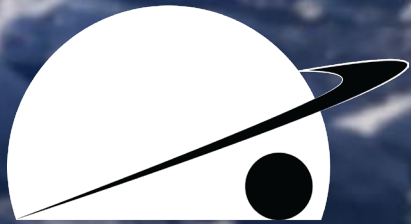


2023 HUMANS TO MARS SUMMIT

CIVIL ENGINEERING AND CONSTRUCTION ON THE MOON AND MARS

May 16-18, 2023

The National Academy of Sciences Building
Washington D.C



ASTROPORT

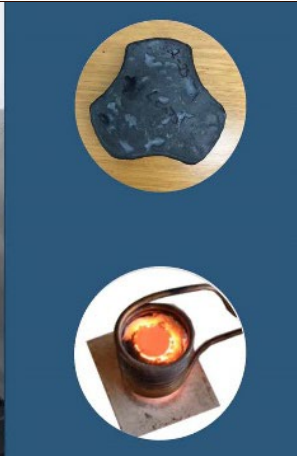
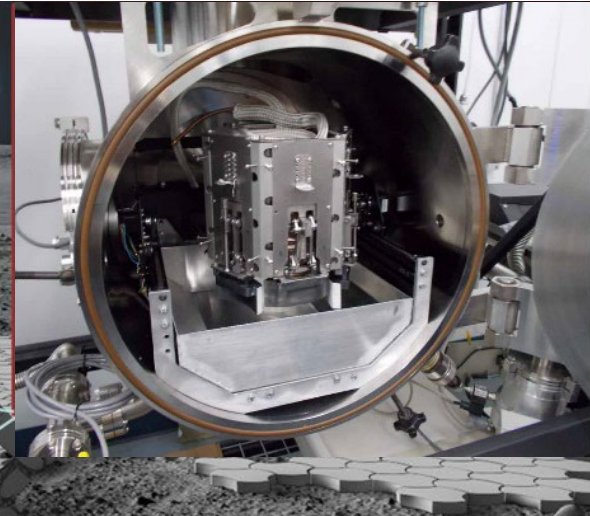
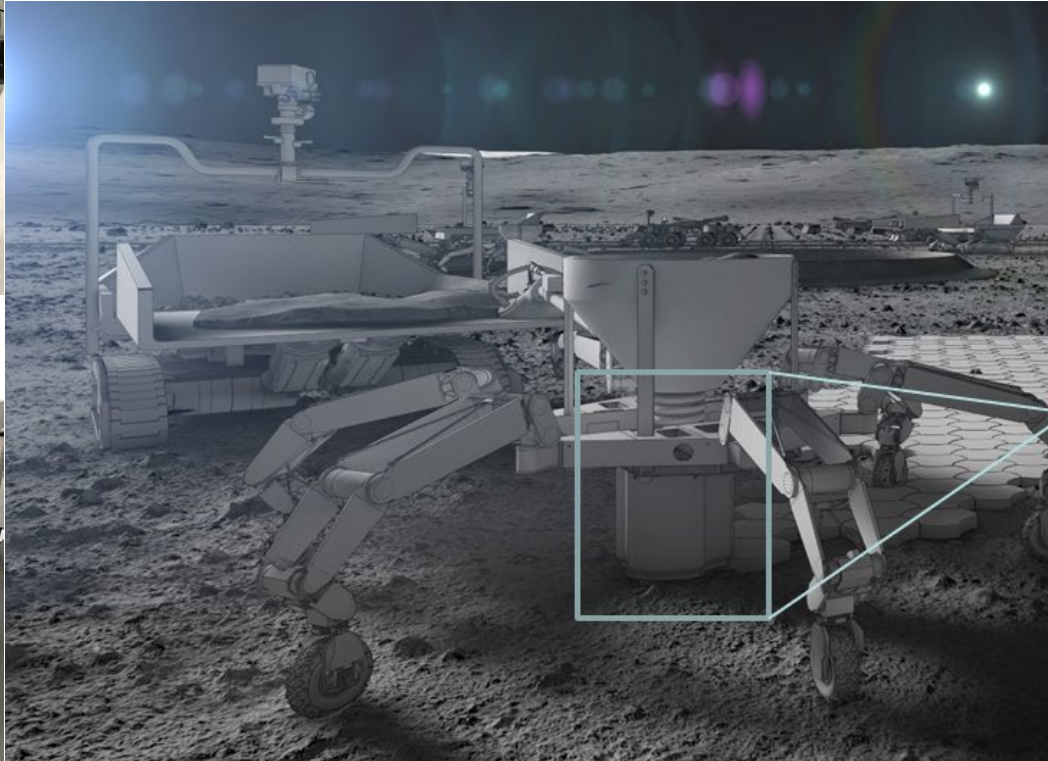
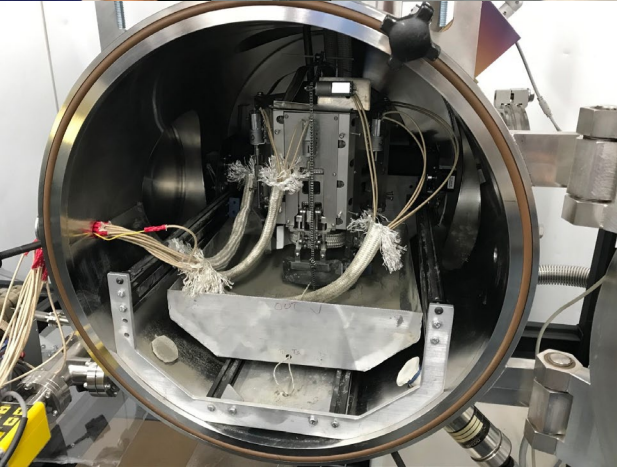
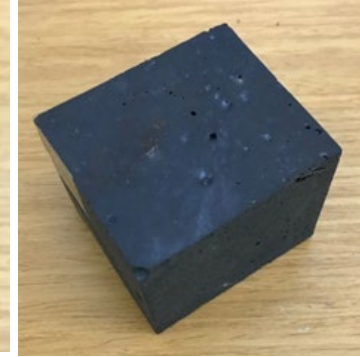
SPACE TECHNOLOGIES

