2024 Planetary Science Technology Symposium

Technology Developed Through VIPER

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NASA Ames Research Center / NASA Johnson Space Center

October 22, 2024

PESTO
Planetary Exploration Science Technology Office

VIPER Rover

Mass

- Launch: 490 kg (with lander interface)
- Roving: 447 kg

Dimensions: 1.7m x 1.7m x 2.5m

Power

- Solar arrays: 320W per panel (450W on corner)
- Battery capacity (start of life @ 0C): 5,420 W-hr

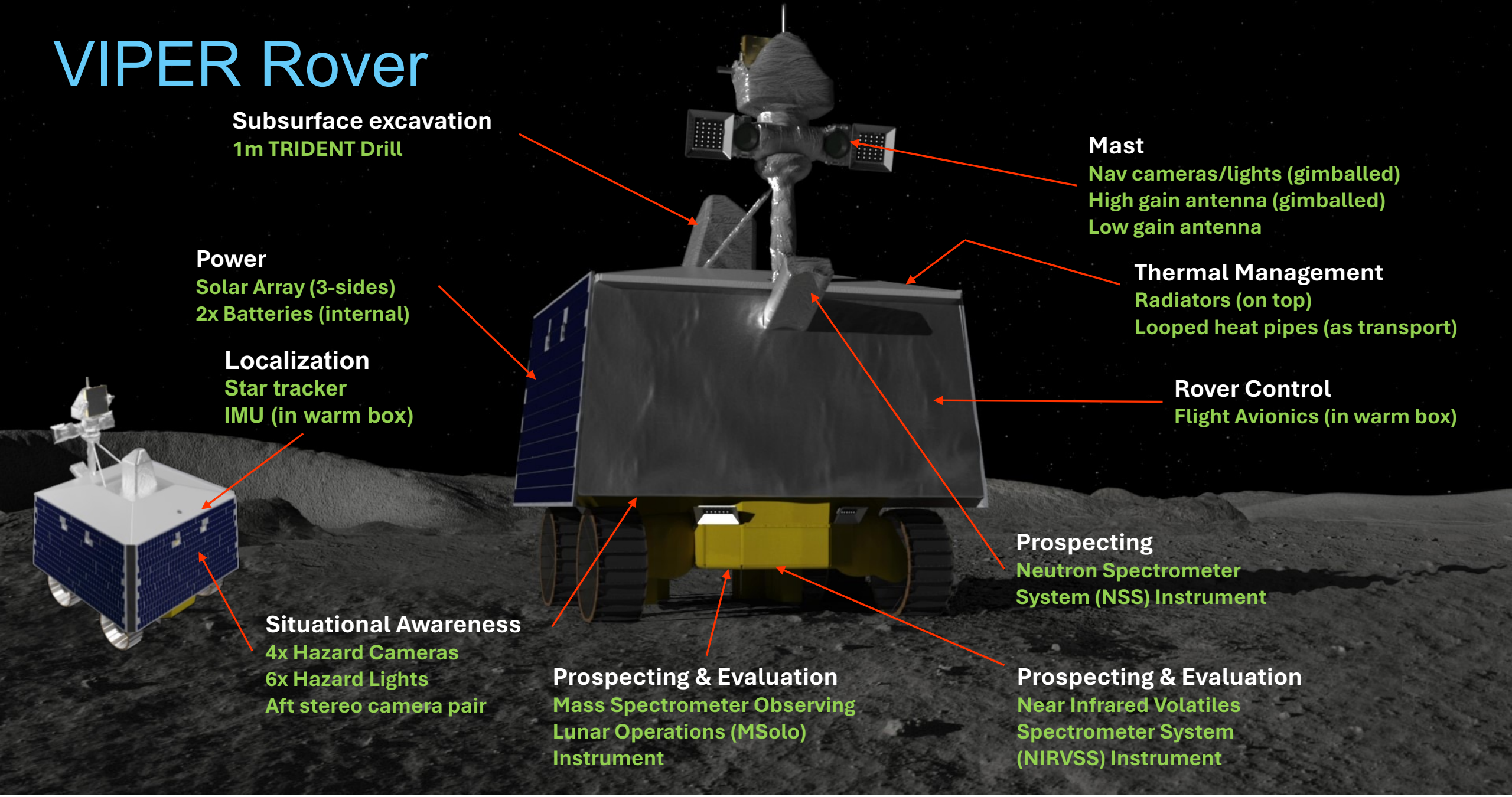
Communications

- X-band Direct-To-Earth (no relay)
- Transmit: 250 sps / 8 Msps (min/max)
- Receive: 250 sps / 75 ksps (min/max)
- Gimballed high gain + fixed low-gain antennas

