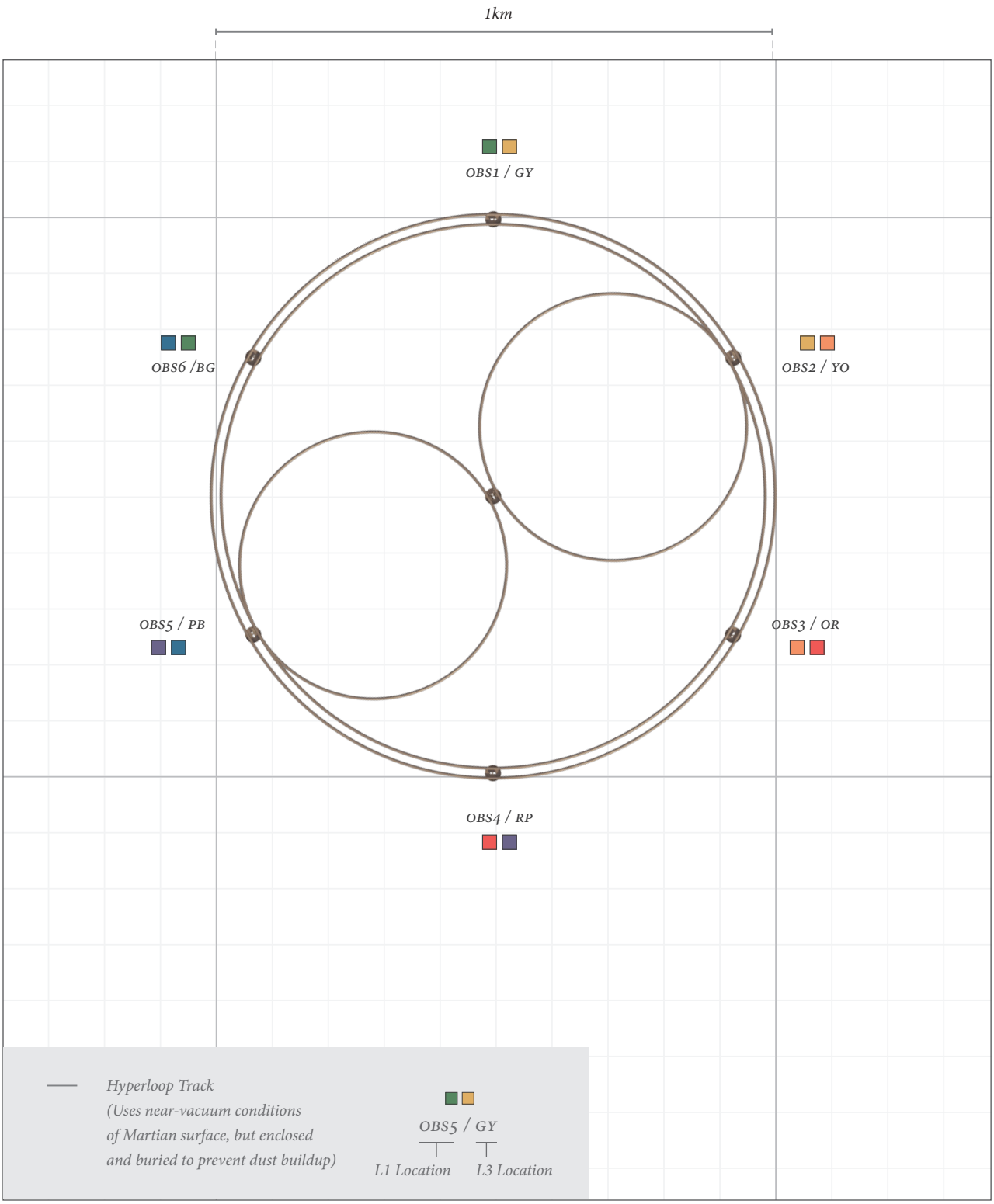
THE CHROMATOPOLIS

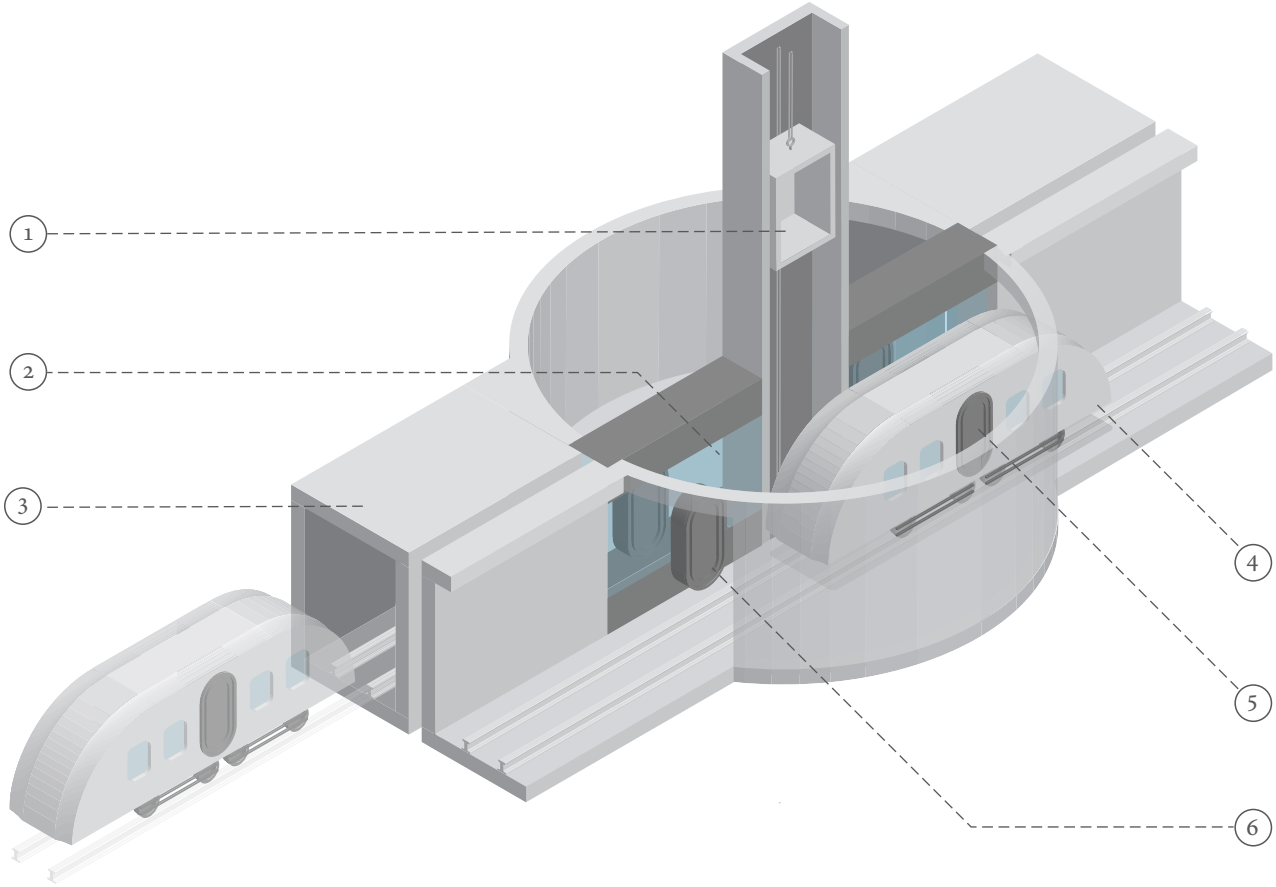
UTOPIA PLANITIA, MARS

L2 Subsurface

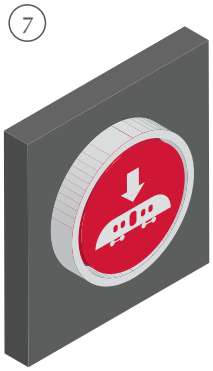
Overview of just-below-ground colony features (– 0-4m)




1km
OBS1 / GY
OBS6 /BG
OBS2 / YO
OBS5 / PB
OBS3 / OR
OBS4 / RP
Hyperloop Track
(Uses near-vacuum conditions
of Martian surface, but enclosed
and buried to prevent dust buildup)
OBS5 / GY
L1 Location
L3 Location



7

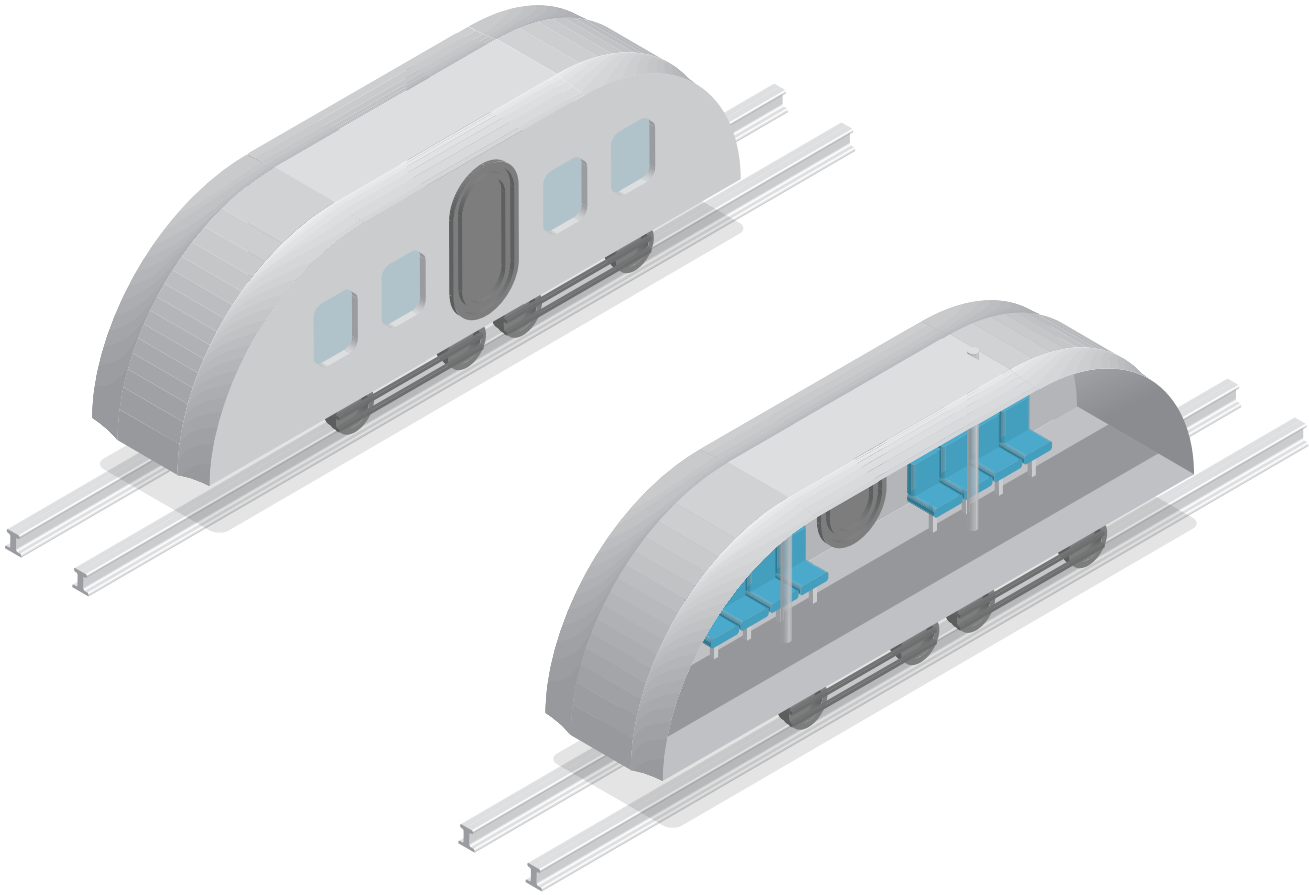


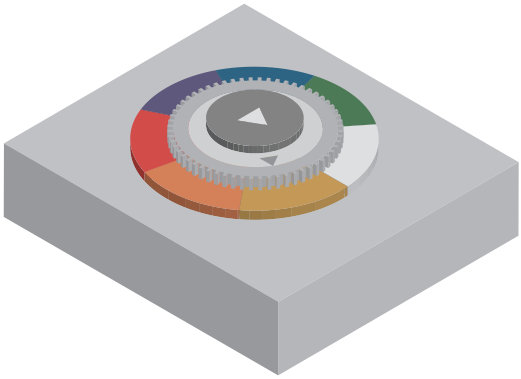
Hyperloop System

The Hyperloop system is a rapid transit network that takes advantage of near-vacuum surface conditions on Mars, obviating the need for pneumatic tubes (required on Earth). The Hyperloop is enclosed to prevent dust buildup and located 1-4m below the Martian surface. Like an elevator, a Hyperloop pod comes to a given location when called (by pressing a button in the station waiting area). On arrival, the pod attaches itself to a port, forming an airtight seal that allows passengers to pass between the car and the station without being exposed to the vacuum in the tunnel.

STATION FEATURES

1. *Elevator to L1 / L3*
2. *Station waiting area*
3. *Martian-natural-vacuum tunnel*
4. *Hyperloop pod*
5. *Airtight plug*
6. *Airtight port*
7. *Hyperloop call button*





Simple Control Mechanism

Without user input, the Hyperloop pod defaults to continuous looping around the exterior of the colony and the core, stopping at each of the seven stations for 30 seconds on average before moving on. However, when called, the hyperloop pod proceeds to its called destination immediately. Once a passenger has boarded, a simple control mechanism is provided for a user to dial in a destination. Their preferred destination is entered into a queue with other passengers' destinations and then sorted by proximity to current location. Emergency services workers are given override access.

