Lunar Outpost Cosmos Surface Mission CONOPS Planning Tool

Maximizing Science Return Through Rapid Data Fusion

June 8th, 2022

Andrew J. (AJ) Gemer, CTO

Lunar Outpost™

Lunar Outpost creates fully autonomous robots and software for conquering extreme environments

Lunar Outpost™

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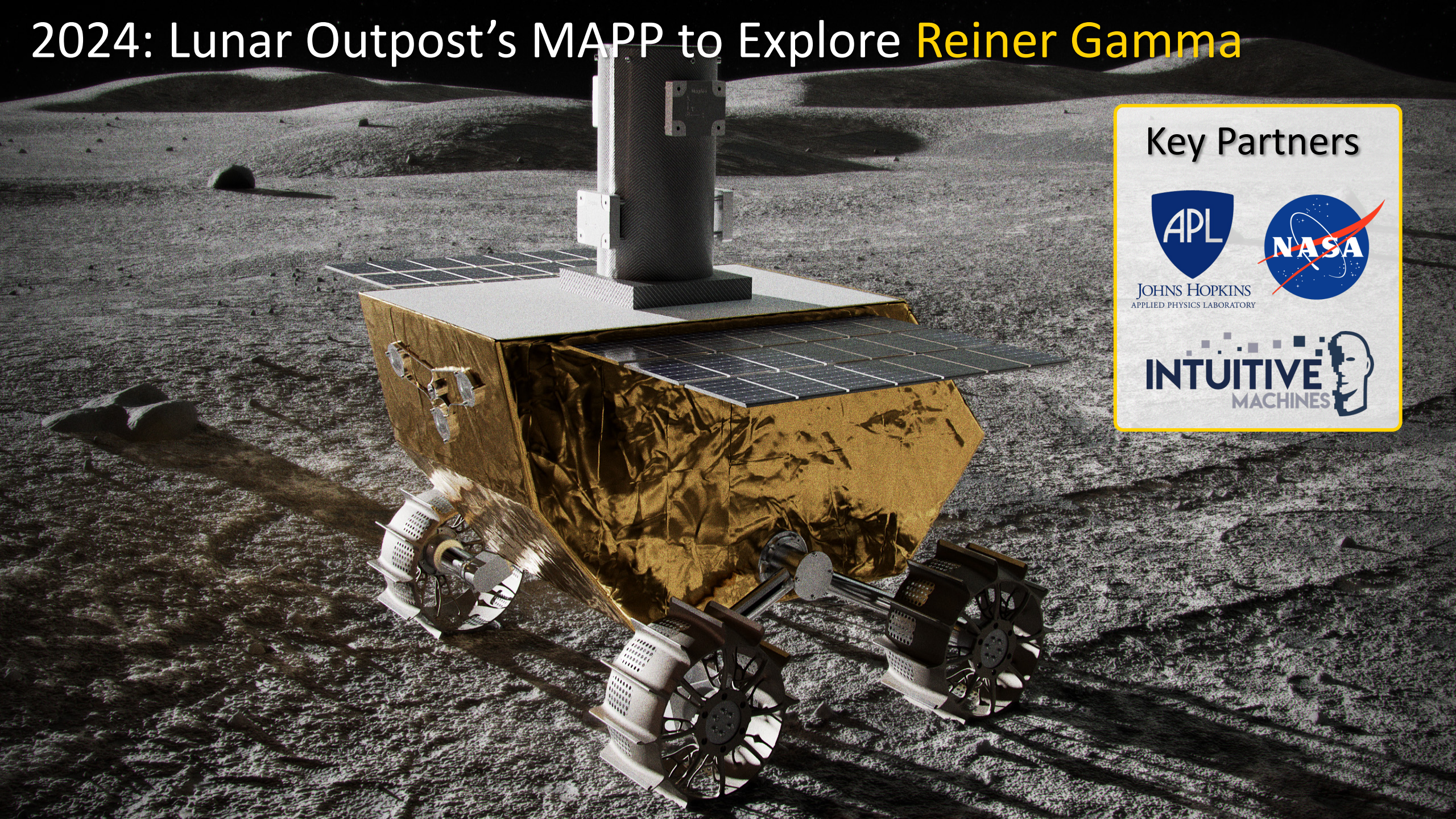
Astrobotic
Q1 2022
Intuitive Machines
Q1 2022
Intuitive Machines
Q4 2022
ispace
Q4 2022
Firefly
Q3 2023
ispace
Q3 2023
Masten
Q4 2023
Astrobotic
Q1 2024
Intuitive Machines
Q2 2024
SpaceIL
Q2 2024
Schrodinger Basin
Q2 2024
ispace
Q4 2024
Gruithuisen Domes
Q1 2025
ESA PROSPECT
Q4 2025
?
?
?
A historic wave of landers…yet little surface mobility

2024: Lunar Outpost's MAPP to Explore Reiner Gamma



Key Partners

APL
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

NASA

INTUITIVE MACHINES

Lunar Outpost Expands

SPACENEWS

Startups raise millions for lunar rovers and asteroid mining

by **Jeff Foust** — June 1, 2022

Lunar Outpost, testing its MAPP lunar rover on Earth, plans to use a funding round to support work on a larger rover. Credit: Lunar Outpost

Lunar Outpost™

Lunar Outpost EU Opens in Luxembourg

June 2, 2022 – Lunar Outpost Inc. is proud to announce that it has established a new European HQ in Luxembourg! The company is entitled Lunar Outpost EU and will focus on cutting-edge thermal technologies complementary to the planetary mobility and robotics platforms, like the MAPP lunar rover, being developed by Lunar Outpost in the United

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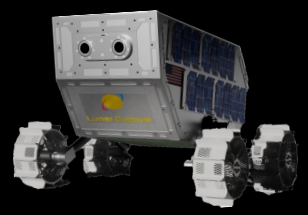
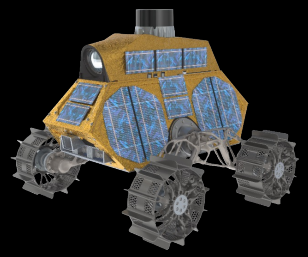
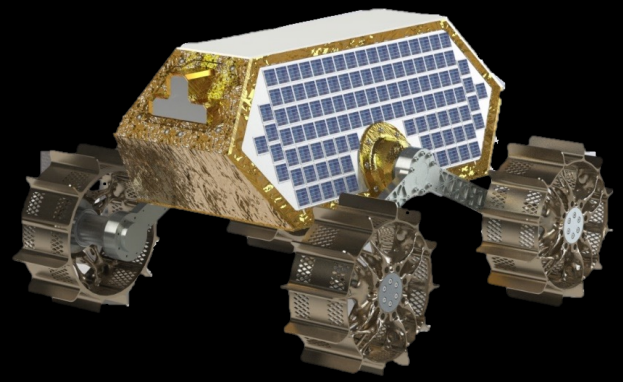
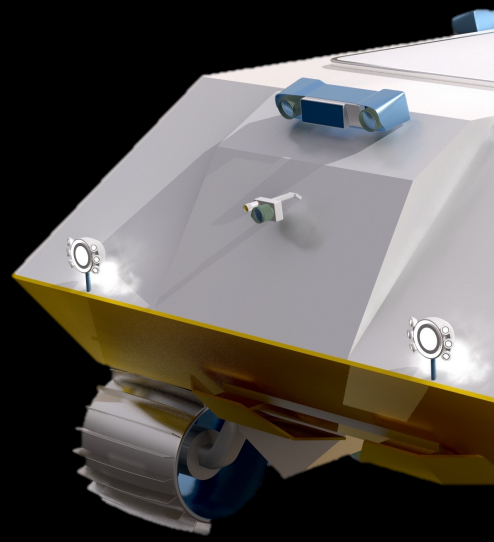
Lunar Rover Lineup

Lunar Outpost™









	M1-MAPP	COLD-MAPP	HL-MAPP
Bounding Envelope	435x483x350mm	435x483x350mm	1.5x1.3x1.3m
Chassis Mass	5.5kg	12kg	200kg
Payload Mass	6.5kg	5kg	100kg
Total Mass	12kg	17kg	300kg
Peak Payload Power	35W	35W	Contact for Info
Operational Lifespan	14 Earth Days	1+ Years	4+ Years
Lunar Night Survival	No	Yes	Yes
Temperature Range Survival	-70 C to +130 C	Contact for Info	Contact for Info
Maximum Surface Speed	10cm/s	10cm/s	Contact for Info
Maximum Surface Range	8km	Contact for Info	Contact for Info
Flight Ready Date	Q2 2021	Q3 2022	Q1 2023