Sam Ximenes, Space Architect

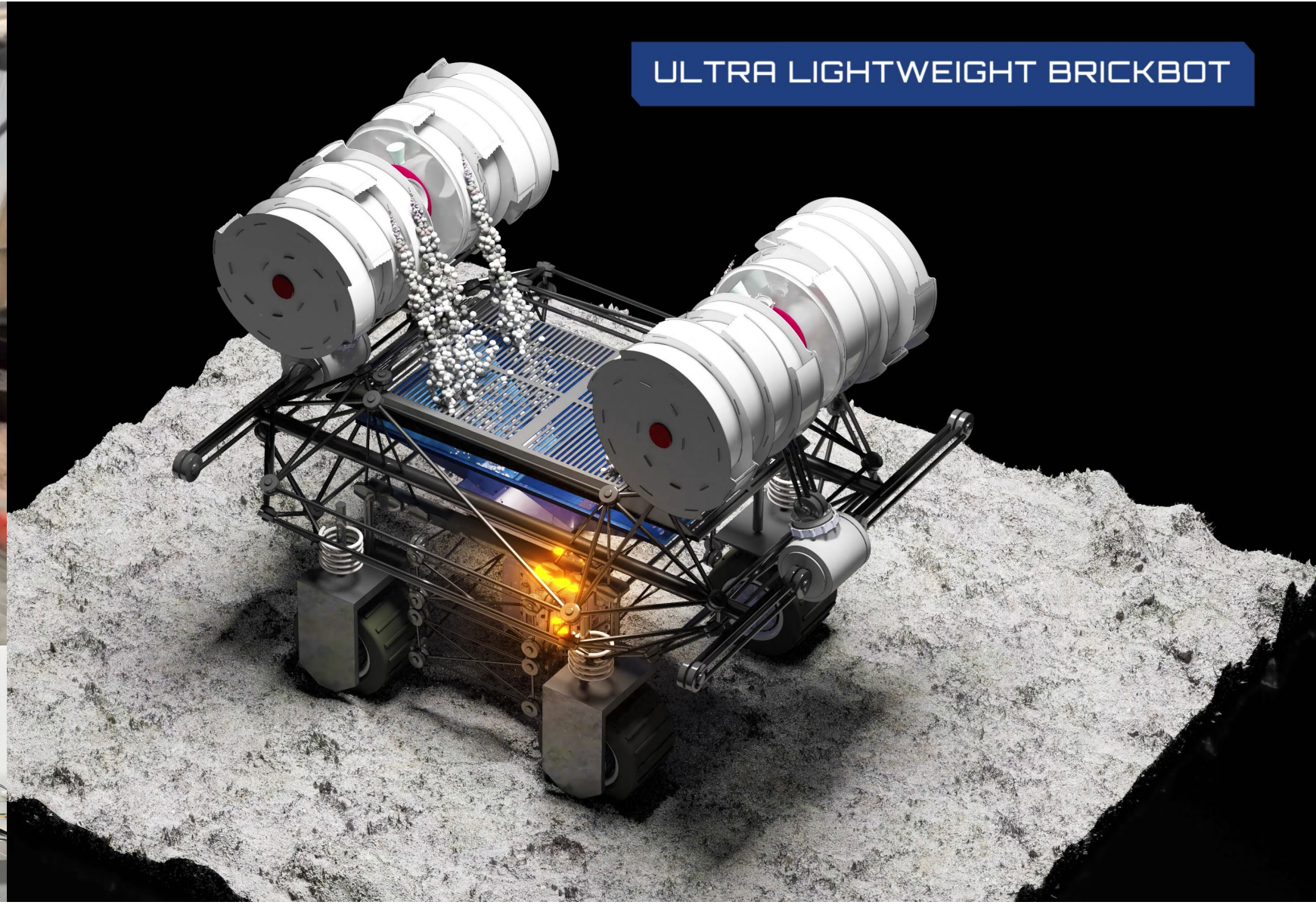
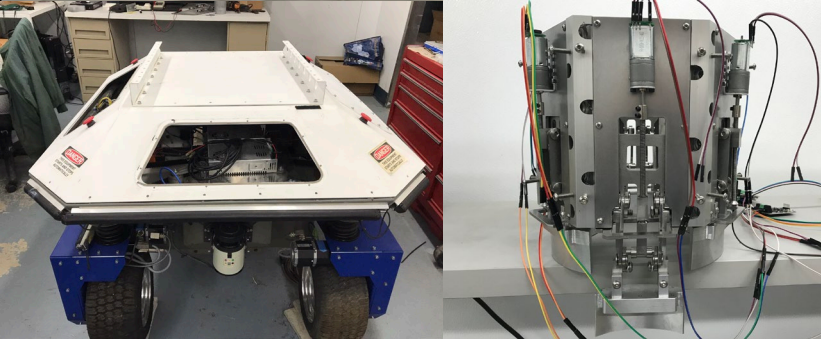
TANGRAM 3DS



MAKING BRICKS FOR LANDING PAD SURFACE



BRICKBOT CONCEPT



TECHNOLOGY TRL ROADMAP

2021

SYSTEM DESIGN

- CONCEPT DESIGN OF CORE SYSTEM ELEMENTS

TRL4

2022

SYSTEM PROTOTYPE

- STTR PH. 1 (COMPLETED)
- BRICK PRODUCED IN LAB ENVIRONMENT

TRL5

2024

BRICKBOT GROUND TEST UNIT

- LUNAR PROVING GROUNDS
- BRICKS PRODUCED IN TESTBED ENVIRONMENT

TRL6

2027

BRICKBOT SURFACE DEMO UNIT

- TECH DEMO MISSION
- IN-SITU BRICKS PRODUCED IN OPERATING ENVIRONMENT

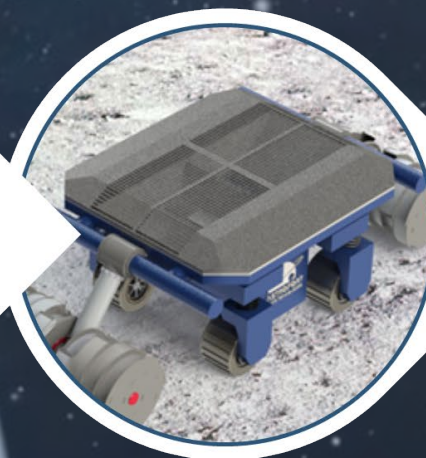
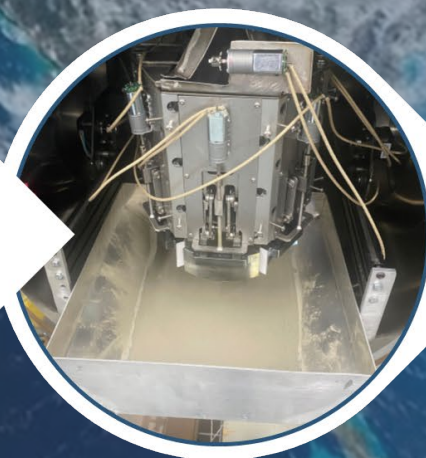
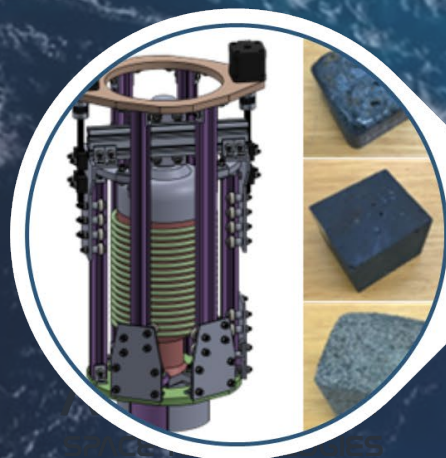
TRL7

