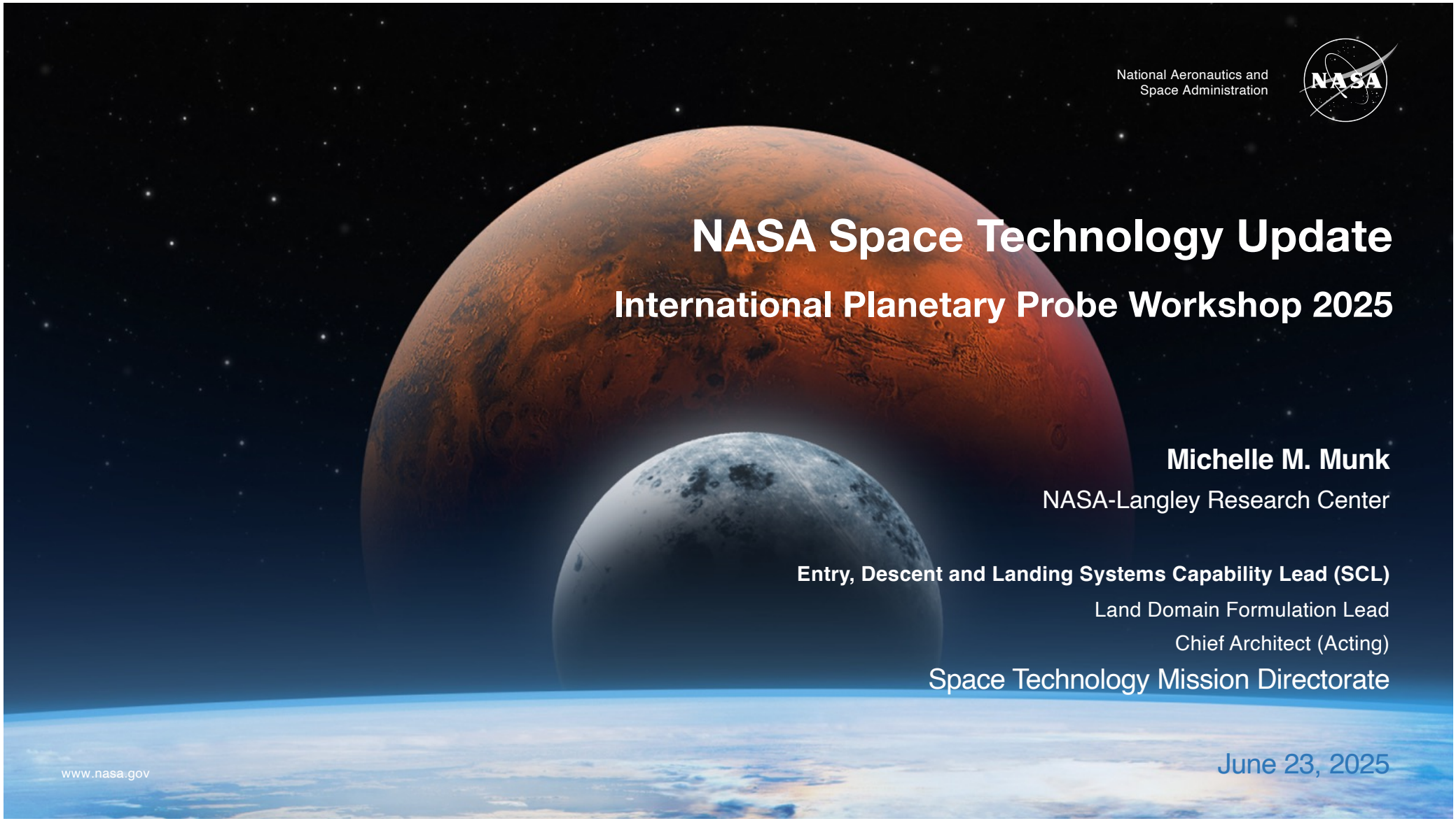


NASA Space Technology Update

International Planetary Probe Workshop 2025

Michelle M. Munk

NASA-Langley Research Center

Entry, Descent and Landing Systems Capability Lead (SCL)

Land Domain Formulation Lead

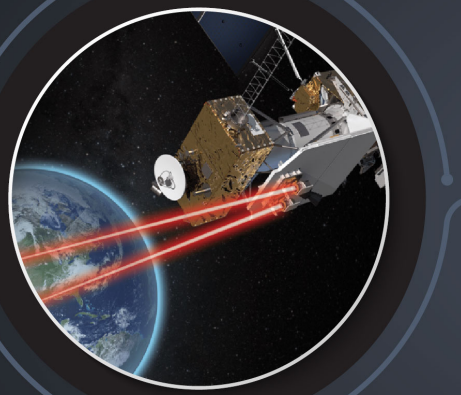
Chief Architect (Acting)

Space Technology Mission Directorate

June 23, 2025

SPACE TECHNOLOGY MISSION DIRECTORATE

The work we do today is shaping the missions of the future while delivering the cutting-edge technology that defines American leadership in space exploration for years to come