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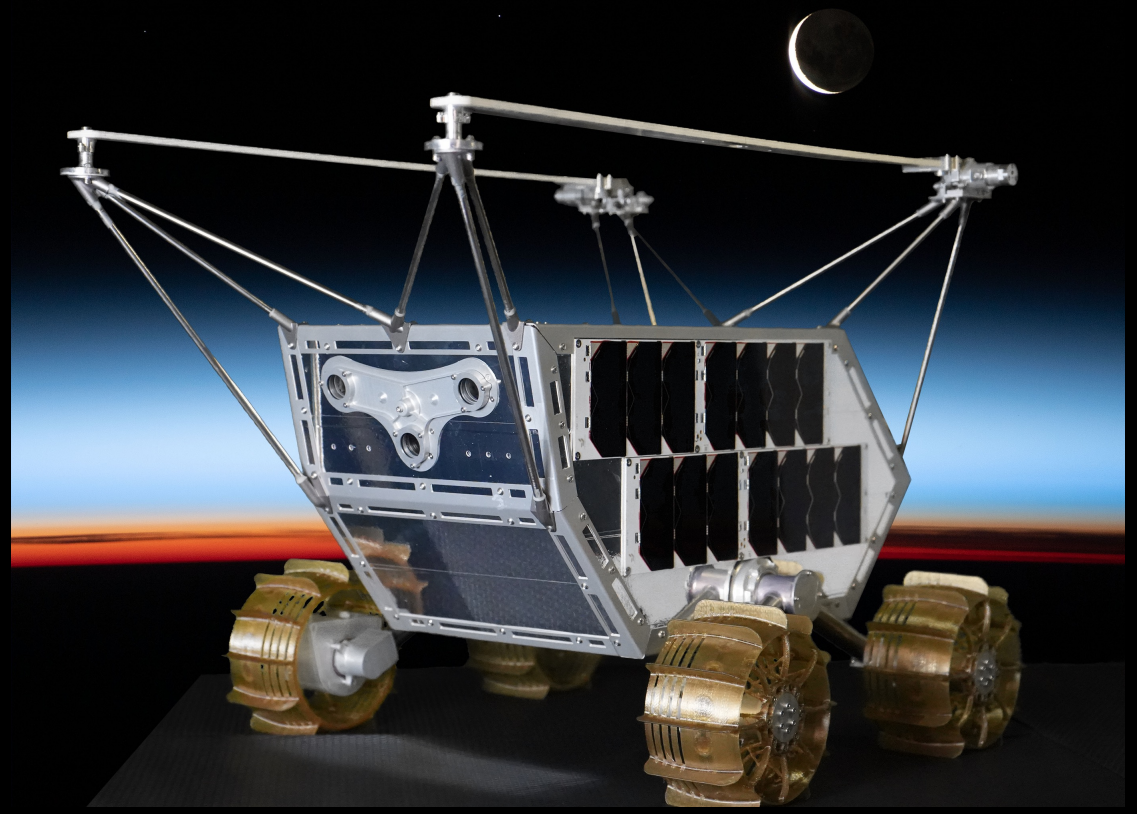
Lunar Outpost Cosmos Mission Planning Tool & Ground Station

Lunar Outpost™

MAPP CONOPS Planning

- Multivariate Objective Optimization
  - Science Objectives
  - Comms availability/bandwidth
  - Environmental Considerations
    - Local terrain
    - Thermal control of MAPP
  - Solar Illumination – Electrical Power
- Constraints
  - 2mpp DTMs
  - Interactions of hardware with lunar environment
  - <u>Time!!! Short Mission Duration; Fast Responses Needed</u>



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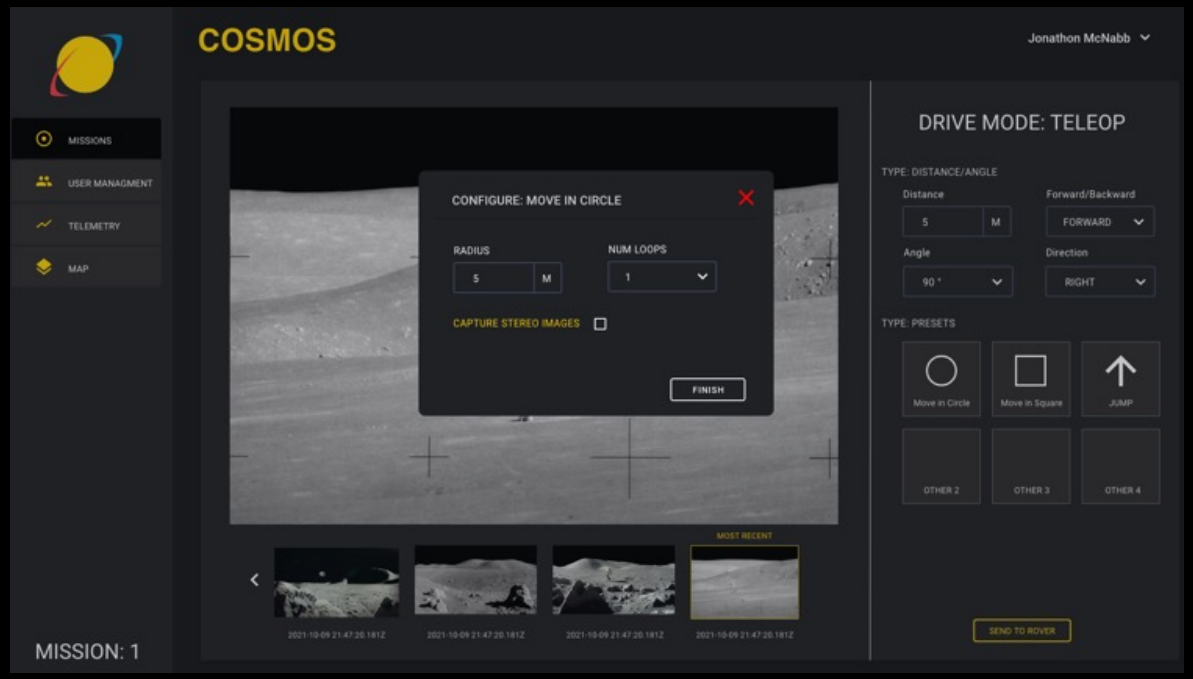
LO Cosmos Ground Station

- Provides operators with needed telemetry data to operate rover
- Allow operators to send commands to the rover
- Provide science team with tools needed to analyze rover environment
- Provide payload customers capabilities to interact with payload/instrument
- Secure ALL data coming from rovers



