

Volatiles Inspecting Polar Exploration Rover

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VIPER Mission

Lunar south pole

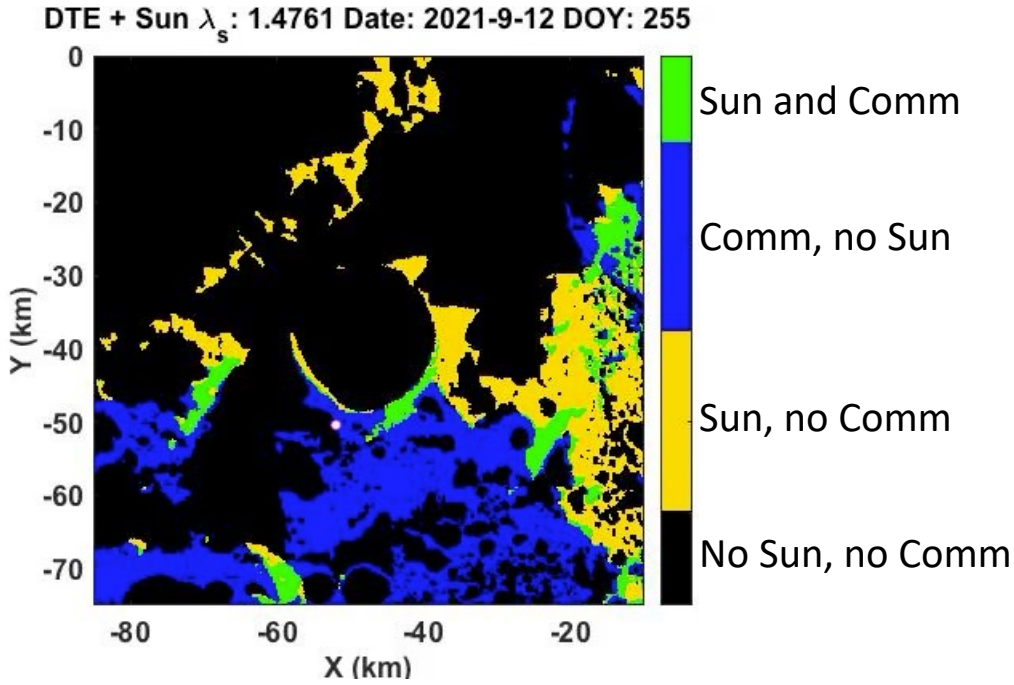
- Commercial launch and landing
- 100+ day mission (including extended survival periods)
- Up to 20 km total drive

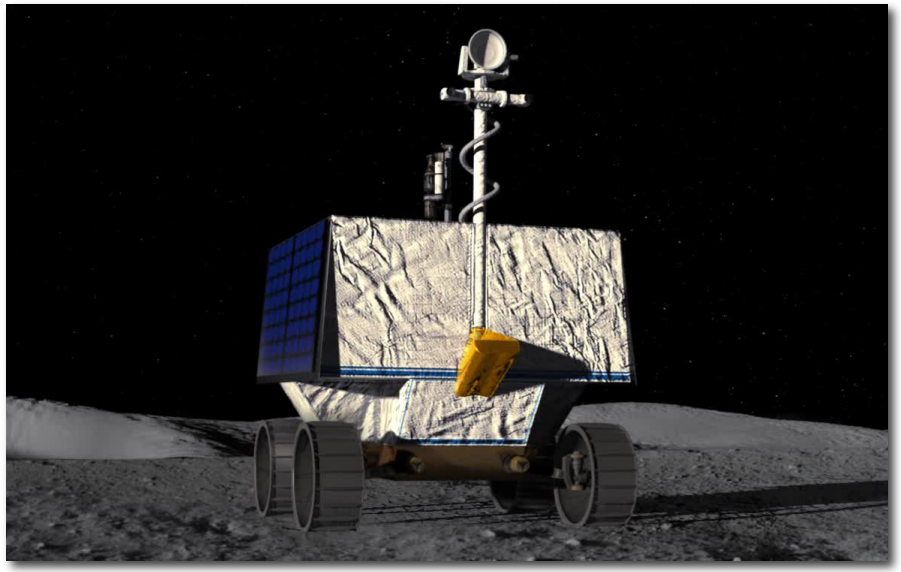
Science objectives

- Characterize distribution and physical state of volatiles (water ice, etc)
- Provide data to evaluate the potential for lunar in-situ resource utilization