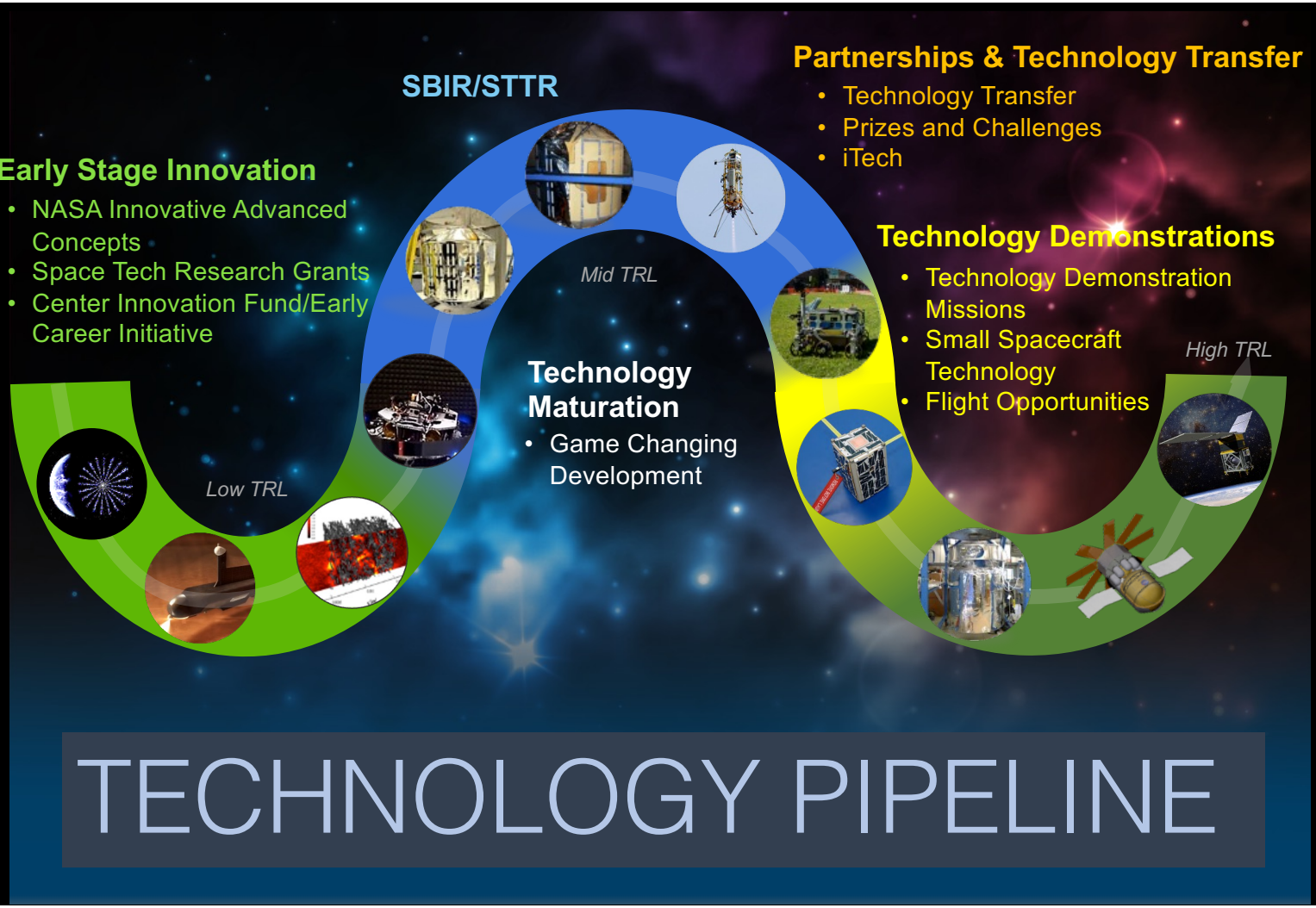


ADVANCE U.S. space technology innovation and competitiveness in a global context

FOSTER innovation by cultivating breakthrough ideas, embracing risk, and fueling a competitive space economy

INSPIRE and develop a powerful U.S. aerospace technology community to improve life here on Earth and in space

STMD Programs – TRL-Based Structure (Current)



Tech Base Functional Domains

GO
Space Transportation

- Advanced Propulsion
- Nuclear Propulsion
- Flight Vehicle Systems (including Ascent Systems)
- Cryogenic Fluid Management

LAND
Space to Surface Operations

- Deceleration Systems
- Guidance & Nav Systems
- Landing Systems & Environments
- Entry Modeling & Instrumentation

LIVE
Surface Infrastructure/ Exploration

- Surface Power
- In Situ Resource Utilization
- Surface Structures & Construction
- Dust Mitigation & Environments
- Surface Mobility & Transportation
- Surface Habitation Systems
- Surface Sustainability & Logistics

EXPAND
In-Space Infrastructure/ Discovery

- Observation Systems
- In-Space Sustainability
- Communications, Positioning, Navigation, & Timing
- In-Space Servicing, Assembly, & Manufacturing
- Small Spacecraft & Distributed Systems