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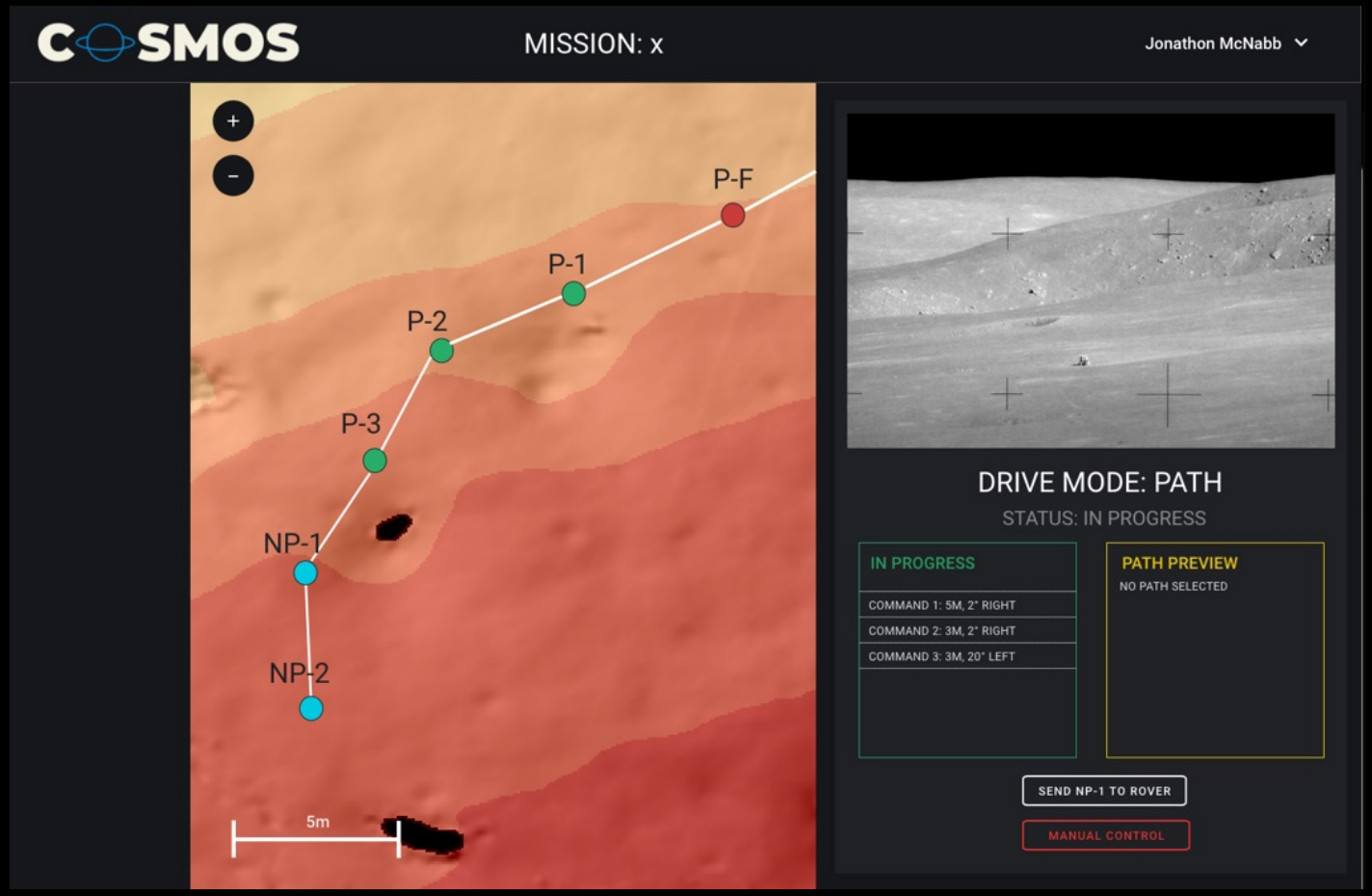
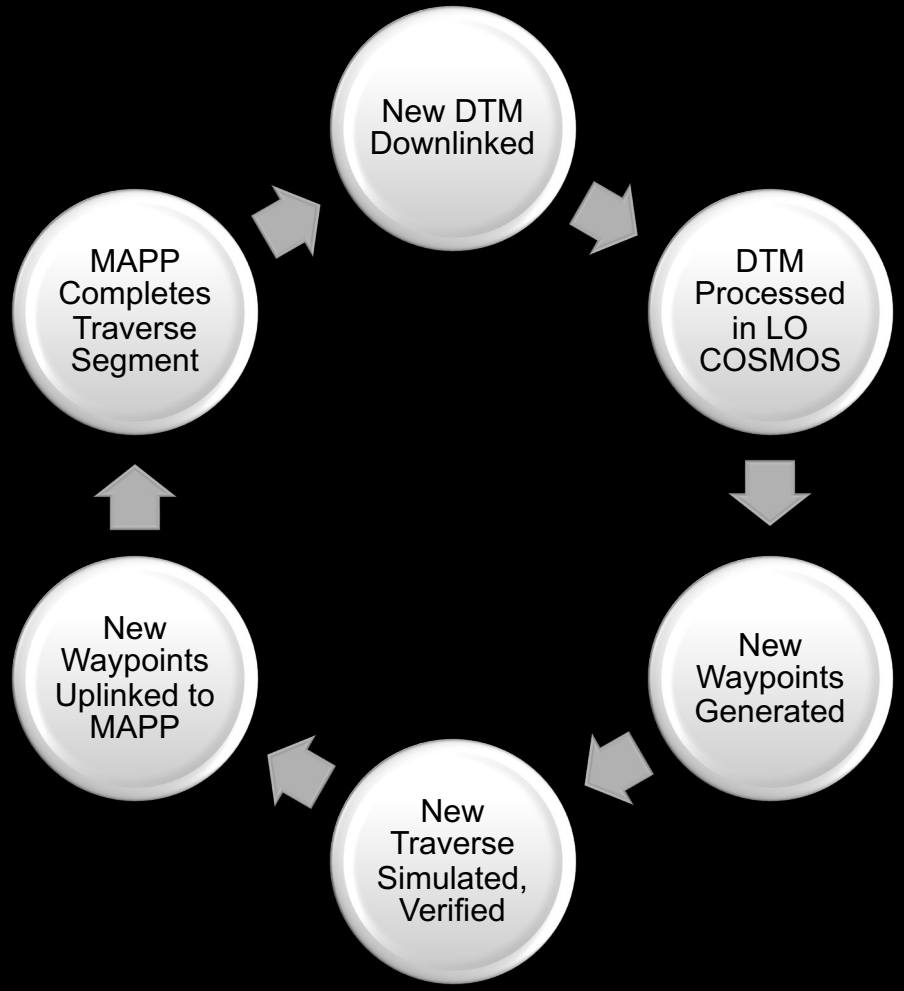
Digital Terrain Mapping





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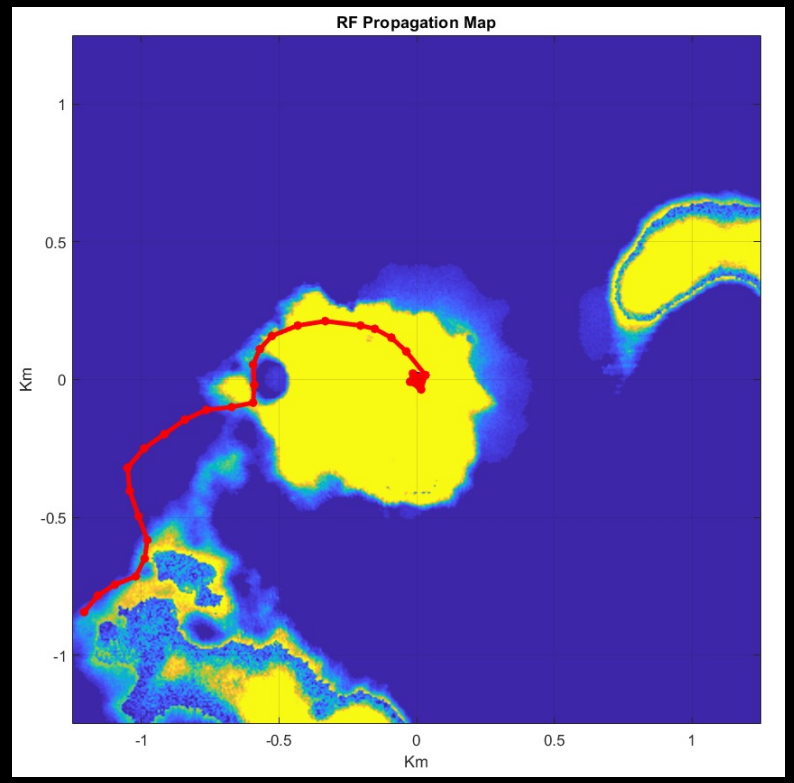
ConOps & Waypoints

- Outputs/Products:
  - Input power to PV arrays
    - Based on solar vector
  - MAPP Motor Power
    - Based on elevation gain/loss
  - Time/date between waypoints
    - Forward calc: time to reach waypoint assuming average speed
    - Backward calc: average speed required to reach waypoint at desired time
  - RF comms propagation over terrain
  - Rover attitude (R/P/Y)
    - Based on local terrain