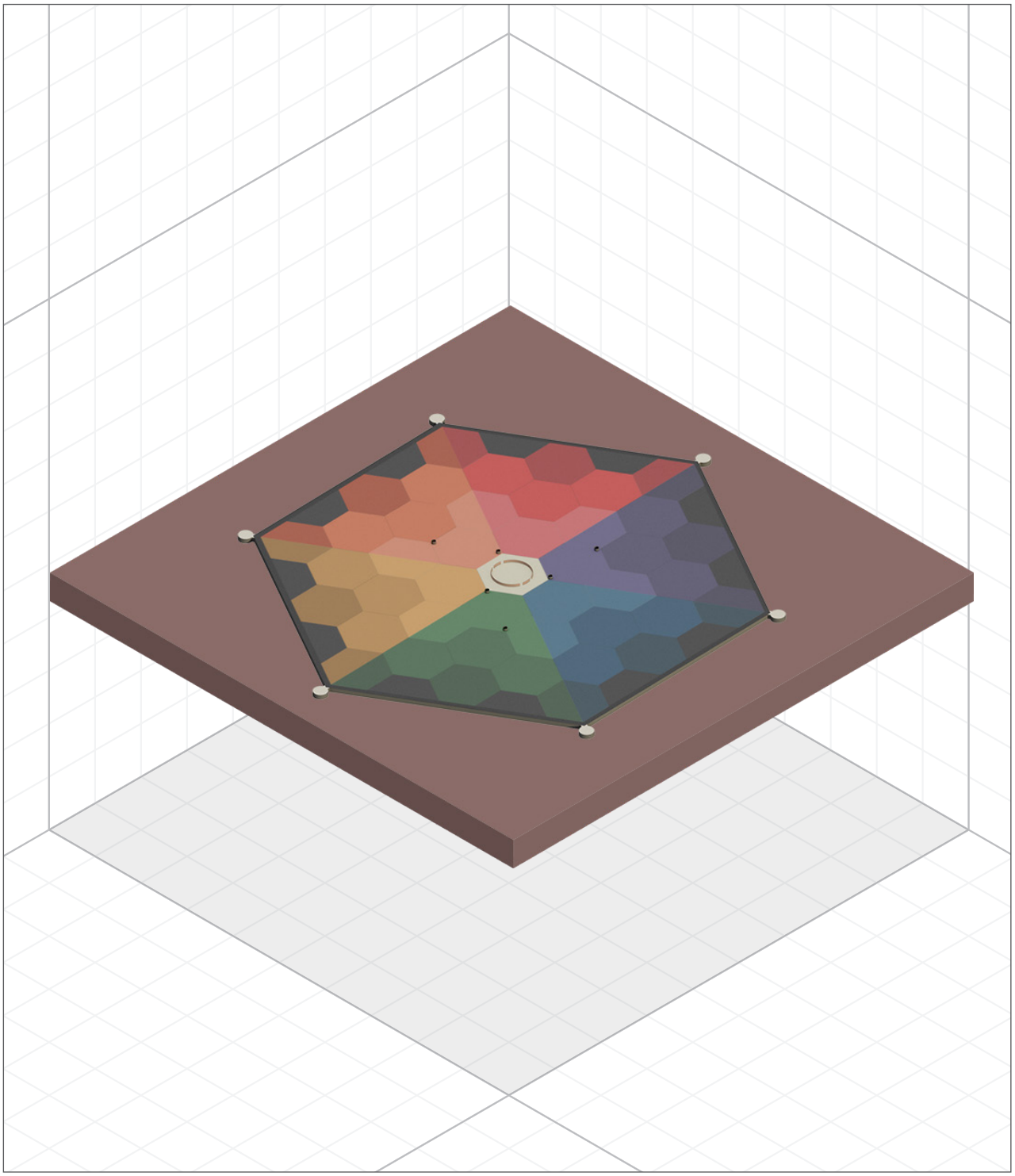
THE CHROMATOPOLIS

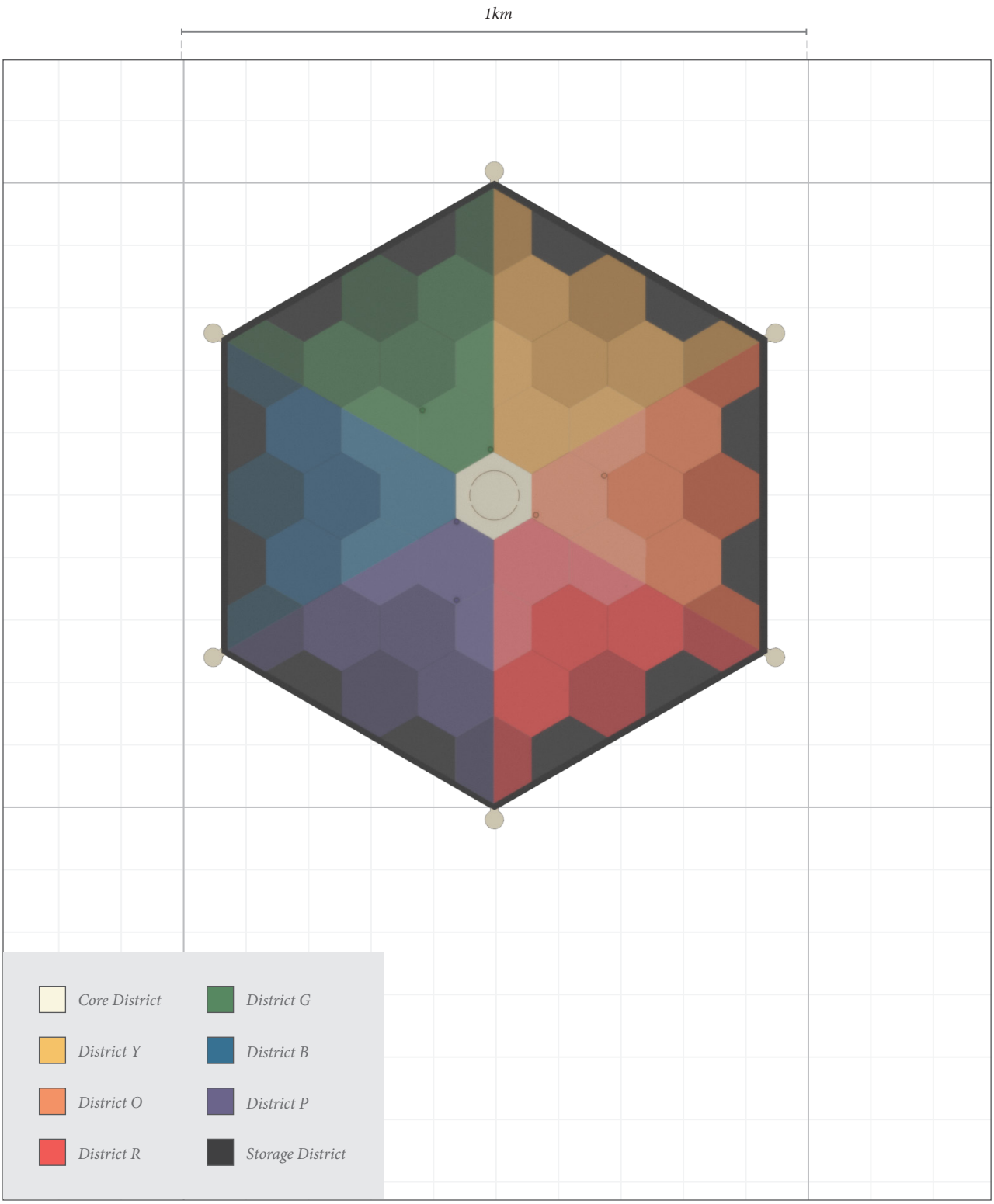
UTOPIA PLANITIA, MARS

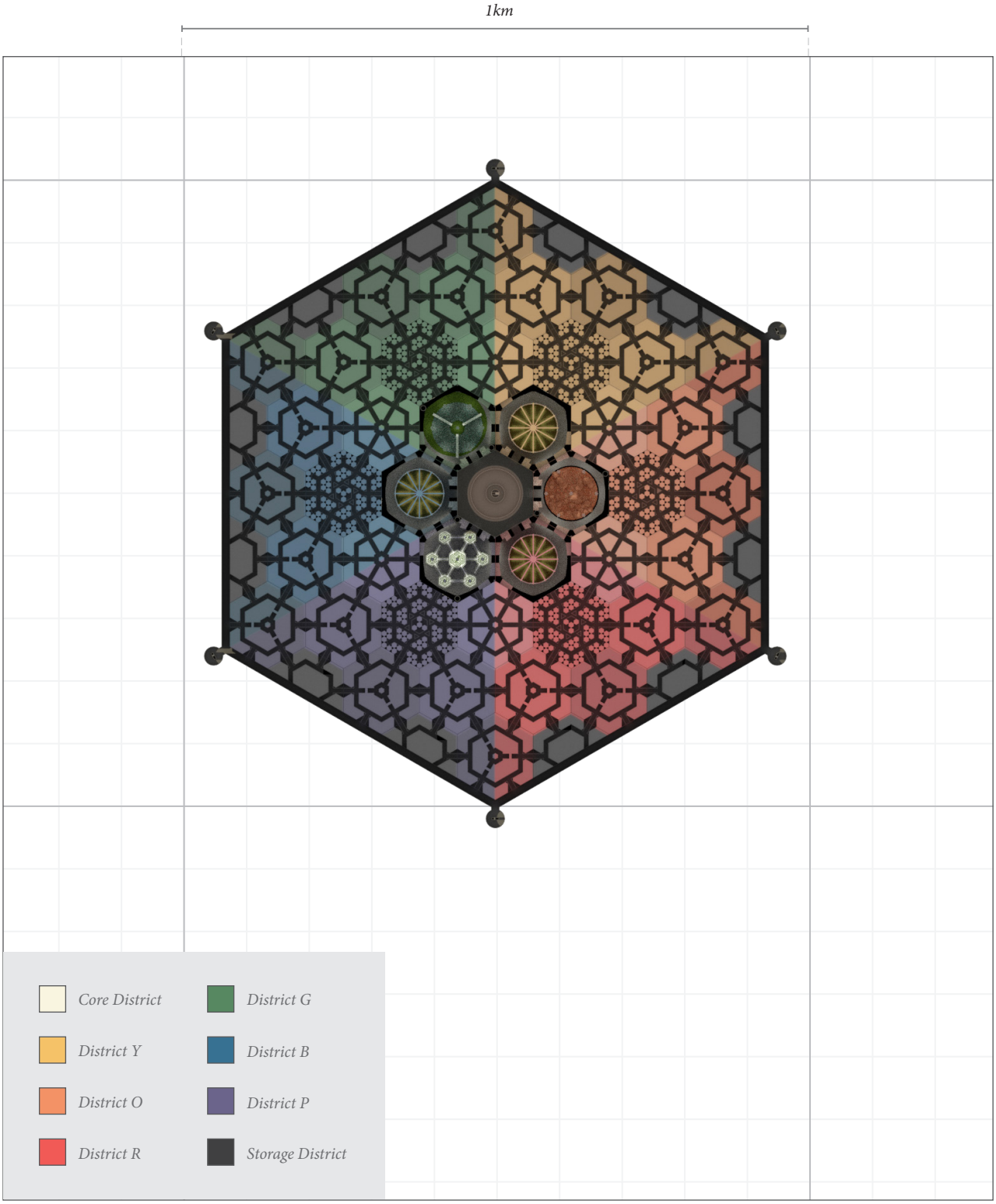
L3

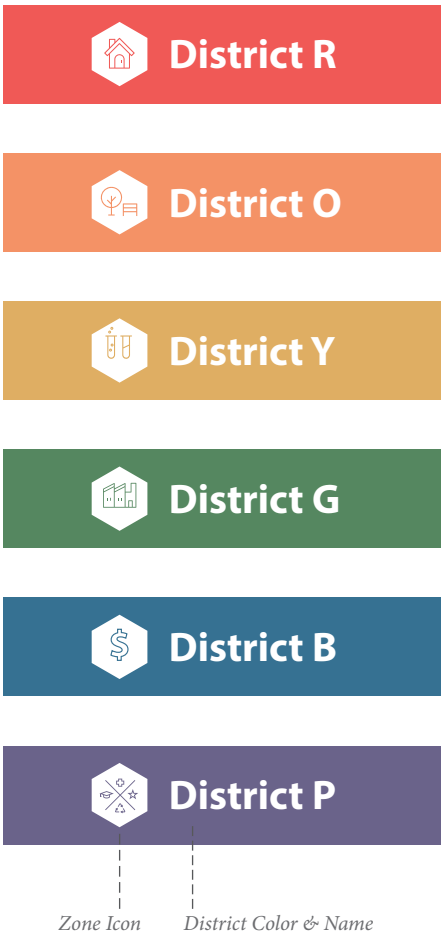
Habitation

Overview of well-below-ground colony features (– 4-14m)



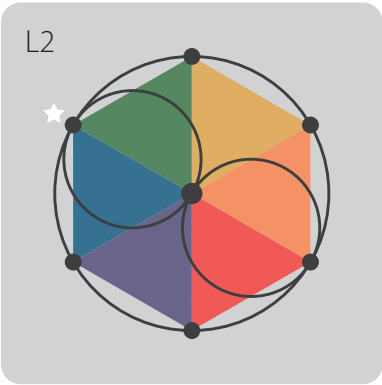

1km
Core District
District G
District Y
District B
District O
District P
District R
Storage District


1km
Core District
District G
District Y
District B
District O
District P
District R
Storage District



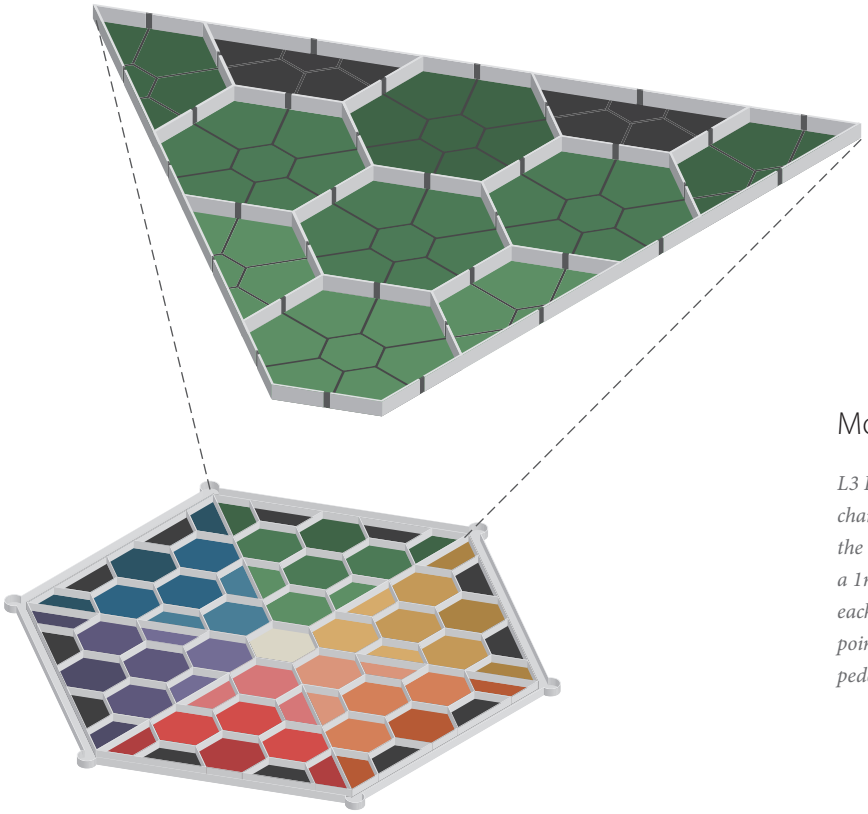
Wall Stripes

Ubiquitous across all interior regions withinthe hexagonal L3 Habitation Level. Gives immediatesense of location through simple icon + color/text pairing. District Names (corresponding to colors) are provided as well to address color-blindness issues among colonists.



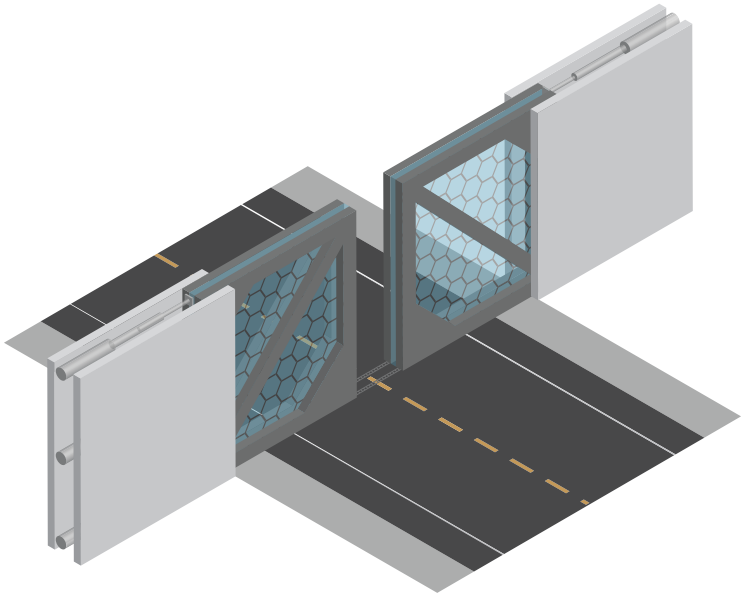
Simplified Contextual Maps

Posted throughout the Habitation & Subsurface levels, this simplified map contextualizes an inhabitant's current location and reminds them how to navigate the colony (transport hub locations, etc.)



