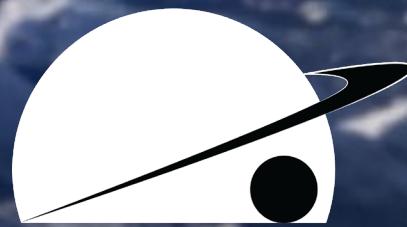


# 2023 HUMANS TO MARS SUMMIT

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

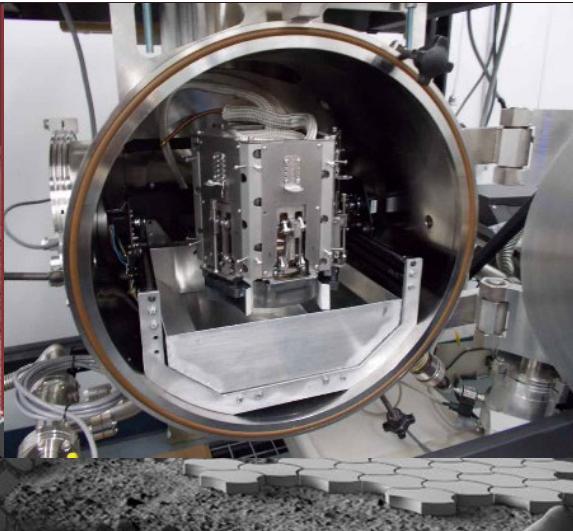
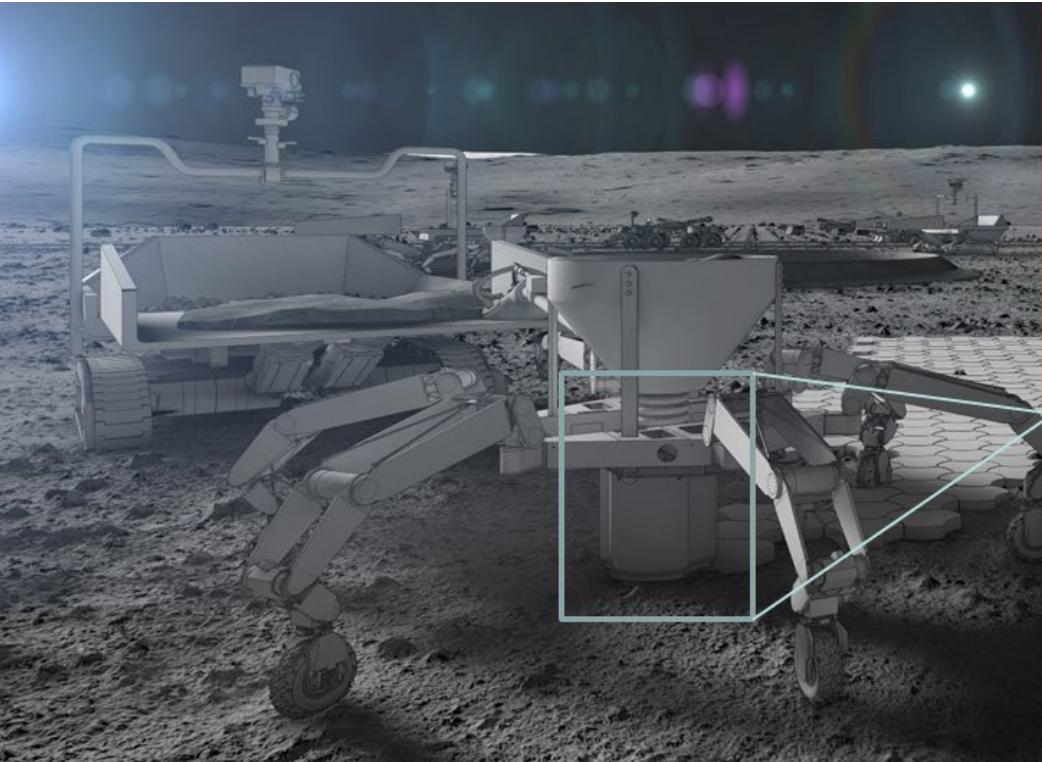
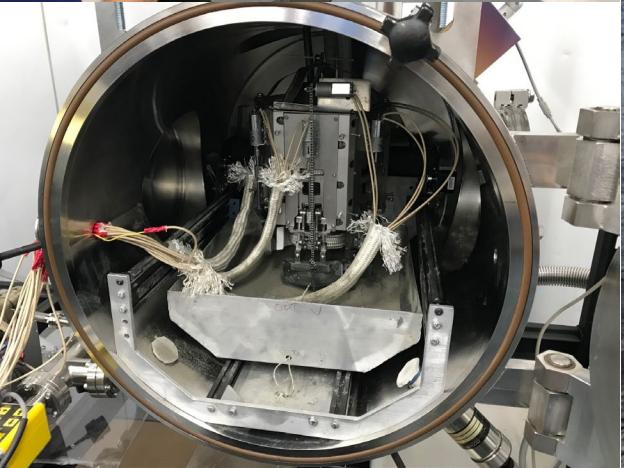