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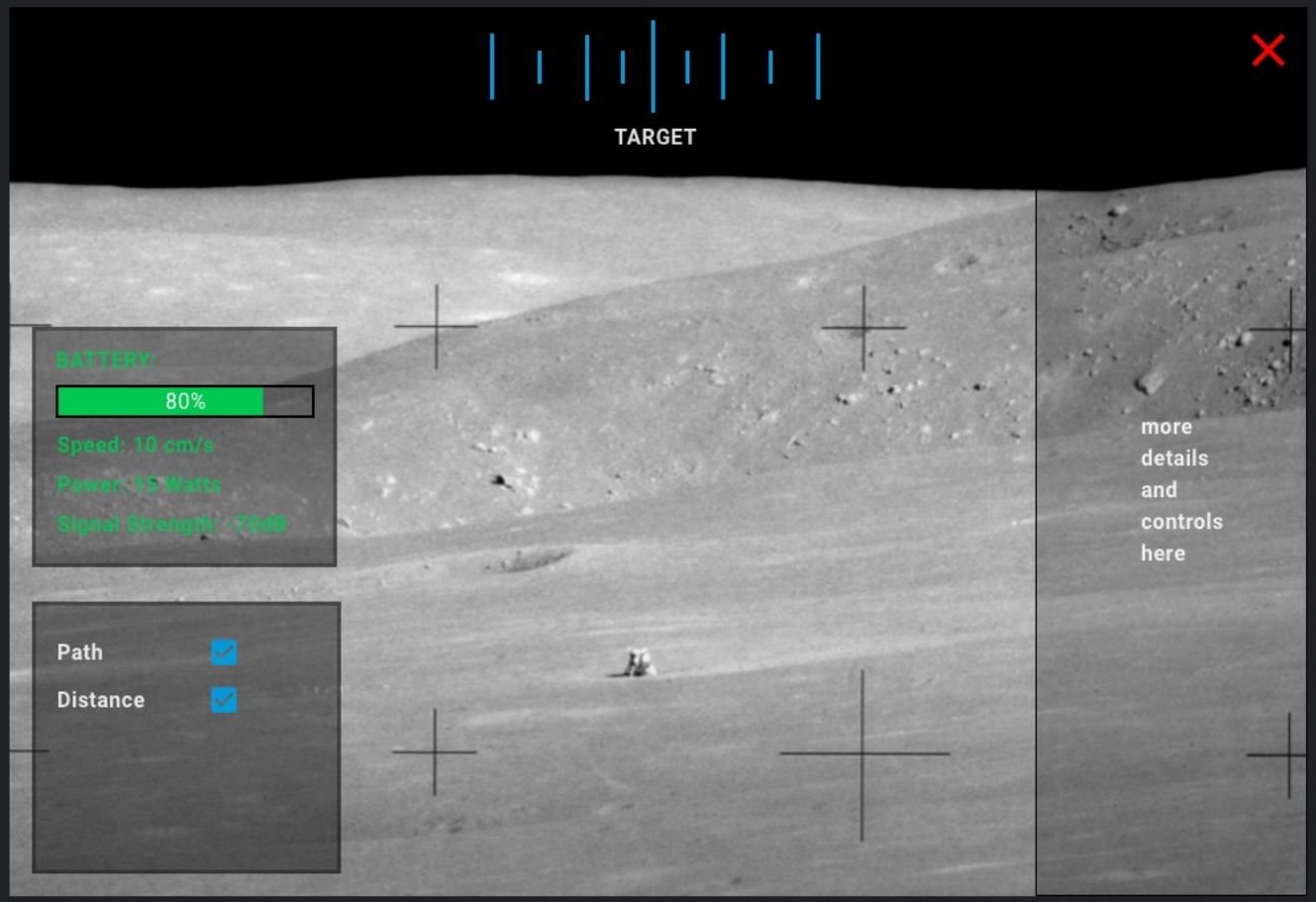
COSMOS

Jonathon McNabb

- MISSIONS
- CONTROL
- TELEMETRY
- MAP



MOST RECENT

2021-10-09 21:47:20.181Z

2021-10-09 21:47:20.181Z

2021-10-09 21:47:20.181Z

2021-10-09 21:47:20.181Z

DRIVE MODE: TELEOP

TYPE: DISTANCE/ANGLE

Distance: 5 M

Forward/Backward: FORWARD

Angle: 90 °

Direction: RIGHT

TYPE: PRESETS

- Move in Circle
- Move in Square
- OTHER 1
- OTHER 2
- OTHER 3
- OTHER 4

TYPE SELECTED: DISTANCE/ANGLE

DISTANCE: 5M, FORWARD
ANGLE: 90 ° RIGHT

SEND TO ROVER

COSMOS

Jonathon Mcnabb

- ROVERS
- CONTROL
- TELEMETRY
- MAP

ROVER BATTERY LEVEL:

39%

UTC 2021/10/09 21:10:22

ELAPSED TIME 12D 04:15:55

AVERAGE CPU USAGE: 50%

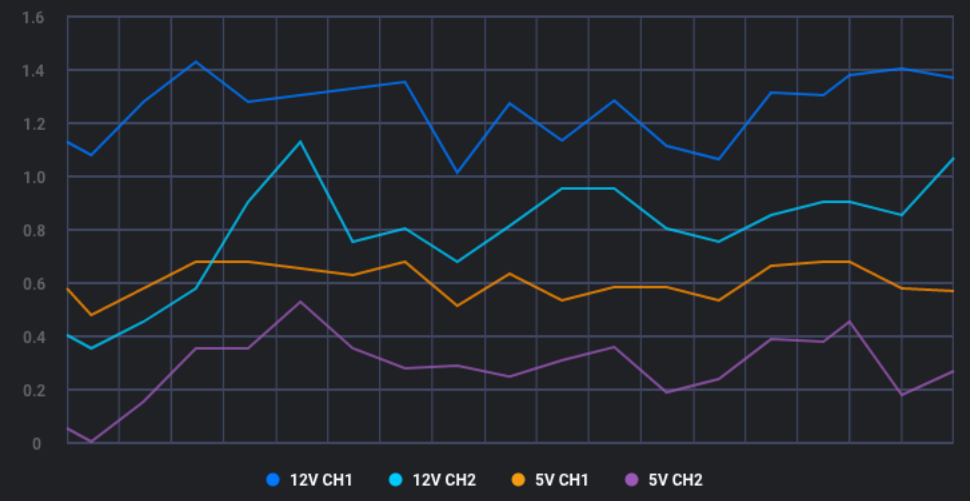
PRIMARY CPU STATUS: ONLINE

SECONDARY CPU STATUS: OFFLINE

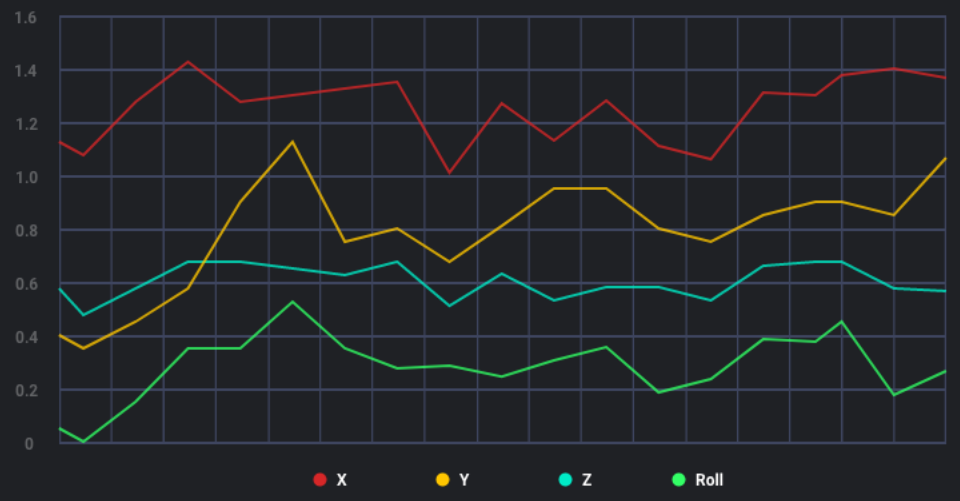
ESTIMATED TIME TILL BATTERY DEPLETION:

5 HOURS, 14 MINUTES

Power Data



Kinematic Data



AVG ROVER DATA BANDWIDTH: 50%

Last update: 3 hours ago

AVG CPU UTILIZATION: 25%

Last update: 3 hours ago

AVG GPU UTILIZATION: 75%

Last update: 3 hours ago

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COSMOS

Jonathon Mcnabb

- MISSIONS
- CONTROL
- TELEMETRY
- MAP

ROVER BATTERY LEVEL:

67%

UTC 2021/10/09 21:10:22

ELAPSED TIME 12D 04:15:55

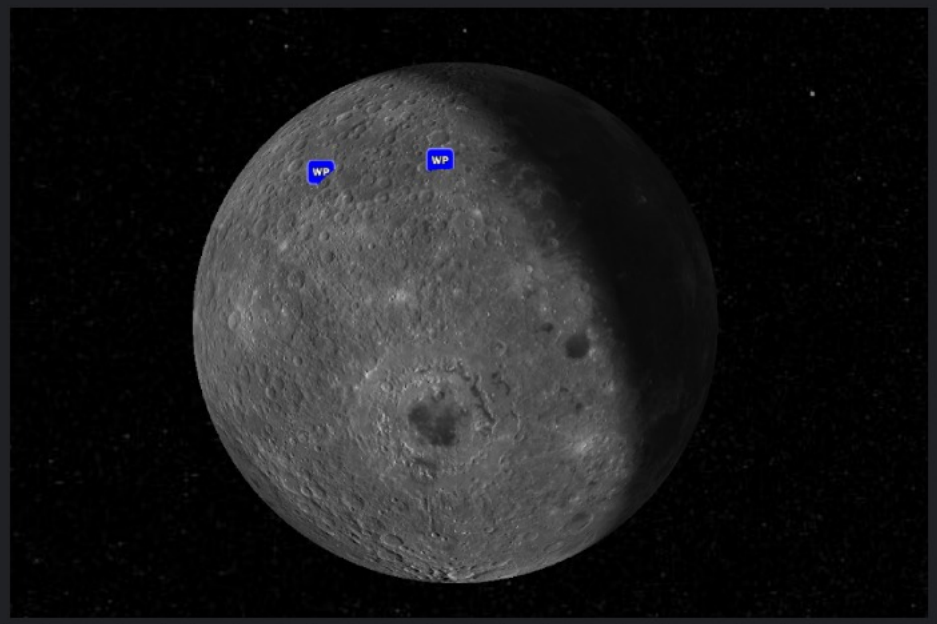
AVERAGE CPU USAGE: 50%

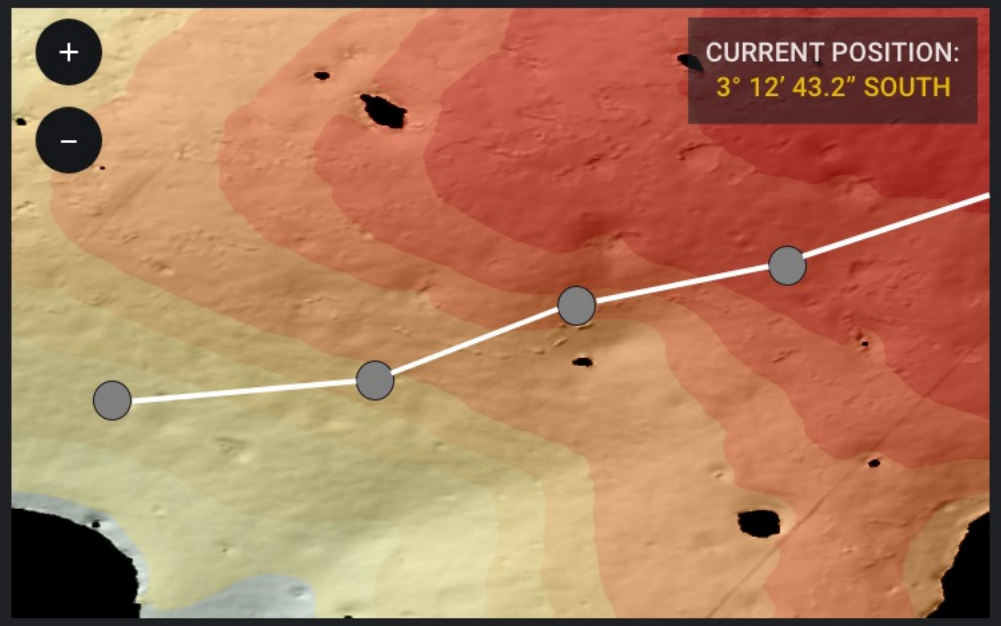
PRIMARY CPU STATUS: ONLINE

SECONDARY CPU STATUS: OFFLINE

ESTIMATED TIME TILL BATTERY DEPLETION:

14 HOURS, 3 MINUTES





AVG ROVER DATA BANDWIDTH: 50%

Last update: 3 hours ago

AVG CPU UTILIZATION: 25%

Last update: 3 hours ago

AVG GPU UTILIZATION: 75%

Last update: 3 hours ago

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COSMOS

Jonathon McNabb

- MISSIONS
- USER MANAGMENT
- TELEMETRY
- MAP

12V Current

5V Current

3.3V Current

Mission Clock

UTC 2021/10/09 21:10:22

ELAPSED TIME

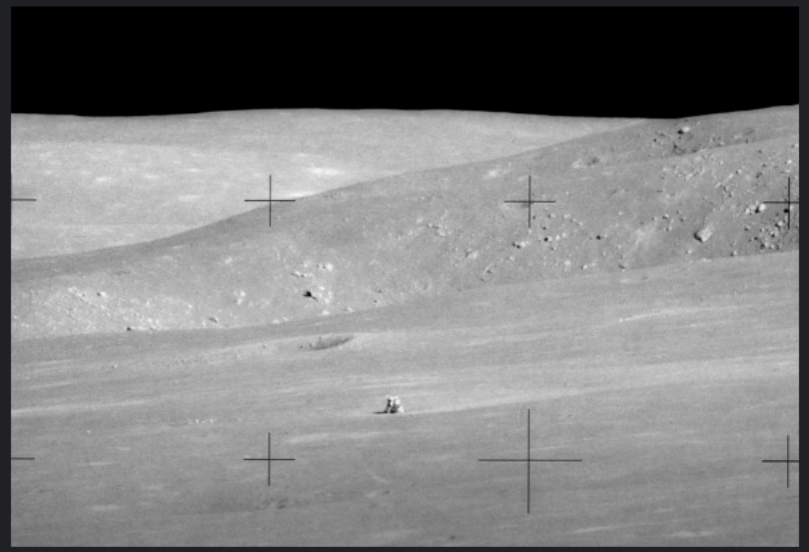
12D 04:15:55

Status Summary

BATTERIES:	64%
TEMPERATURE:	20° C
COMMS:	ONLINE
MOBILITY:	OFFLINE
OTHER:	5%
OTHER:	ONLINE

Imagery

CAMERA: STEREO_R



RECEIVED IMAGES

- 2021/10/09 21:10:22
- 2021/10/09 21:09:22
- 2021/10/09 21:08:22
- 2021/10/09 21:07:22
- 2021/10/09 21:06:22
- 2021/10/09 21:05:22
- 2021/10/09 21:04:22
- 2021/10/09 21:03:22
- 2021/10/09 21:02:22
- 2021/10/09 21:01:22
- 2021/10/09 21:00:22
- 2021/10/09 20:59:22
- 2021/10/09 20:58:22
- 2021/10/09 20:57:22
- 2021/10/09 20:56:22
- 2021/10/09 20:55:22

Comms Table

VALUE	TYPE	TIMESTAMP
23	TEMP	2021-10-09 21:47:20.181Z
5	12V Cur	2021-10-09 21:47:20.181Z
3	5V Cur	2021-10-09 21:47:20.181Z
1.21	3.3V Cur	2021-10-09 21:47:20.181Z
ON	MOTOR	2021-10-09 21:47:20.181Z
41	TEMP	2021-10-09 21:47:20.181Z
1.3	IMU	2021-10-09 21:47:20.181Z
23	12V Cur	2021-10-09 21:47:20.181Z
23	5V Cur	2021-10-09 21:47:20.181Z
23	3.3V Cur	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z
23	TEMP	2021-10-09 21:47:20.181Z

Warnings

- High Current on 12V line @ 12:55:20
- Temperature reached 20° C @ 14:13:35
- High Motor Current @ 1:45:34
- Failed to Parse Local Image