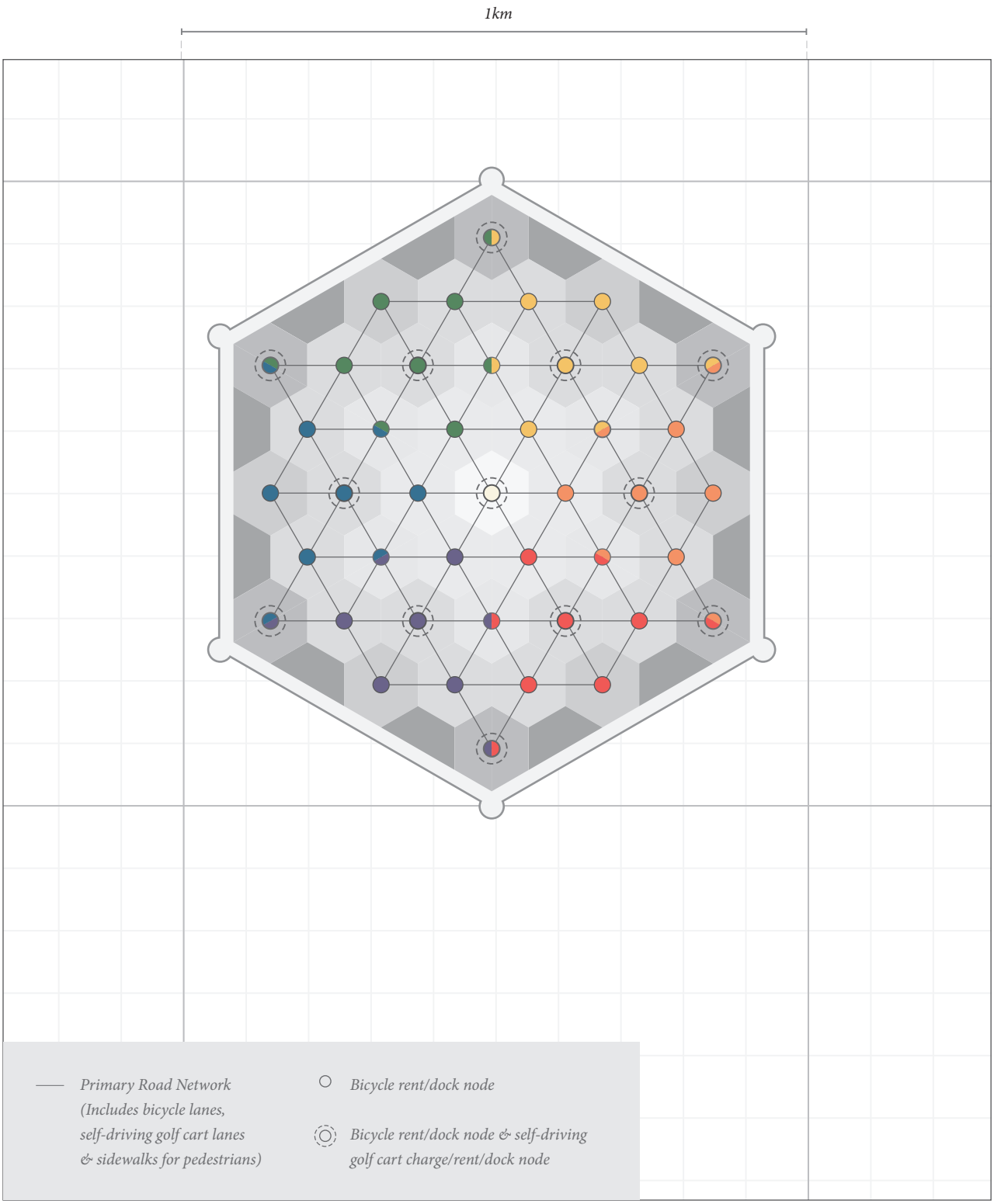
Modular Design of Hex Regions

L3 Habitation is divided into large hexagonal chambers that each contain a particular section of the colony. Chambers are all physically separated by a 1m-thick wall running between them. Each face of each hexagonal chamber contains one ingress/egress point with a road/sidewalk path for vehicles and pedestrians.



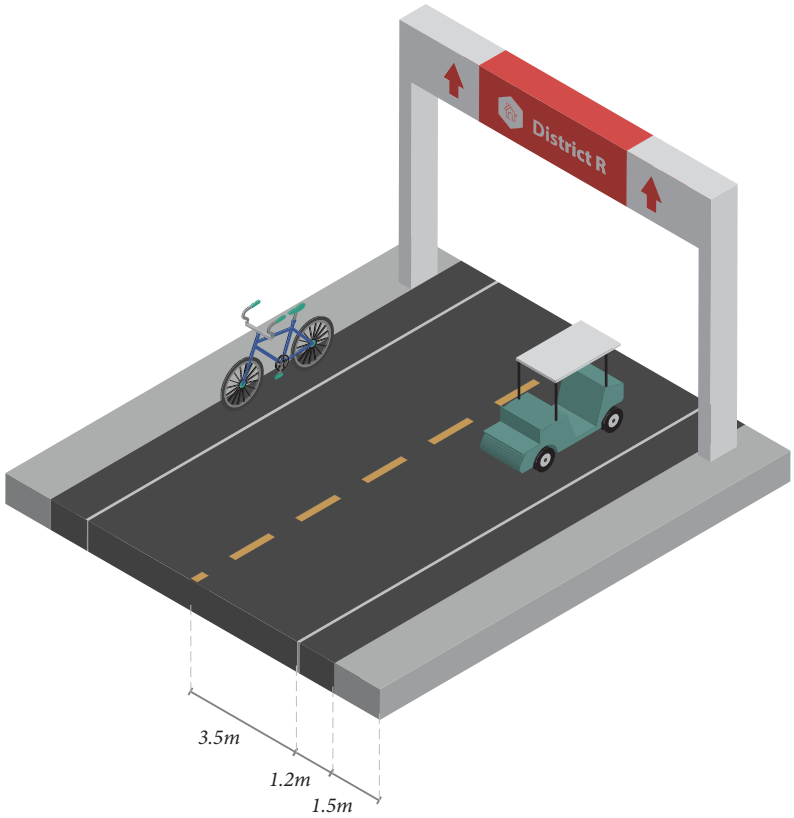
CONTAINMENT PROCEDURE

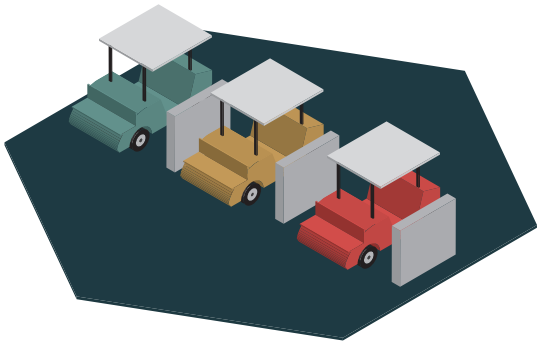
In the event of catastrophic loss of atmospheric containment, air pressure, or other possible disasters, these ingress/egress points are all designed to be immediately sealable, allowing for emergency protection of colonists from loss of breathable atmosphere or (conceivably) a temporary quarantine measure in the event of infectious disease outbreak.


1km
Primary Road Network (Includes bicycle lanes, self-driving golf cart lanes & sidewalks for pedestrians)
Bicycle rent/dock node
Bicycle rent/dock node & self-driving golf cart charge/rent/dock node

Road Structure

Bicycles, self-driving golf carts, and walking are the-standard modes of transportation within the colony.Both are widely available at rental stations.

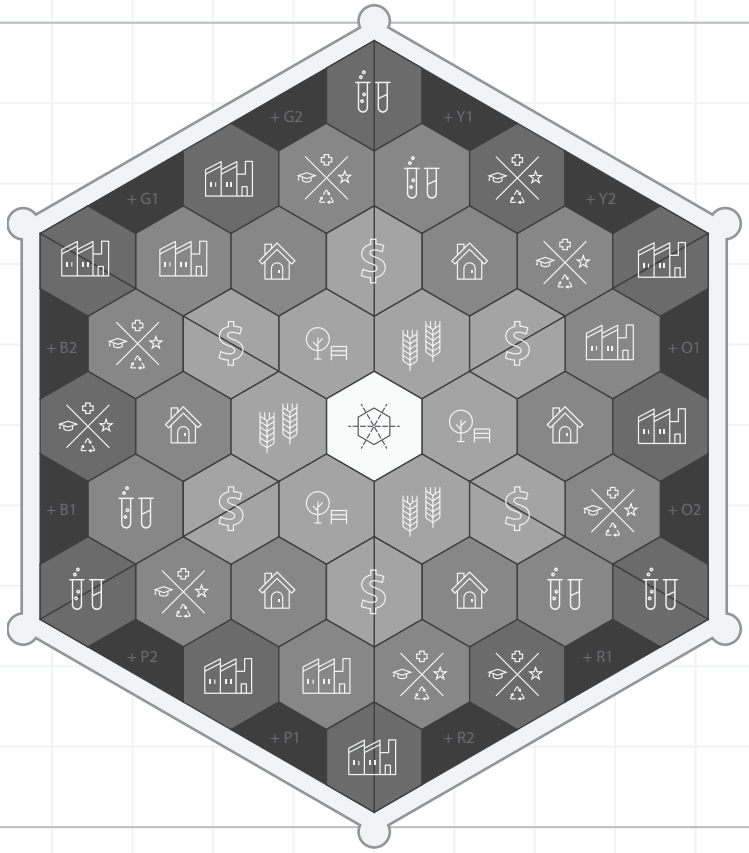




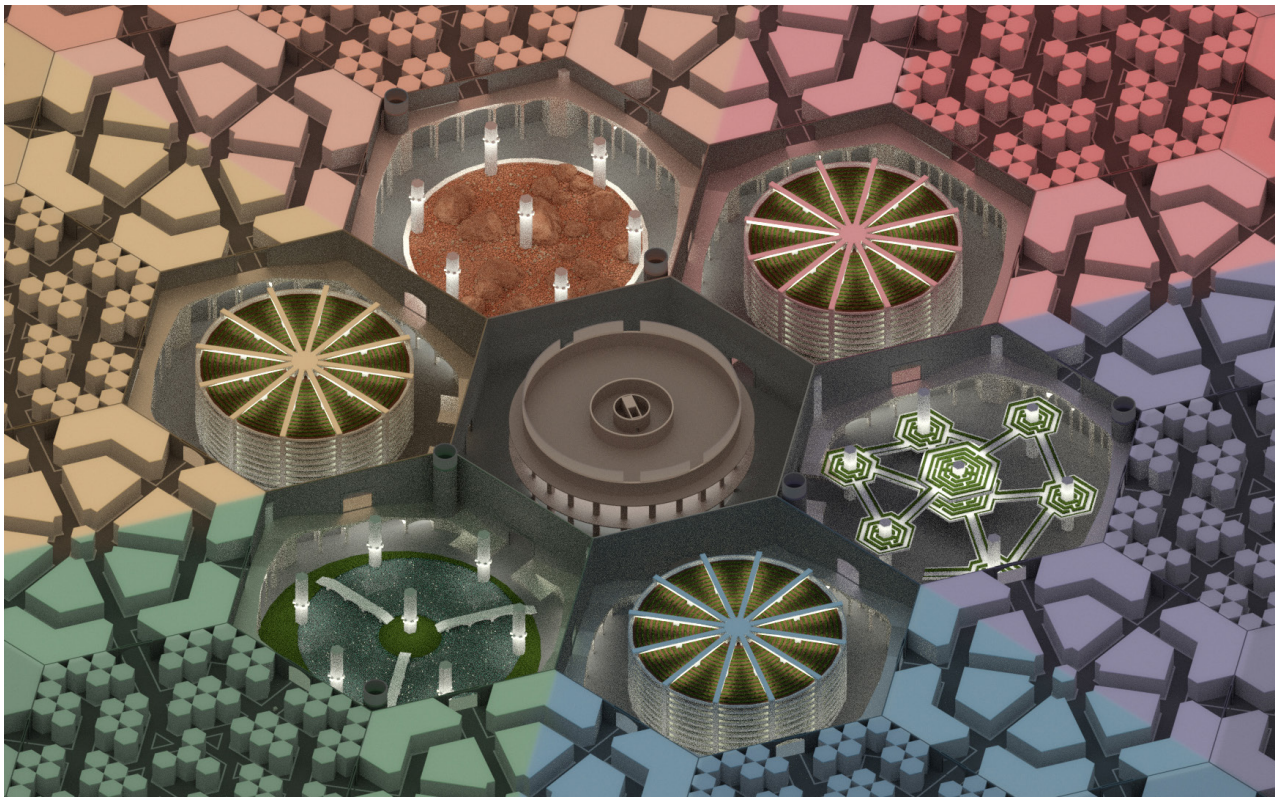
Self-driving golf carts

Taking advantage of maturing self-driving tech, the colony uses electric autonomous golf carts controlled by a simple push-button interface (or voice activation for the sake of convenience and the visually impaired). Self-driving vehicles reduce the likelihood of accidents and increase the efficiency of transportation. A mobile phone app similar to Uber allows users to call a self-driving golf cart to his or her location within L3 if a dock node is not immediately available or if all golf carts at a particular location are rented out

Charge/Rent/Dock nodes for golf carts are conveniently located in 13 evenly-distributed locations throughout the habitation level, ensuring that dying batteries should not be an issue for those who require transportation.

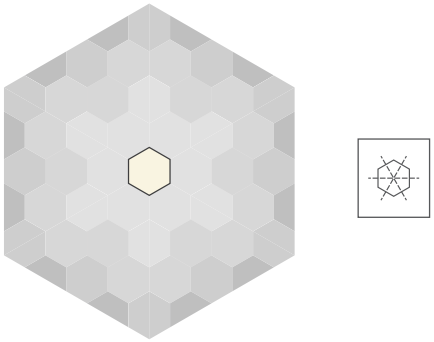


Cultural Core (CC)	*Research & Dev. (RD)*	*Residential (RS)*
Parks & Recreation (PR)	*Critical Services (CS)*	*Farms (FM)*
Commercial (CM)	*Resource Gen. (RG)*	+ CX *Storage/Mixed Use (MISC)*

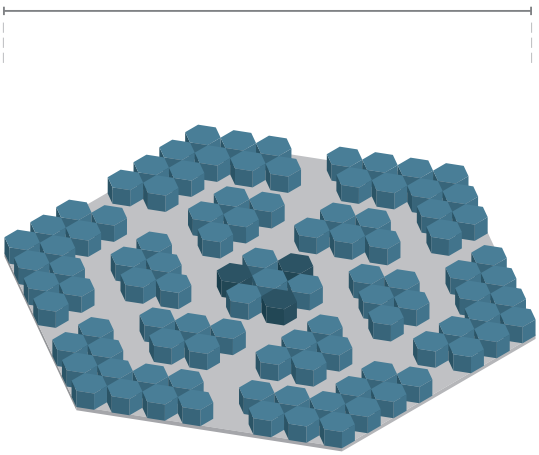


Cultural Core

The Cultural Core is located at the center point of the L3 Habitation level. The core is a large caverous room designed to serve as a central gather point, lounge, performance space, and meeting hall. Wide open spaces allow for massive gatherings of colonists if necessary. Raised platforms 15m above the floor (halfway to ceiling) provide a unique stage for plays, speeches, announcements and general gatherings. Vaulted archway bridges converge from the vertices of the hexagonal space to meet in the middle, providing an almost neoclassical aura. At the center of the space lies the core column, containing staircases and elevators leading up to the central hyperloop station and the Central dome at surface level.



