3rd International AIAA Space Architecture Gathering

A Vision of the Future Built-in-Place Architectures

Kriss J. Kennedy, Architect

March 27, 2021

UNITED SPACE STRUCTURES

TECHNE' Architects LLC

PRECURSOR TECHNOLOGIES

CGI Images by Precursors Technologies, LLC

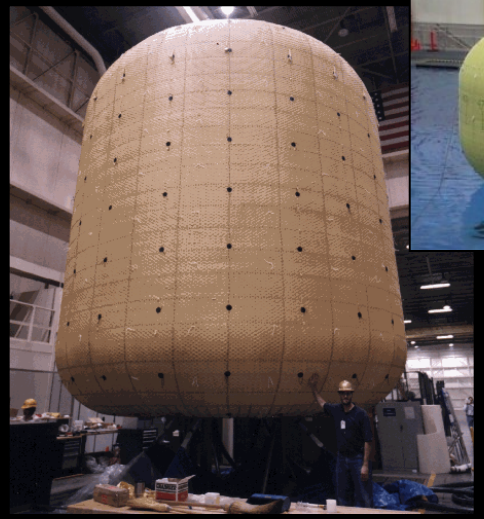
“If our long-term survival is at stake,
we have a basic responsibility to our species
to venture to other worlds.”

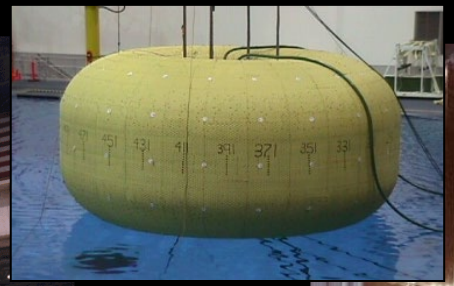
– Carl Sagan, Pale Blue Dot: A Vision of the Human Future in Space, 1994. (JW)

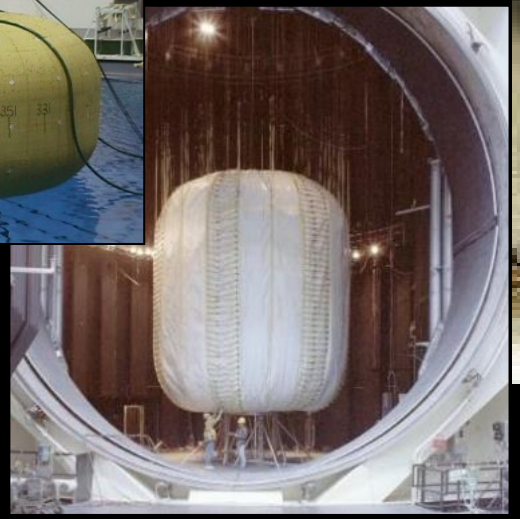
What if...

UNITED SPACE STRUCTURES

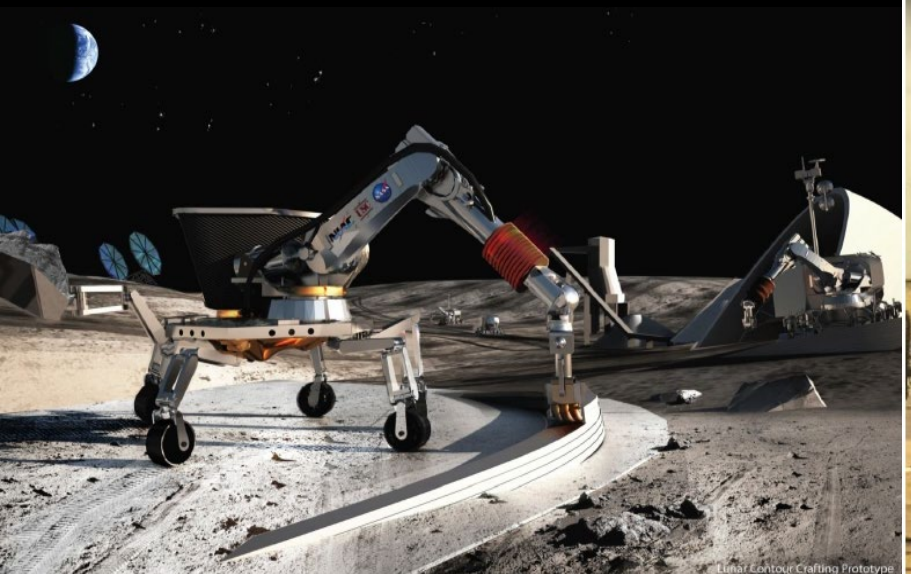
What If...

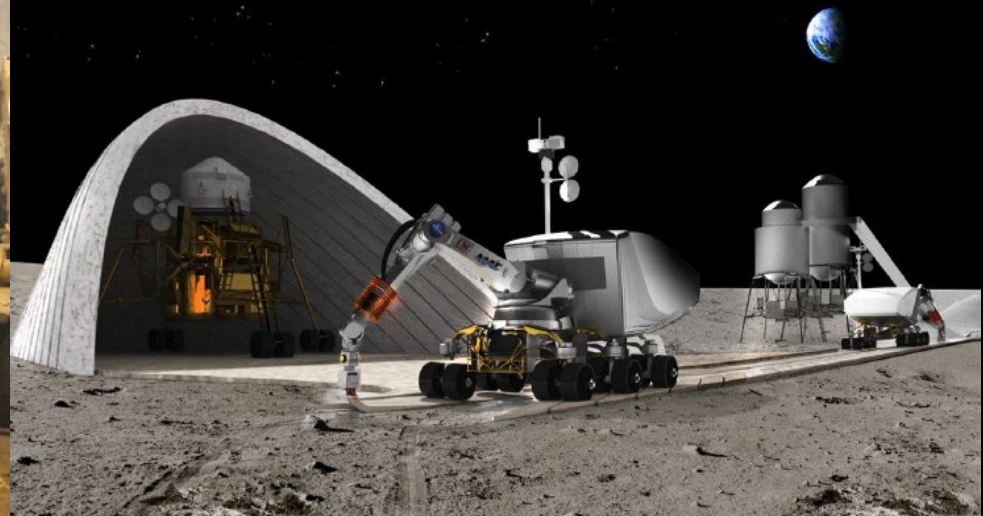






Credit & Images Courtesy:
NASA & 3D Printed Habitat Challenge
AI Space Factory
Branch Technology
Contour Crafting, LLC
Pennsylvania State University





The future is here...

OUR VISION

Providing habitation capabilities to enable Lunar and Martian commerce to thrive in support of human exploration and resource consumption to become Earth-independent while establishing permanent sustainable human presence on the Moon and Mars.

OUR MISSION

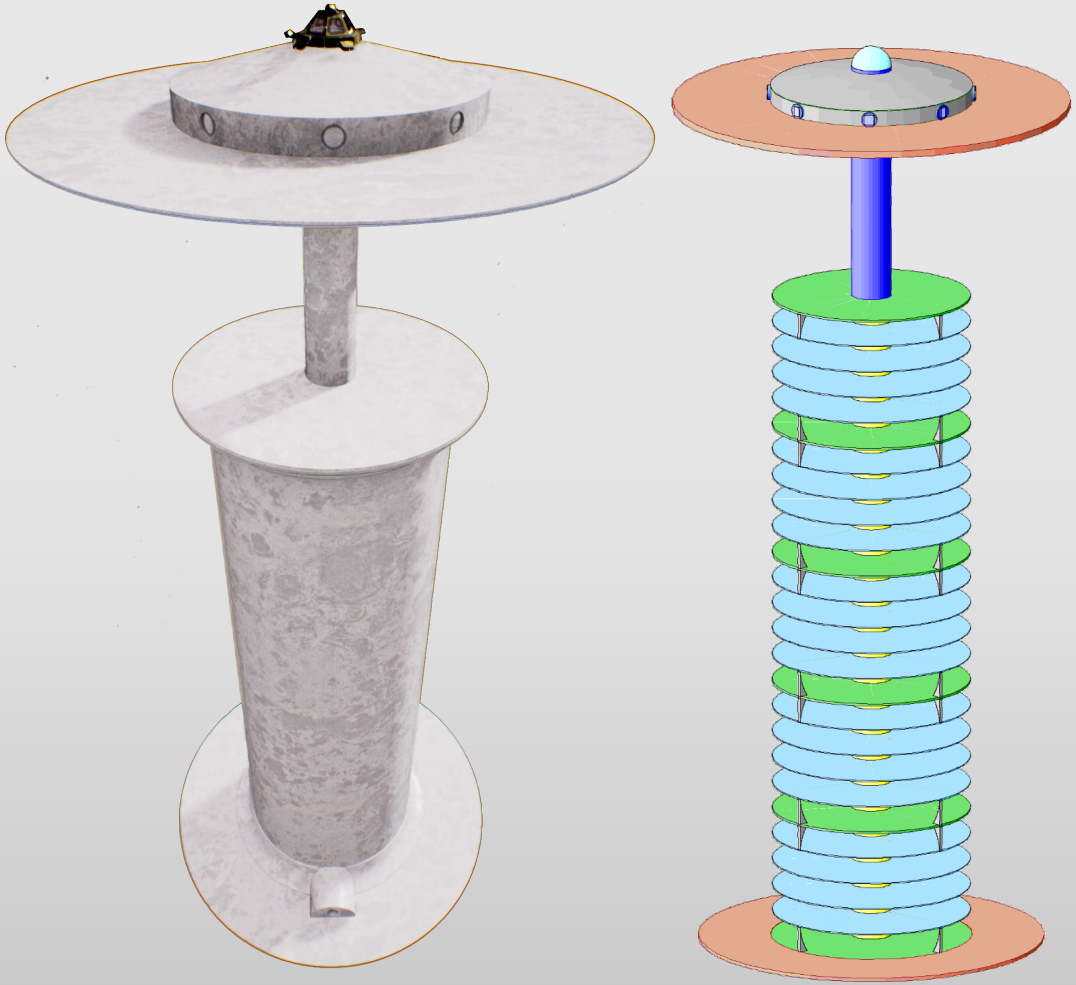
Design and development of a Lunar and Martian Architecture capability that enables a thriving space economy to support humans working and living on the Moon within a decade and to be among the first private companies to establish a presence on Mars in the future colony proposed by Space-X.