ASTROPORT  
SPACE TECHNOLOGIES



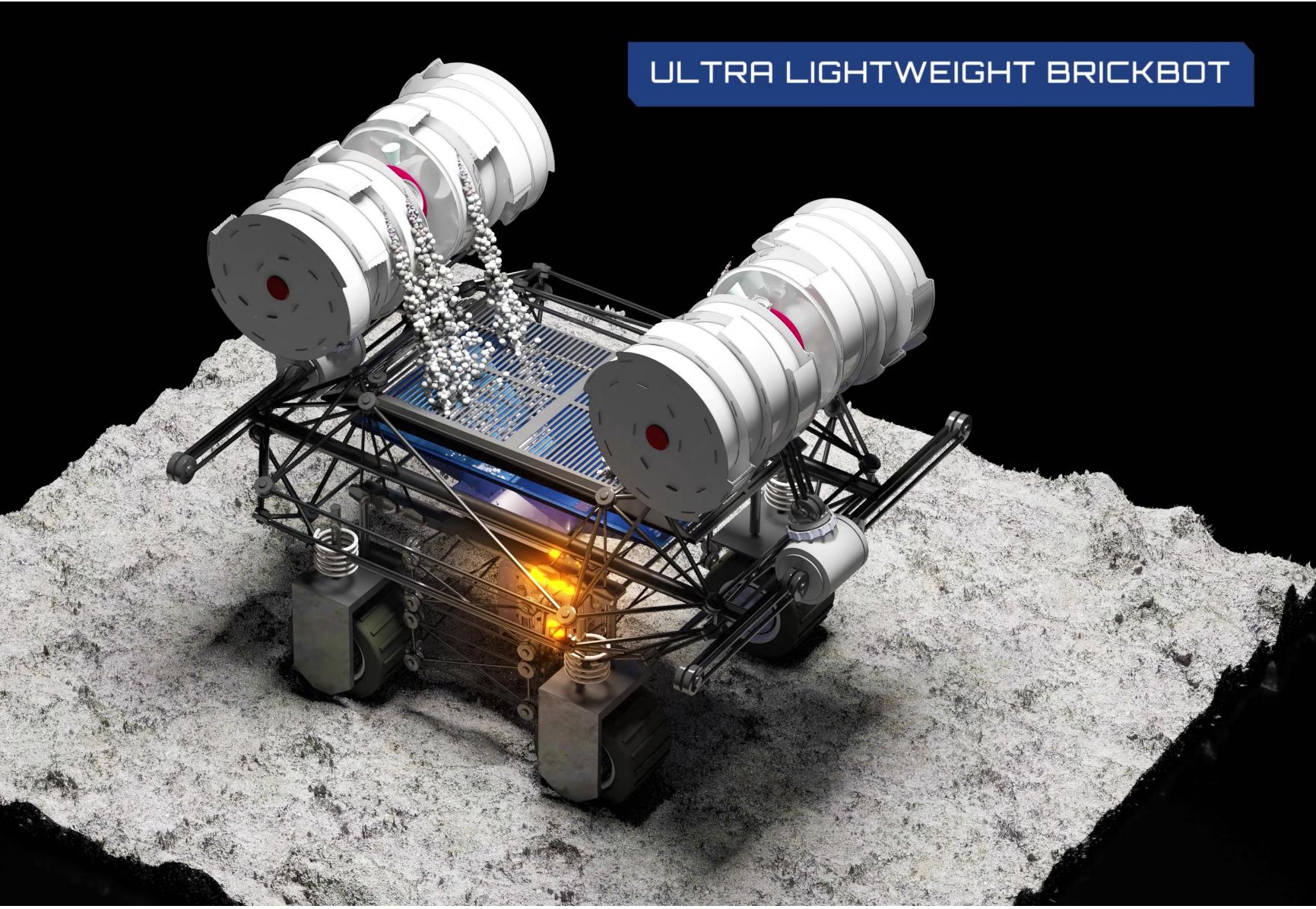
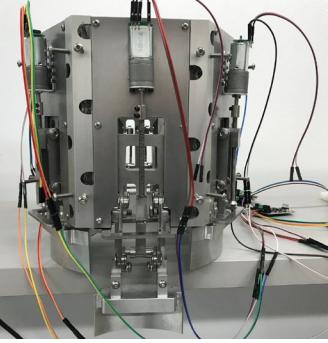
# MAKING BRICKS FOR LANDING PAD SURFACE