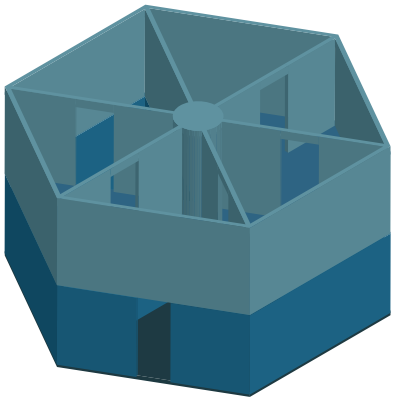
~165m



Communities

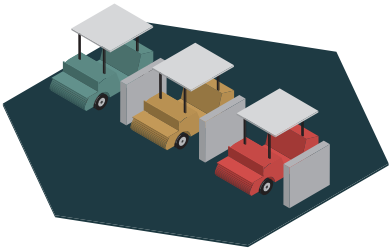
Each Residential Zone is large enough to accomodate 100 houses. These houses are organized into subgroup pods to allow wide enough roads for flow-through traffic. Adjacent houses also share a small patio/deck space, facilitating community formation.

~11m



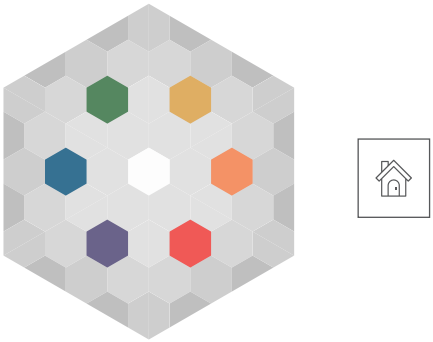
Living spaces

Given the dimensions of the hexagonal dwellings, and the fact that each should be able to accomodatetwo stories, each should have ~150 m² of available space.



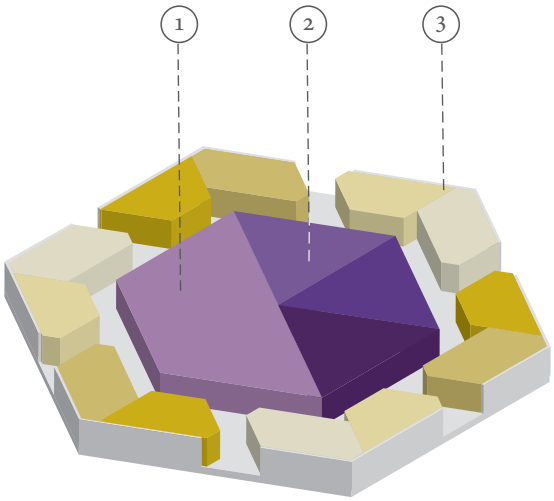
Resources

Each community is equipped with several spaces for collective use, including a community recreation center a bike rental/dock node, and a self-dricing golf cart charge/dock node



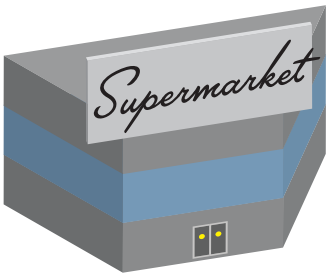
Population

If we assume that 2-4 people may live comfortably in 150m² of space, the population of each community at full occupancy should fall in the 200-400 range. Altogether, the six communities that make up the colony yield a final population range of 1200-2400



STOREFRONT TYPES

1. *Superstore*
2. *Satellite store*
3. *Mom-and-pop shop*



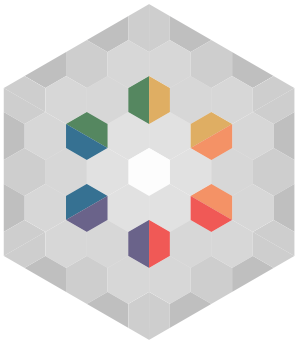
SUPERMARKET

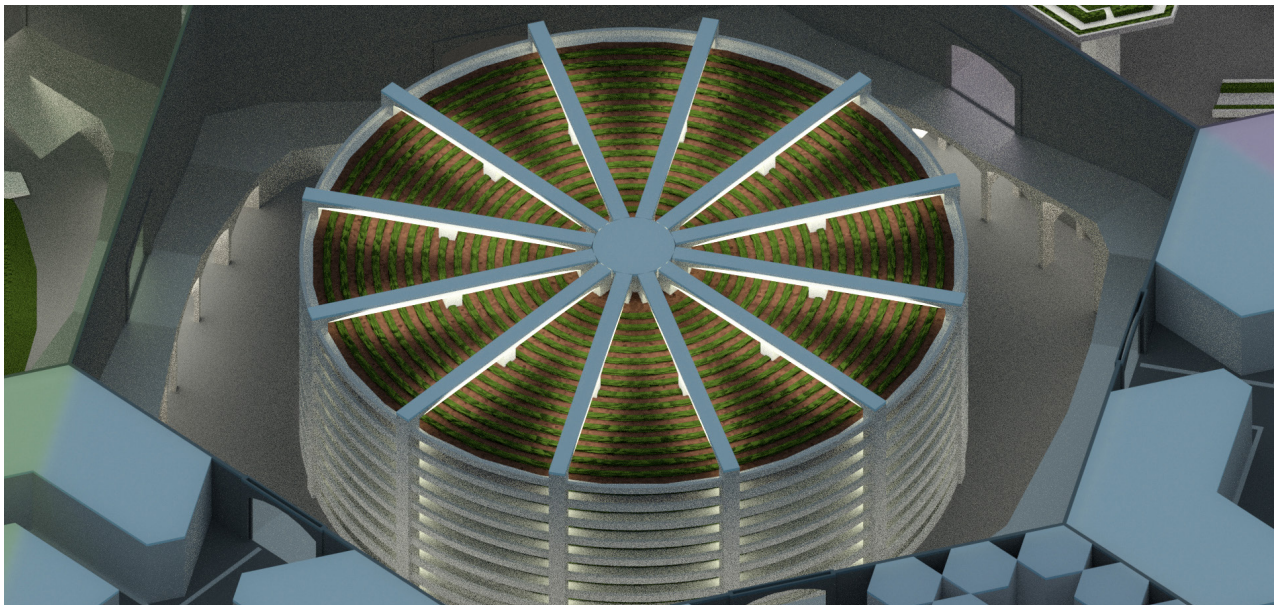
RESTAURANT

BARBER SHOP

Commercial District

The Chromatopolis takes advantage of the benefits of free enterprise within its small community instead of relying on extensive central planning. Entrepreneurs may rent space in the commercial district to sell their goods and services. The Chromatopolis can accomodate a wide range of business sizes depending on the needs of its constituents — from a family-owned small business to an interplanetary grocery chain.





Creating Soil from Regolith

1. SIEVE REGOLITH

Sieve pulverized regolith to reach desired particle size (40%-40%-20% mix of sand, silt, and clay particles)

2. FILTER REGOLITH

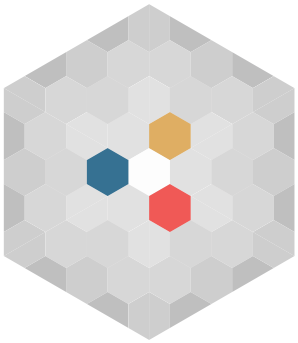
Test for and filter contaminants (peroxides, salts, heavy metals like Cd, Pb, Al, Ni, Cu, Cr, Fe, As, Mn, Zn)

3. FERTILIZE

add plant, animal, and human waste as fertilizer to furnish phosphorus and Nitrogen, potassium mix (N P K)

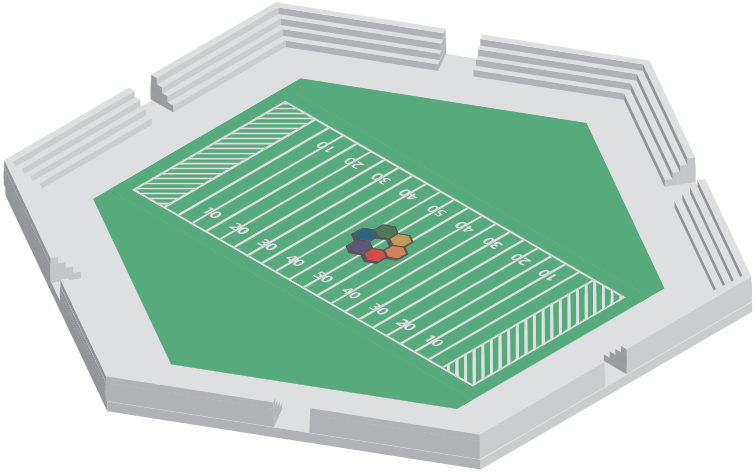
4. ADD ORGANISMS

Introduce worms and micro-organisms (nitrogen fixing bacteria) to create self-sustaining nitrogen cycle

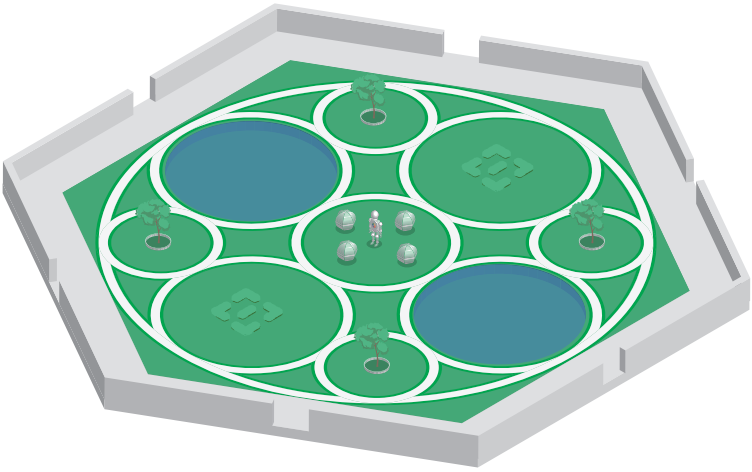


Farm Districts

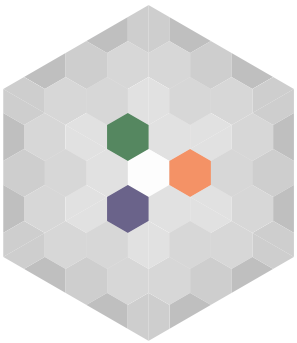
The goal of farming in the Chromatopolis is primarily to create food and oxygen sources from sustainable agriculture. Colonists must first create soil from Martian regolith. Once the soil is prepared, seeds are planted and watered using center-pivot irrigation methods. Sunlight from solar periscopes as well as artificial lamp light is used to induce photosynthesis. Colonists use standard crop rotation and general farming best-practices to maintain a balanced ecosystem and prevent crop failures. Potential crops include tomato, rye, radish, pea, leek, spinach, garden rocket, cress, quinoa, and chives



GAME FIELD CONFIGURATION



RECREATION PARK CONFIGURATION

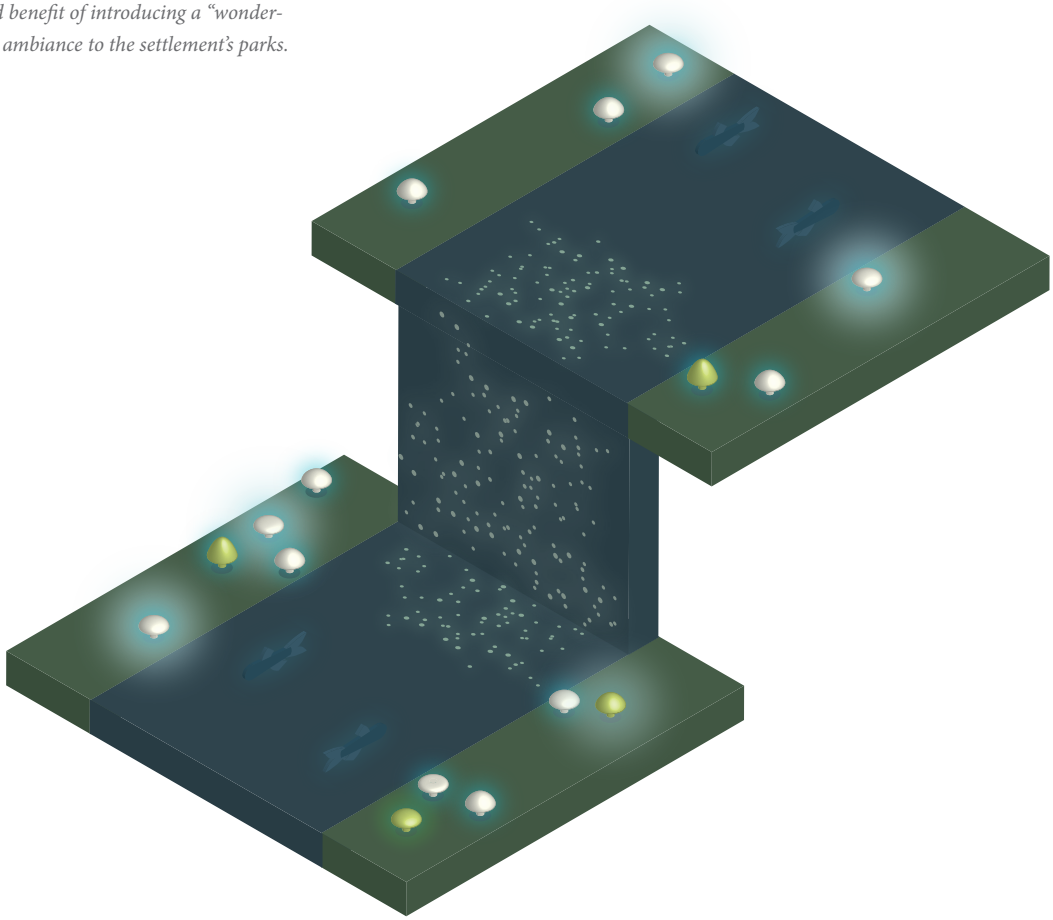


Recreation Districts

Living in a confined and mostly undergound space may be exceptionally difficult for some people, particularly if that space feels austere, stale, and utilitarian. In that sense, the parks and recreation districts of the Chromatopolis will play a crucial psychological role in helping colonists maintain balance, cohesion, and well-being in their daily lives. Parks and recreation spaces may be configured in any number of ways, preferably involving well-maintained greenery to break up the monotony of more industrial portions of the colony. Official social events, weddings, and sports may take place in these areas.

Bioluminescent Waterfalls

A novel means of providing illumination in the colony, particularly at night, is using bioluminescent organisms. This has the added benefit of introducing a "wonderland" ambiance to the settlement's parks.