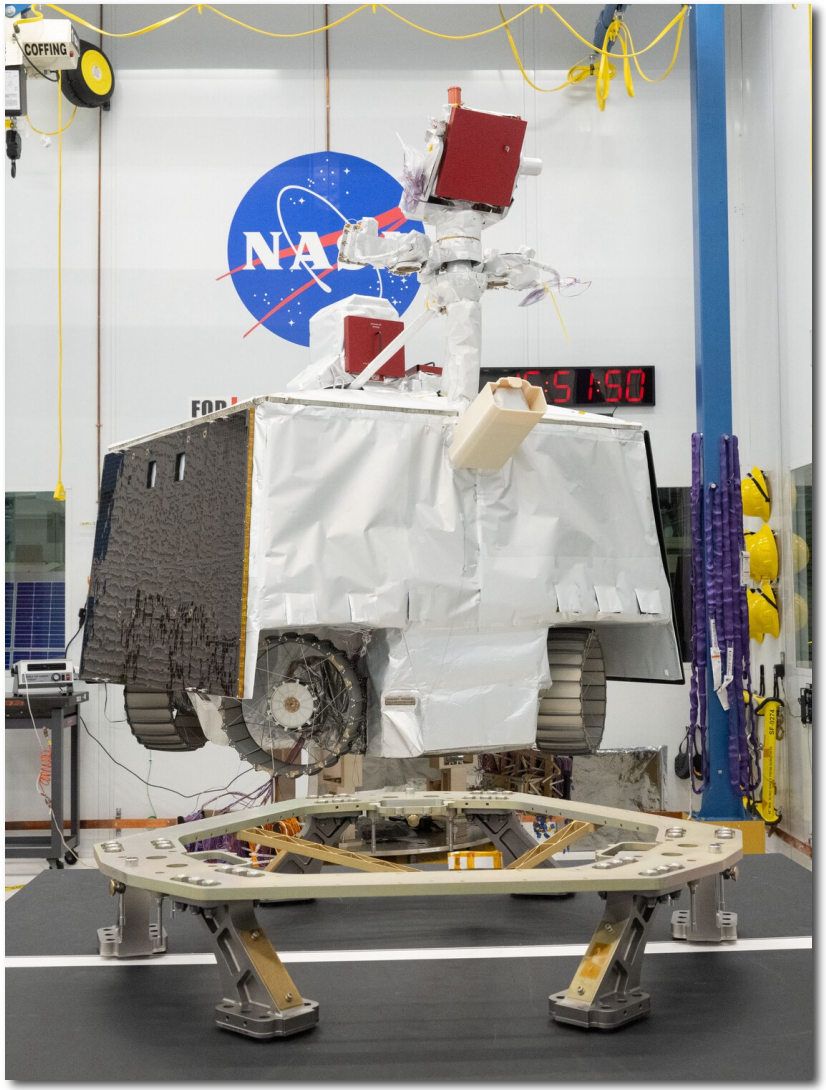
A few unique challenges (among many…)

- Dynamic environment: light + shadows
- Real-time mission ops and science
- Prospecting & “speed made good”





Flight Rover



100% complete (4 June 2024)



Entering JSC Chamber A for “TVAC”



A new type of planetary rover

First NASA lunar rover

- Designed for the “dynamic” lunar environment
- Emphasis on high operational cadence and traverse speed
- Significantly lower cost than Mars rovers (but higher risk)

Interactive operations

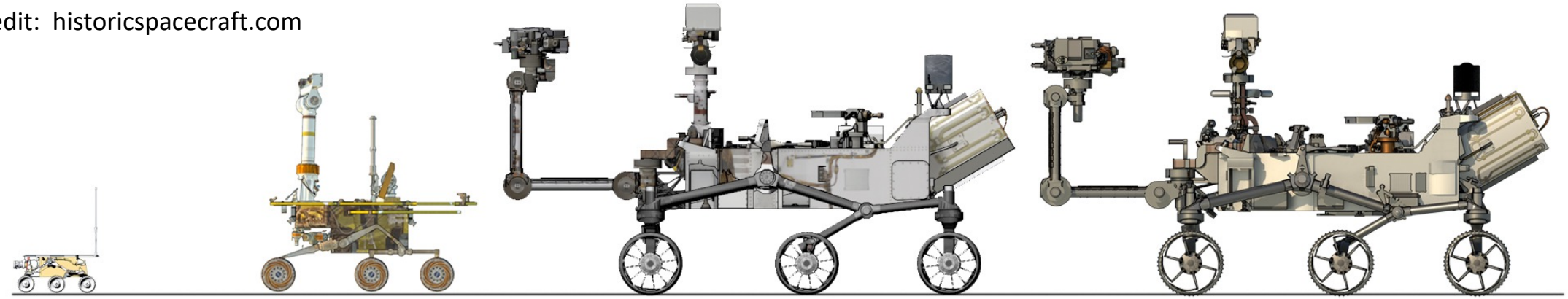
- “Real-time” mission control: rover operations + science team
- Single waypoint driving (approx. 4 m / command cycle)
- Hybrid of human exploration (Shuttle, Space Station) and Mars rover mission operations

Hybrid avionics and software

- BAE RAD 750 v3 (rad-hard, 198 MHz PPC, similar to 1997 PowerMac G3) + SP0 (rad-tolerant, 1 GHz PPC, similar to 2010 iPhone 4) computing
- Flight software is split between on-board and ground
- Ground software uses Robot Operating System 2 (ROS2)

Rover Comparison

Credit: historicspacecraft.com

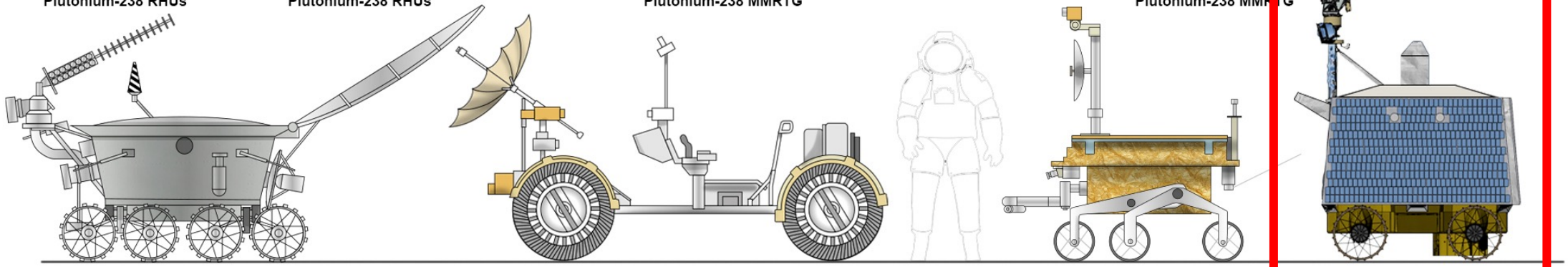


Sojourner (1996)
0.6m x 0.5m x 0.3m
11kg
Top Speed: 5cm/s
Plutonium-238 RHUs

Mars Exploration Rover (2004)
1.6m x 2.3m x 1.5m
180kg
Top Speed: 5cm/s
Plutonium-238 RHUs