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# BRICKBOT CONCEPT



# TECHNOLOGY TRL ROADMAP

2021

SYSTEM  
DESIGN

- CONCEPT DESIGN OF CORE SYSTEM ELEMENTS

2022

SYSTEM  
PROTOTYPE

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

2024

BRICKBOT  
GROUND TEST UNIT

- LUNAR PROVING GROUNDS
- BRICKS PRODUCED IN TESTBED ENVIRONMENT

2027

BRICKBOT SURFACE  
DEMO UNIT

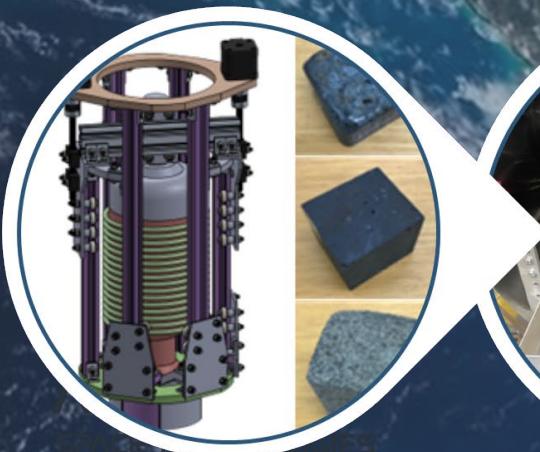
- TECH DEMO MISSION
- IN-SITU BRICKS PRODUCED IN OPERATING ENVIRONMENT

2030+

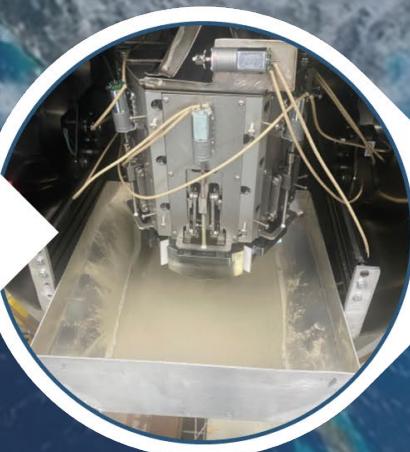
LUNATRON™  