MISSION: 1

COSMOS

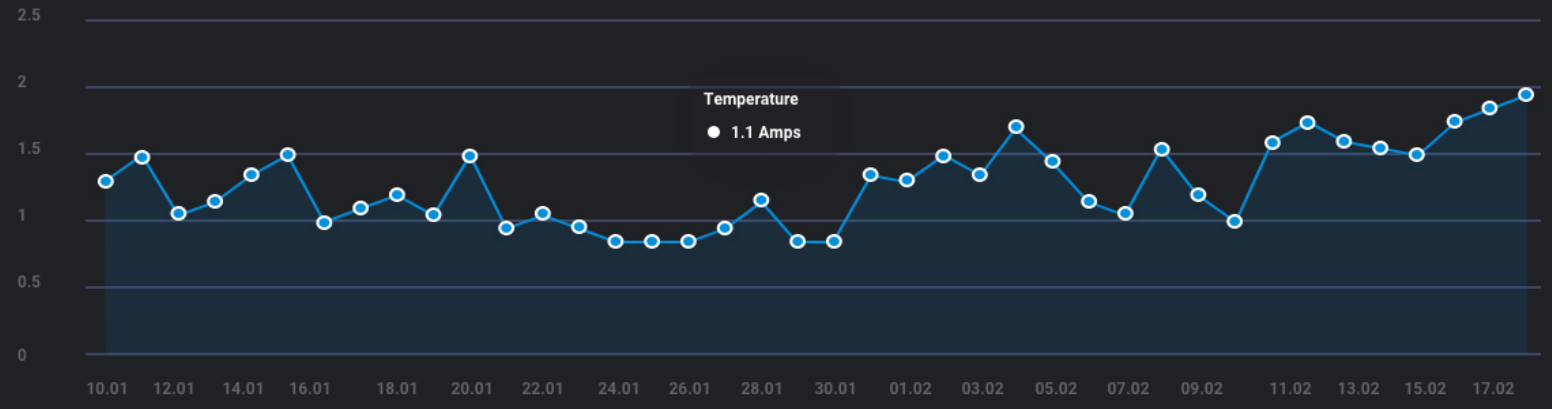
Jonathon McNabb

- MISSIONS
- USER MANAGMENT
- TELEMETRY
- MAP

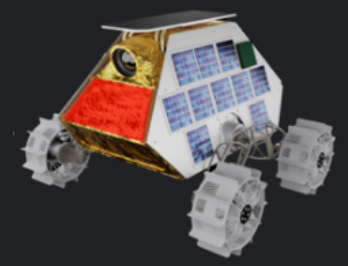
TEMPERATURE VIEW

FRONT TOP TEMPERATURE

Today | Week | Month

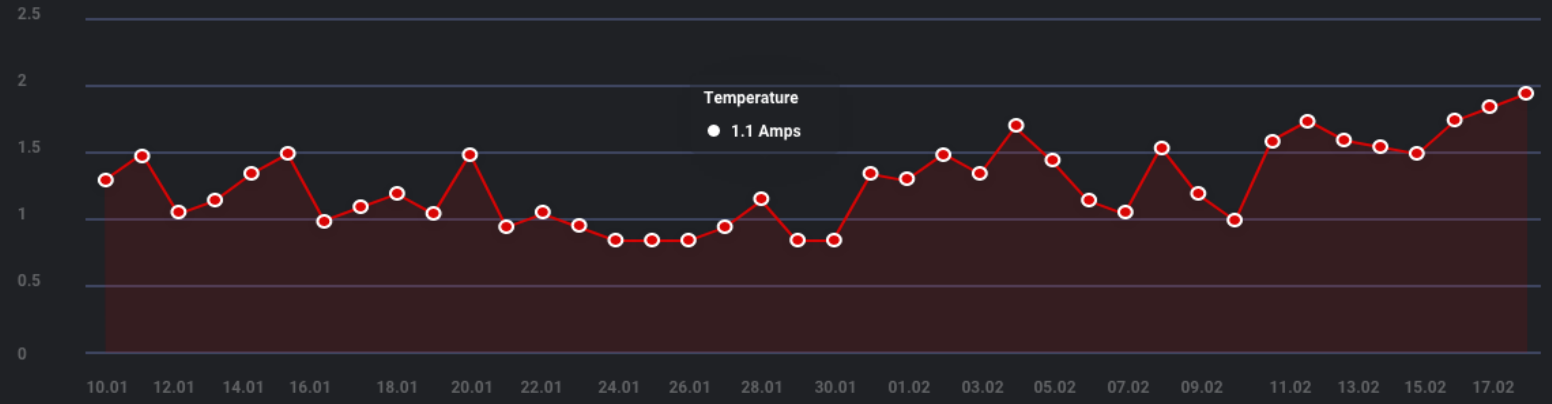


Location: FRONT TOP

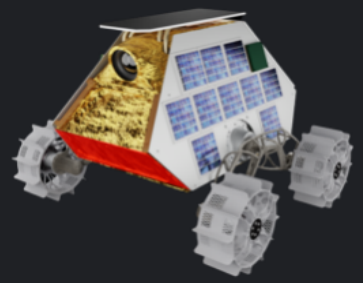


FRONT BOTTOM TEMPERATURE

Today | Week | Month

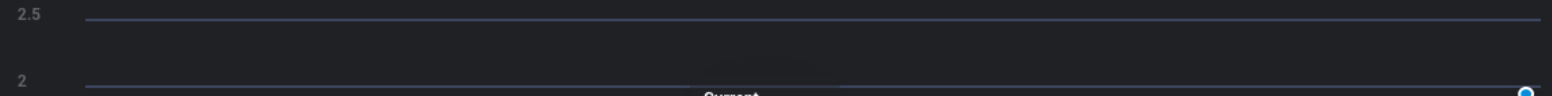


Location: FRONT BOTTOM



CAMERA TEMPERATURE

Today | Week | Month



Location: CAMERA

MISSION: 1

COSMOS

Jonathon McNabb

- MISSIONS
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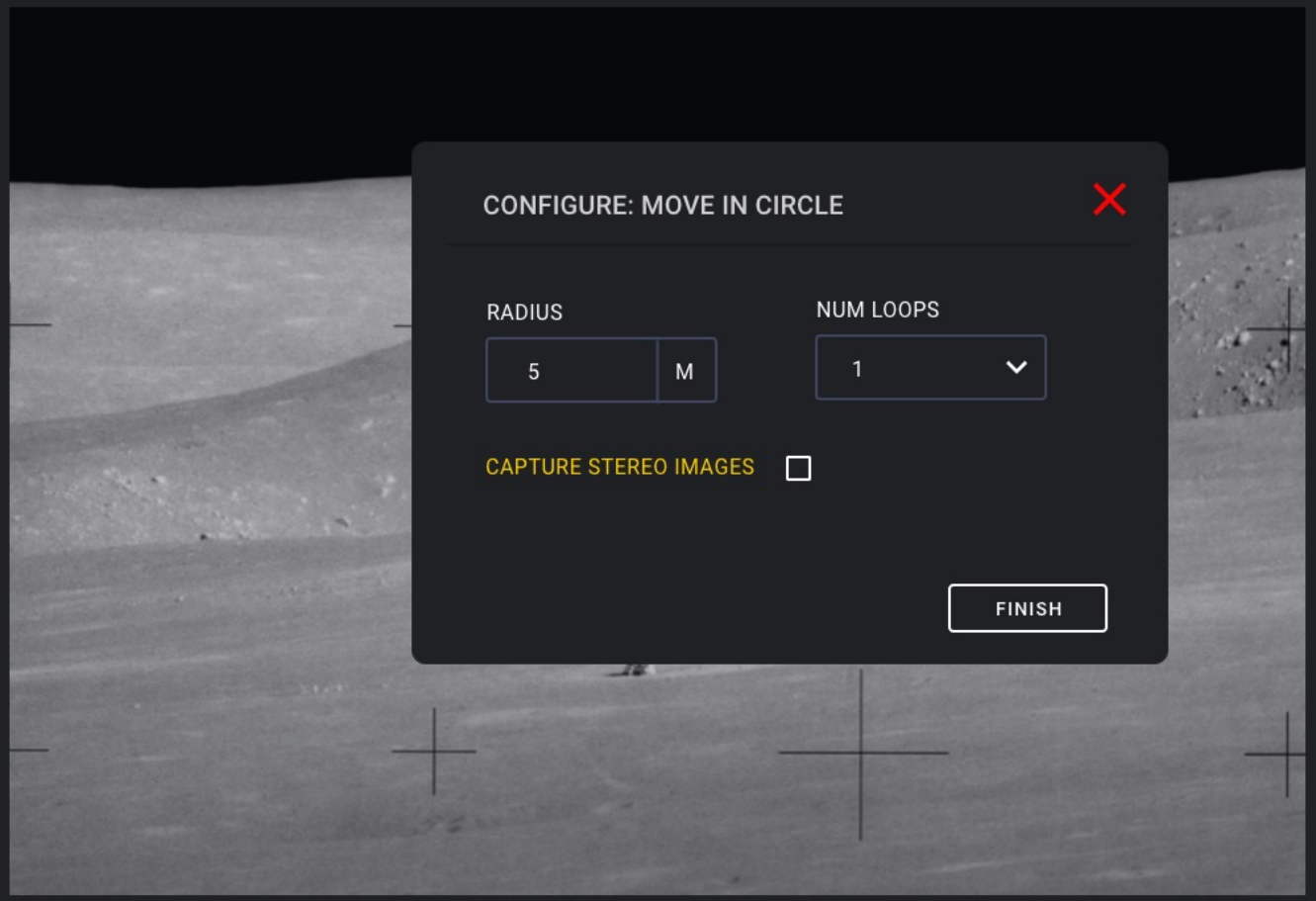