UNITED SPACE STRUCTURES

Commercial (Lunar) Real Estate Paradigm

25 story Al Bahr Towers in Abu Dhabi, UAE

Al Bahr Towers is designed by Abbey Holford Rowe Architects (formerly Aedas UK)



Proposed Lunar Lava Tube Tower stands 25 levels tall.

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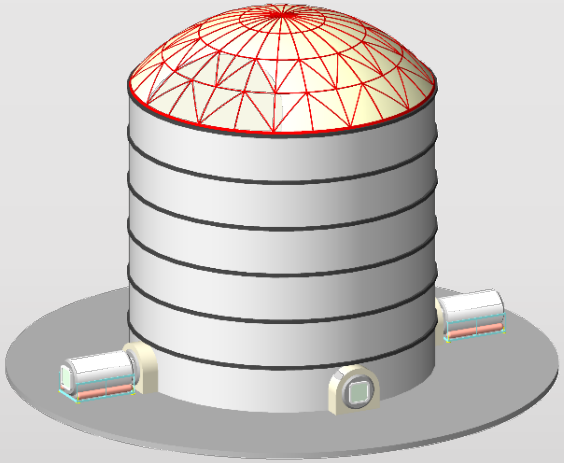
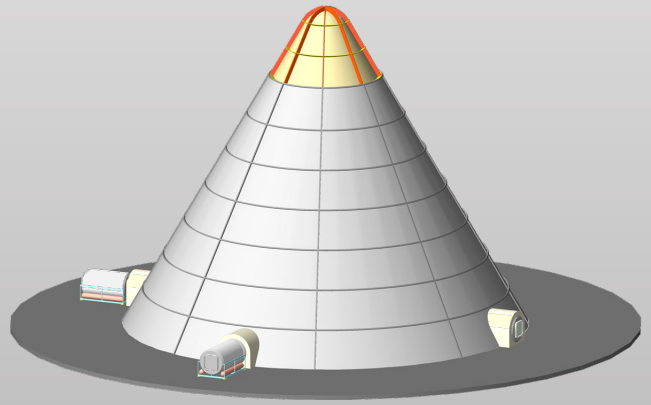
What If...
Built-in-Place Large Scale In-Situ Derived Architectures





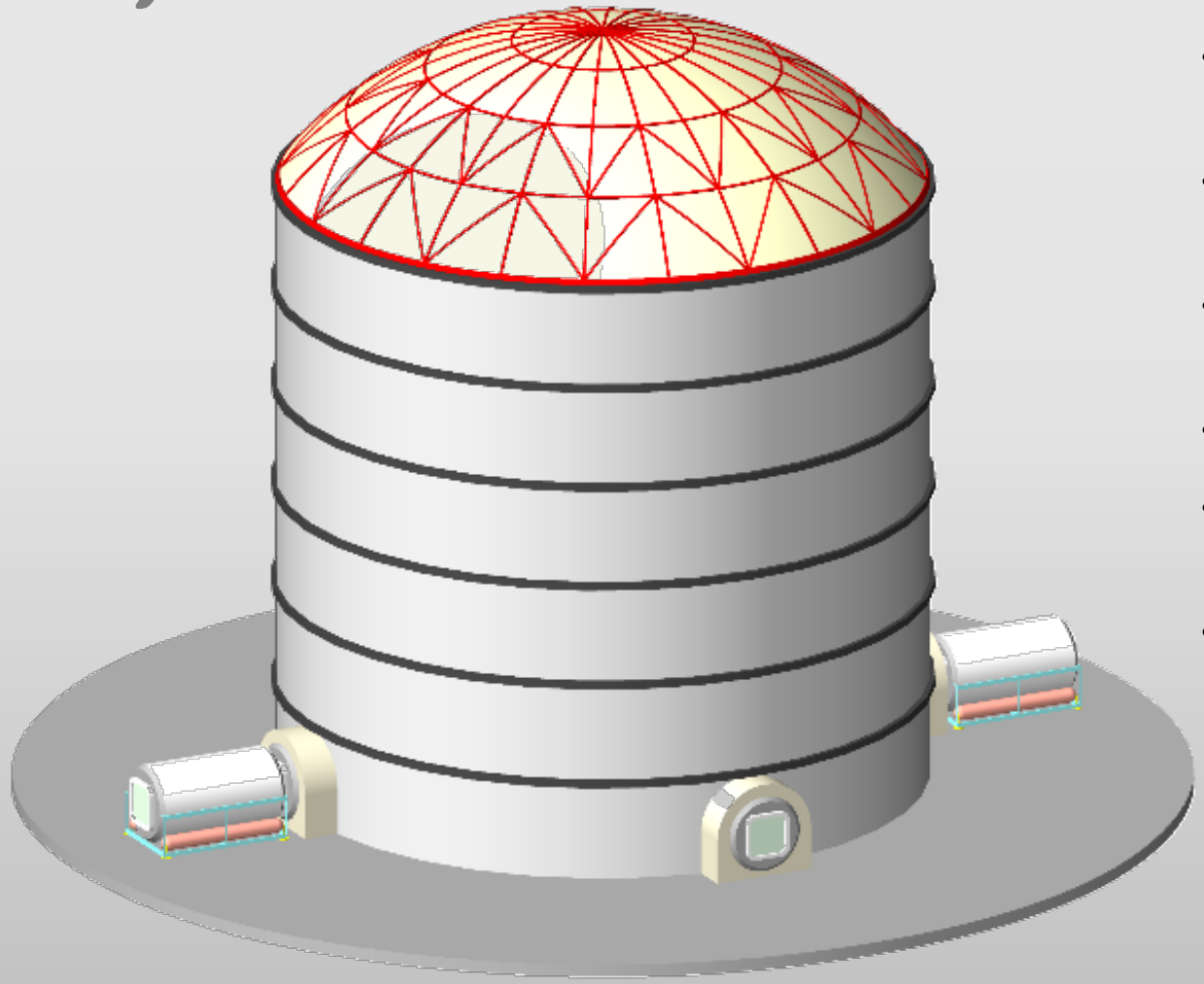
PRECURSOR TECHNOLOGIES

Value Proposition

- Space Architecture & Settlement Tipping Point: A Paradigm Shift
- ISRU-Derived Structures using Automated Additive Construction
- Permanent, Earth-Independence, Self-Sustaining
- Robustness, Simplicity, Scalable, Safety
- Bold, Aggressive, Large Scale Facilities
- Forcing Function of Technologies, Capabilities, and Services Needed
- Collaboration & Partnerships Opportunities
  - Technology & Architecture/Engineering Opportunities
  - Tentative collaborations w/ 2 robotics companies & 5 universities

Fund Phase 1

Surface Architecture
Cylindrical Tower Facility



- United Space Structures has patent pending designs of scalable surface tower architectures.
- Each tower will be tailored to each unique customer-driven requirements, functionality, characteristics, and size.
- Facility shell wall uses a dual-wall design to reduce radiation exposure to human while living and working within the facility.
- The dome tops have the option of being solid or with glazing.
- Surface towers can be multi-level, scalable diameter, and have thousands usable square feet of living and working floor space.
- Close proximity to proposed commercial outposts and colonies enables leveraging of local infrastructure, resources, and services resulting in cross-contracting and mutually synergistic benefits of a robust ecosystem.