OPERATING SYSTEM

- FULLY OPERATIONAL SYSTEM
- COMMENCE CONSTRUCTION OF LLP

TRL4



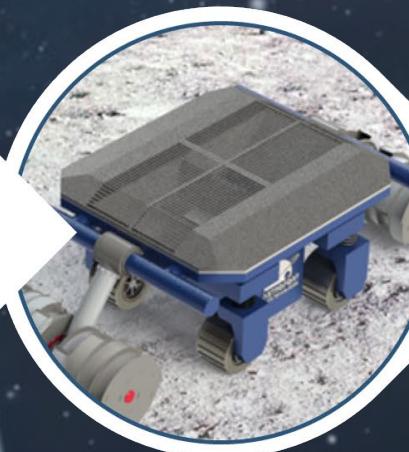
TRL5



TRL6



TRL7



TRL9





# SITE PREPARATION AND CONSTRUCTION



## SCALE OF BULK REGOLITH CONVEYANCE

95<sup>th</sup> percentile male

Indication of flattest terrain within the perimeter

Site 1

26,353 m<sup>3</sup>

Site 2

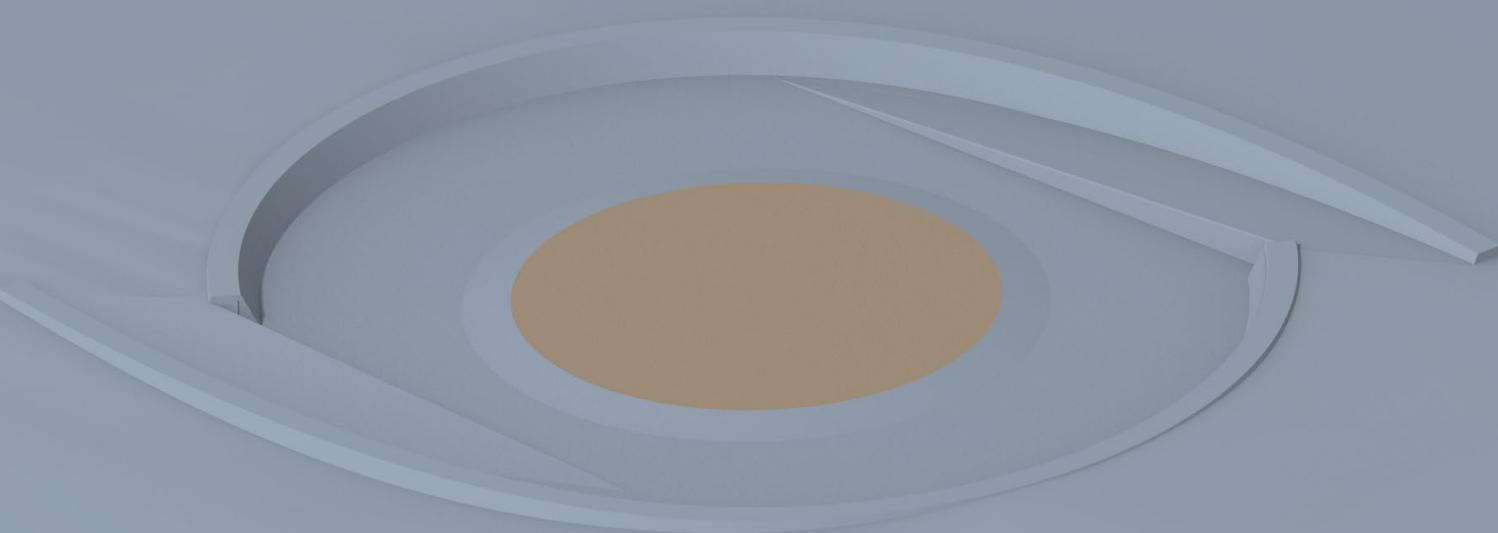
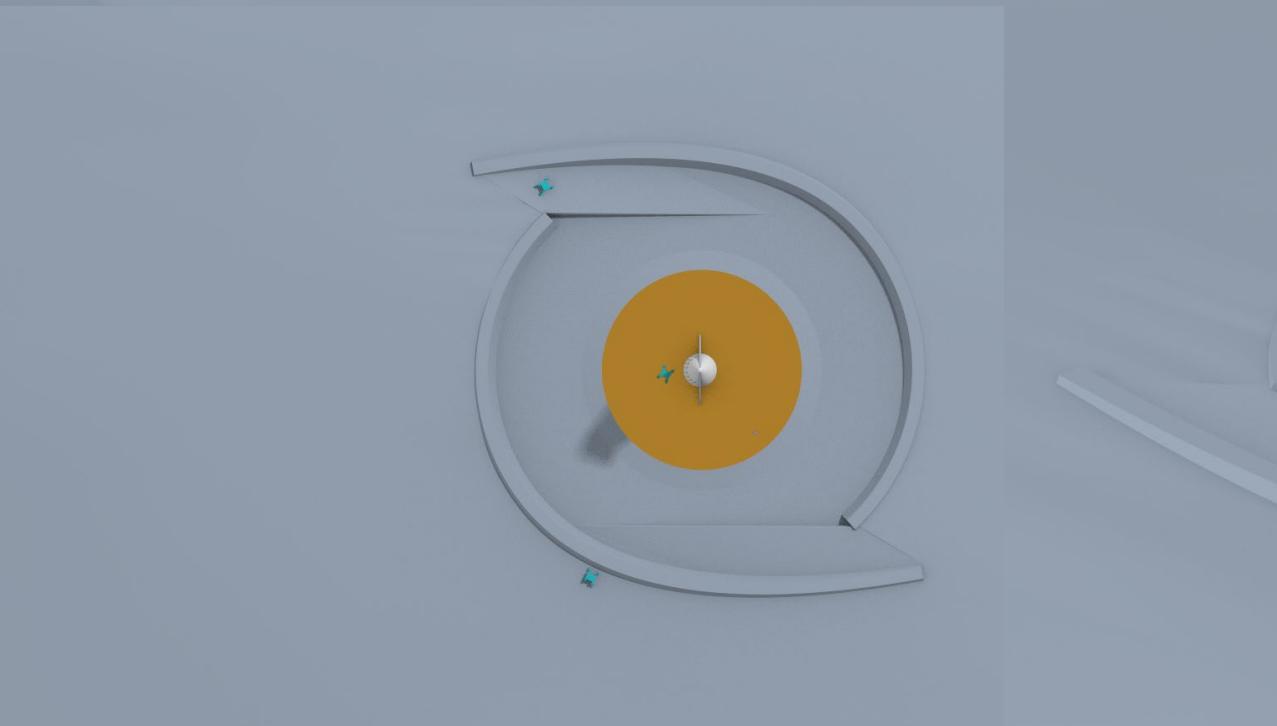
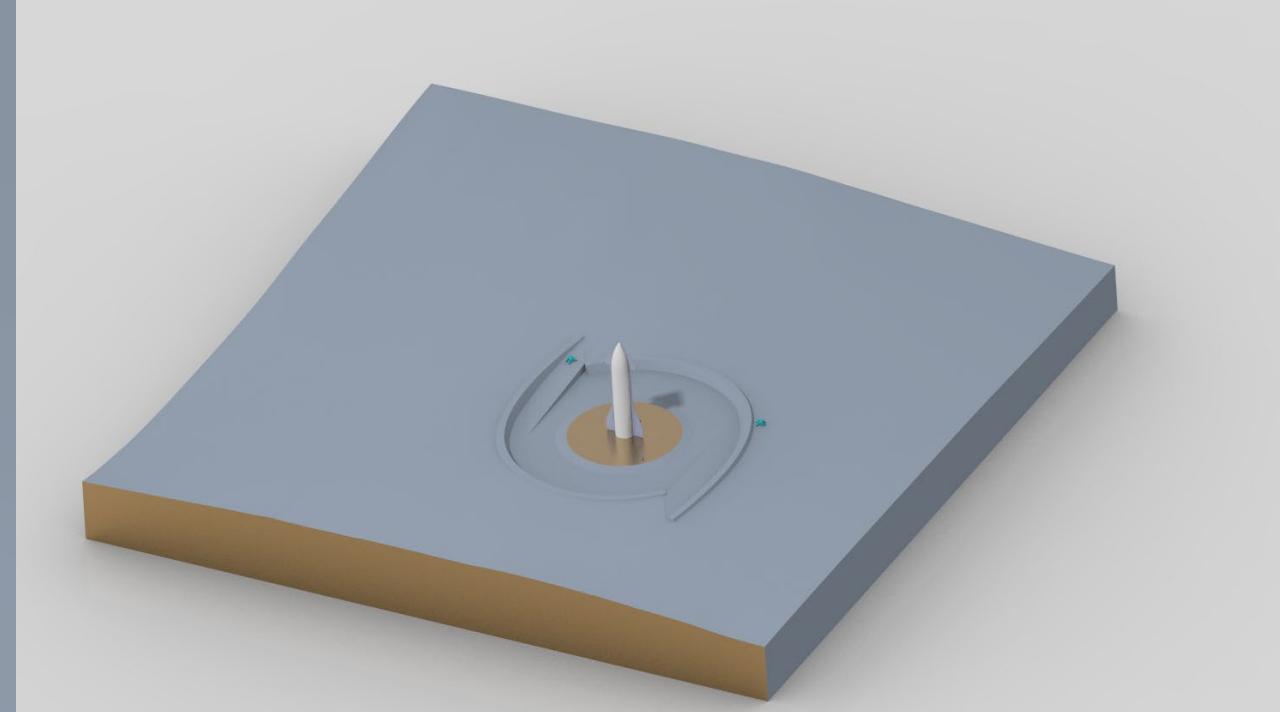
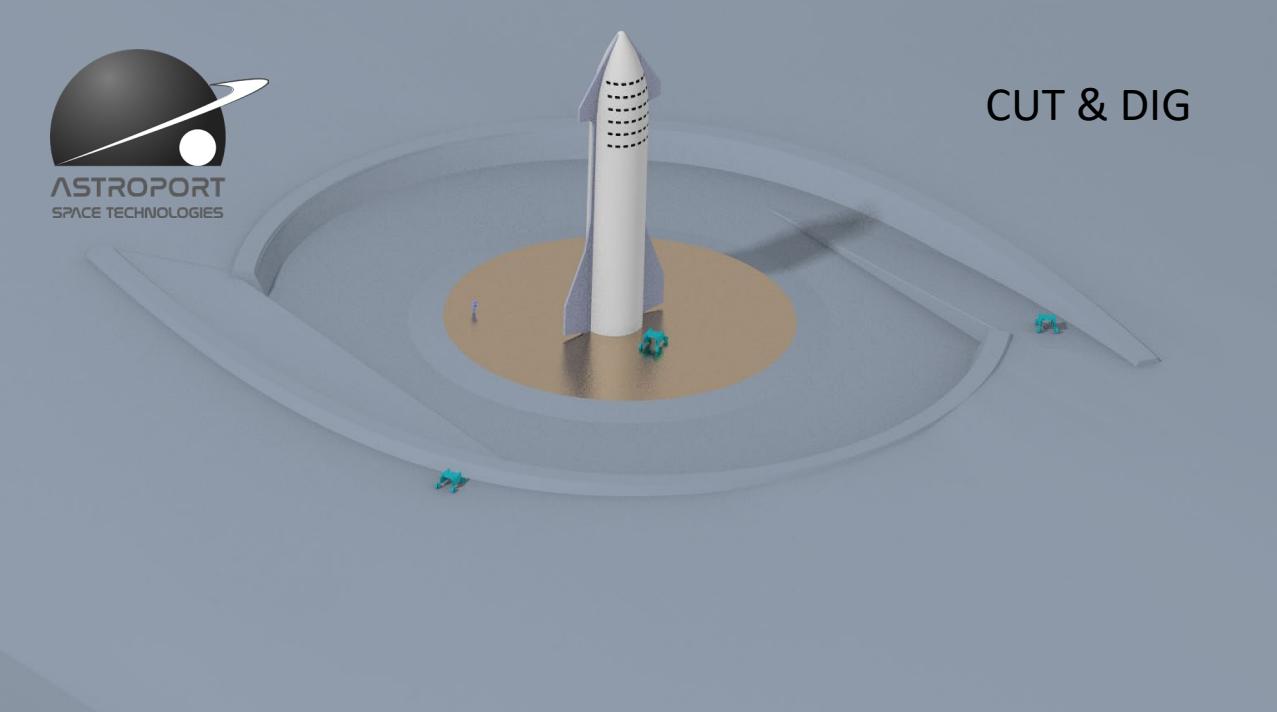
32,707 m<sup>3</sup>