Shadow Survival

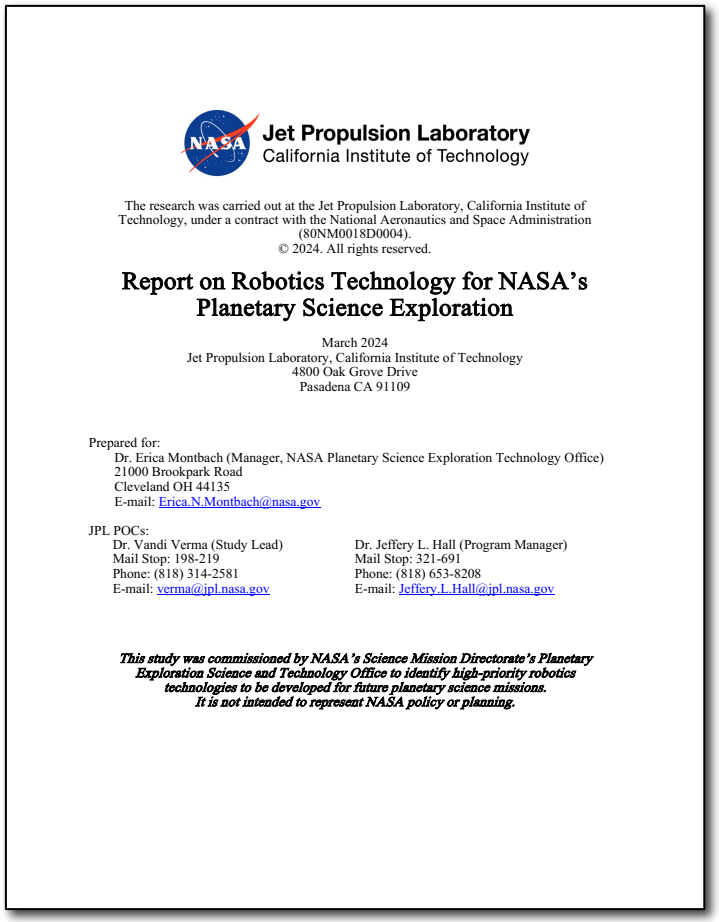
- 9 hr (ops in PSR), 50 hours (low power hibernate)

VIPER Rover


Subsurface excavation
1m TRIDENT Drill
Mast
Nav cameras/lights (gimballed)
High gain antenna (gimballed)
Low gain antenna
Power
Solar Array (3-sides)
2x Batteries (internal)
Thermal Management
Radiators (on top)
Looped heat pipes (as transport)
Localization
Star tracker
IMU (in warm box)
Rover Control
Flight Avionics (in warm box)
Prospecting
Neutron Spectrometer System (NSS) Instrument
Situational Awareness
4x Hazard Cameras
6x Hazard Lights
Aft stereo camera pair
Prospecting & Evaluation
Mass Spectrometer Observing Lunar Operations (MSolo) Instrument
Prospecting & Evaluation
Near Infrared Volatiles Spectrometer System (NIRVSS) Instrument

VIPER relevance to PESTO robotics tech needs

Perception for Challenging Lighting (R1)	• terrain hazard classification SW • photoclinometry based DEM production SW • horizon line prediction SW
Perception Components (R2)	• artificial lighting for ops and perception • star tracker on rover
Surface Navigation for Day/Night (R3)	• visual odometry for lunar polar region SW • absolute localization for lunar polar region SW
Steep and Irregular Terrain Access (R9)	• active suspension system HW + SW • real-time slip estimation SW • hybrid locomotion gaits SW
Cold Tolerant Components (R10)	• wheels + grousers • actuators + complex electronics • thermal management system