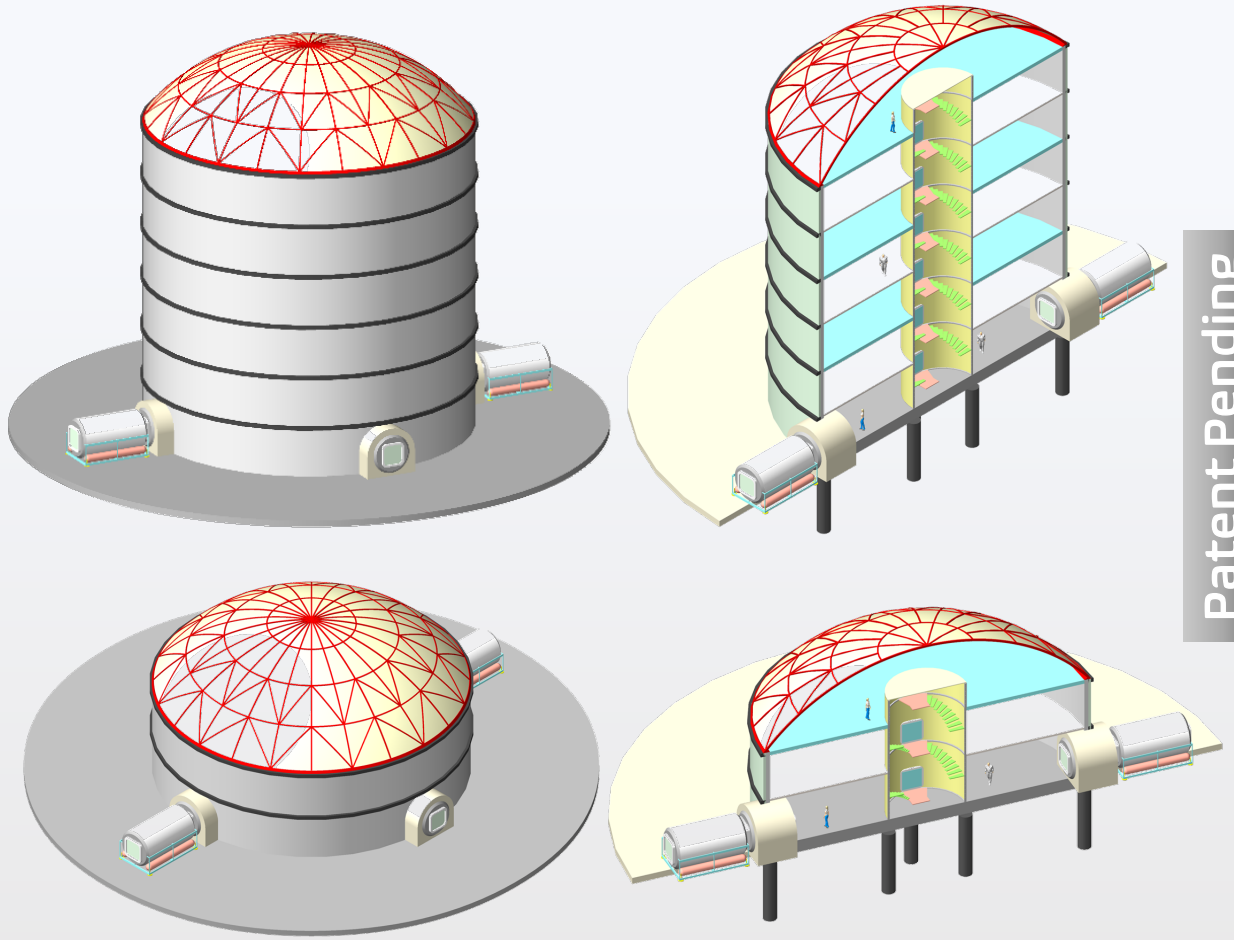
Patent Pending

UNITED SPACE STRUCTURES

Lunar Surface Tower Facility Concept
Cylindrical Architecture

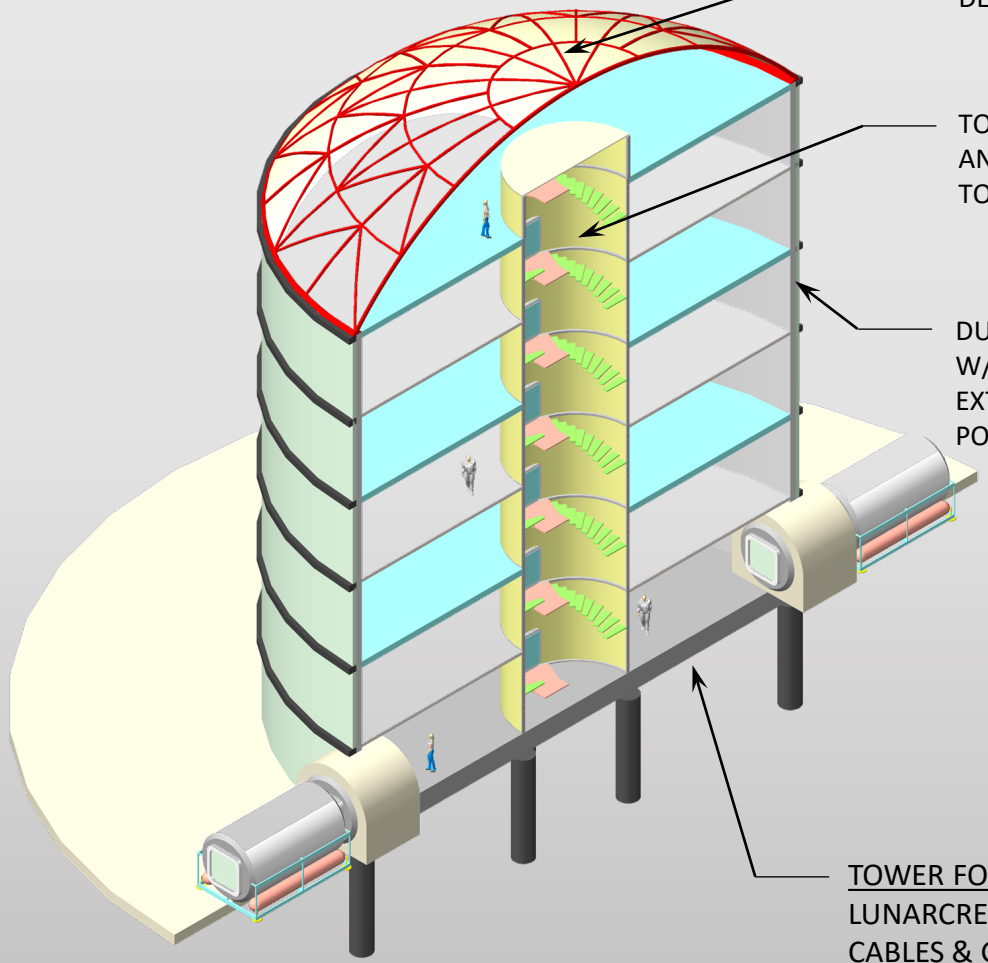
Shape and Scale of Tower Structure:

- **Cylindrical "cast-in-place" reinforced lunarcrete structure.**
- **Tentative Internal Operating pressure ~14.7 or 10.2 psia**
- **Independent Pressure Central Core**
- **~30-meter tall / 98.42 feet**
- **~7 Stories/Levels @ 4 m / 13.1' Top Finish Floor to Top Finish Floor**
- **25-meter diameter @ Base / 82.02 feet diameter**
- **Estimated Tower Dual-Wall thickness: ~ 0.5 m (19.7")**
- **Typical Floor Thickness: 0.16 m (6 inches)**
- **Bulkhead Floor Thickness: 0.33 m (13 inches)**
- **Total Floor Area = 2,968.84 m2 total (31,956.33 ft2)**
  - **Floor Area – Core = 452.39 – 28.27 = 424.12 m2**



Patent Pending

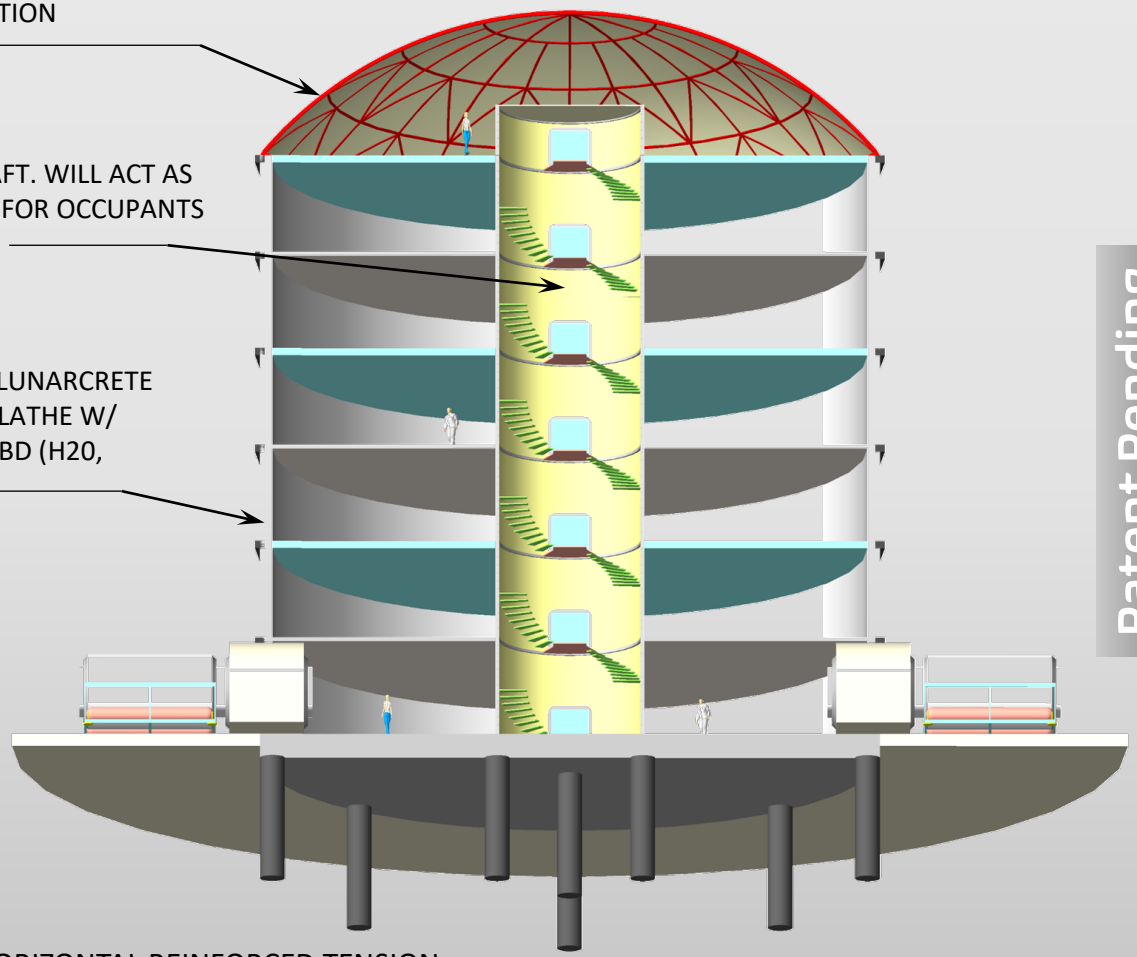
Cylindrical Surface Tower 3D Cross Section



TOWER GEODESIC DOME: OBSERVATION DECK & GLAZING W/ SUNSHADES

TOWER CORE VERTICAL ACCESS SHAFT. WILL ACT AS AN INDEPENDENT PRESSURE SHAFT FOR OCCUPANTS TO EGRESS VIA STAIRS TO SURFACE.