Mars Science Laboratory (2011)
3.0m x 2.8m x 2.1m
900kg
Top Speed: 4cm/s
Plutonium-238 MMRTG

Mars 2020 Rover (2020)
3.0m x 2.7m x 2.2m
1025kg
Top Speed: 4.2cm/s
Plutonium-238 MMRTG



Lunokhod 1 & 2 (1970/1973)
2.3m x 1.6m x 1.5m
840kg
Top Speed: 55cm/s
Polonium-210 heat source

Lunar Roving Vehicle (1971/1972)
3.1m x 1.6m x 1.5m
210kg
Top Speed: 500cm/s
2 silver-zinc 36 volt batteries

1 meter

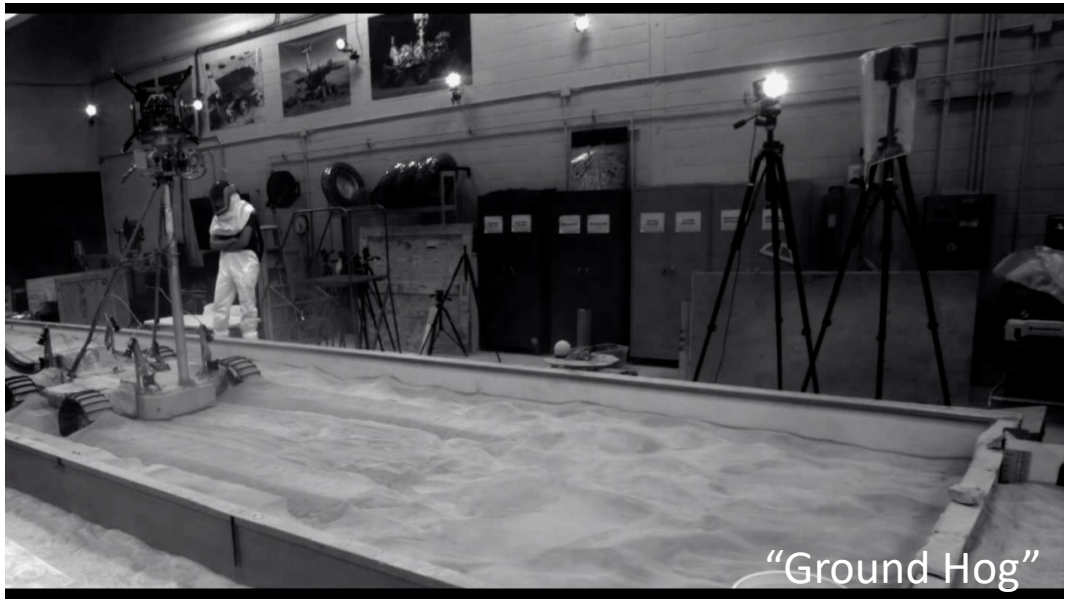
Yutu (2013/2019)
1.5m x 1.1m x 1.1m
140kg
Top Speed: 5cm/s
Plutonium-238 RHUs

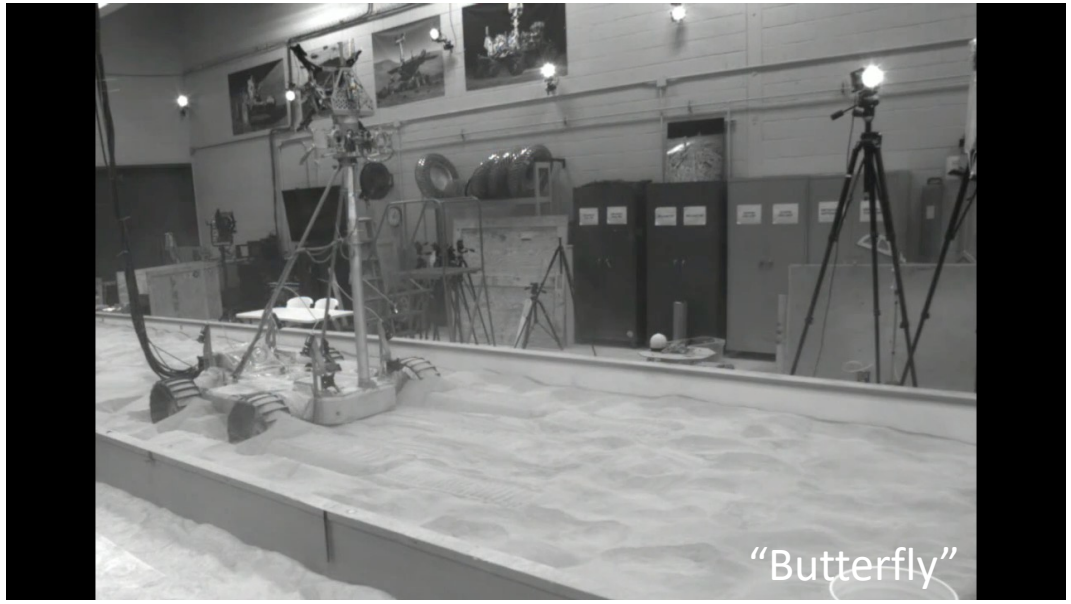
VIPER
1.5m x 1.5m x 2.0m
430kg
Top Speed: 20cm/s
Electric heaters only