Site 3

33,967 m<sup>3</sup>



## CUT & DIG





## VOLUME SUMMARY – LEVELING BY CUT & DIG

### LLP Site Prep Area (Cut Volume)

100 m dia. + ramps  
4 m cut depth

### LLP

Pad  
60 m dia.  
1 m elevation

apron

Apron 20 m radius

Volume is TBD (surface material is TBD)

Area 5,027 m<sup>2</sup>

### Berms (Regolith or RegoPacs)

At surface grade,  
1 m height

### RegoPac Walls

4,068 bags  
(.25 x .85 m)

43,615 m<sup>3</sup>

95<sup>th</sup> percentile male

2,400 m<sup>3</sup>

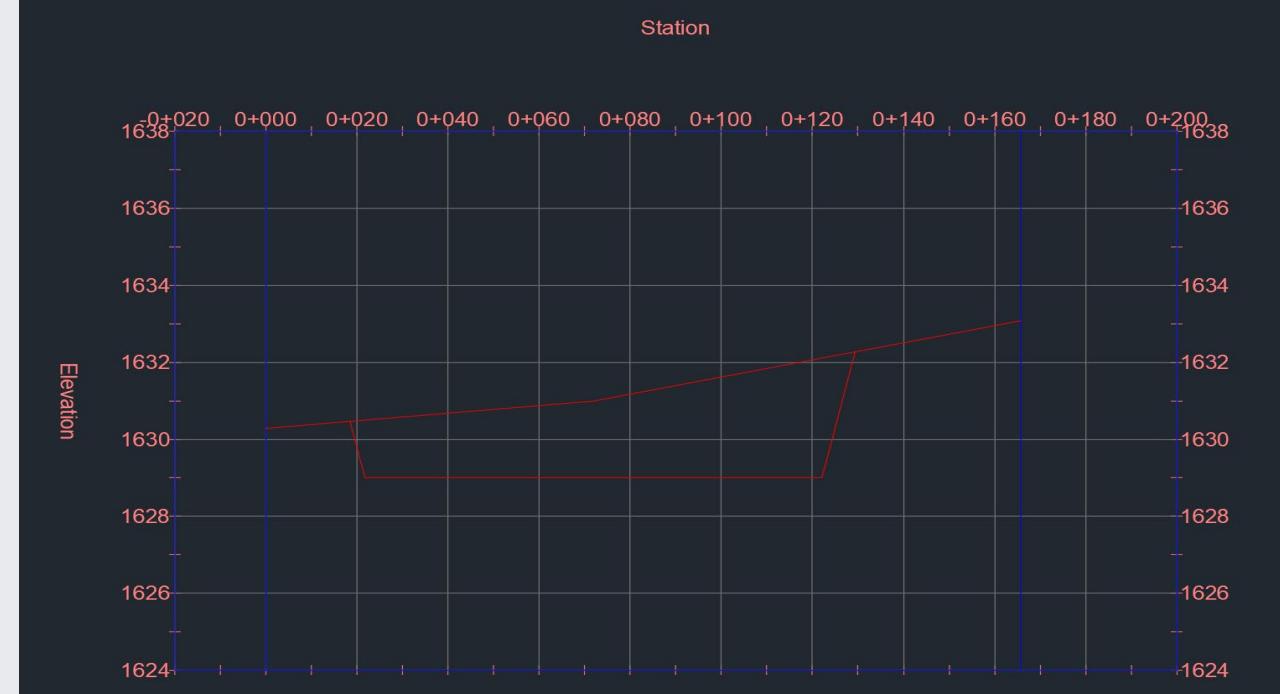
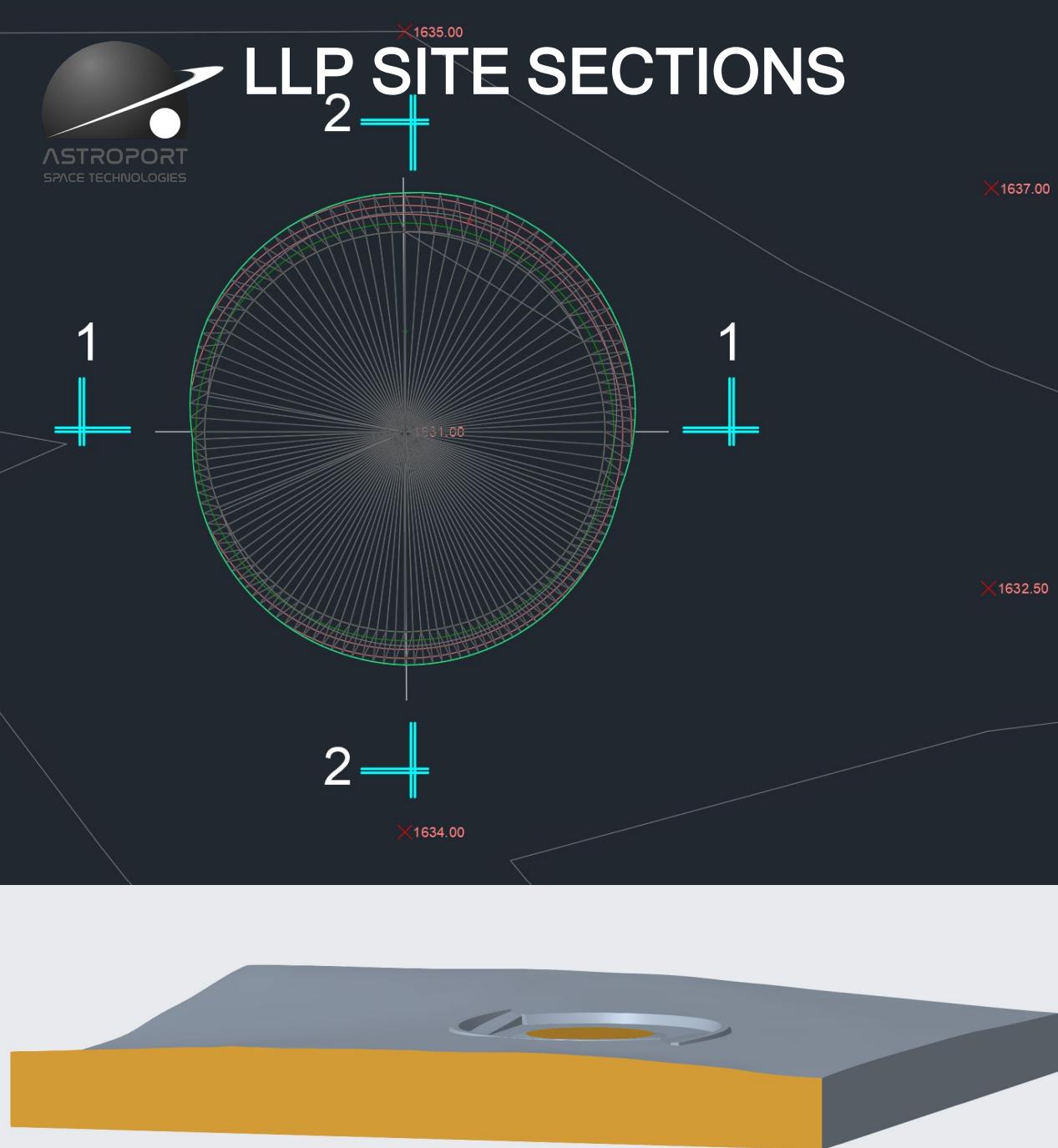
1,035 m<sup>3</sup>