DUAL WALL PRESSURE STRUCTURE. LUNARCRETE W/ BASALT TENSION REINFORCING/LATHE W/ EXTERNAL CAVITY HULL FILLED W/ TBD (H20, POLYETHYLENE, ETC)

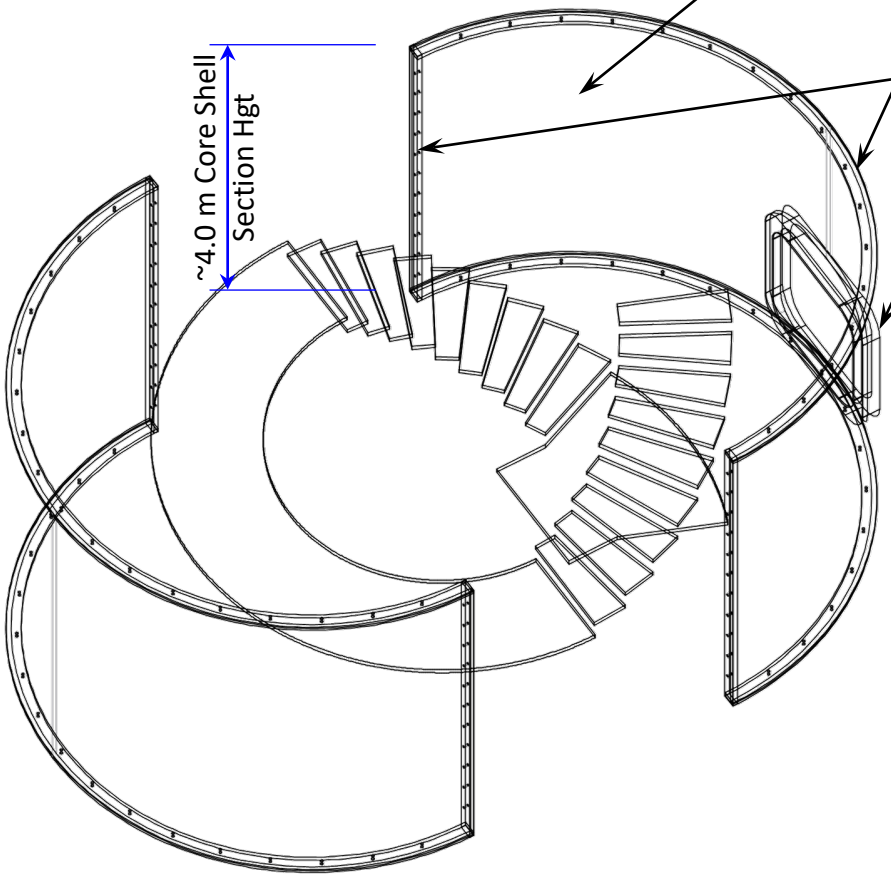


Patent Pending

<u>TOWER FOUNDATION SLAB</u>:
LUNARCRETE FOUNDATION SLAB WITH HORIZONTAL REINFORCED TENSION CABLES & GLASS FIBERS. TIE SHELL WALL VERTICAL REINFORCING CABLES INTO FOUNDATION SLAB WITH GEOPIER SUPPORTS

UNITED SPACE STRUCTURES

Core Vertical Access Shaft Structure Shell

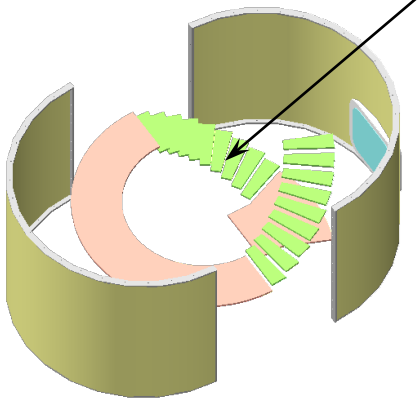


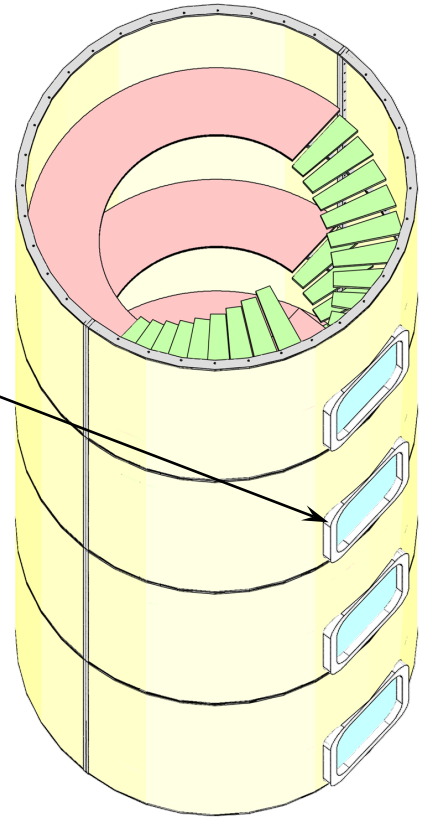
Prefabricated Core Pressure Shell Half
~6.0 m Core Shell O.D.

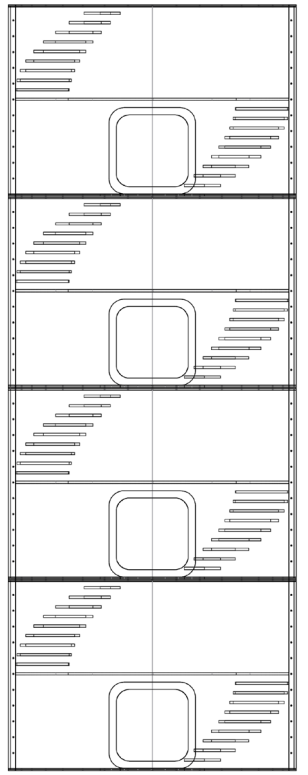
Core Shell Seal and Flange.
Bolt Pattern Shown