2030+

LUNATRON™ OPERATING SYSTEM

- FULLY OPERATIONAL SYSTEM
- COMMENCE CONSTRUCTION OF LLP

TRL9





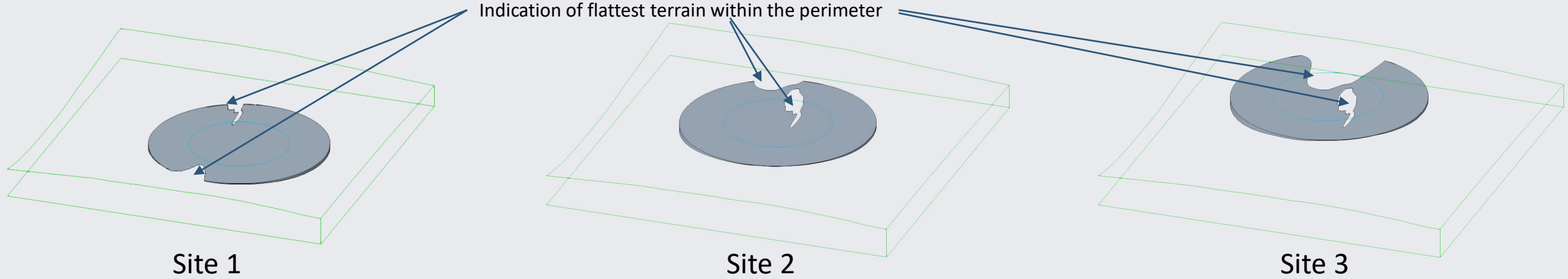
SITE PREPARATION AND CONSTRUCTION





SCALE OF BULK REGOLITH CONVEYANCE

95th percentile male

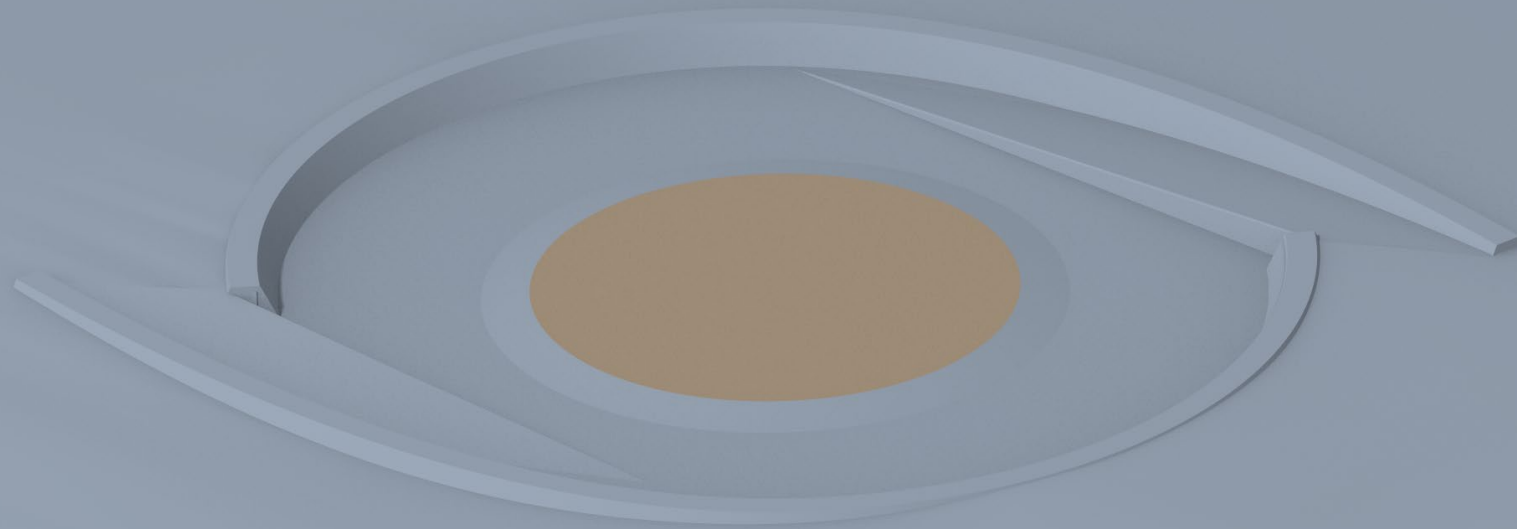
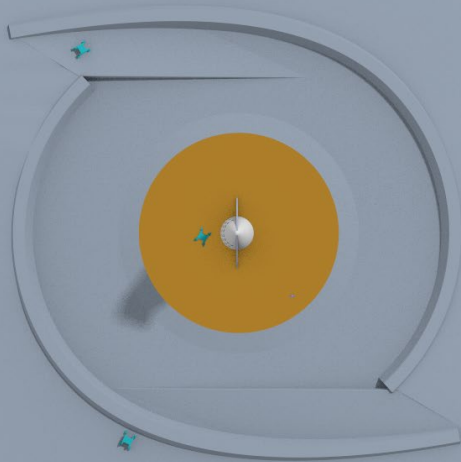
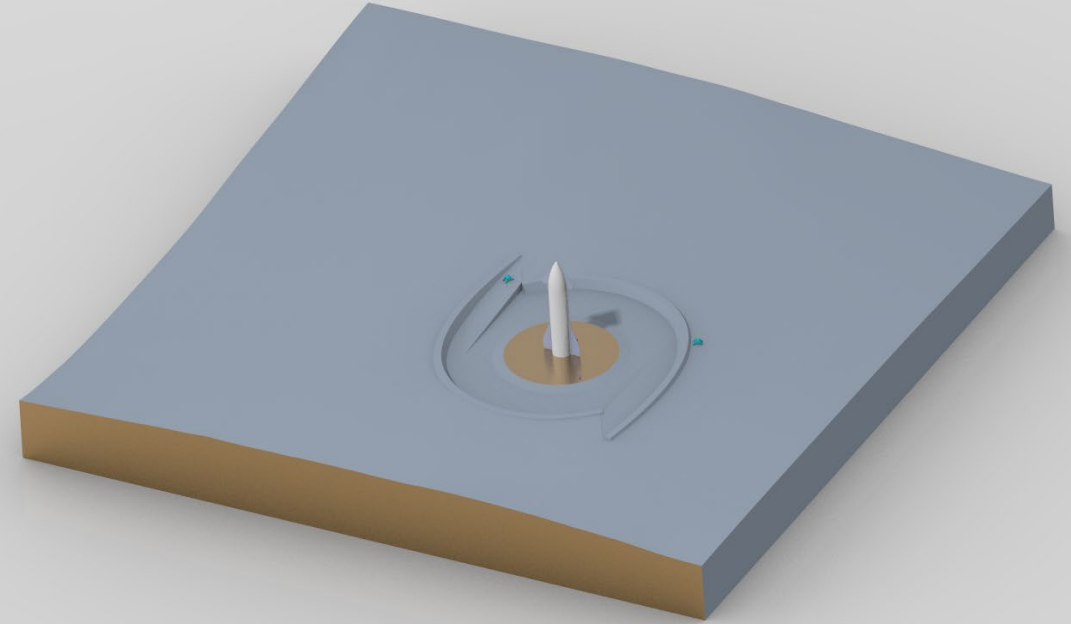
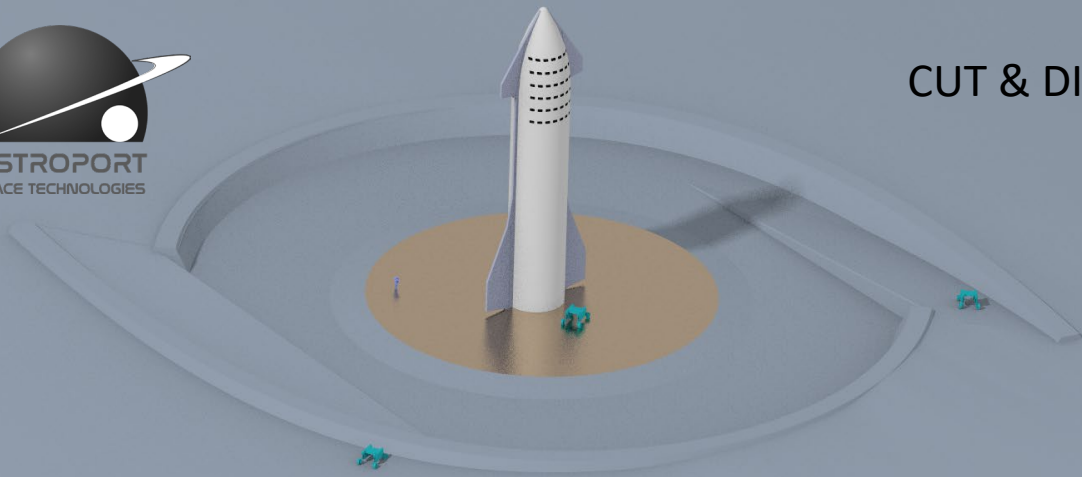