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2021-10-09 21:47:20.181Z

DRIVE MODE: TELEOP

TYPE: DISTANCE/ANGLE

Distance: 5 M

Forward/Backward: FORWARD

Angle: 90 °

Direction: RIGHT

TYPE: PRESETS

- Move in Circle
- Move in Square
- JUMP
- OTHER 2
- OTHER 3
- OTHER 4

SEND TO ROVER

MISSION: 1

Contact

AJ Gemer - CTO

+1-720-987–4060

AJ@LunarOutpost.com

Lunar Outpost™

Already a profitable multiplanetary company, upon our Mission 1, Lunar Outpost will be one of two companies operating on 3 planetary bodies

2022 A multiplanetary company

Lunar Outpost™

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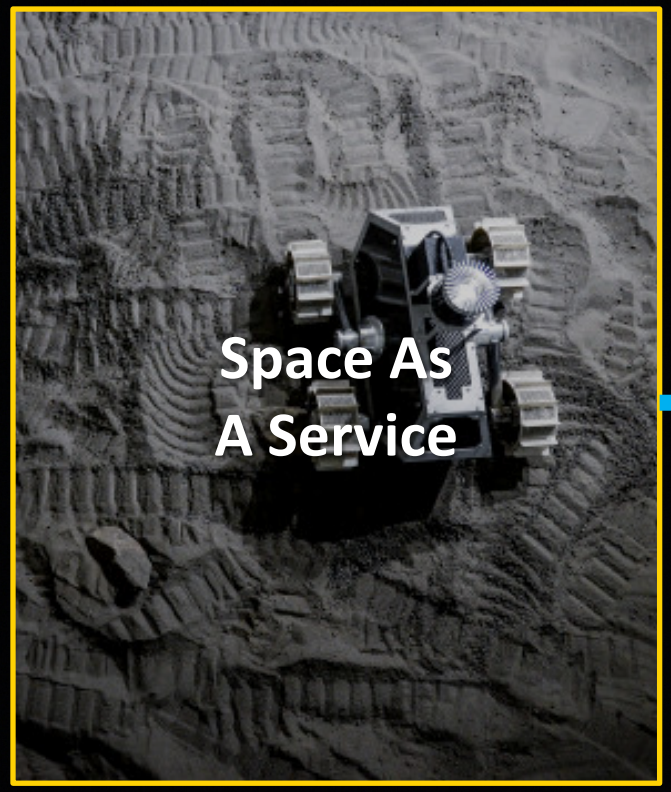
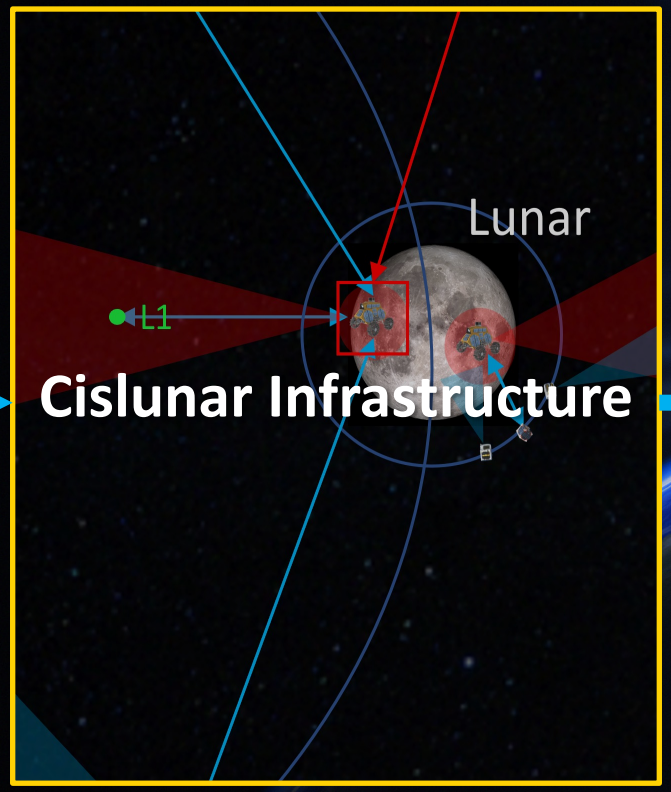
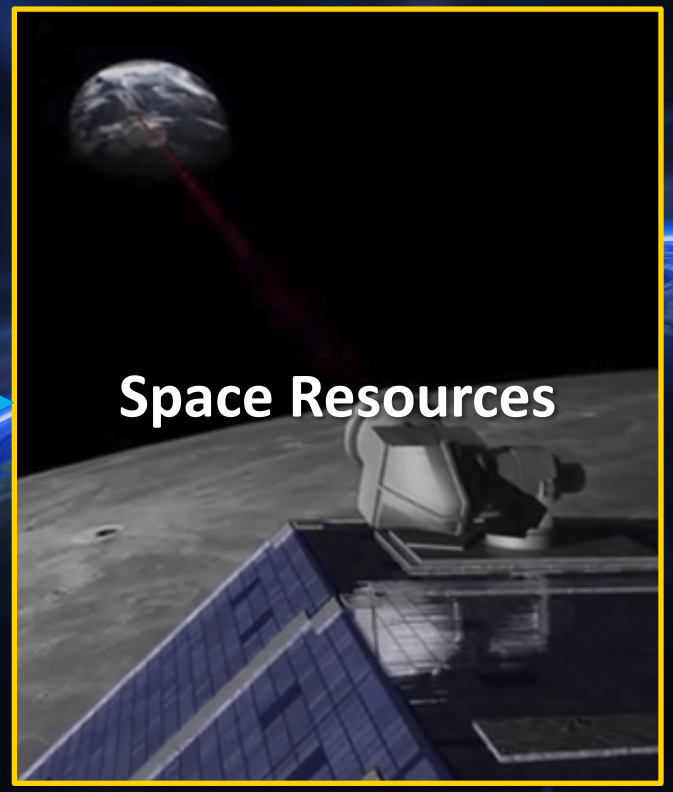
Launching at the Dawn of a New Economy