Pre-Integrated Bulkhead & Hatch

Scarring for Stair Treads, Landing,
Elevator, and Utility Chaseway

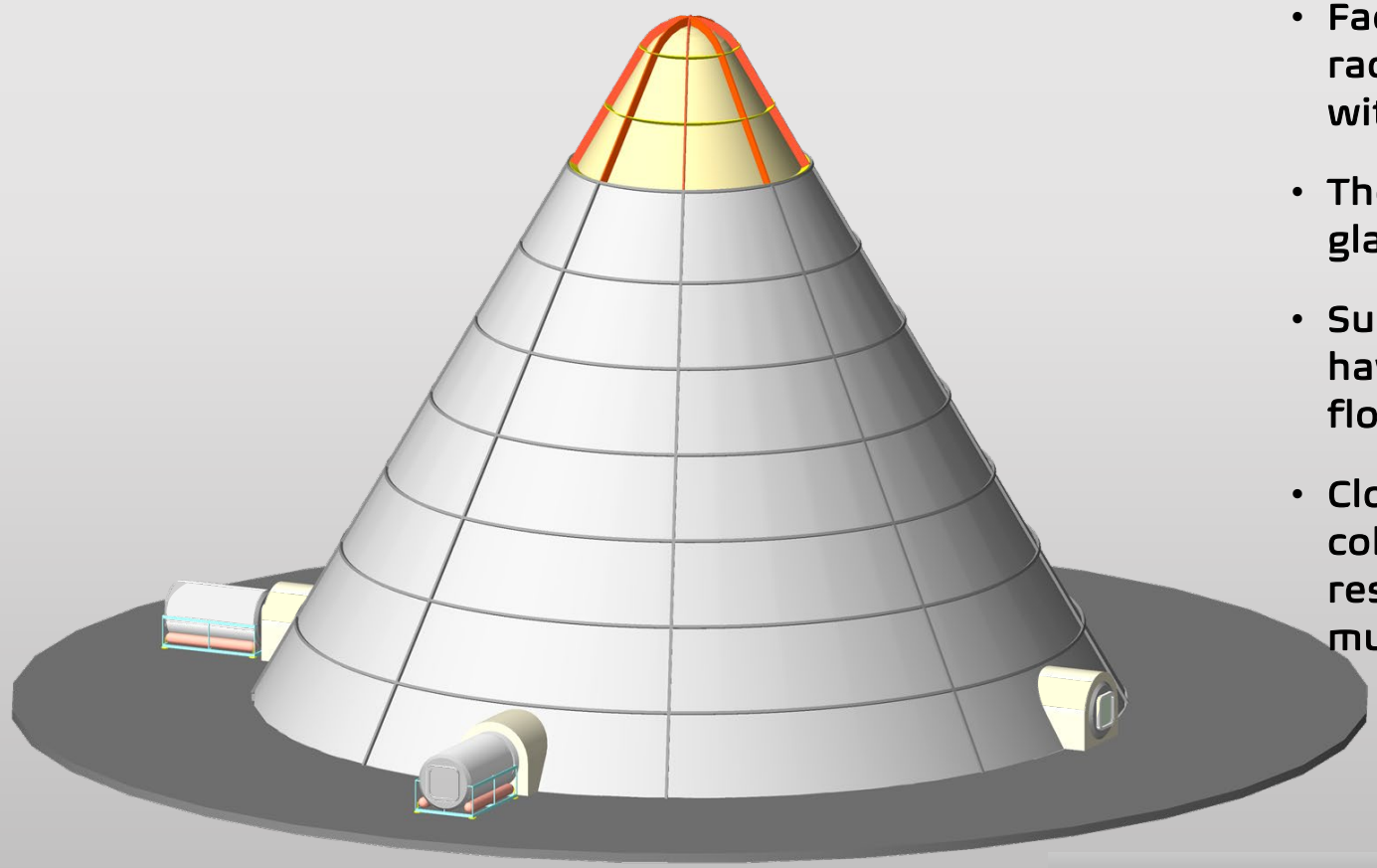






Elevator System and Utility Chaseway are not shown

Surface Architecture
Conical Tower Facility



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- Each tower will be tailored to each unique customer-driven requirements, functionality, characteristics, and size.
- Facility shell wall uses a dual-wall design to reduce radiation exposure to human while living and working within the facility.
- The dome tops have the option of being solid or with glazing.
- Surface towers can be multi-level, scalable diameter, and have thousands usable square feet of living and working floor space.
- Close proximity to proposed commercial outposts and colonies enables leveraging of local infrastructure, resources, and services resulting in cross-contracting and mutually synergistic benefits of a robust ecosystem.

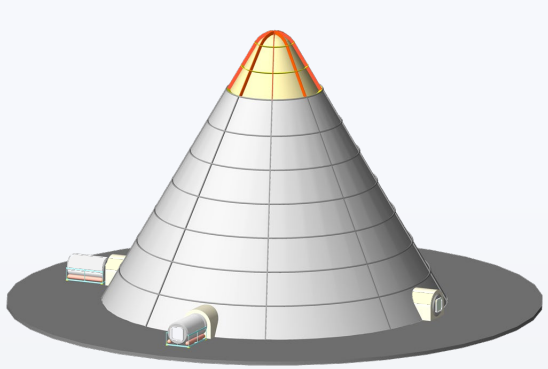
Patent Pending

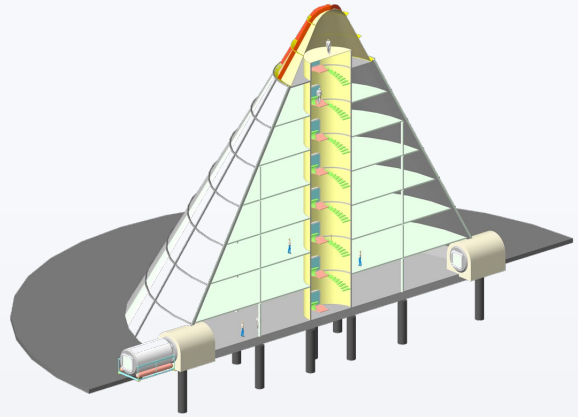
UNITED SPACE STRUCTURES

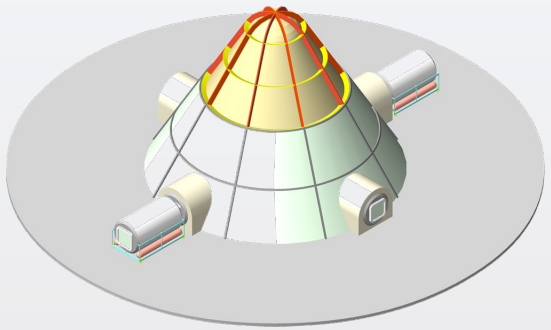
Lunar Surface Tower Facility Concept
Conical Architecture

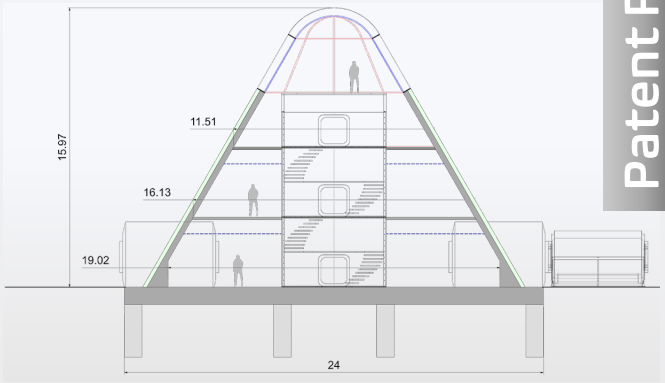
Shape and Scale of Tower Structure:

- Conical “cast-in-place” reinforced lunarcrete structure.
- Internal Operating pressure ~14.7 or 10.2 psia
- Independent Pressure Central Core
- ~35.5-meter tall / 116.47 feet
- ~8 Stories/Levels @ 4 m / 13.1’ Top Finish Floor to Top Finish Floor
- 45 meter diameter @ Base / 147.64 feet diameter
- Estimated Tower Dual-Wall thickness: ~ 0.5 m (19.7”)
- Typical Floor Thickness: 0.16 m (6 inches)
- Bulkhead Floor Thickness: 0.33 m (13 inches)
- Total Floor Area = 5,400 m2 total (58,125 SF)
  - Floor Area varies per Floor



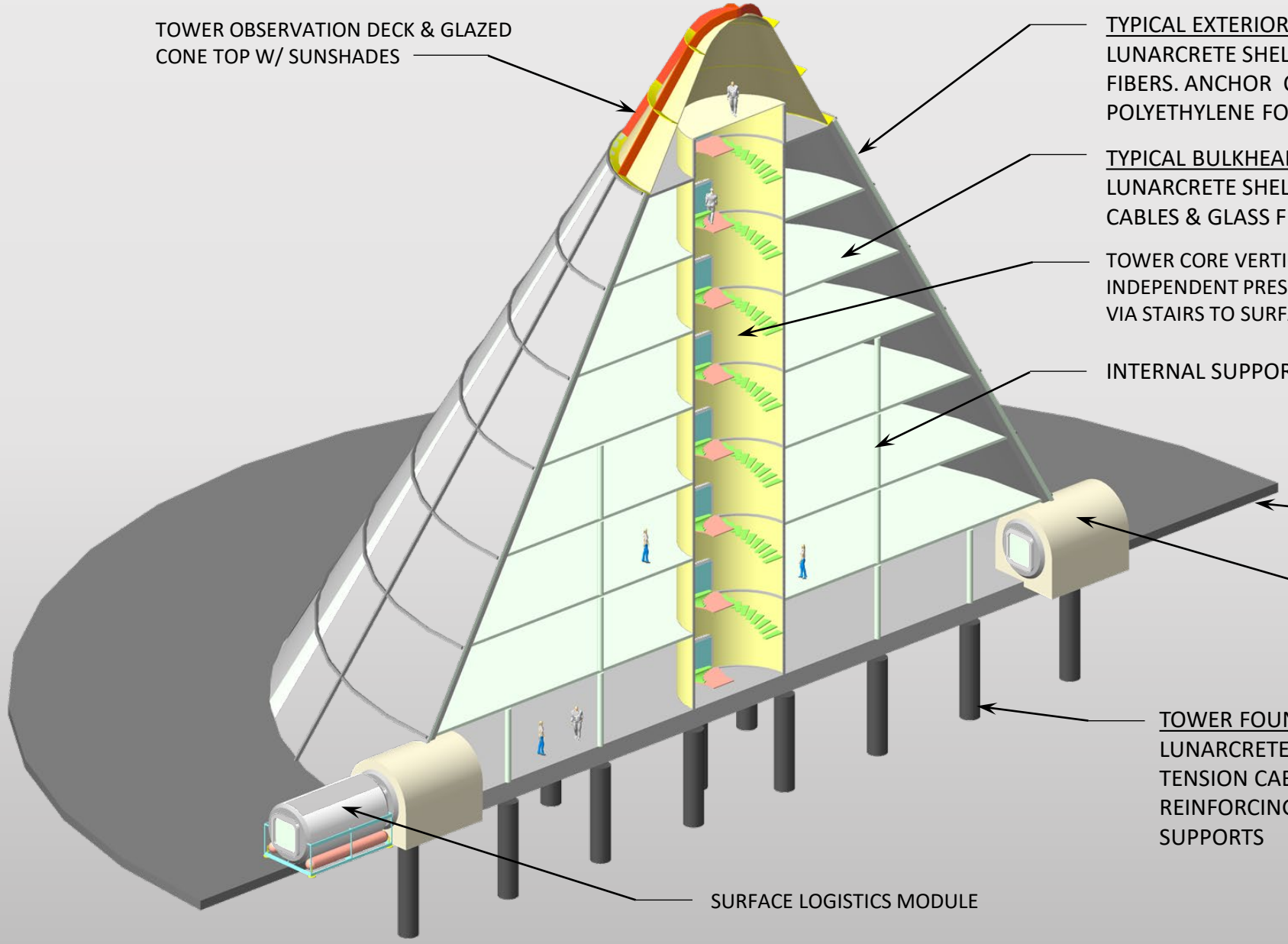






Patent Pending

Conical Tower 3D Cross Section



TOWER OBSERVATION DECK & GLAZED CONE TOP W/ SUNSHADES

TYPICAL EXTERIOR SHELL WALL:
LUNARCRETE SHELL WALL WITH BASALT REINFORCED TENSION CABLES & GLASS FIBERS. ANCHOR CABLES TO SURFACE. DUAL HULL FILLED WITH TBD (WATER, POLYETHYLENE FOAM, ETC). SPRAY-ON INTERNAL SEALANT/COATING.