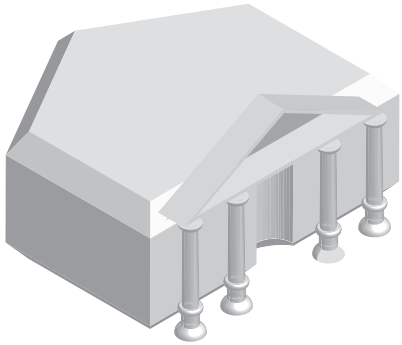


FUNGI

Breeds of fungi and mushrooms like Mycena chlorophos, Omphalotus olearius, Panellus stipticus, and others provide bioluminescentillumination under the right conditions. Thesemay be used to light parts of the city in an aesthetically pleasing manner.

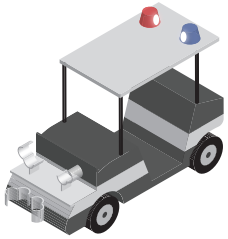
FISH & ALGAE

Certain algaes that grow in warm-water climates (e.g. Pyrocystis fusiformis, Pyrocystis noctiluca) produce light when stimulated by movement — for instance, near a waterfall feature in a park. Bioluminescent fish also exist (Isistius brasiliensis, Lampanyctodes hectoris), but extensive study must be conducted beforehand to determine what types of fish could coexist in this specific environment.



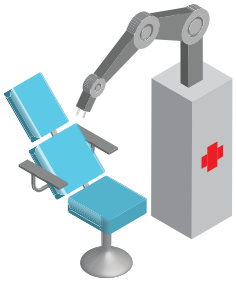
GOVERNMENT

Colony government will be roughly based on the system laid out in the United States Constitution with a few key differences. Due to the small extent of the colony, 12 total representatives will be elected to the legislative branch (two reps from each of the six residential districts). One colony President will be directly elected by eligible voters (≥18 y/o). The president will appoint three supreme court justices who will arbitrate all legal disputes, civil and criminal.



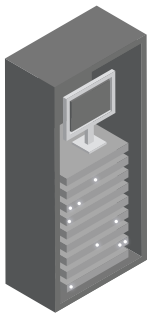
POLICING

Police and emergency services vehicles & facilities



MEDICAL NEEDS

Central hospital, distributed infirmaries, Surgical Robots.

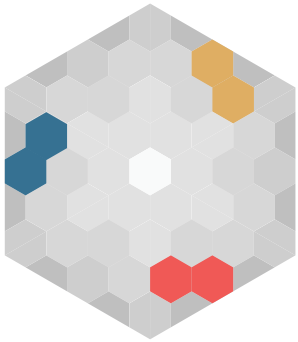


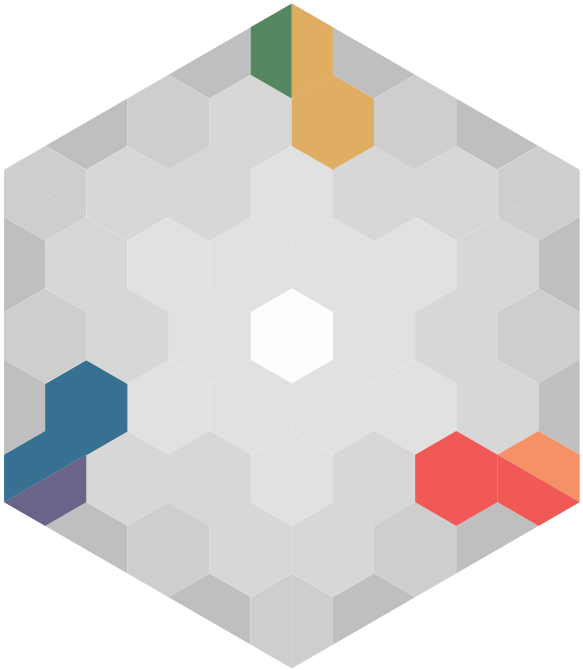
CONNECTIVITY

Intranet & satellite internet (with long latency)

Critical Services

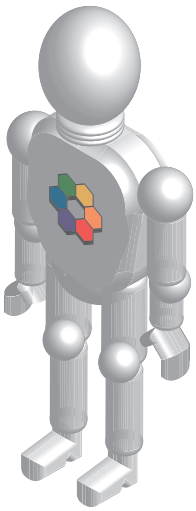
The critical services zones of the Chromatopolis provide for all of the government, medical, policing, schooling, waste management, maintenance, water distribution & sewage treatment needs of the colony. Primary & secondary schooling are available locally; some University schooling is available locally depending on the faculty expertise available in the colony at any given time, but many classes must be taken remotely via Earth-Mars distance education programs. Intranet servers allow for a local Chromatopolis Intranet network containing crucial encyclopedic knowledge and other information ported from the Internet on Earth. Internet connectivity is also permitted via satellites orbiting Mars, though latency is crippling — 3-21 minutes for each one-way website request assuming the satellite is available.





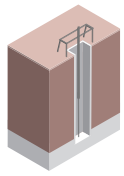
Research & Development

The Chromatopolis colony will be populated by a much-larger-than-average contingent of scientists, especially in the early stages. Given access to the Martian landscape, these scientists and specialists are perfectly suited to spend time discovering new ways of adapting the Martian environment for human habitation, and adapting humanity to coexist with the Martian environment — isolating resources from the environment without causing ecological damage, researching the geological history of Mars, conducting expeditions and experiments in the Martian environment and more. Generous space is alotted in the colony to these efforts for both practical reasons and idealistc reasons — on the one hand, for humans to thrive and expand their presence on the red planet, constant innovation and adaptation will be required. On the other, we fundamentally believe that building the Chromatopolis should not be a strictly commercial endeavor with purely commercial goals and ends — that science-for-science's sake should have a place in the foundational ethos of the colony.



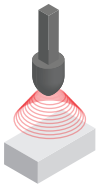
Water Extraction Process

Water exists at a depth of 10m-170m in the Utopia Planitia region.[15]



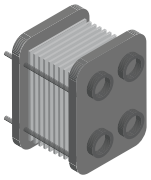
1. DRILL BOREHOLE

Drill to appropriate depth to reach ice/regolith mixture



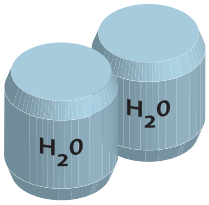
2. FIRE MICROWAVE GUN

Fire microwave gun at ice/regolith mix to create water vapor[16]



3. CONDENSE VAPOR

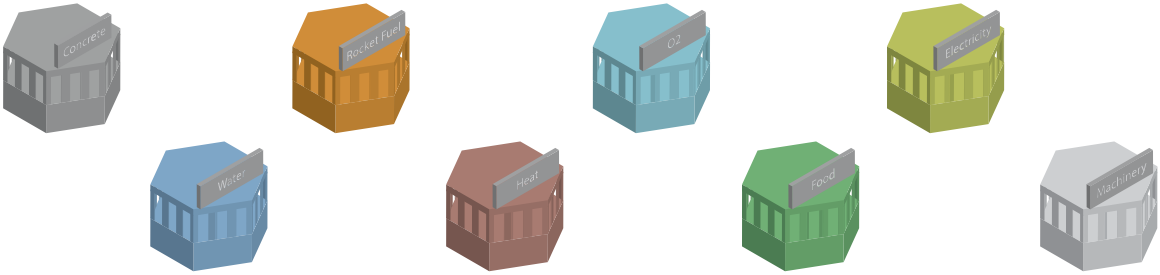
Use condenser plate heat exchanger to condense vapor into liquid



4. STORE LIQUID

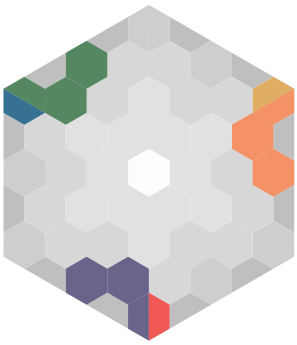
Store liquid under Earth-like temp. and pressure conditions

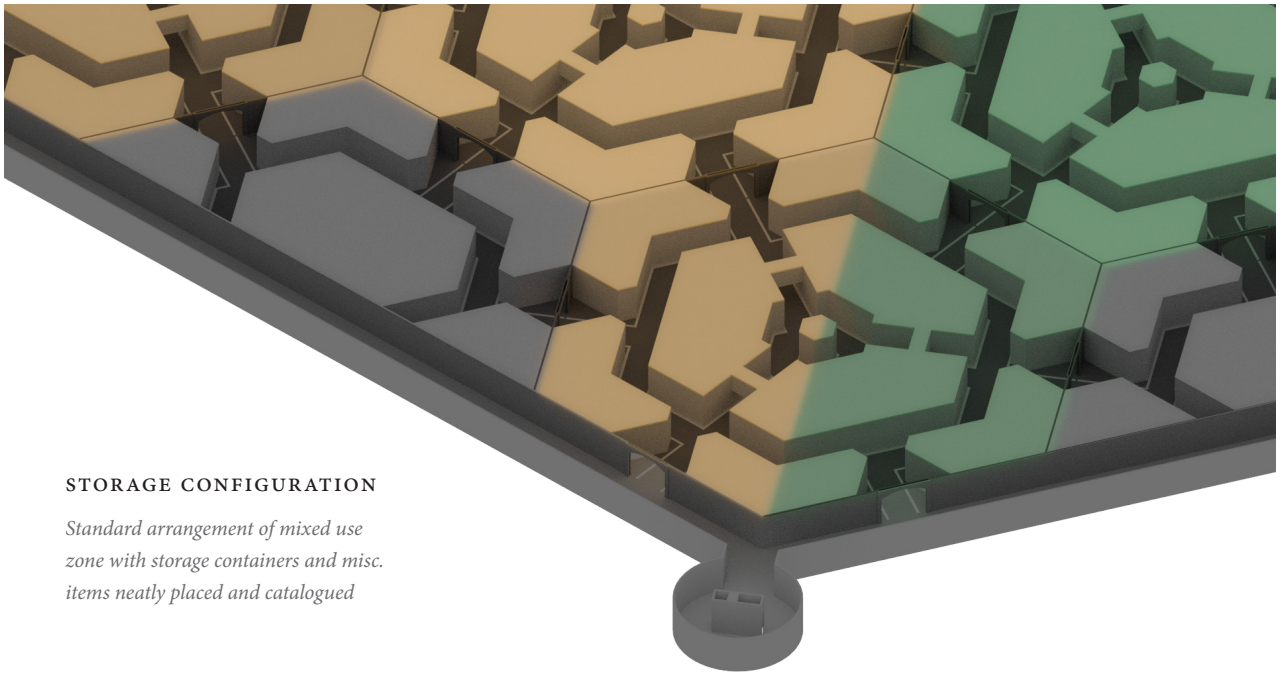
Example Generation Sites



Resource Generation

Resource generation is one of the most crucial tasks for keeping the Chromatopolis safe, functional and self-sustaining. Given its importance and the space requirements necessary to produce adequate quantities of needed materials, Resource Generation is given the largest relative allotment of space within the colony, primarily at its periphery. Resource generation in most cases is responsible only for production of resources and not distribution (covered mostly by commercial and critical services zones). However, RG does directly distribute electricity and oxygen.



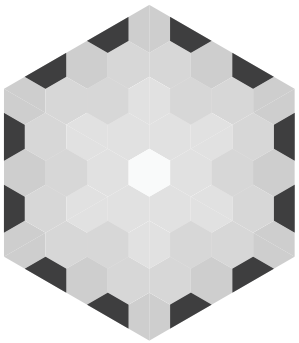


STORAGE CONFIGURATION

Standard arrangement of mixed use zone with storage containers and misc. items neatly placed and catalogued

Mixed Use Zones

The mixed-use zones on the fringes of the Chromatopolis habitation level are primarily intended to serve as storage compartments for physical and goods produced on Mars or imported from Earth via commercial re-supply shipments (e.g. food, building materials, vehicles, batteries, fuel, parts). These zones may be refrigerated if necessary. Alternatively, these spaces may be converted to other types of spaces as required (for instance, if more farms are necessary, or more research spaces, or more commercial spaces, these can be built without too much difficulty). One playful idea for this space is to convert part of one zone into a Martian-themed Parkour boulder course, complete with authentic Martian boulders, but lacking the near-vacuum surface conditions that would typically require a space suit to traverse them.



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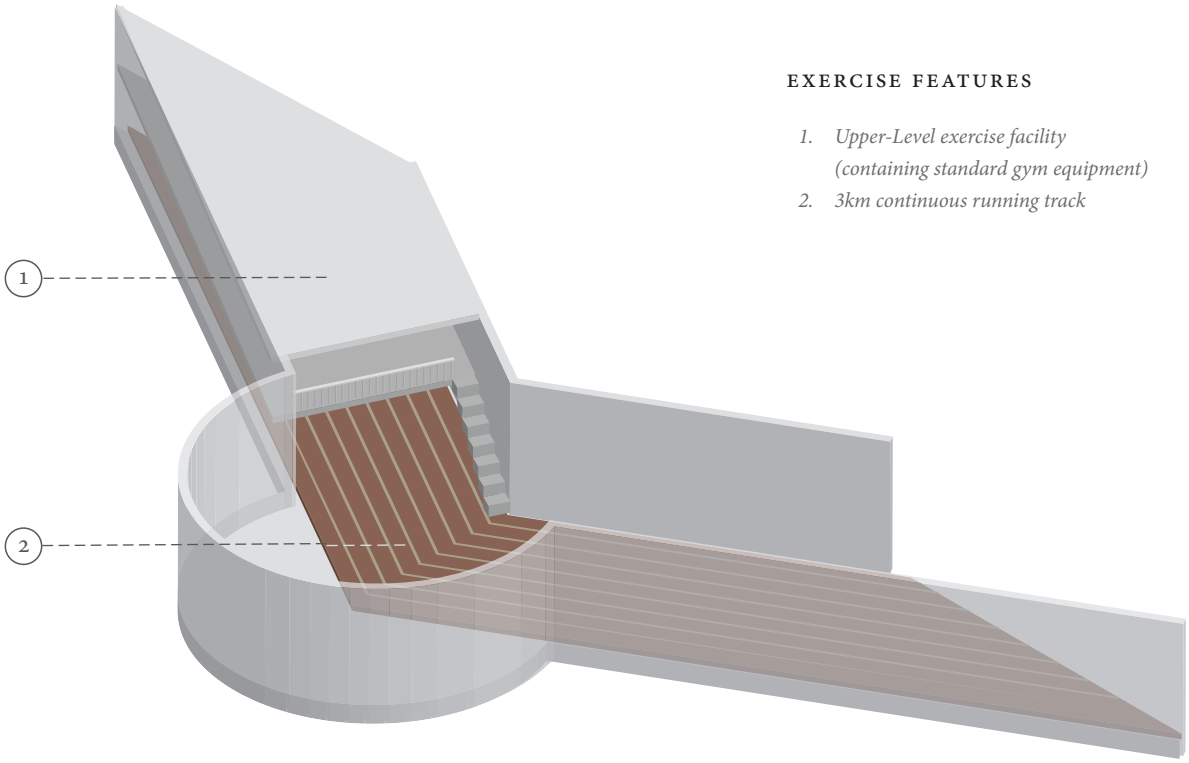
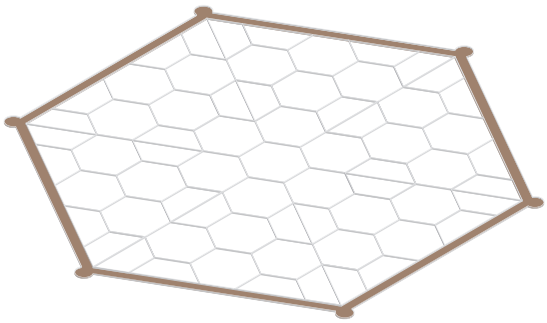