Alternate Mobility Modes

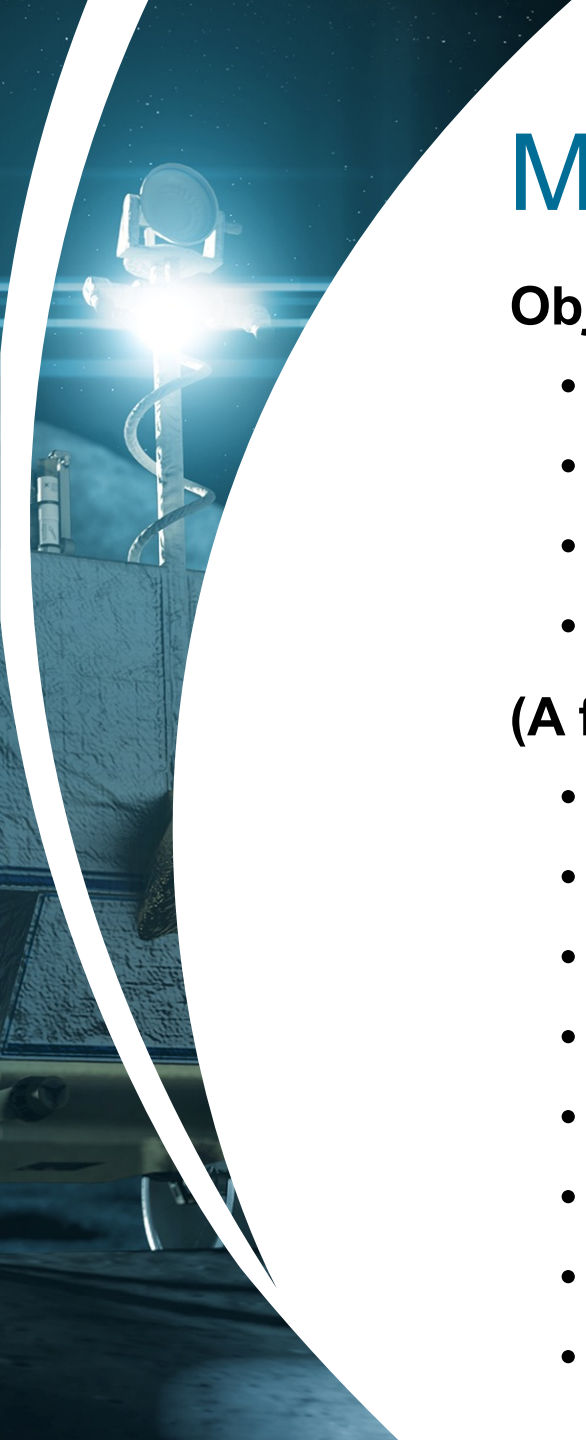
8x speed











Mission Planning

Objectives

- Develop activity, resource, and traverse plans
- Strategic and tactical plans, including contingency handling
- Robustly achieve full science success under uncertainty
- Real-time replanning, particularly when operating in science stations