TYPICAL BULKHEAD FLOOR SLAB:
LUNARCRETE SHELL FLOOR BULKHEAD WITH HORIZONTAL REINFORCED TENSION CABLES & GLASS FIBERS. TIE TENSION REINFORCING CABLES INTO SHELL WALL.

TOWER CORE VERTICAL ACCESS SHAFT. WILL ACT AS AN INDEPENDENT PRESSURE SHAFT FOR OCCUPANTS TO EGRESS VIA STAIRS TO SURFACE.

INTERNAL SUPPORT COLUMNS AS REQUIRED

ROVER PORT SINTERED PAVED AREA

SURFACE ACCESS: ROVER & LOGISTICS PORT

TOWER FOUNDATION SLAB:
LUNARCRETE FOUNDATION SLAB WITH HORIZONTAL REINFORCED TENSION CABLES & GLASS FIBERS. TIE SHELL WALL VERTICAL REINFORCING CABLES INTO FOUNDATION SLAB WITH GEOPIER SUPPORTS

SURFACE LOGISTICS MODULE

Patent Pending

UNITED SPACE STRUCTURES

Lunar Lava Tube Tower Facility Architecture

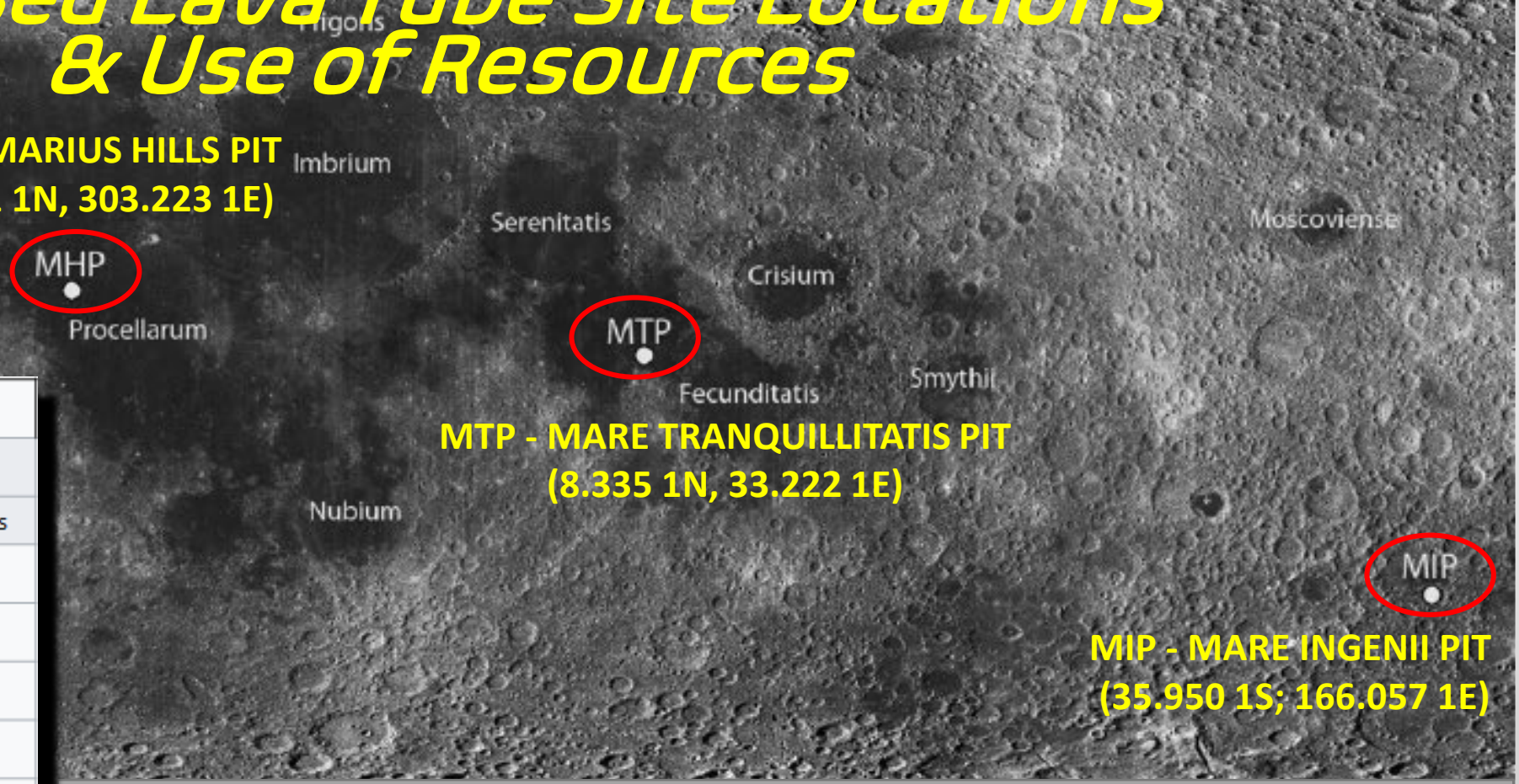
- There are ~62 known lava tubes on the Moon identified from current surface imaging data. Each lunar lava tube is at least a few kilometers long. Our early exploration goals will be to select prospective sites.
- Since the facilities are located within the lava tubes, the dangers of exposure from radiation and meteors is nearly eliminated.
- United Space Structures has patent pending designs of scalable surface tower architectures.
- Each tower will be tailored to each unique customer-driven requirements, functionality, characteristics, and size.
- Facility shell wall uses a waterless Sulfur binder reinforced Lunarcrete.
- The top has a Rover Port for Surface Access.
- Close proximity to proposed commercial outposts and colonies enables leveraging of local infrastructure, resources, and services resulting in cross-contracting and mutually synergistic benefits of a robust ecosystem.

Patent Pending

PRECURSOR TECHNOLOGIES

Proposed Lava Tube Site Locations & Use of Resources

MHP - MARIUS HILLS PIT
(14.091 1N, 303.223 1E)



MTP - MARE TRANQUILLITATIS PIT
(8.335 1N, 33.222 1E)

MIP - MARE INGENII PIT
(35.950 1S; 166.057 1E)

Lunar surface chemical composition[1]

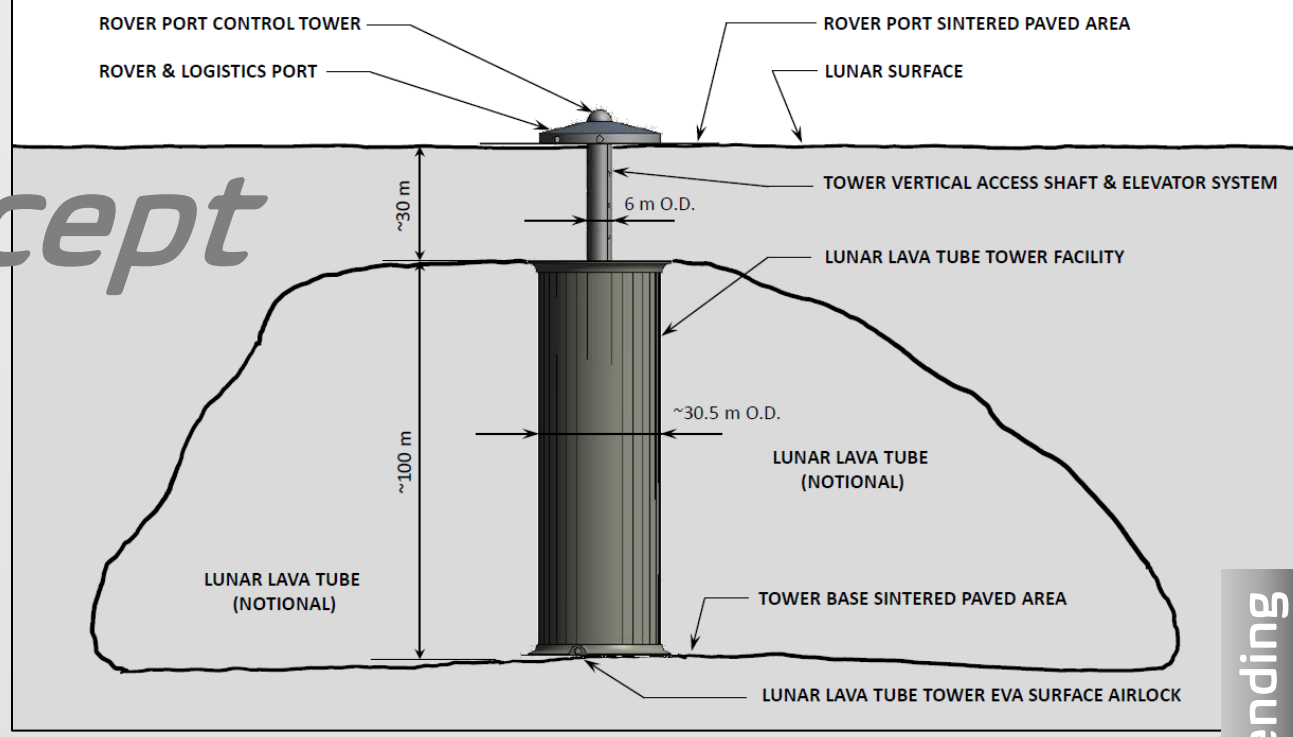
Compound	Formula	Composition	
		Maria	Highlands
silica	SiO_2	45.4%	45.5%
alumina	Al_2O_3	14.9%	24.0%
lime	CaO	11.8%	15.9%
iron(II) oxide	FeO	14.1%	5.9%
magnesia	MgO	9.2%	7.5%
titanium dioxide	TiO_2	3.9%	0.6%
sodium oxide	Na_2O	0.6%	0.6%
		99.9%	100.0%