Revenue generation through all stages of the New Cislunar Economy

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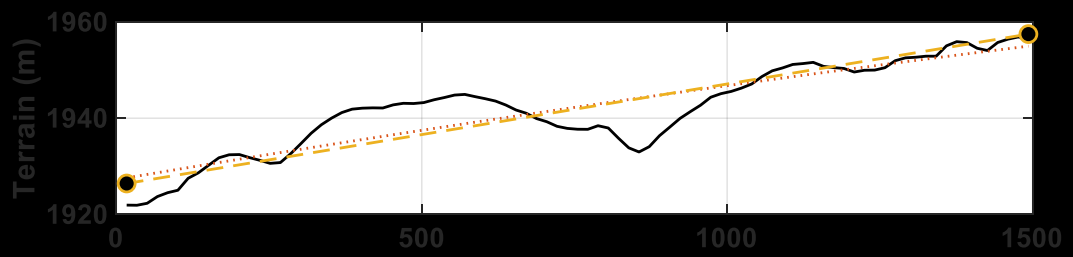
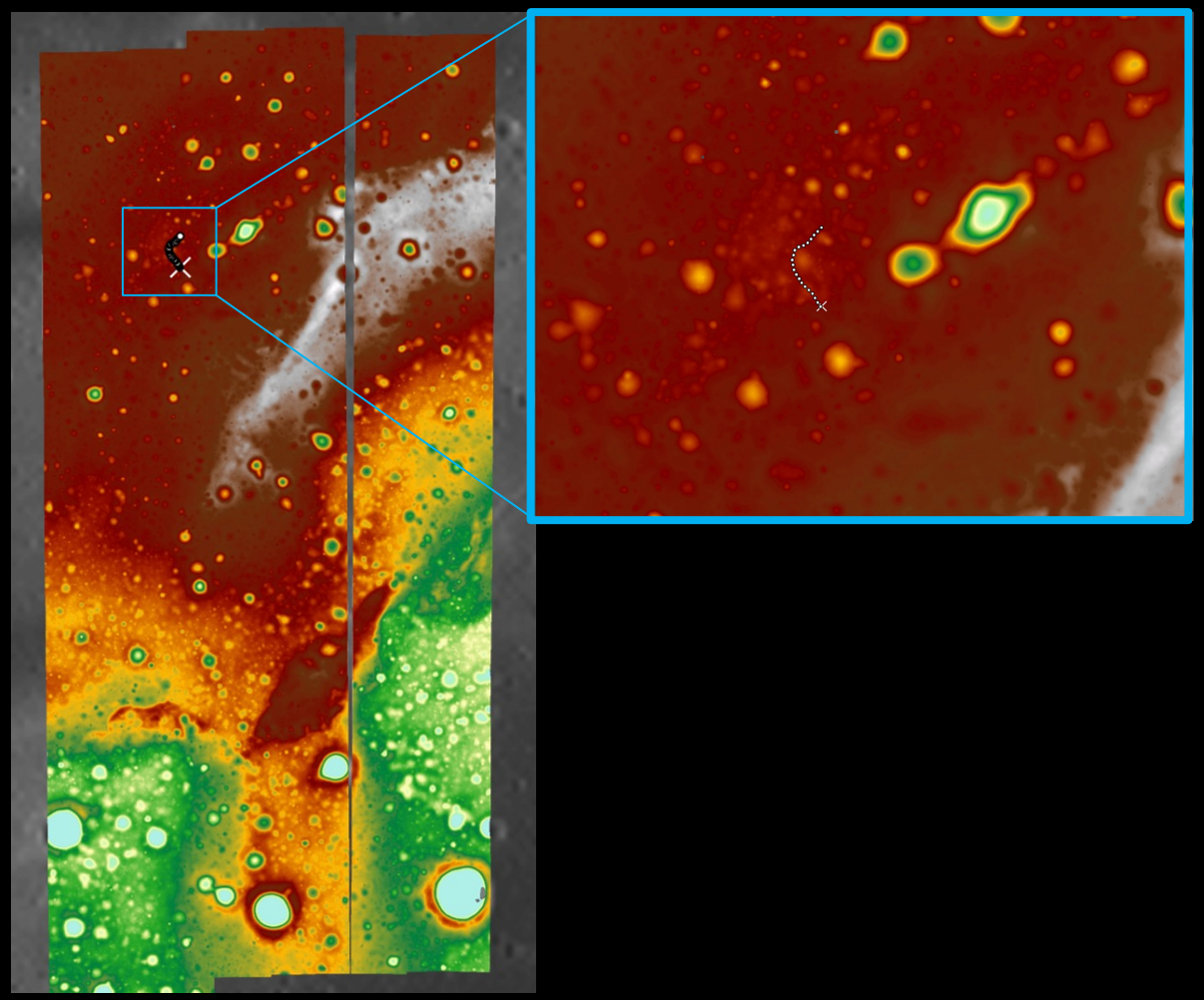
ConOps & Waypoints

- DTM imported from LROC NAC data
- Downsampled to landing site +/- 1.5km
- 3D surface mesh generated; filled by interpolation
- Initial waypoints imported from .CSV
- Elevation calculated at each waypoint
- Waypoints plotted on surface
- Elevation profile generated (example below)





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COSMOS

Jonathon McNabb

- MISSIONS
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- TELEMETRY
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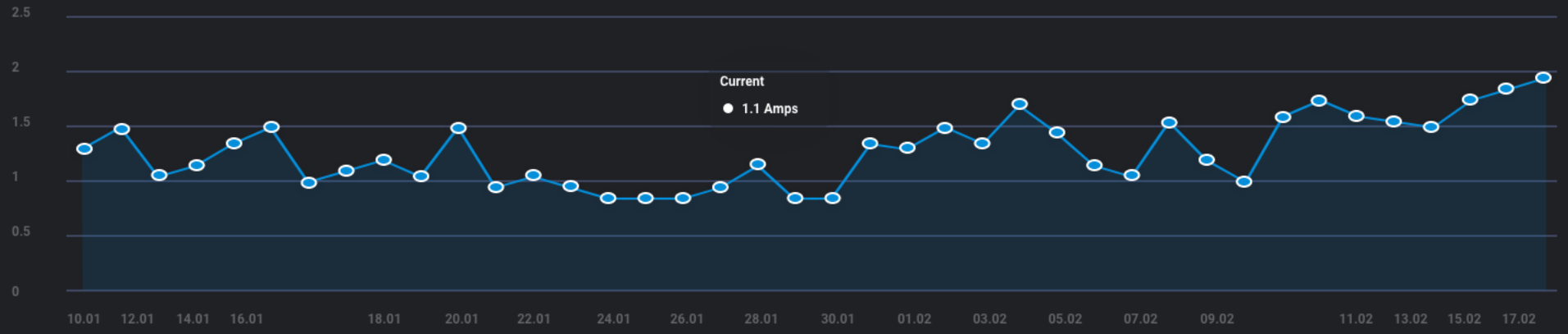
POWER VIEW

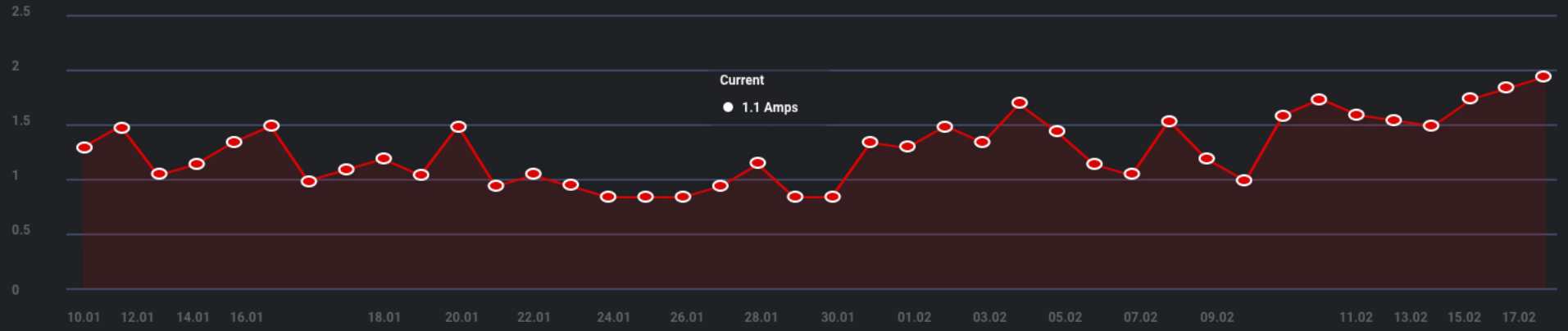
12V Current Consumption

Today | Week | Month



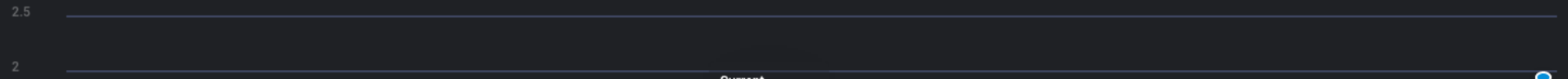
5V Current Consumption

Today | Week | Month



3.3V Current Consumption

Today | Week | Month



MISSION: 1

Conclusions

- LO Cosmos enables adaptable rover mission planning
- Maximizes science return, value to payloads
- Reduces mission risk through rapid fusion of new mission data

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