26,353 m³

32,707 m³

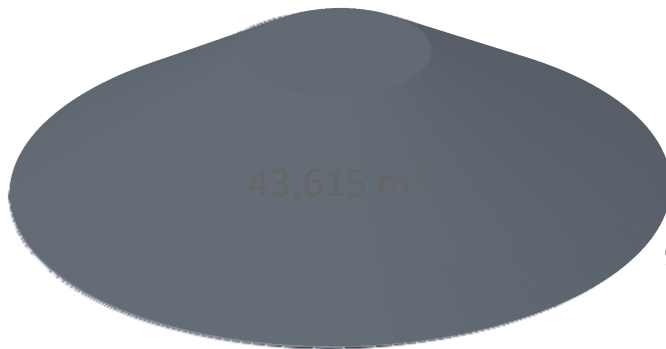
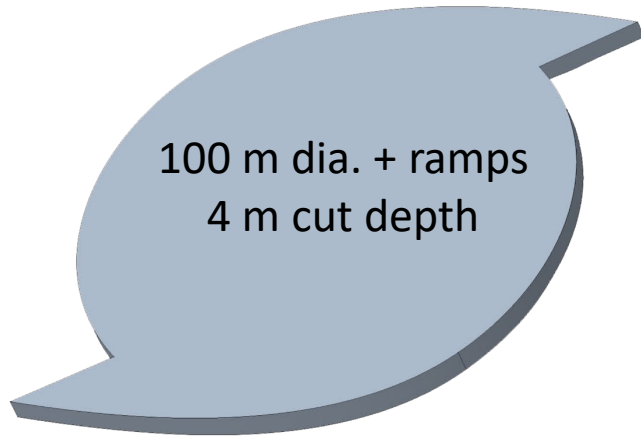
33,967 m³

CUT & DIG



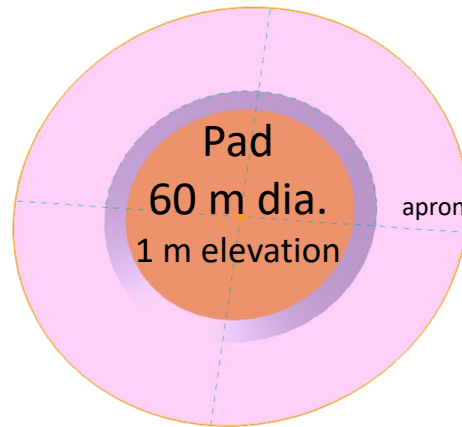
VOLUME SUMMARY – LEVELING BY CUT & DIG

LLP Site Prep Area (Cut Volume)



95th percentile male

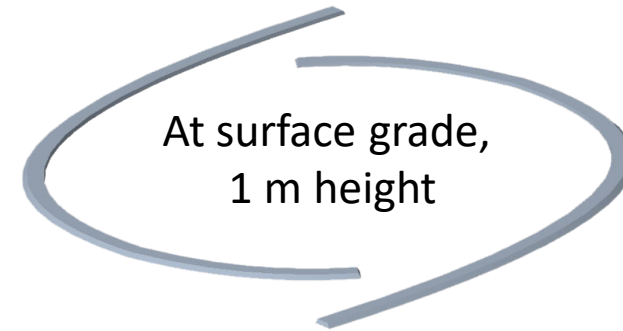
LLP



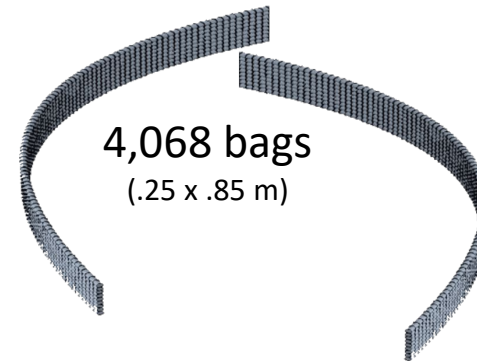
Apron 20 m radius
Volume is TBD (surface material is TBD)
Area 5,027 m²



Berms (Regolith or RegoPacs)