https://en.wikipedia.org/wiki/Geology_of_the_Moon

From documented papers by Dave McKay, the following set of criteria can be used for selecting the optimum lunar mining site for Al, Si, Ti, Fe, and H2 ores:

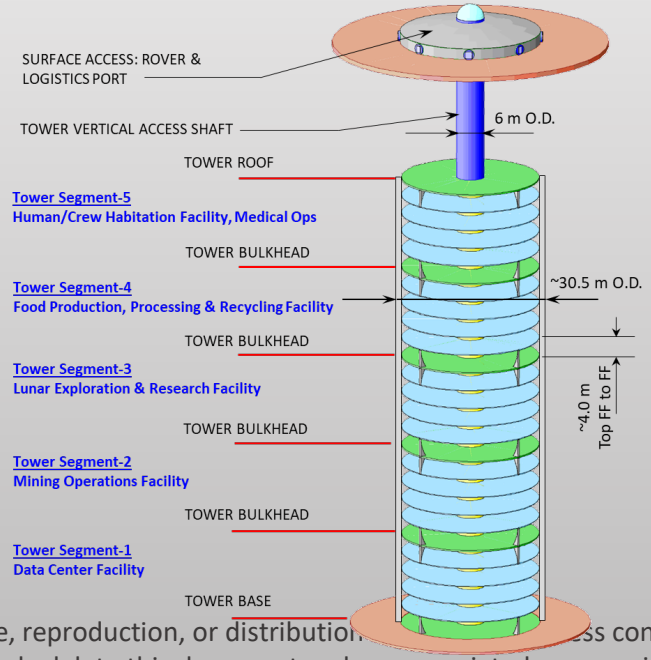
1. The site should be rich in anorthite preferably as rich as the Apollo 16 site
2. The anorthite deposit must consist of relatively immature regolith to increase the amount of available anorthite.
3. The site should also be rich in high TiO2 mare basalt regolith.
4. The mare basalt regolith should be relatively mature to increase the hydrogen content.
5. The site must be flat enough to allow easy surface mining.

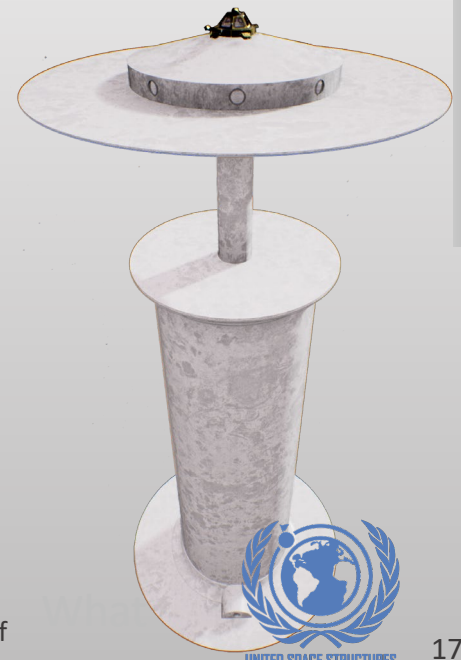
Lunar Lava Tube Tower Facility Concept



Shape and Scale of Tower Structure:

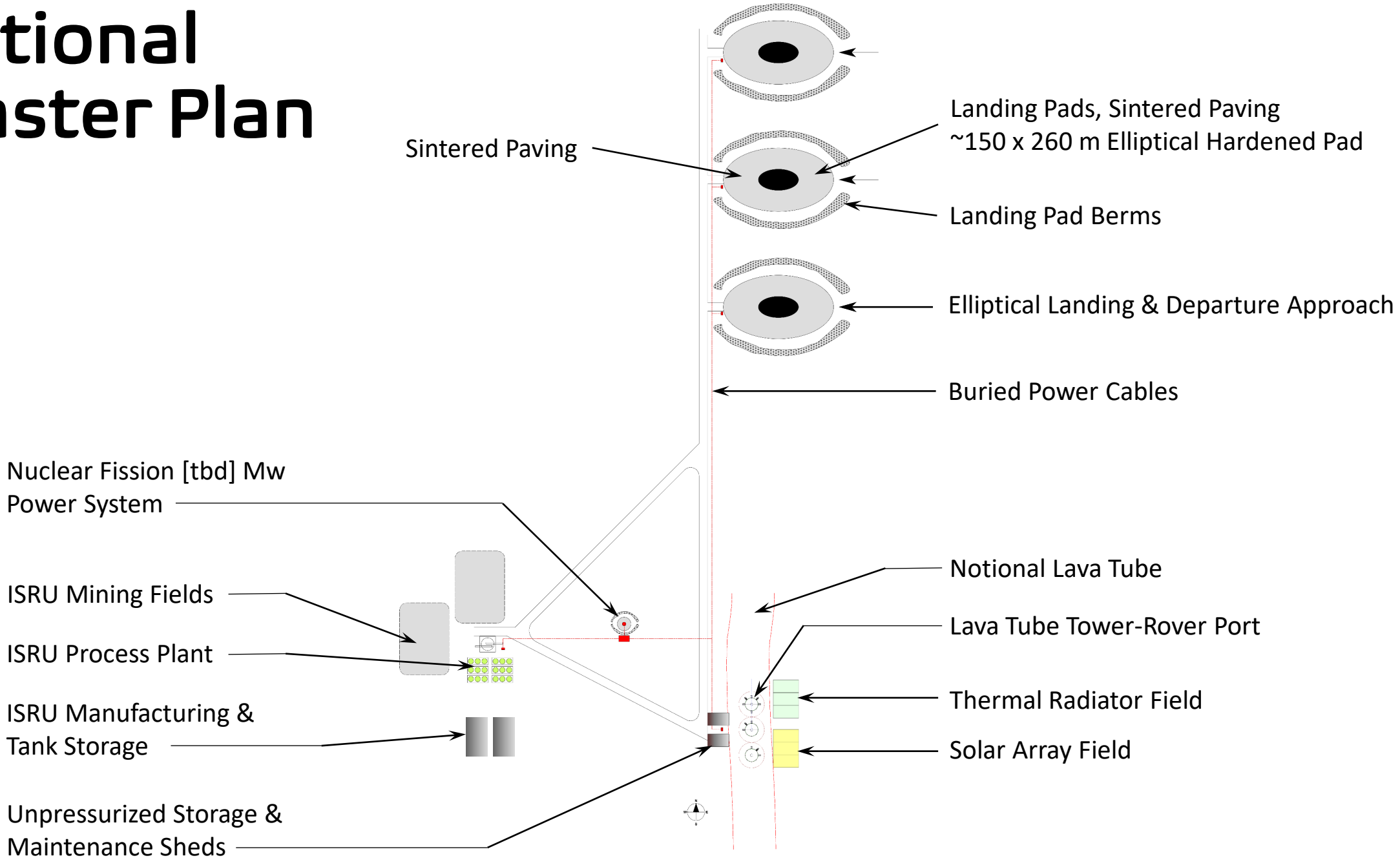
- Cylindrical high-rise cast-in-place reinforced lunarcrete structure.
- Internal Operating pressure 14.7 or 10.2 psia
- Independent Pressure Central Core
- ~100-meter tall / 328 feet
- ~25 Stories/Levels @ 4 m / 13.1' Top Finish Floor to Top Finish Floor
- 30.5 meter diameter / 100 feet diameter
  - (15.25-meter radius / 50.8 feet radius)
- Estimated Tower wall thickness: ~ 0.33 m (13 inches)
- Typical Floor Thickness: 0.16 m (6 inches)
- Bulkhead Floor Thickness: 0.33 m (13 inches)
- Area per Floor = ~699.34 m2 (7,527,5 SF) each floor.
  - Includes core floor area.
- Total Floor Area = x 25 = 17,483.5 m2 total (188,190.8 SF)
  - Includes core floor area.