Jet Propulsion Laboratory
California Institute of Technology

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

Report on Robotics Technology for NASA's Planetary Science Exploration

March 2024
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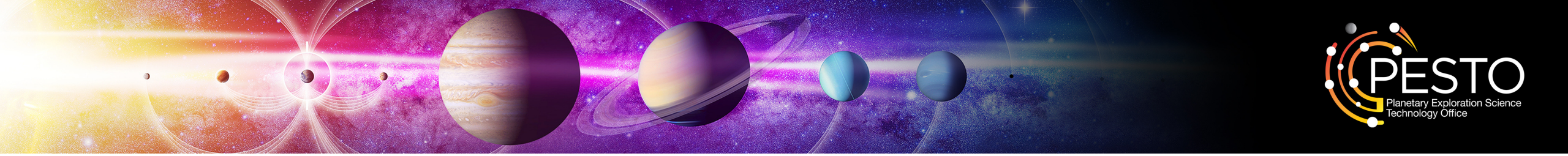
This study was commissioned by NASA's Science Mission Directorate's Planetary Exploration Science and Technology Office to identify high-priority robotics technologies to be developed for future planetary science missions. It is not intended to represent NASA policy or planning.



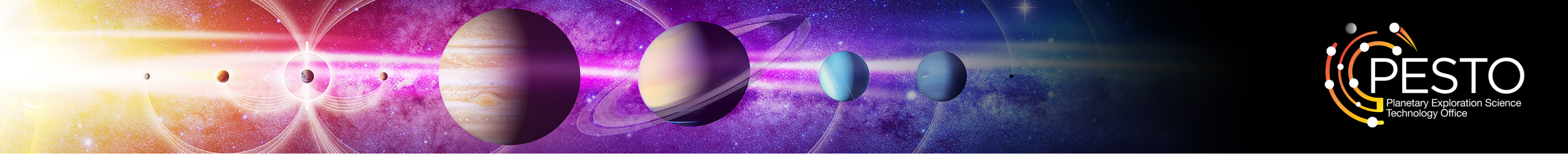
VIPER Innovations

Hardware

- First rover designed to operate for multiple lunar day/night cycles without use of any radioisotopes (RHU or RTG)
- First NASA rover with hybrid locomotion gaits (combined active control of propulsion, steering, and suspension)
- First rover with artificial (supplemental) lighting system for ops & perception
- First rover with star tracker for absolute orientation measurements
- First lunar rover with loop heat pipe thermal management system

Software

- First hybrid flight software for lunar rovers using cFS (on-board) and ROS2 (off-board)
- High-fidelity real-time lunar rover simulator for development, V&V, and ops training
- High-resolution (1 m/pixel) photoclinometry-based DEM production
- High-quality synthetic terrain generation (4 cm/pixel)
- Terrain-relative navigation for relative (3m) and absolute (20m) lunar polar localization
- Real-time directional comm antenna Earth pointing while driving over rough terrain
- Autonomous comm link recovery



VIPER Innovations

Mission Ops

- AI-based strategic traverse planning (incoporates multiple solvers and planning under uncertainty)
- Tactical planning technology for dynamic operational environment
- Open-source mission operator interfaces (including "Do It Yourself" public mission control)
- Real-time interactive science rover operations (hybrid of ISS real-time and Mars rover command-cycle)

Commercial

- Real-time slip estimation software (ProtoInnovations) – *SBIR + STTR*
- Hybrid mobility gait control software (ProtoInnovations) – *SBIR + STTR*
- TRIDENT rotary-percussive drill (Honeybee) – *SBIR*
- Modified COTS mass spectrometer for MSOLO and NIRVSS – *SBIR*
- PRIDE ops procedure system (TRACLabs) – *SBIR*

VIPER Panelists




Instruments & Real-time Science Ops

- Jen Heldmann (ARC), Science Team

Mechatronics

- Bill Bluethmann (JSC), Rover Lead

Navigation System

- Matt Deans (ARC), Rover Ground Software Lead

Software (on-board and ground)

- Terry Fong (ARC), Rover Deputy