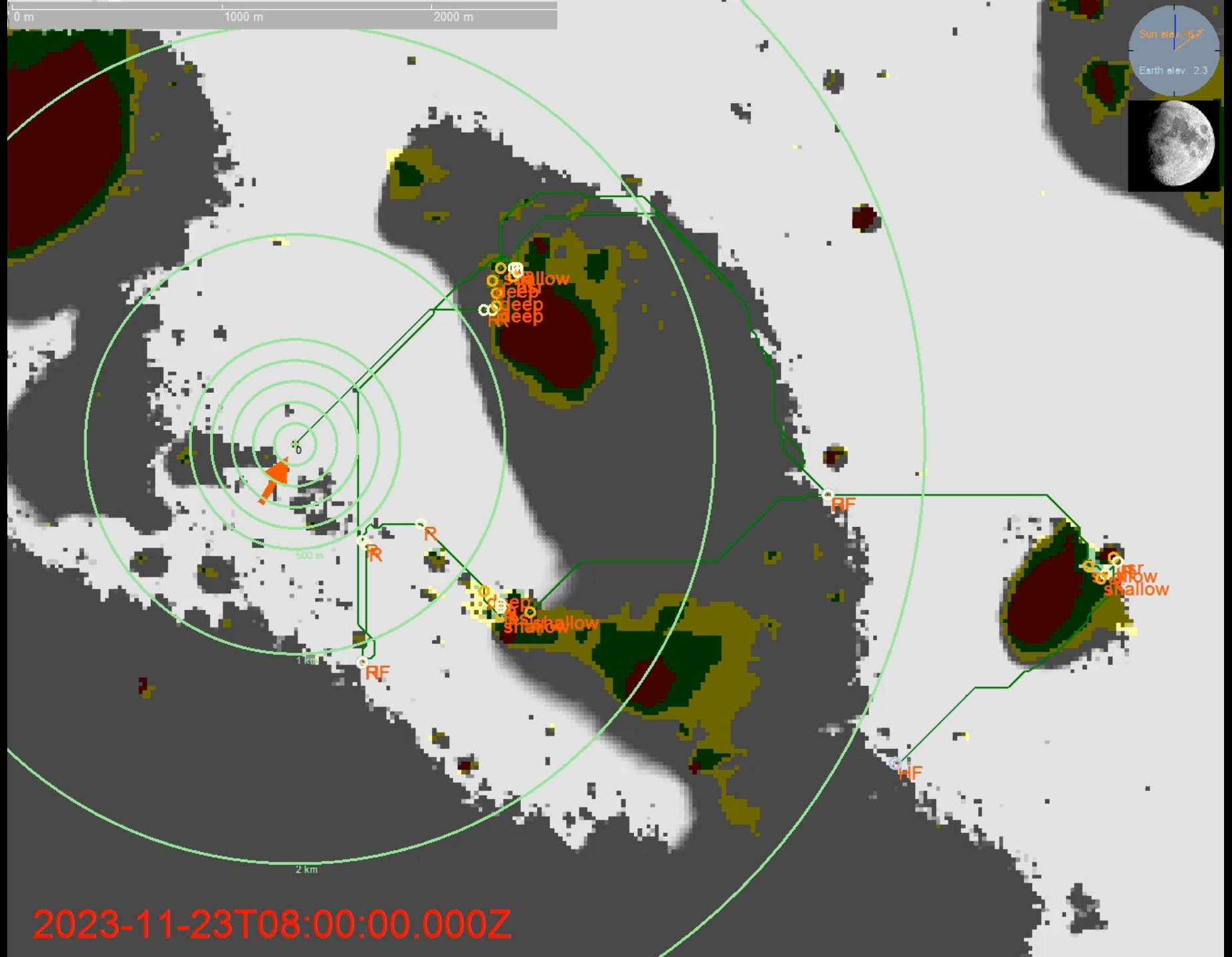
(A few) constraints

- Measure distribution and state of lunar polar volatiles
- Solar-powered rover with limited battery (shadow endurance)
- Lunar summer “season” (~100 Earth days max)
- Line-of-sight data communications to Earth
- 20 km max drive, 15 deg slopes, 20 cm step obstacles (design limit)
- 10 cm/s drive speed while prospecting (instrument limit)
- 1 cm/s “Speed Made Good” (average rate of progress)
- Moving shadows cast by rover and terrain (0.1 to 1.8 cm/s)