EXERCISE FEATURES

1. *Upper-Level exercise facility (containing standard gym equipment)*
2. *3km continuous running track*

Outer Exercise Ring zones

Exercise is an important component of daily life in the Chromatopolis for the same reason that it's an important component of daily life on the International Space Station: in the absence of Earth's gravity, muscles atrophy and bone density decreases. Martian gravity, while more than an human being would experience in Space or on the Moon, is still 38% of Earth's gravity, and colonists must remain active. To that end, the Chromatopolis contains several exercise facilities around the perimeter of the colony. A 3km running track encircles the colony completely. At various points on this running track are accessible second-level exercise facilities containing standard gym equipment

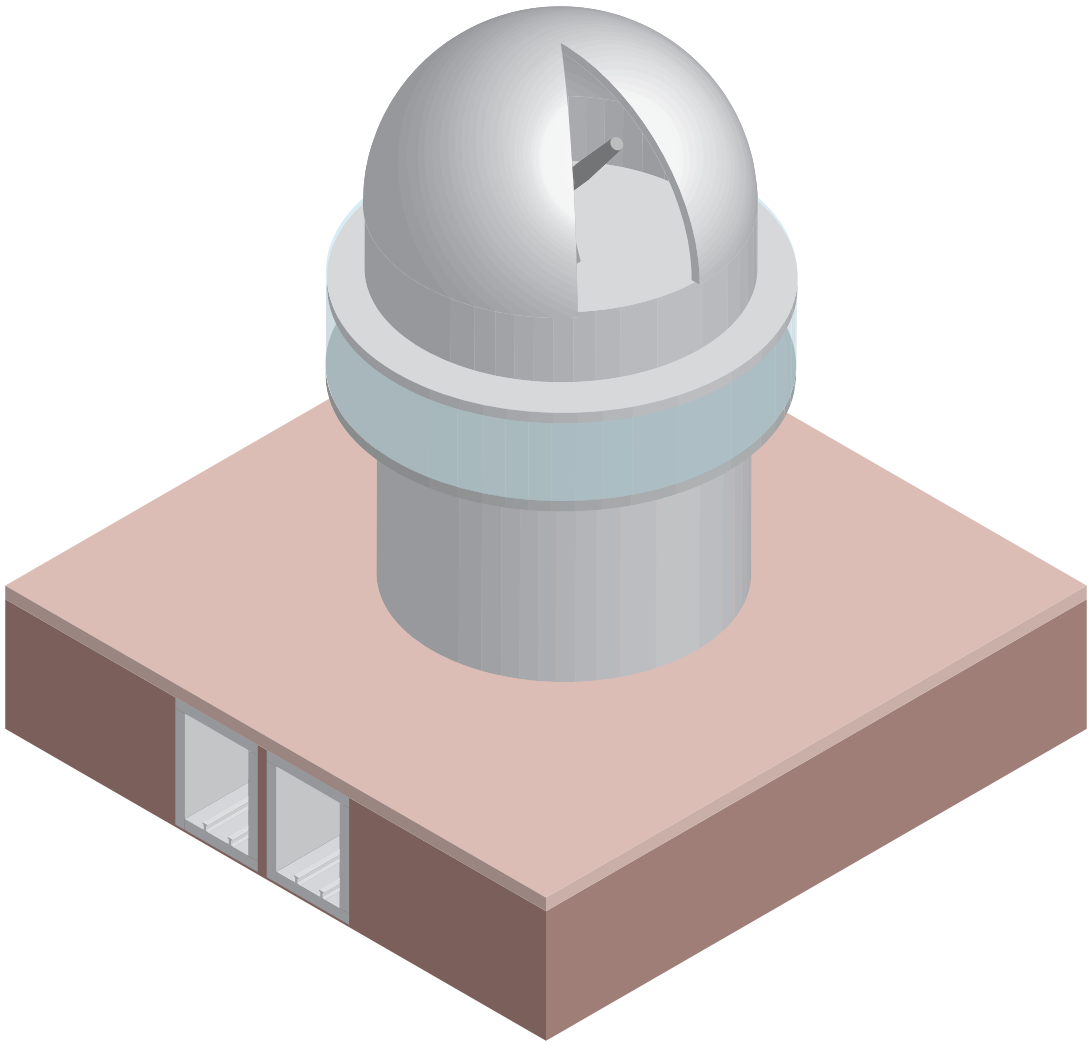


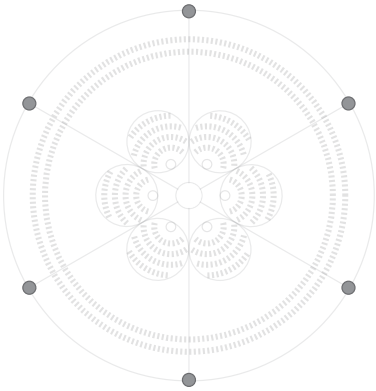
THE CHROMATOPOLIS

UTOPIA PLANITIA, MARS

OC Outer Columns

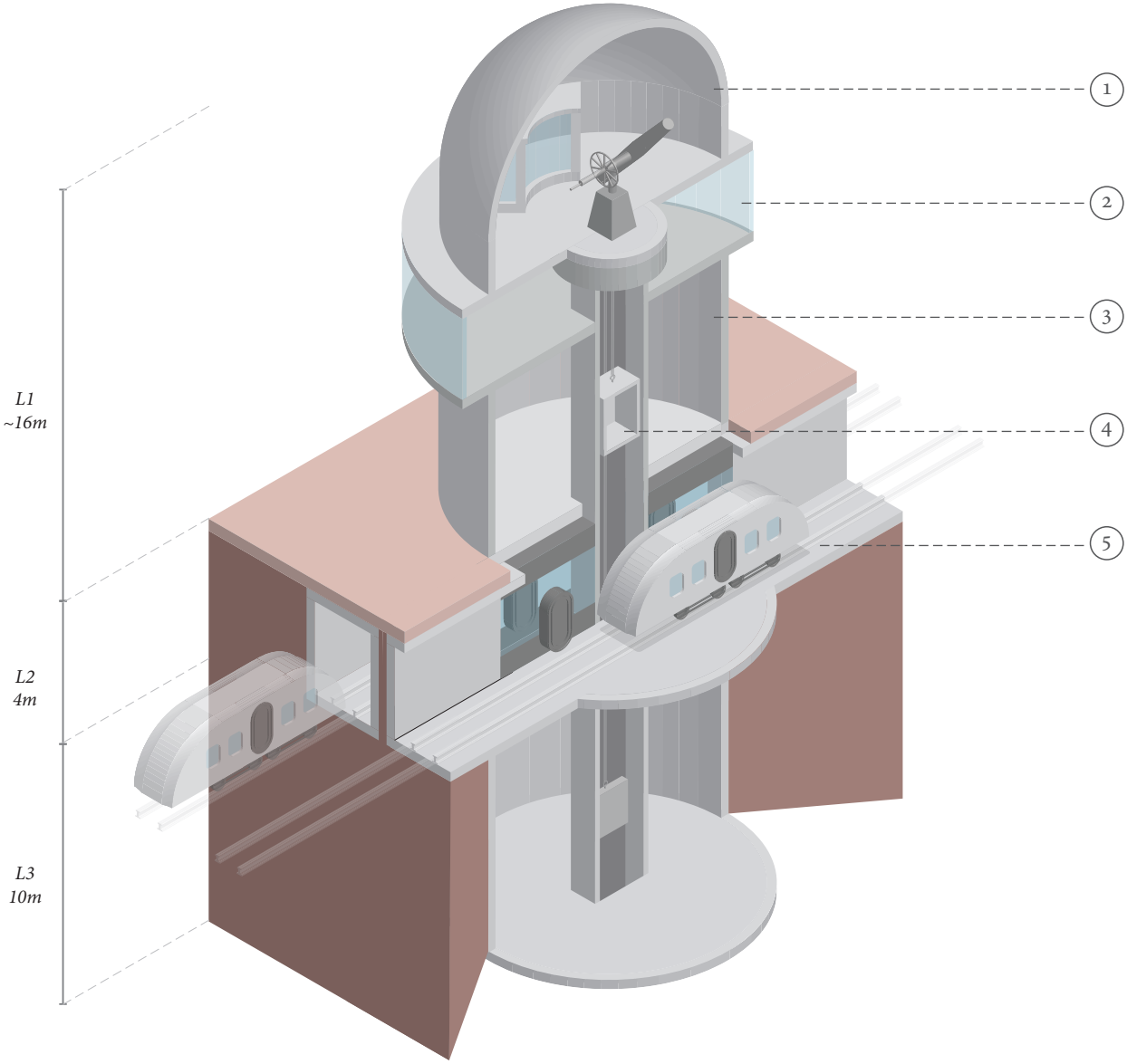
Multi-purpose design & function of exterior column spaces





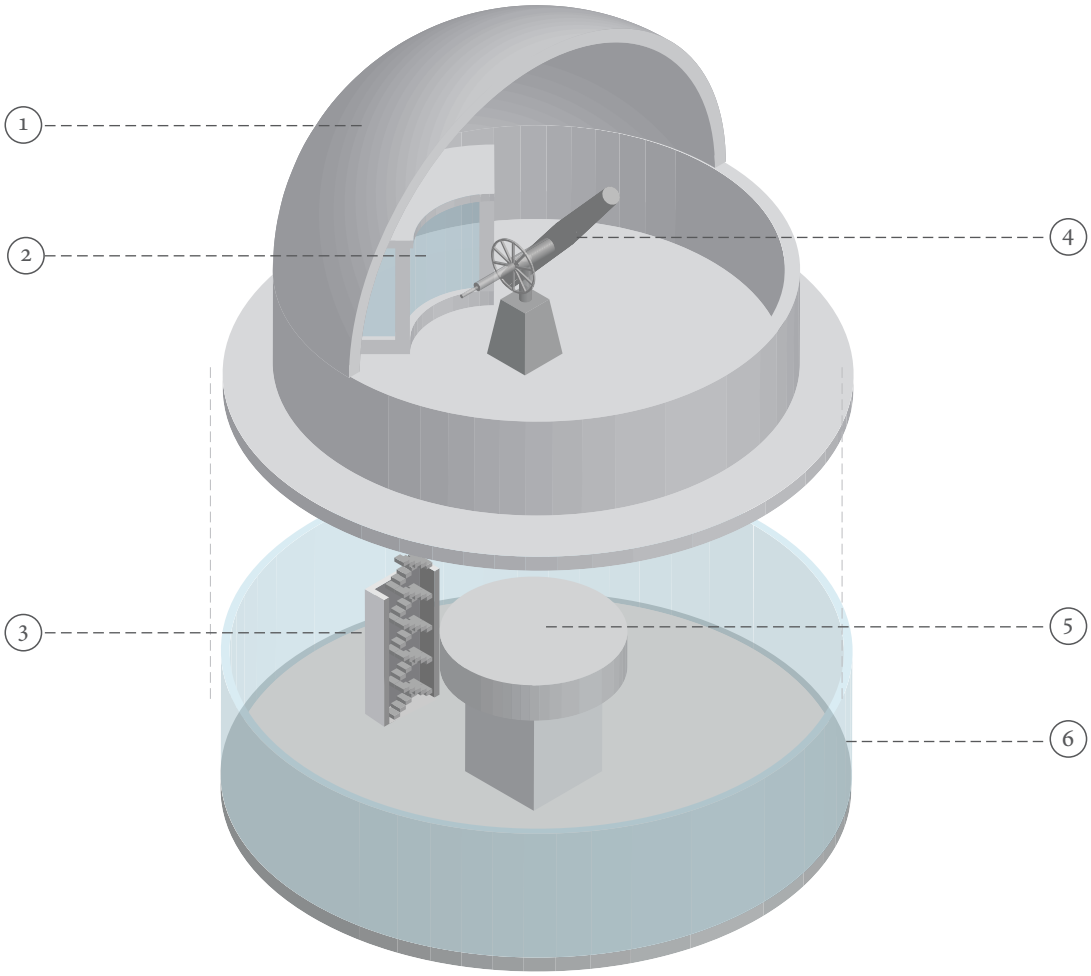
Outer Columns

Six multi-functional columns line the exterior extrema of the hexagonal colony. Each column connects L1, L2, and L3 together. The L1 portion of each column features an observation deck for visitors, an astronomical observatory, and surface garage. L2 features a transportation hub for the hyperloop system. L3 connects to the outer exercise ring.



Columns Cross Section

1. *Astro Observatory dome (L1/C)*
2. *Observation deck (L1/B)*
3. *Surface Garage (L1/A)*
4. *Elevator (L1-L3)*
5. *Hyperloop hub (L2)*