550 m<sup>3</sup>

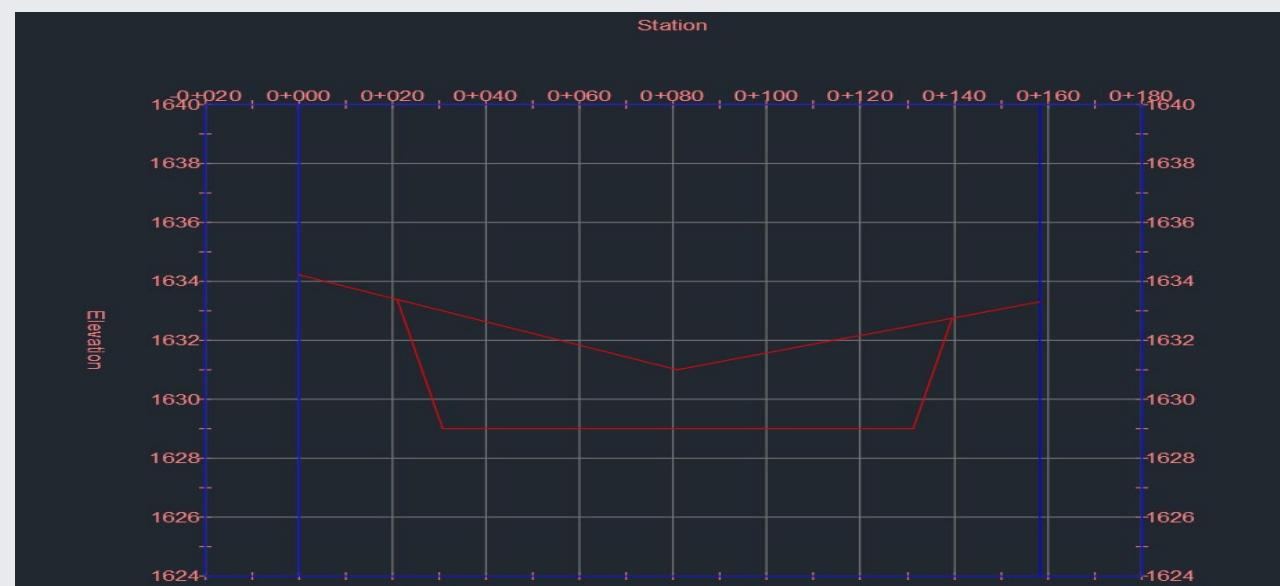
**Total Volume = 47,600 m<sup>3</sup>**



# LLP SITE SECTIONS



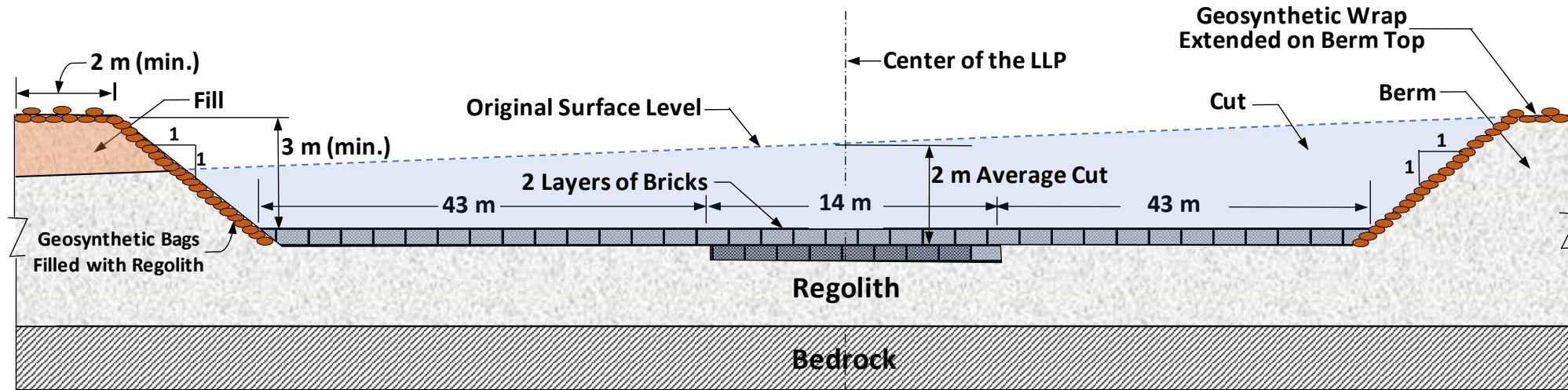
**Total cut volume: 26,533 Cu.m.**



# GEOTECHNICAL CONSIDERATIONS

## REGOLITH GEOTECHNICAL PROPERTIES FOR SITE PREPARATION & EXCAVATION

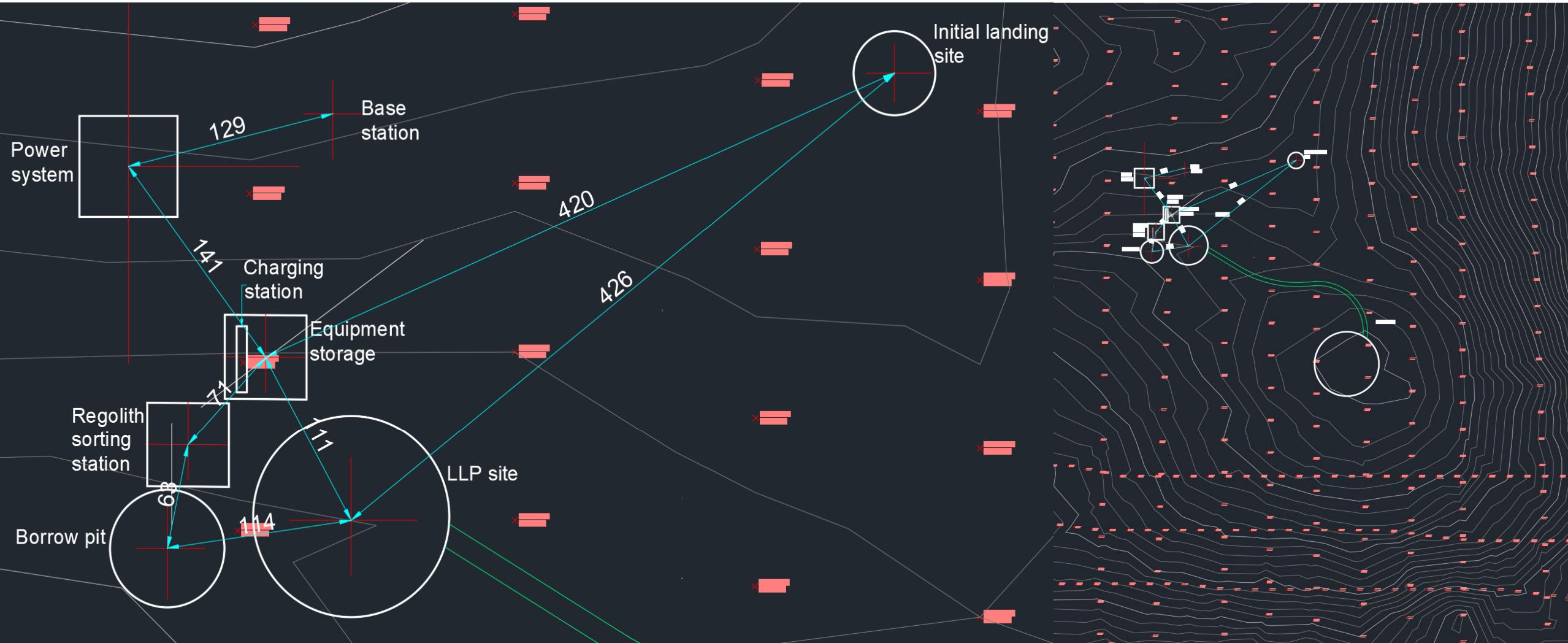
Particle Size Distribution	Shear Strength
Particle Shapes	Permeability and Diffusivity
Specific Gravity	Bearing Capacity
Bulk Density and Porosity	Slope Stability
Relative Density	Trafficability
Compressibility	Bedrock Depth



LLP Cross-Section  
(Not to Scale)