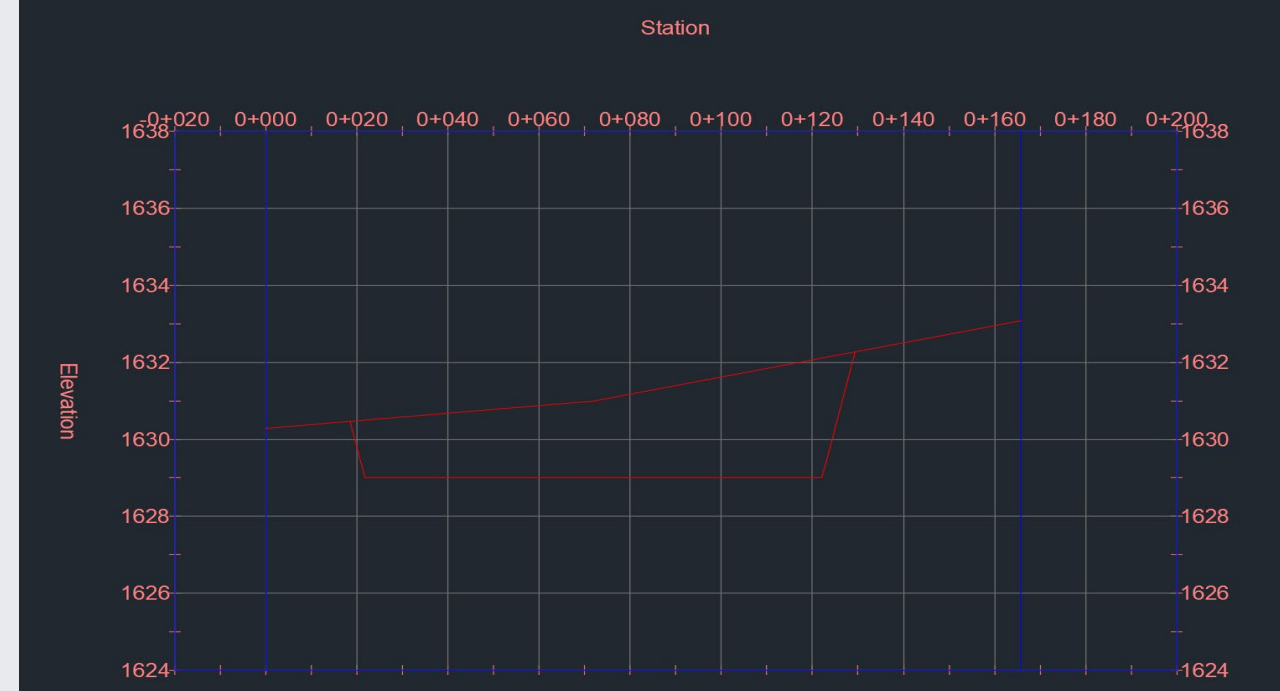
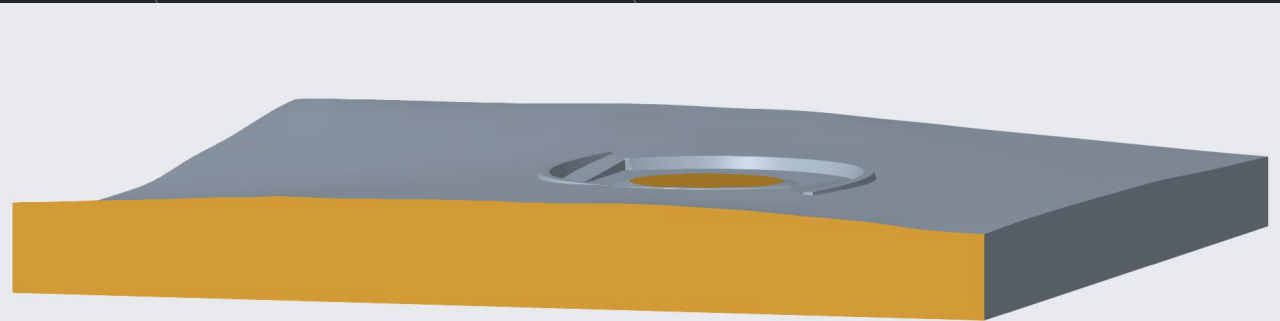
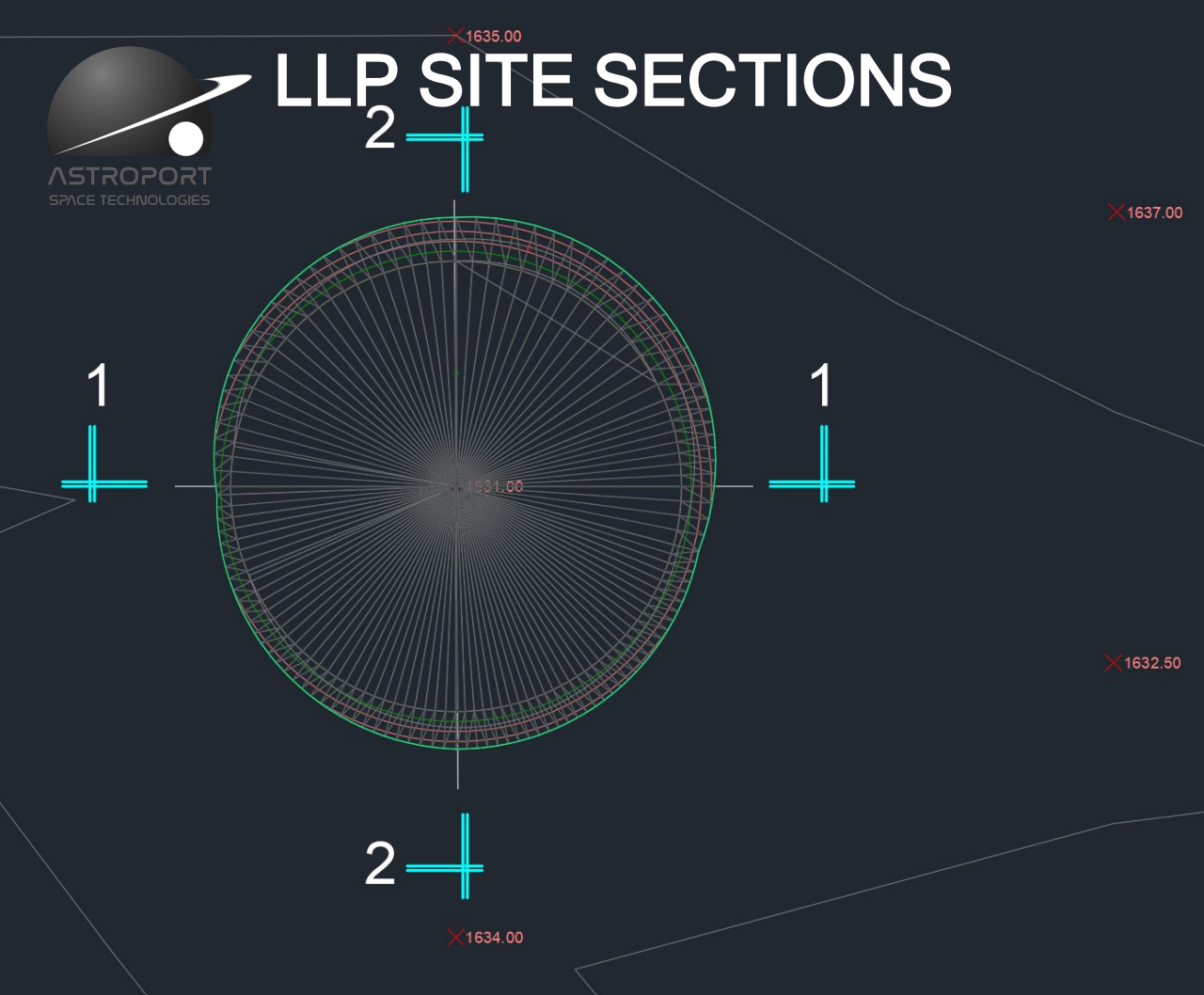
RegoPac Walls