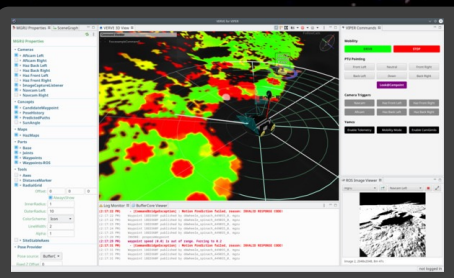
Example Traverse Plan

2023-11-23
to
2024-03-07

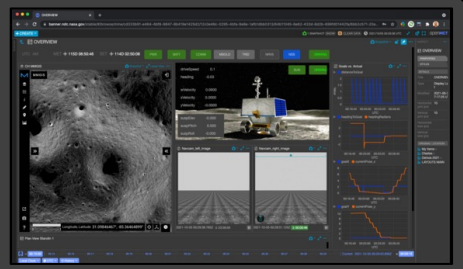
106 days



Mission Operations



Rover Driving



Mission Monitoring

KSC
MSOLO

JSC
Rover Systems & Thermal

ARC
Systems & Execution

Comms round trip ~6 - 10 sec



Lander

Science Station

Traverse Points
~ 50 m

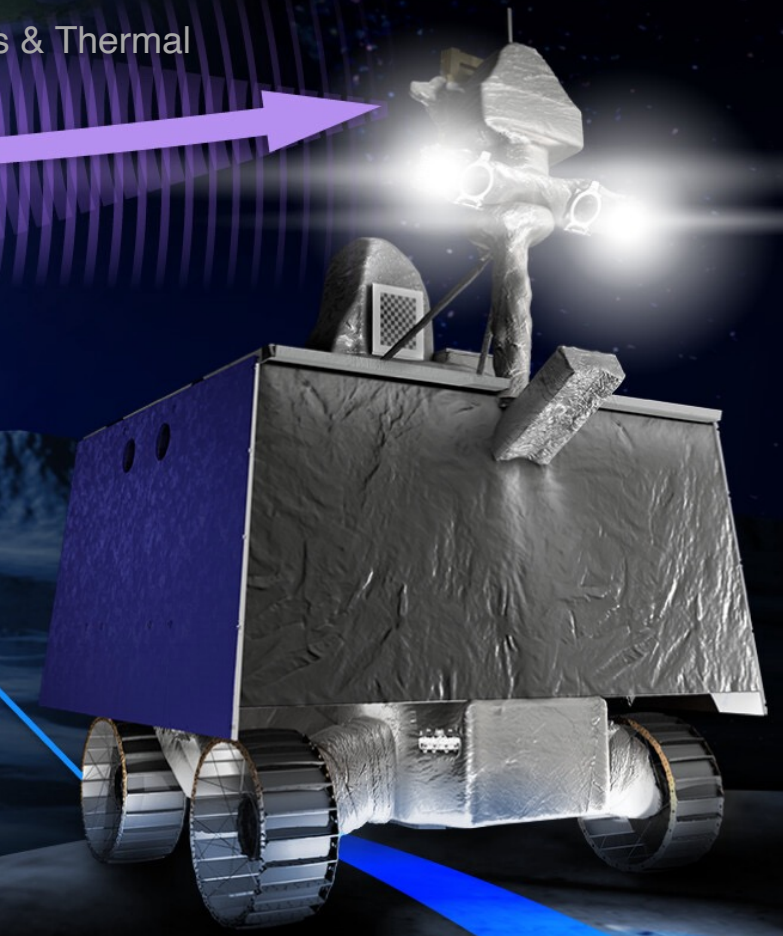
Waypoints
~ 5 m

Drill A

Drill B

Drill C

Science Station

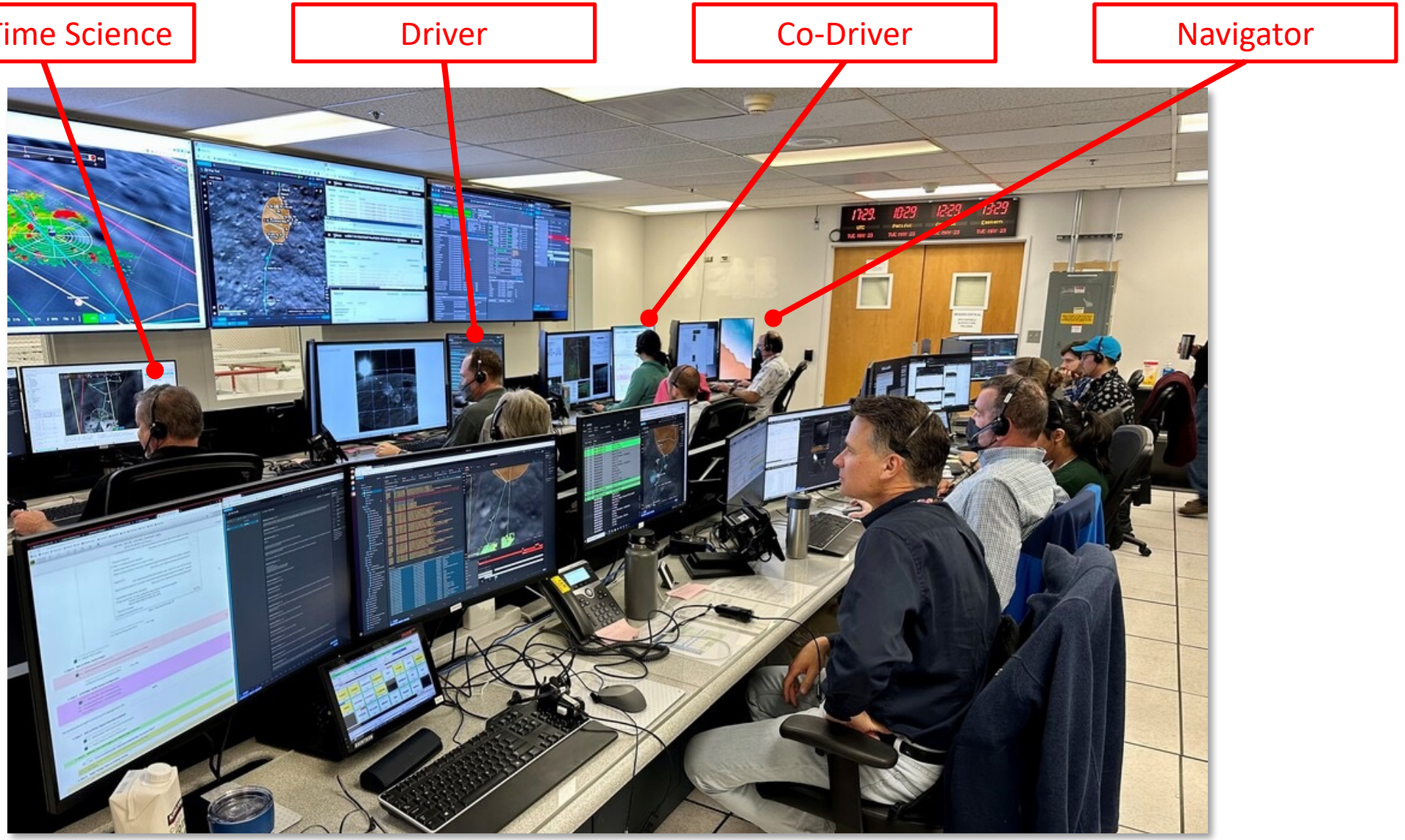


Mons Mouton (84.6°S, 31.0°W)
near Nobile Crater

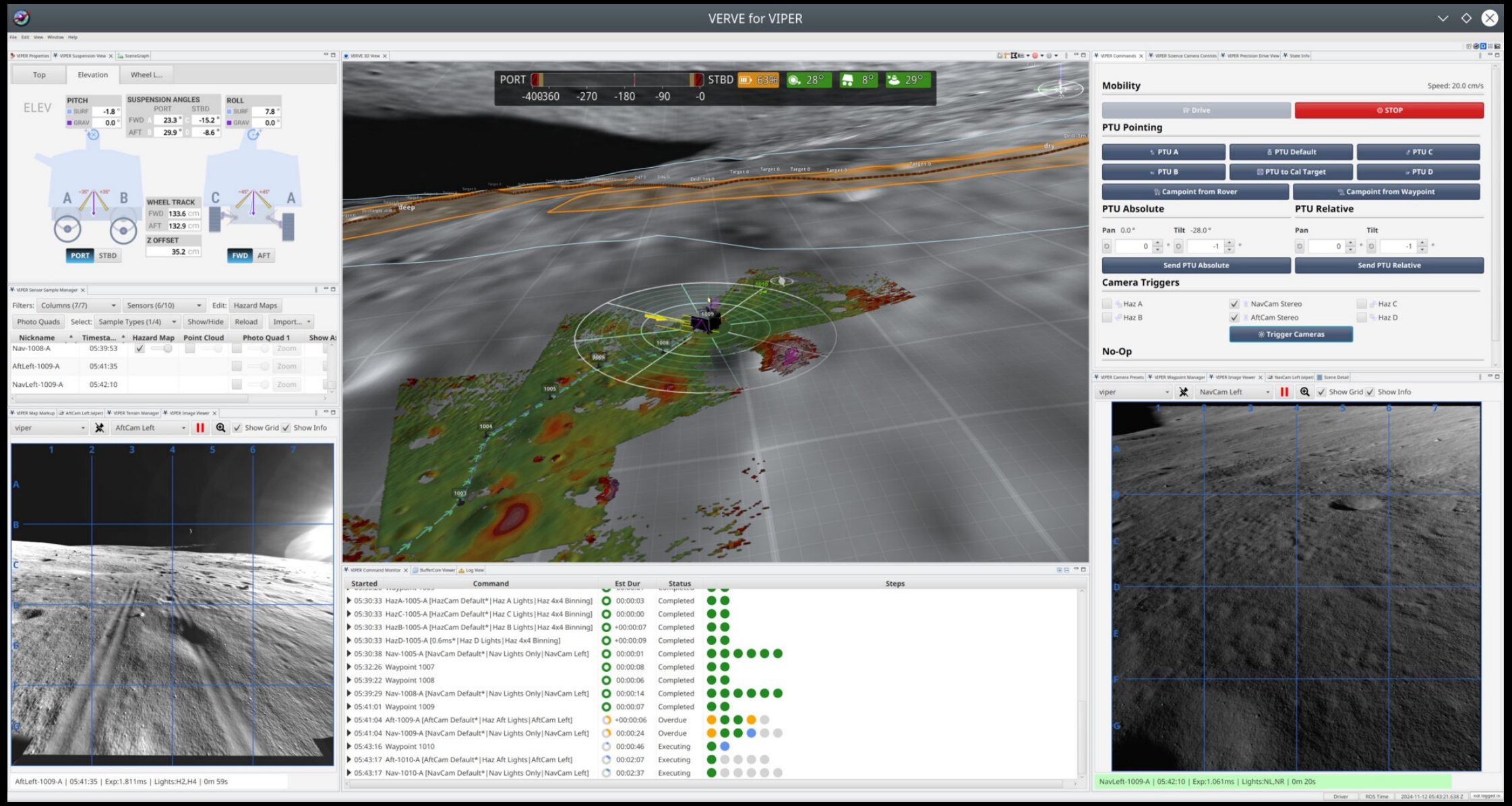
Mission Control Center



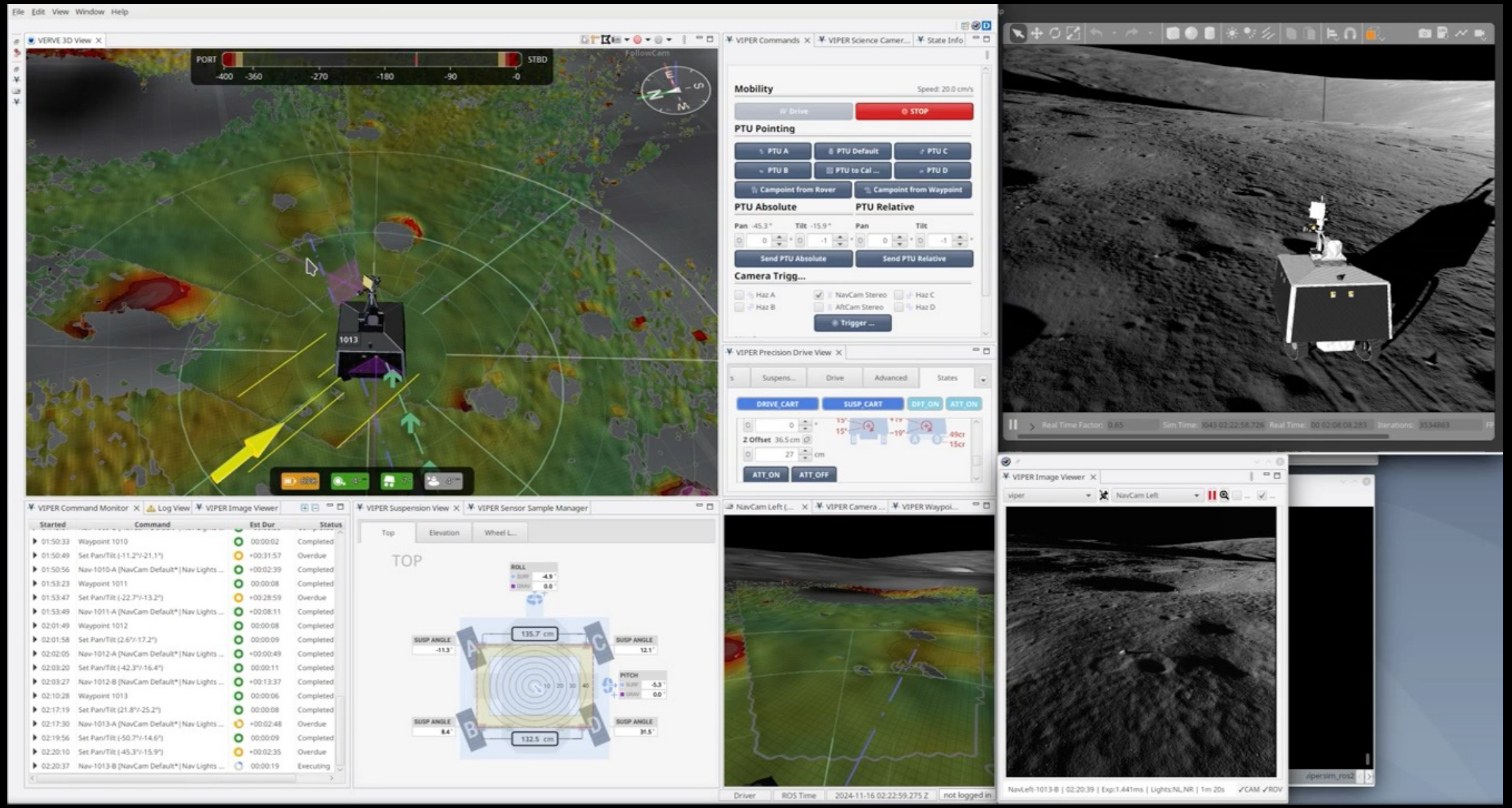
“Drive Team”