Patent Pending

Notional Master Plan



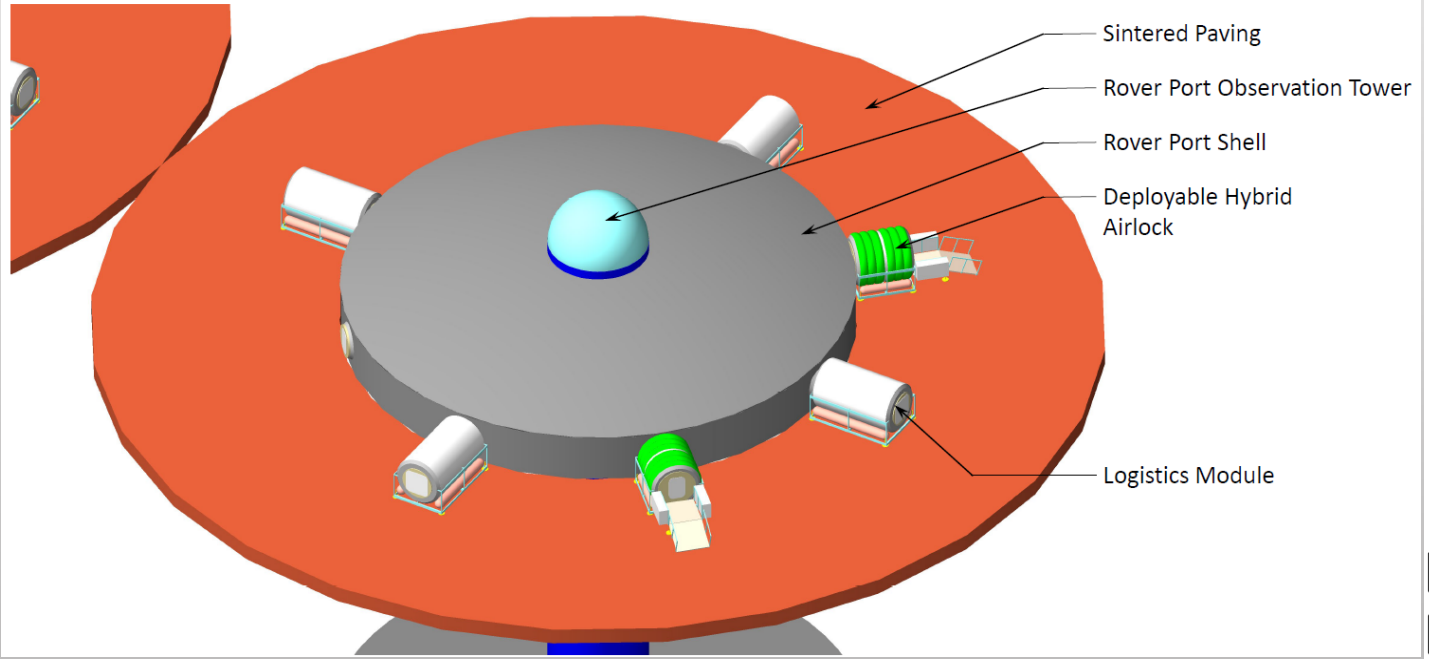
Patent Pending

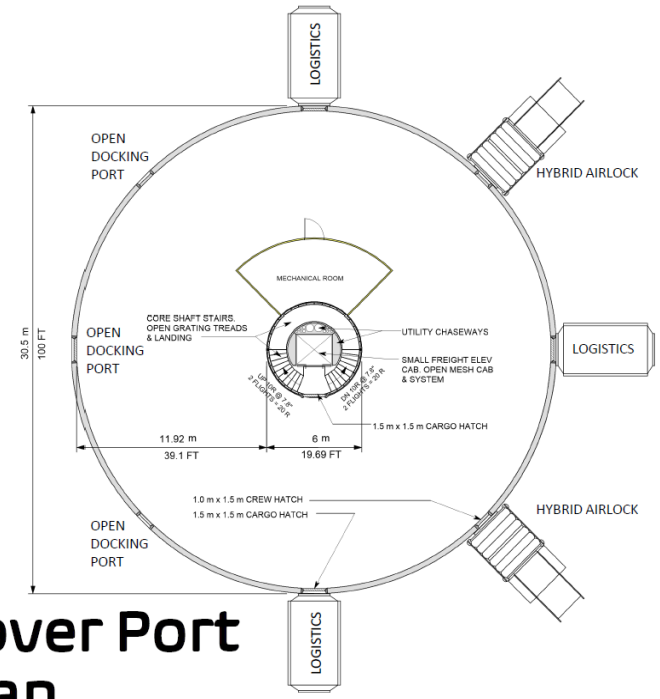
Lunar Lava Tube Tower Facility Rover Port

CGI Images by Precursors Technologies, LLC

Patent Pending

ROVER PORT ARCHITECTURE





Rover Port Plan

Tower Facility Architecture

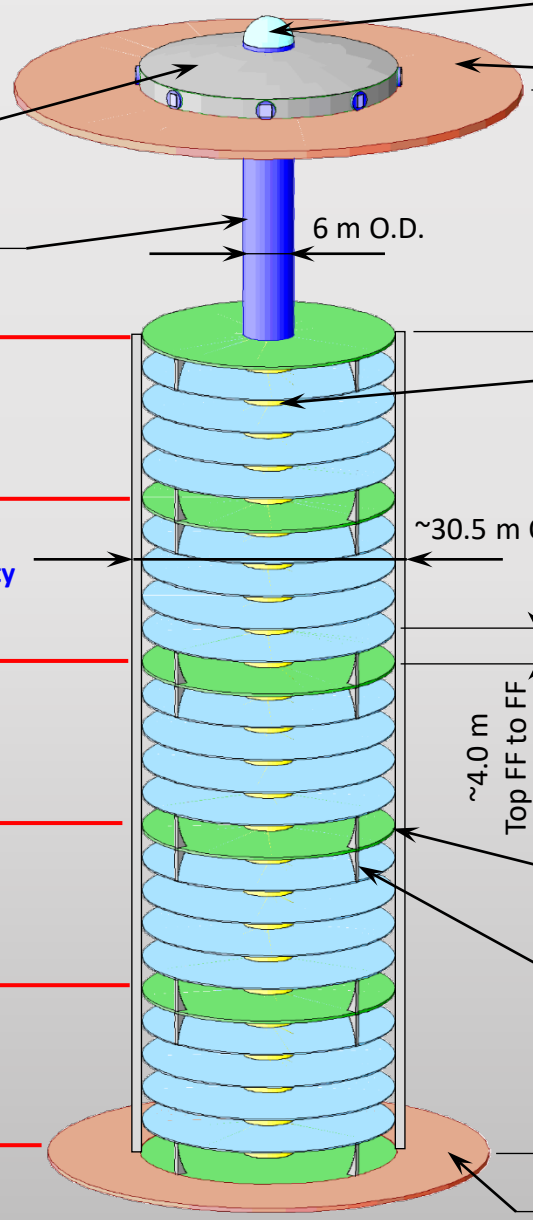
Tower Segment-5
Human/Crew Habitation Facility, Medical Ops

Tower Segment-4
Food Production, Processing & Recycling Facility

Tower Segment-3
Lunar Exploration & Research Facility

Tower Segment-2
Mining Operations Facility

Tower Segment-1
Data Center Facility



ROVER PORT OBSERVATION & CONTROL TOWER

ROVER PORT SINTERED PAVED AREA

TOWER CORE VERTICAL ACCESS SHAFT. WILL ACT AS AN INDEPENDENT PRESSURE SHAFT FOR OCCUPANTS TO EGRESS VIA STAIRS TO SURFACE.

TOWER FLOOR ACTS AS A BULKHEADED TO ENABLE A TOWER SEGMENT TO BE ISOLATED IN CASE OF A PRESSURE BREACH

TOWER FLOOR BULKHEAD INTERNAL SUPPORT BUTTRESS. TBD IF REQUIRED

TOWER BASE SINTERED PAVED AREA

Patent Pending

UNITED SPACE STRUCTURES

Summary

- Space Architecture & Settlement Tipping Point: A Paradigm Shift
- ISRU-Derived Structures using Automated Additive Construction
- Permanent, Earth-Independence, Self-Sustaining
- Robustness, Simplicity, Scalable, Safety
- Bold, Aggressive, Large Scale Real Estate Facilities
- Forcing Function of Technologies, Capabilities, and Services Needed
- Collaboration & Partnerships Opportunities
  - Technology & Architecture/Engineering Opportunities
  - Tentative collaborations w/ 2 robotics companies & 5 universities
- USS, Inc. “crowdfunding” with Netcapital

Fund Phase 1

Architecture beyond Earth

United Space Structures, Inc

https://united-space-structures.com/

TECHNE' Architects, LLC

https://www.techne-architects.com/

Precursor Technologies

https://www.precursortech.net/

Tentative Partnerships & Collaborations

ASTROBOTIC

HONEYBEE ROBOTICS

SPACEX

USOS-LI

SPACE INDUSTRIES

TEXAS A&M UNIVERSITY

UNIVERSITY OF CENTRAL FLORIDA 1963

SCHOOL OF MINES 1874 COLORADO

Microsoft

Google

aws

Berkeley UNIVERSITY OF CALIFORNIA

healthyworkplaces AN INTERDISCIPLINARY CENTER