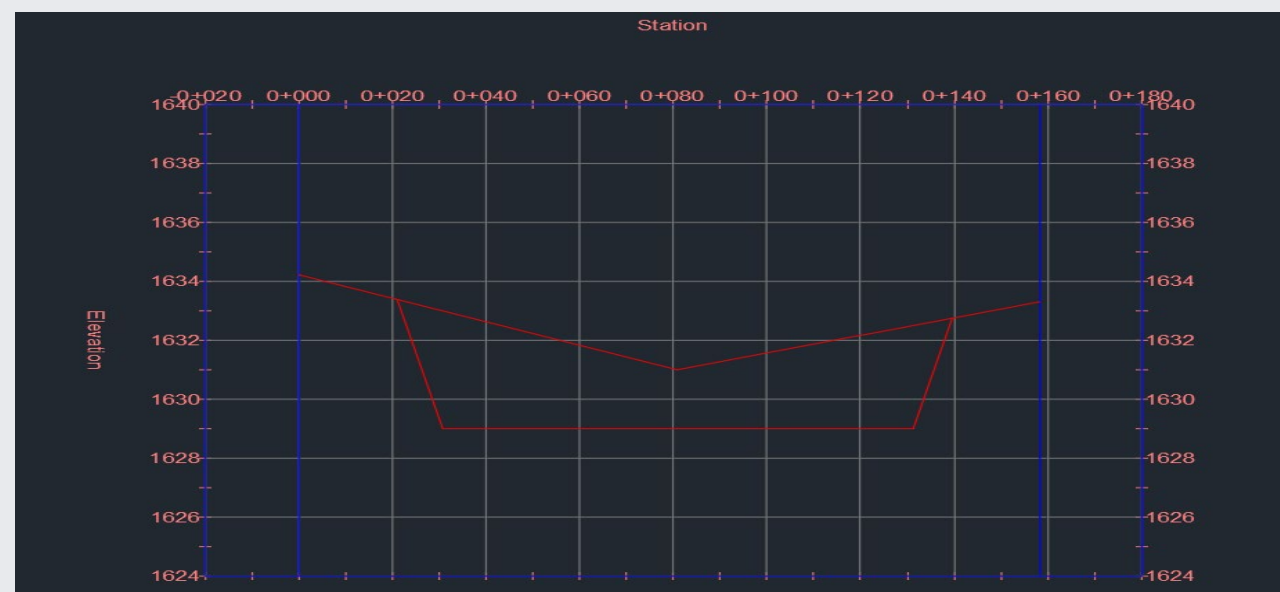
Total Volume = 47,600 m³



LLP SITE SECTIONS



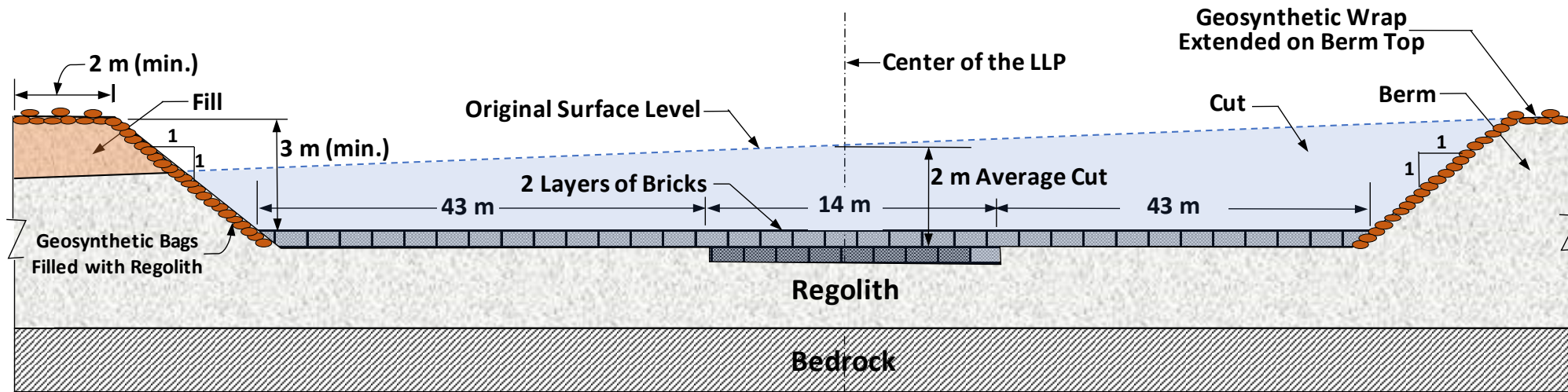
Total cut volume: 26,533 Cu.m.