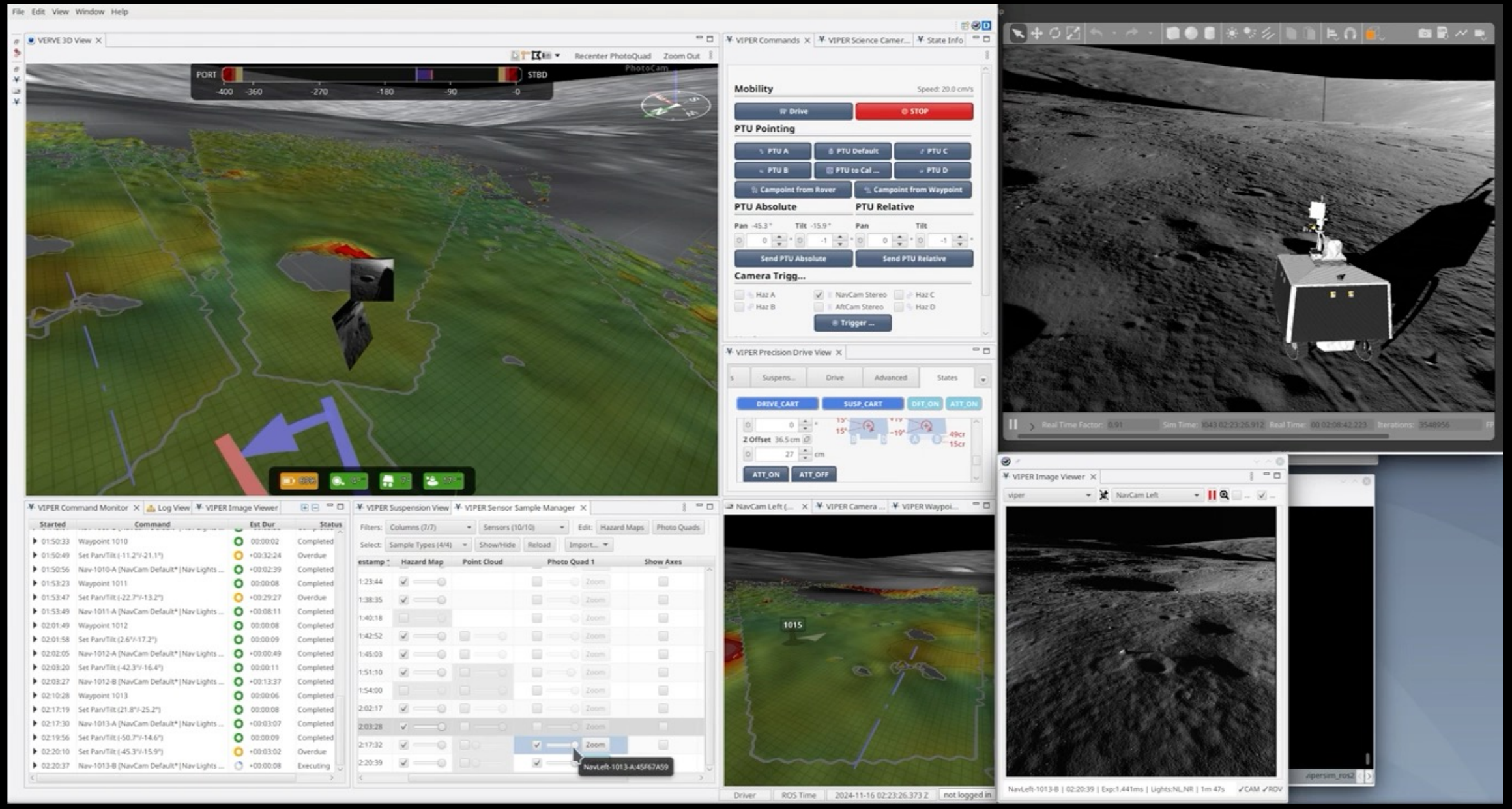
Rover Driving Interface (VERVE)



VERVE + RSIM (Assess terrain + place waypoint)



VERVE + RSIM (Refine waypoint + drive)




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NASA