# SITE LAYOUT

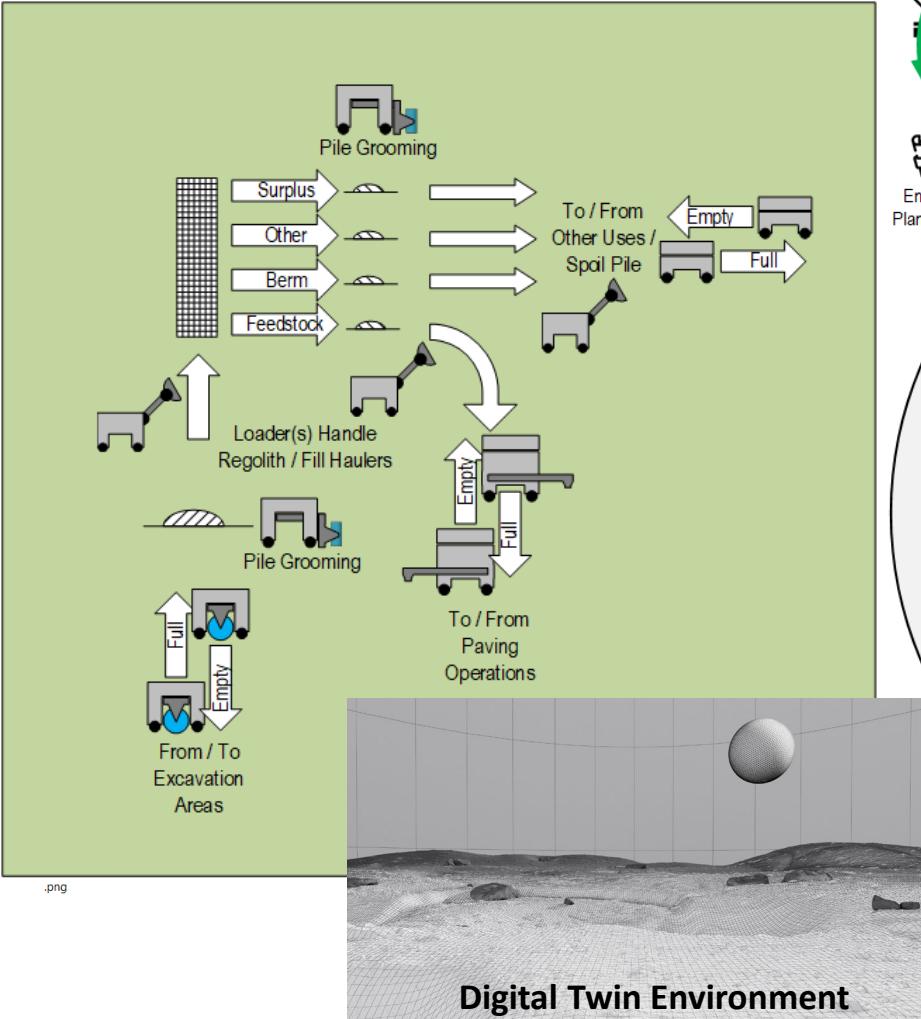


# DEVELOPING THE CONOPS

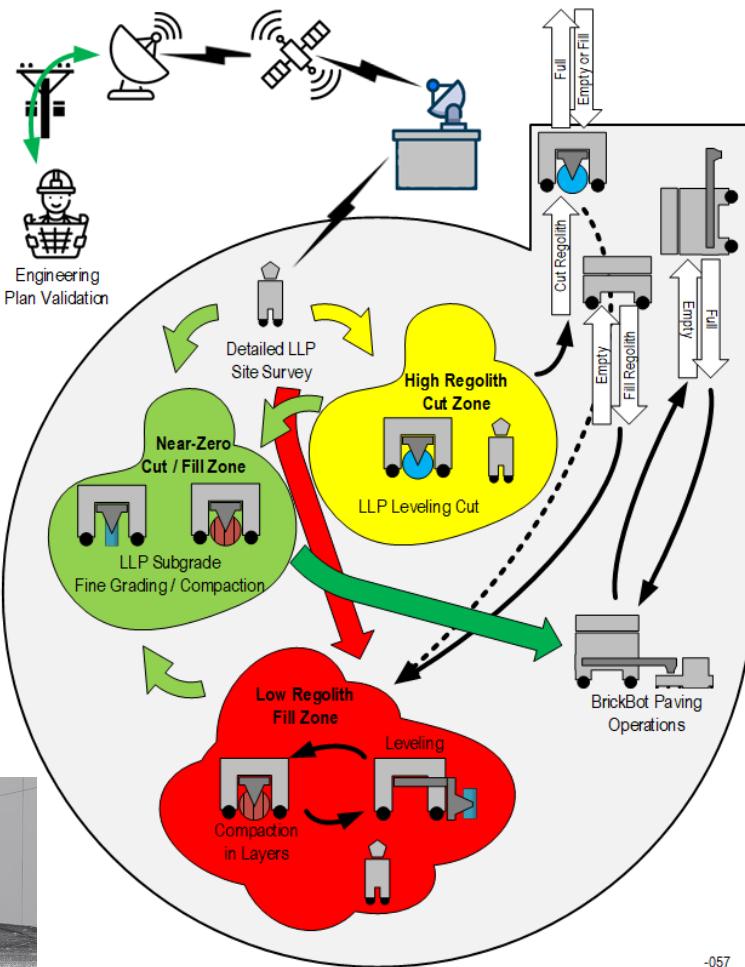
## Equip asset Db with engineering parameters

Table 1 - Notional equipment complement

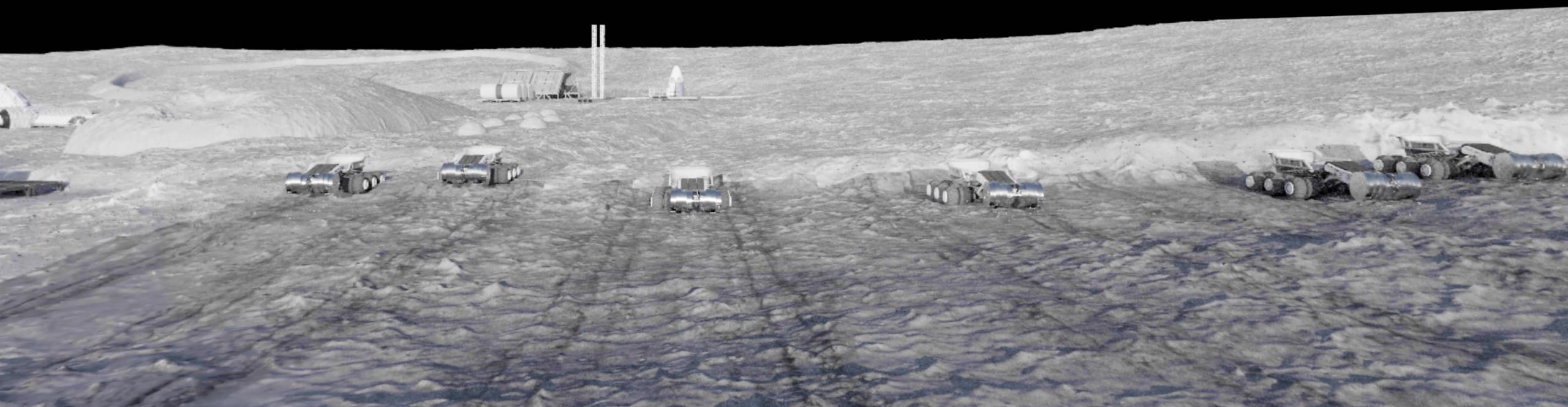
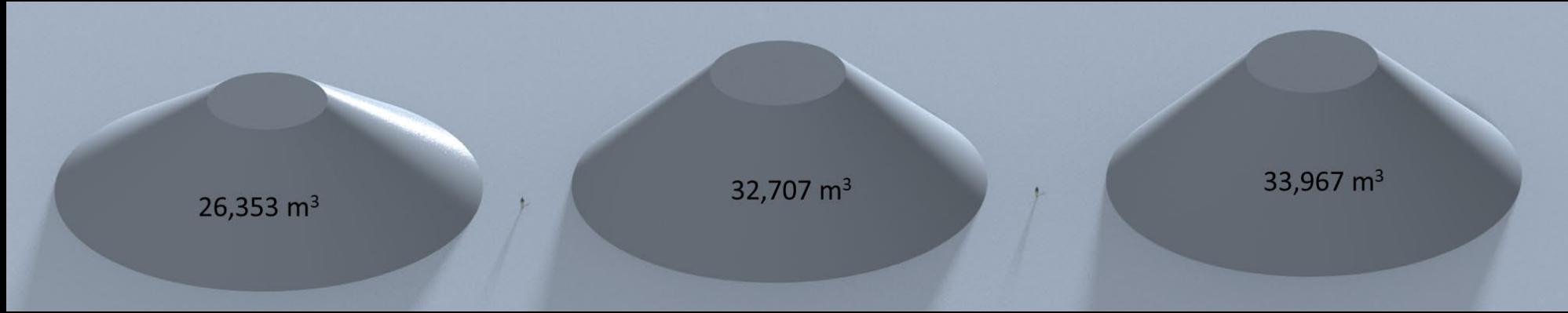
Item	Type	#	Comments
Site lighting assembly	Relocatable item	8	May not be required
Base Station	Free standing item	1	Provides communications center, link to space
Power System	Free standing assembly	1	Includes deployed elements, e.g., solar array, radiator
Equipment shelter	Free-standing enclosure	1	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"> <li>• Carry equipment to needed locations</li> <li>• Provide mobility for attached tools</li> </ul>
Surveyor	Small, self-moving platform	1	Continuous, precise site location / elevation surveys
Lifter / Carrier	GMM Attachment	1	<ul style="list-style-type: none"> <li>• Forklift for moving equipment</li> <li>• Used to relocate non-mobile items</li> </ul>
Dexterous Arm	GMM Attachment	1	Used for unscripted tasks
Rock Drill	GMM Attachment	1	Used to perforate large rocks for breakage
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"> <li>• 12 Relocatable</li> <li>• 5 Freestanding</li> <li>• 8 Self-moving</li> <li>• 14 Attachments for GMM</li> </ul>



## ConOps flow diagrams



-057



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