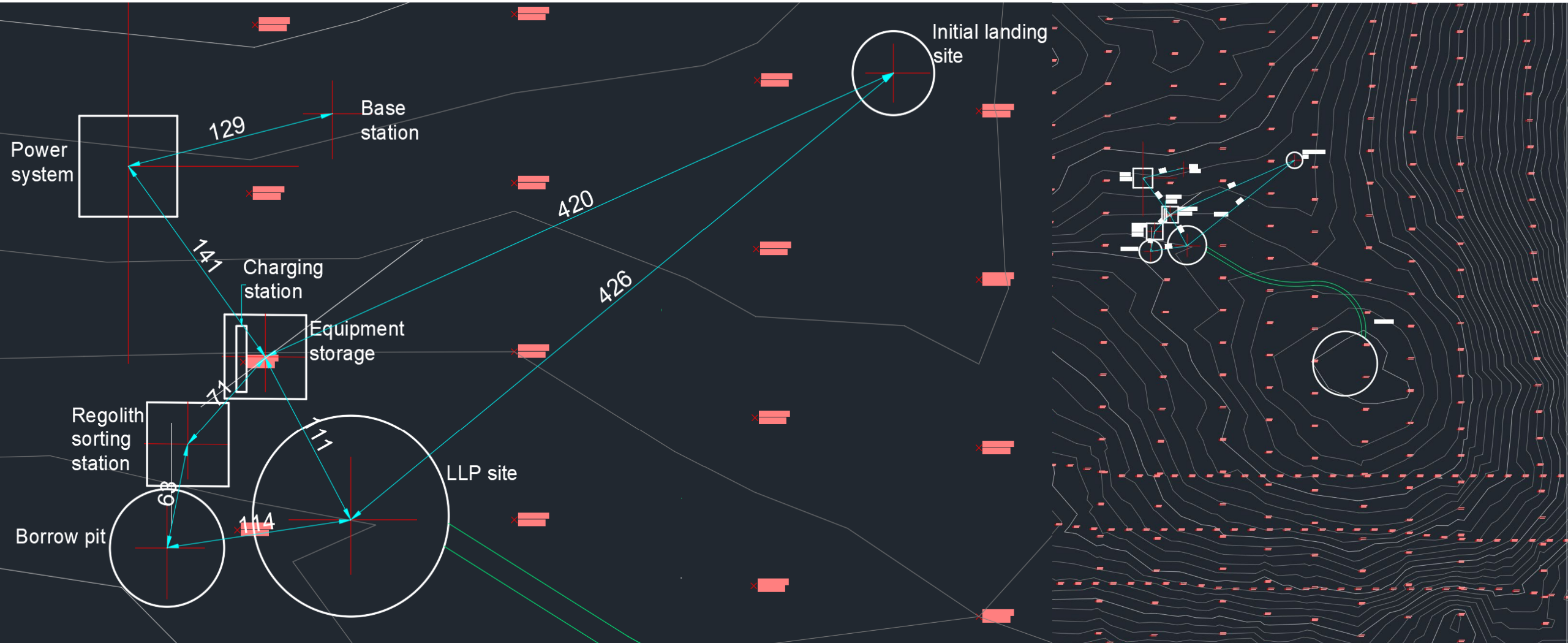
GEOTECHNICAL CONSIDERATIONS

REGOLITH GEOTECHNICAL PROPERTIES FOR SITE PREPARATION & EXCAVATION

Particle Size Distribution	Shear Strength
Particle Shapes	Permeability and Diffusivity
Specific Gravity	Bearing Capacity
Bulk Density and Porosity	Slope Stability
Relative Density	Trafficability
Compressibility	Bedrock Depth



SITE LAYOUT



DEVELOPING THE CONOPS

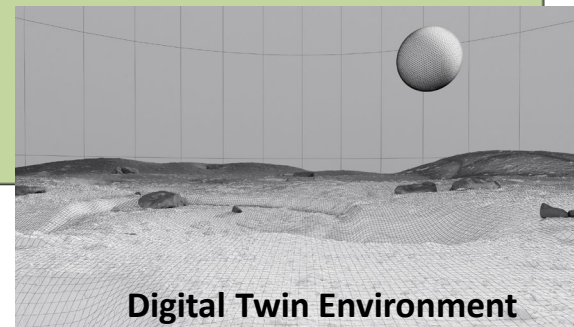
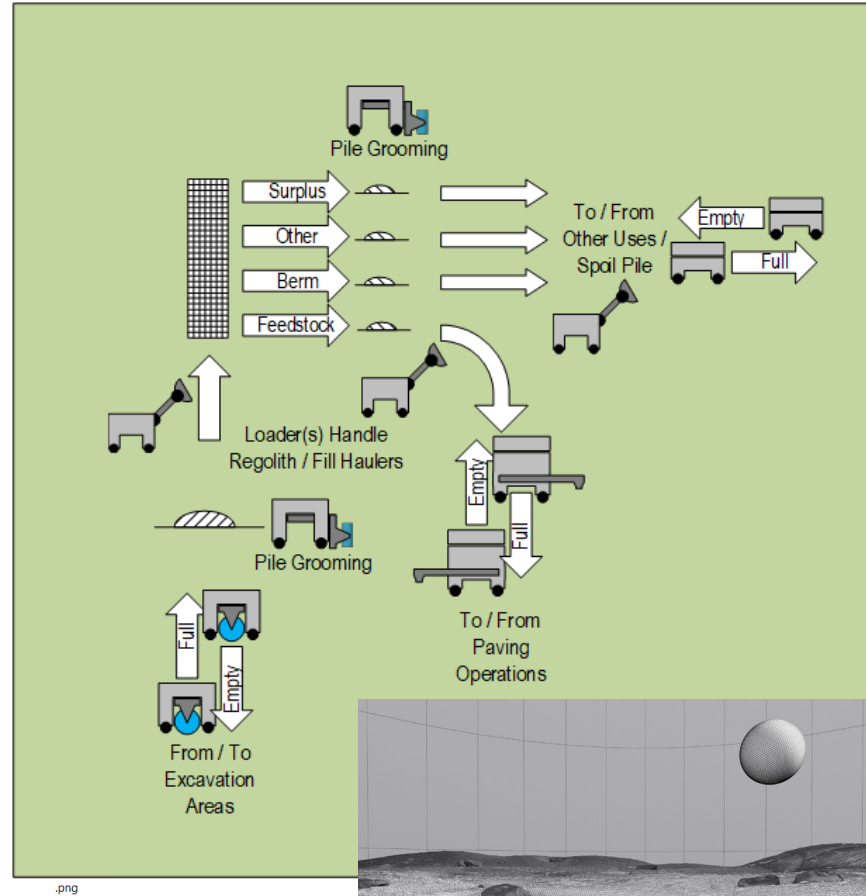
Equip asset Db with engineering parameters