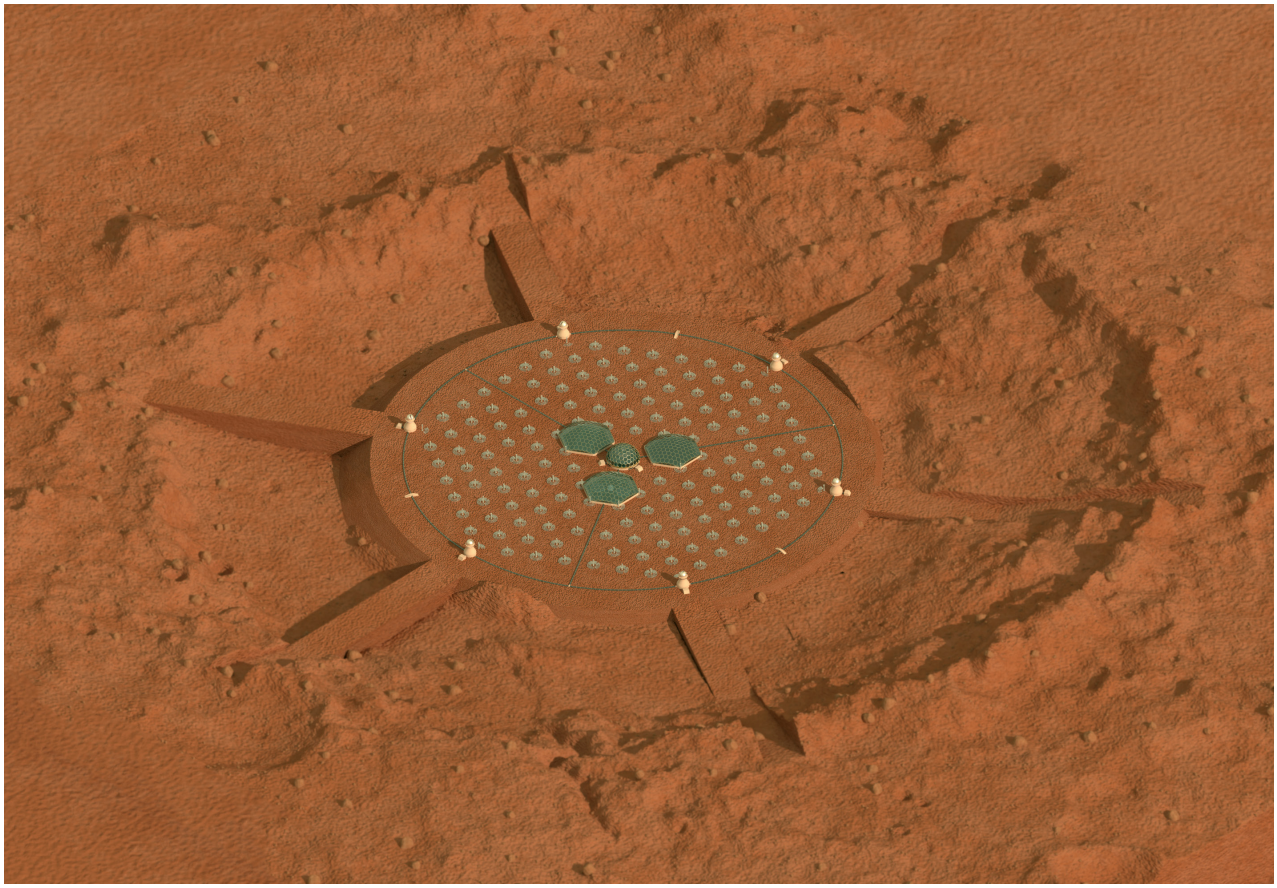
Observatories

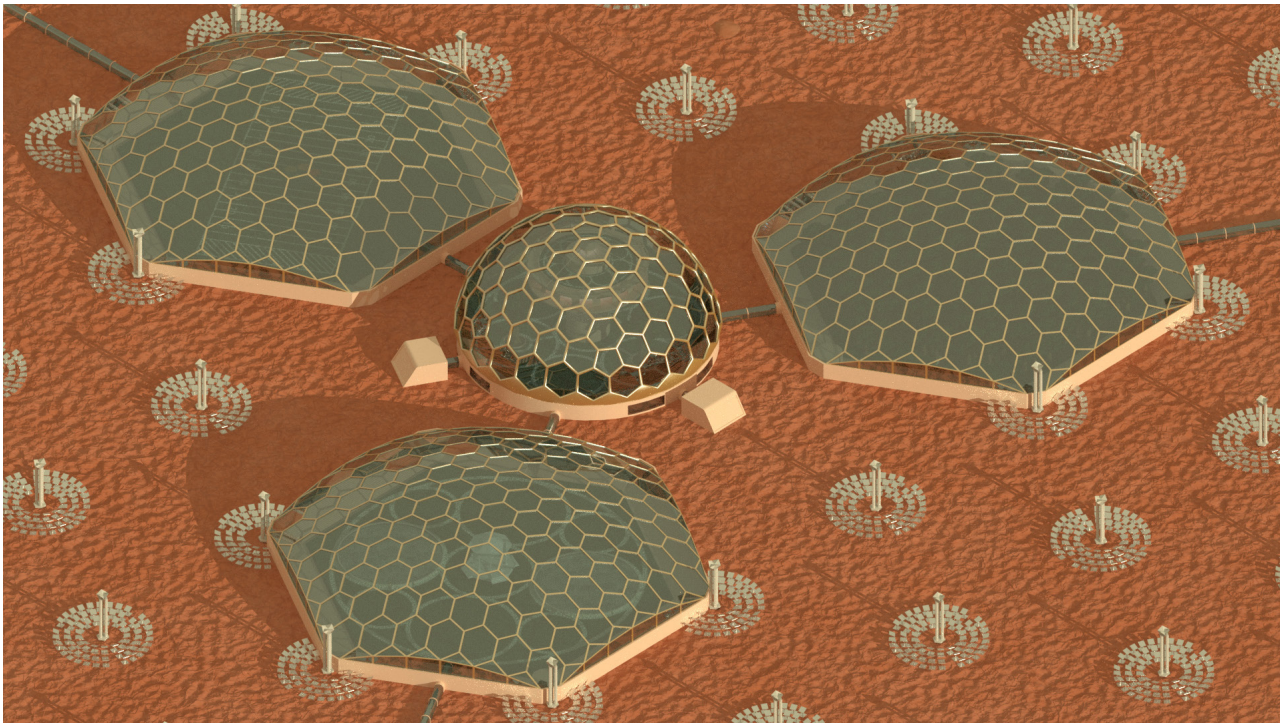
The lower observation deck of each outer column serves as a recreational viewing platform for colonists, much as the central dome's viewing platforms do. However, the space in the outer columns is much more limited and human capacity is much lower than in the central dome. The elevator/stairway shaft at the center of the outer columns is equipped with vibration damping materials so as not to disturb astronomical observations above. The observatory space and telescopes on the upper level are typically open to the near-vacuum of the Martian surface during telescope operation, and operators must work in the stairway-accessible booth. Each of the six observatories monitors astronomical phenomena in different bands of the electromagnetic spectrum (Visible light, radio, gamma rays, infrared, UV, X-Rays).

1. *Retractible dome*
2. *Telescope control booth*
3. *Stairs to control booth*
4. *Telescope*
5. *Vibration-dampened elevator shaft*
6. *Acrylic/plexiglas windows*

Renderings

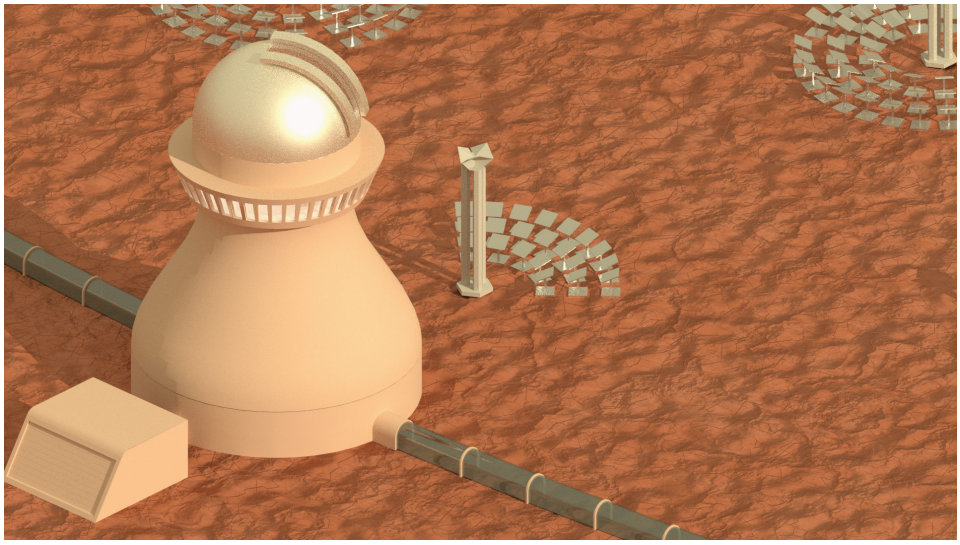
3D views of colony



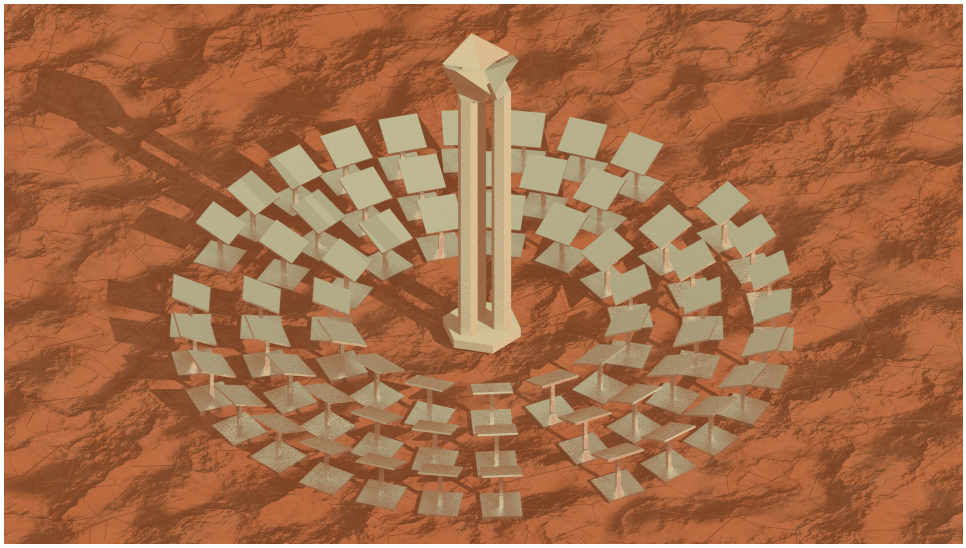


Central Dome Ext.

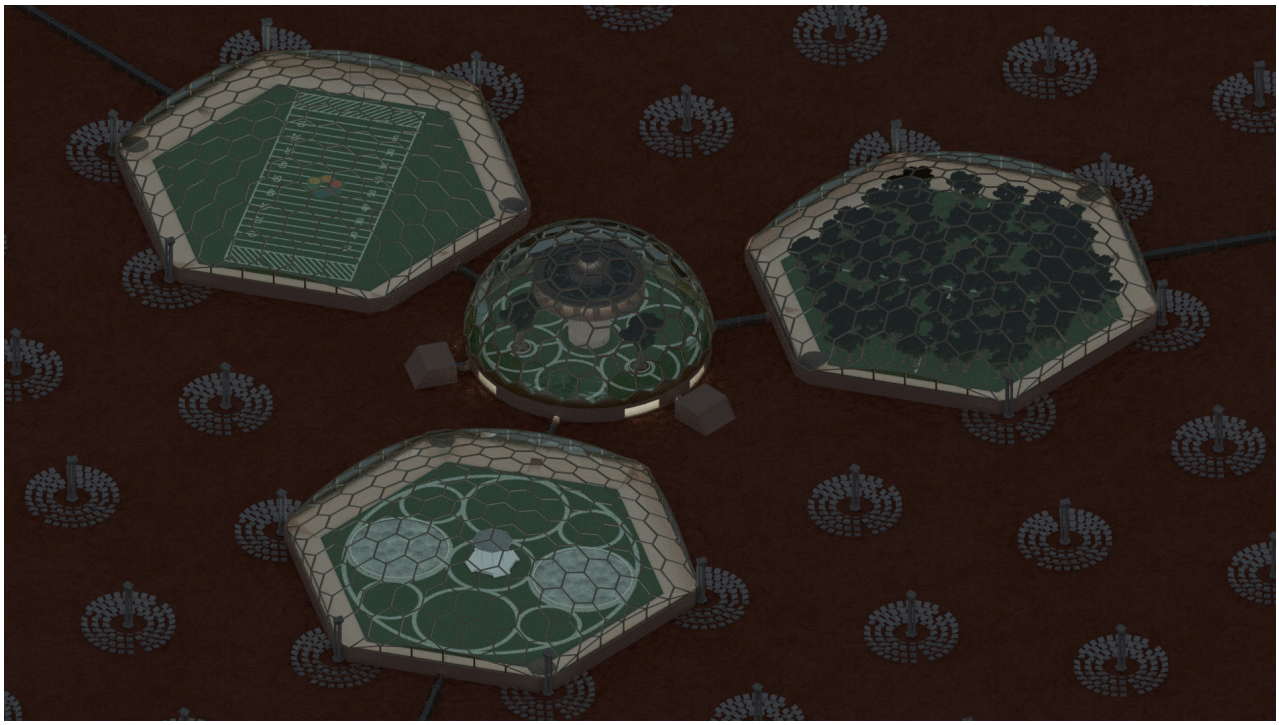
Solar Periscopes, roads, and the central dome



Observatory Column Ext.

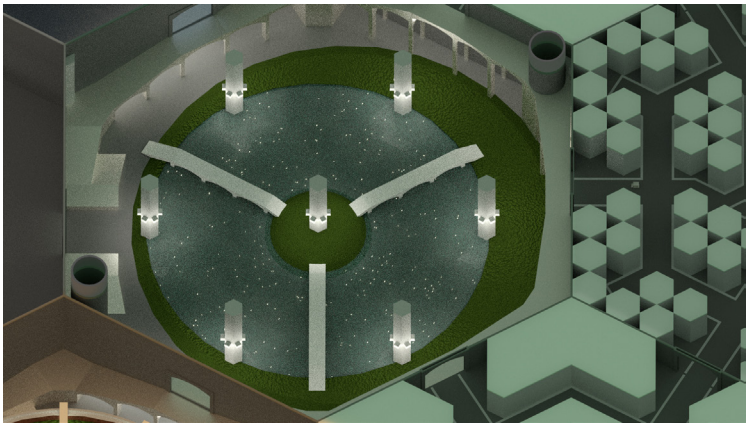


Solar Periscope Ext.



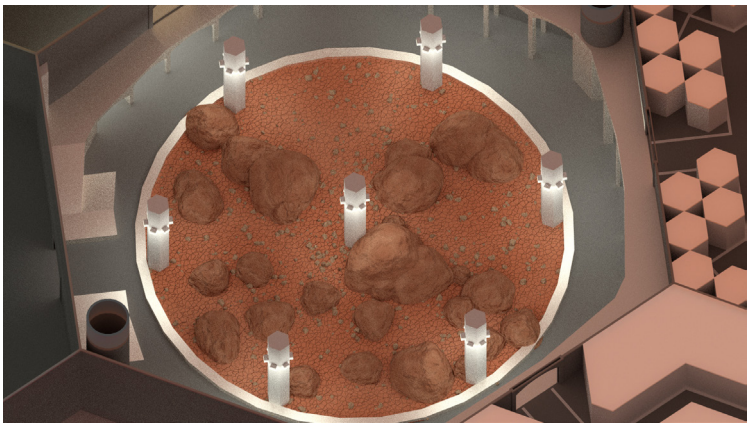
Surface Night Scene

with Human-scale detail



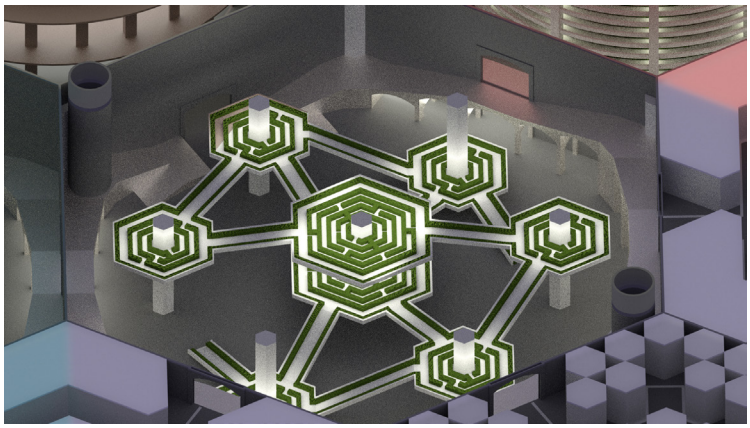
Bioluminescent Pond

Garden features bioluminescent plants & animals



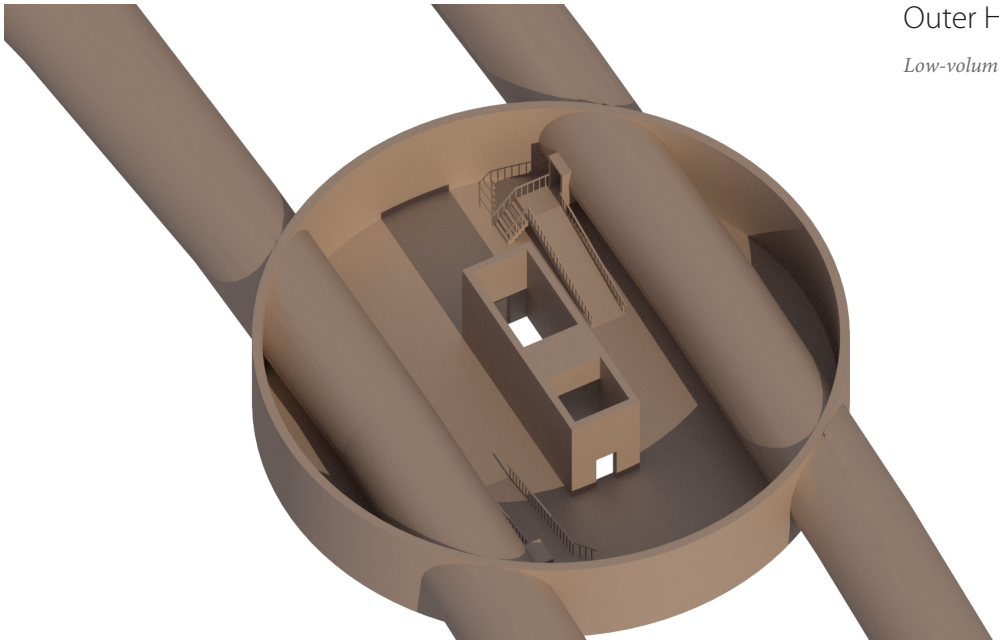
Martian Surface Training Area

Designed to be adapted to the needs of both educational and recreational users. Parkour on Martian rubble or learning how to navigate the terrain as preparation for surface travel.