Table 1 - Notional equipment complement

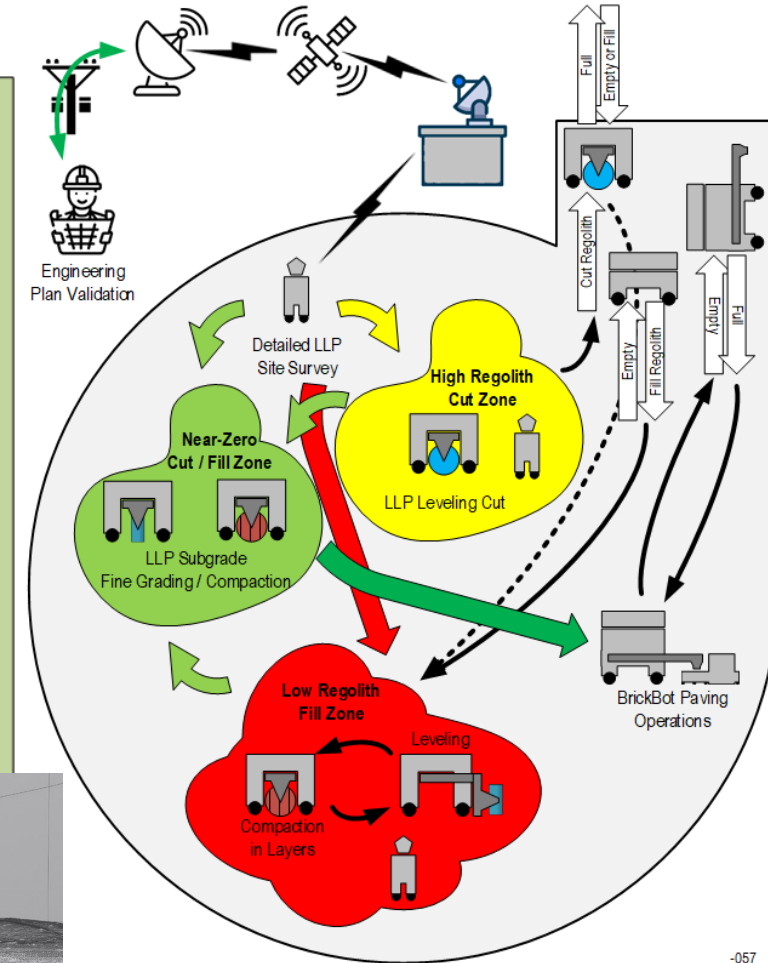
Item	Type	#	Comments
Site lighting assembly	Relocatable item	8	May not be required
Base Station	Free standing item	1	Provides communications center, link to space
Power System	Free standing assembly	1	Includes deployed elements, e.g., solar array, radiator
Equipment shelter	Free-standing enclosure	1	Protection from ejecta, deep space, sun, etc.
Crusher	Free standing item	1	Crush large rocks
Screening machine	Free standing item	1	Separate regolith by size
Bag filling machine	Free standing item	0	Benefit / feasibility analysis in progress
General Mobility Machine (GMM)	Self-moving platform	5	<ul style="list-style-type: none"> Carry equipment to needed locations Provide mobility for attached tools
Surveyor	Small, self-moving platform	1	Continuous, precise site location / elevation surveys
Lifter / Carrier	GMM Attachment	1	<ul style="list-style-type: none"> Forklift for moving equipment Used to relocate non-mobile items
Dexterous Arm	GMM Attachment	1	Used for unscripted tasks
Rock Drill	GMM Attachment	1	Used to perforate large rocks for break
Rock Breaker	GMM Attachment	1	Used to break large rocks for transport
Ripper	GMM Attachment	1	Used to break up tightly bound regolith
Rotating drum excavator	GMM Attachment	3	Self-loading excavation / transportation tool
Excavator, backhoe	GMM Attachment	1	Excavate inaccessible terrain, e.g., crater wall
Scraper	GMM Attachment	0	Self-loading excavation / transportation tool
Trencher	GMM Attachment	1	Trench digging tool, e.g., burying cable
Grader	GMM Attachment	1	Medium regolith moving blade at GMM centerline
Compactor	GMM Attachment	1	Rotating, vibrating drum to compact placed regolith
Bulldozer	GMM Attachment	1	Heavy regolith moving blade at GMM "front"
Loader	GMM Attachment	1	Bucket loader mounted at GMM "front"
Dedicated hauler	Self-moving item	2	Use with excavators, loader, screening / bagging machines, BrickBot
BrickBot	Relocatable item	4	In-place brick manufacturing
Total		38	<ul style="list-style-type: none"> 12 Relocatable 5 Freestanding 8 Self-moving 14 Attachments for GMM

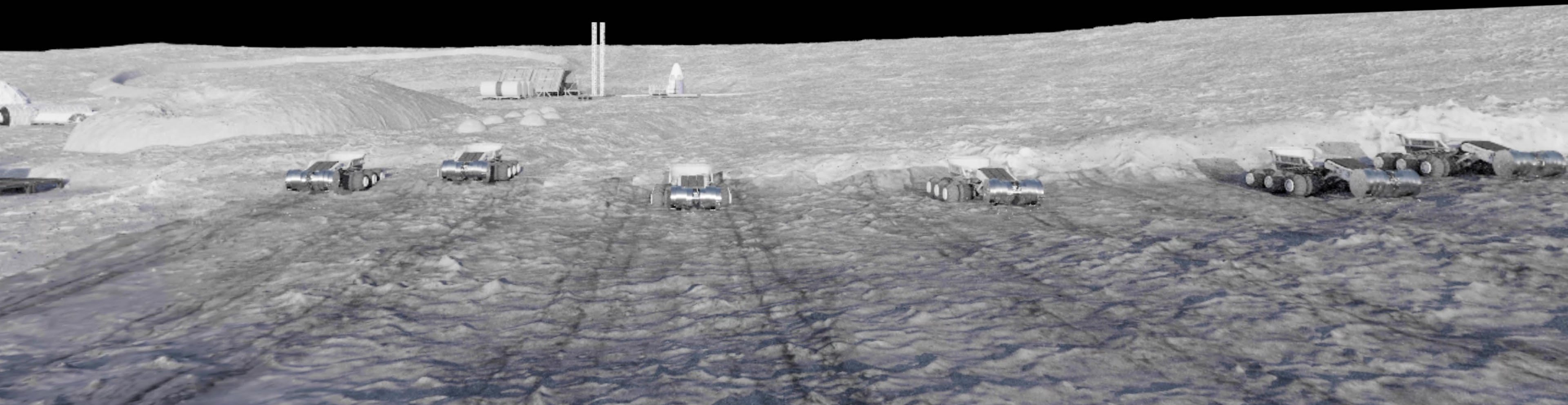
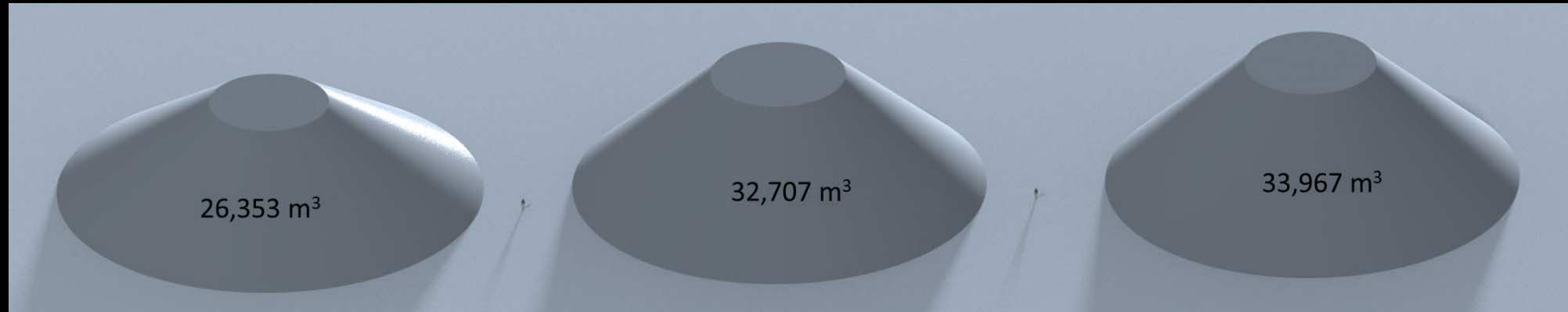


ConOps flow diagrams



Digital Twin Environment





THE MOVEMENT OF BULK REGOLITH FOR PLANETARY SURFACE INFRASTRUCTURE CONSTRUCTION WILL BE A FORMIDABLE UNDERTAKEN