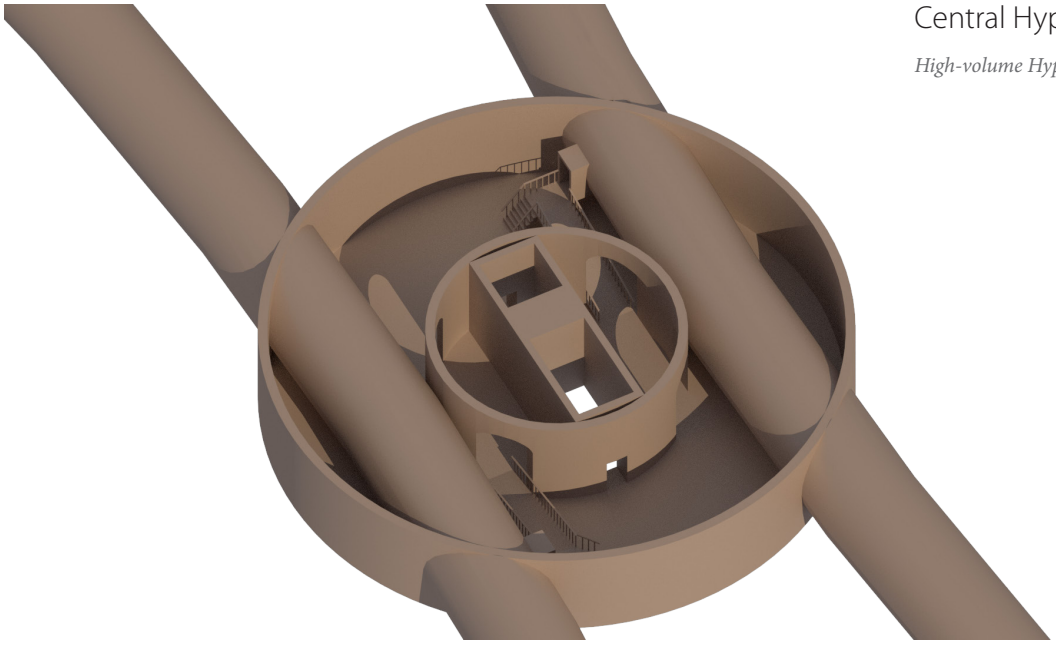
Multi-level maze gardens

Designed to encourage wandering and provide residents with a zen-like atmosphere as needed.



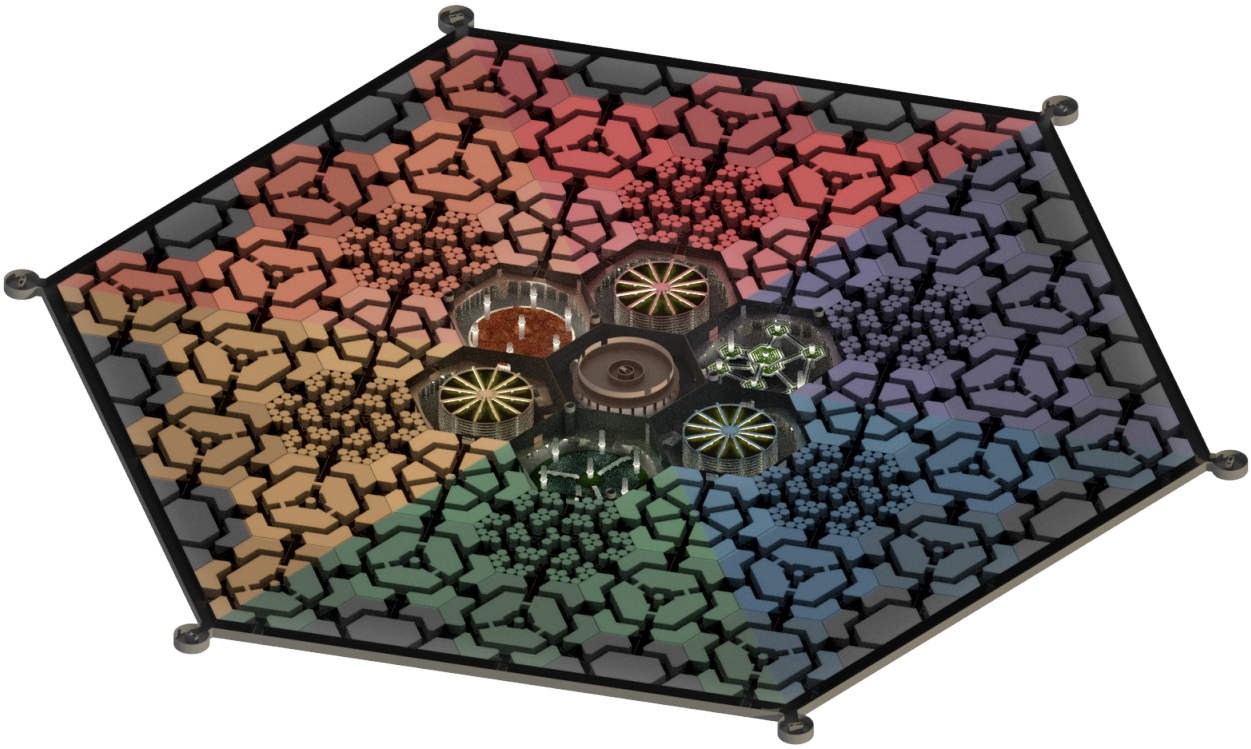
Outer Hyperloop Station

Low-volume Hyperloop transport hub



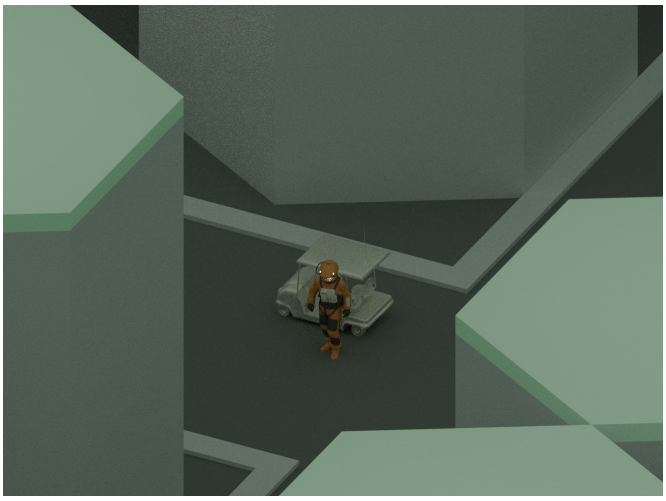
Central Hyperloop Station

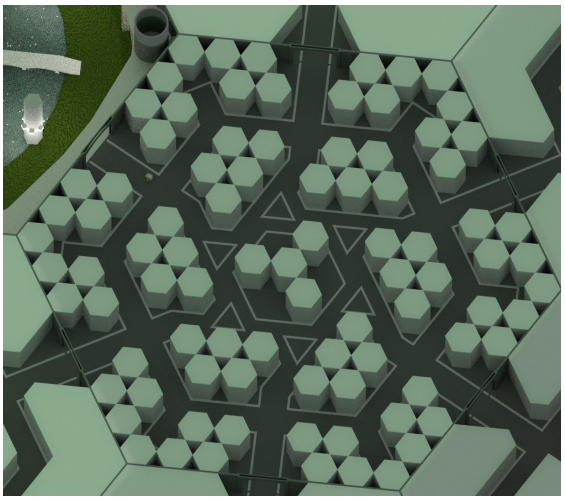
High-volume Hyperloop transport hub

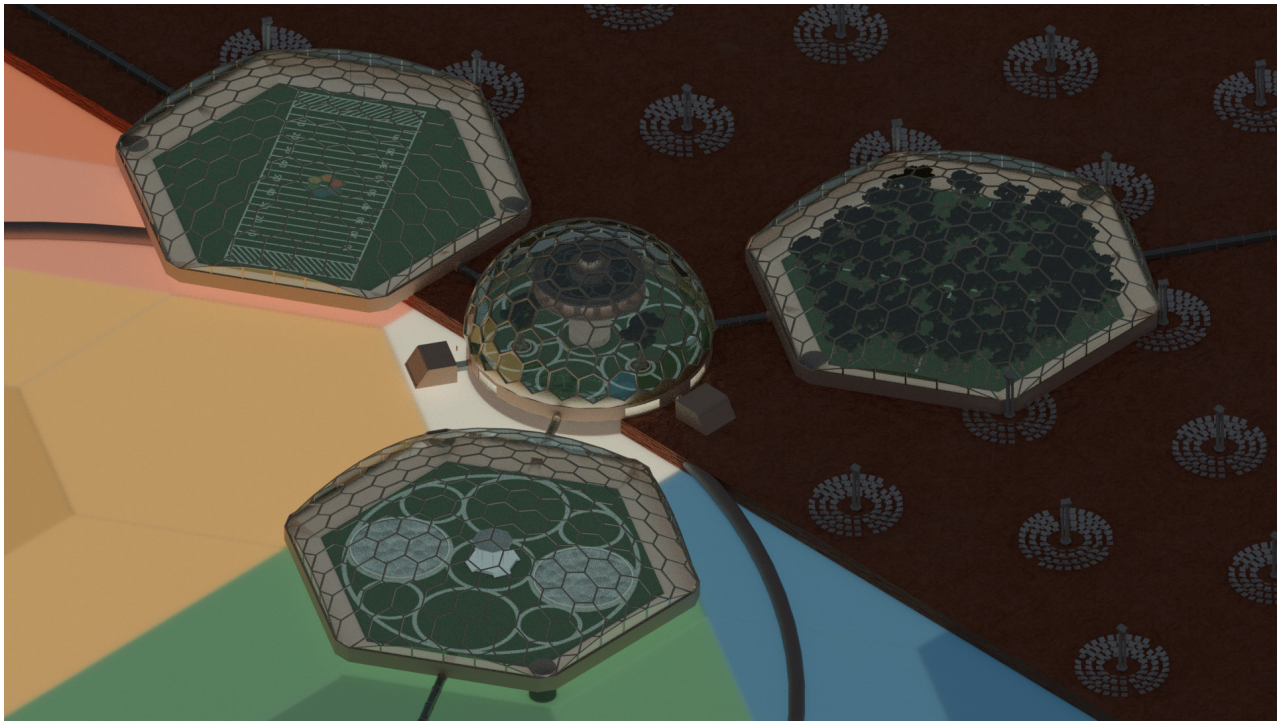


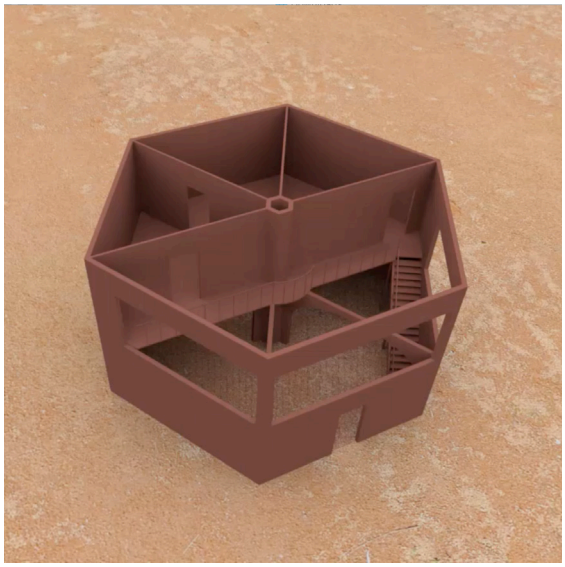
L3 Full View

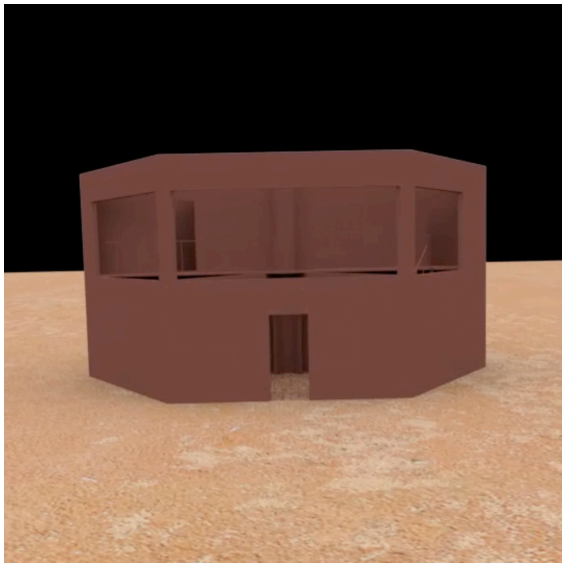
Invluding Residential detail with human and self-driving golf cart for scale.











Exterior

Modular hexagonal design,
large clerestory windows

Interior

Vaulted flying buttresses,
central support column, & balcony

Appendix

Sources, Inspirations, Attributions, and Contributor Notes

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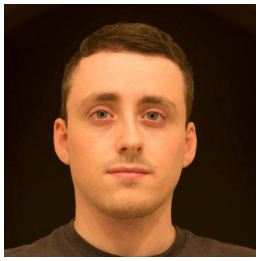
DIANE TURNSHEK

Diane Turnshek is an astronomer in the Dept. of Physics at Carnegie Mellon University and the Dept. of Physics and Astronomy at University of Pittsburgh. She publishes hard science fiction with a focus on space colonization and first contact. Her love of astronomy and science fiction led her to crew the Mars Desert Research Station near Bryce Canyon, UT in 2012, where she turned her attention to dark-sky advocacy. In 2015, Diane received a Dark Sky Defender award from the International Dark-Sky Association for her contribution to light pollution mitigation.



MATT FINLAY

Matt Finlay is a Writer, Designer, and Artist. He attended Carnegie Mellon University, where he was the President of the CMU Astronomy Club for three years, and graduated in 2014 with a degree in Creative Writing. Matt currently works as a Senior Designer at a mobile security startup in San Antonio, TX, where he develops branding, collateral, and visual-literary narratives.