ENABLE
Foundational Capabilities

- Avionics & Sensors
- Robotics & Autonomy
- Advanced Materials, Structures & Manufacturing
- Advanced Power & Thermal

- Capability Portfolio

CATALYSTS
Innovative Mechanisms

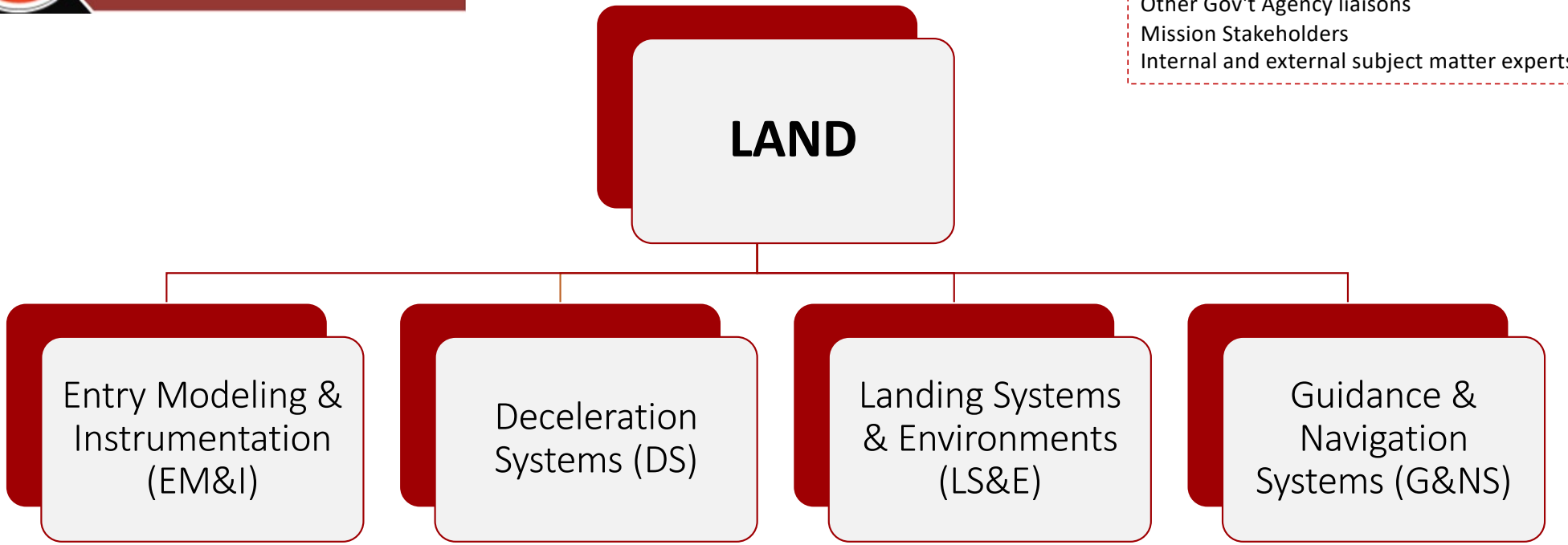
- NIAC/CIF/ECI
- STRG
- PCC
- Tech Transfer
- SBIR/STTR
- Flight Opportunities
- TP/ACO
- Inclusive Innovation

2024-06-28

Land Domain Structure

LAND
Space to Surface Operations

Steering/Control Boards
Existing EDL SCLT Members
MD Liaisons: SMD, ESDMD, ARMD, STMD
Other Gov't Agency liaisons
Mission Stakeholders
Internal and external subject matter experts



2024 Integrated Shortfall Ranking – Entry, Descent and Landing

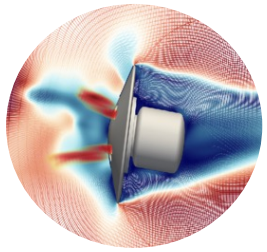
Capability	Integrated Ranking	Shortfall ID: Title	Org
Entry Descent and Landing	22	1569: High-Mass Mars Entry and Descent Systems	DS
Entry Descent and Landing	24	1571: Navigation Sensors for Precision Landing	G&NS
Entry Descent and Landing	25	1573: Terrain Mapping Capabilities for Precision Landing and Hazard Avoidance	G&NS
Entry Descent and Landing	26	1562: Advanced Algorithms and Computing for Precision Landing	G&NS
Entry Descent and Landing	28	1568: Entry Modeling and Simulation for EDL Missions	EM&I
Entry Descent and Landing	37	1563: Aerocapture for Spacecraft Deceleration and Orbit Insertion	DS
Entry Descent and Landing	43	1565: Assessment and Validation Capabilities for Integrated Precision Landing Systems	G&NS
Entry Descent and Landing	74	1566: Characterization of Plume Surface Interaction	LS&E
Entry Descent and Landing	106	1574: Validated Performance Models for Planetary Parachutes	EM&I
Entry Descent and Landing	131	1564: Aeroshell In-Situ Flight Performance Data During EDL	EM&I
Entry Descent and Landing	143	1570: Lander Capabilities for Soft Touchdown	LS&E
Entry Descent and Landing	146	1567: Entry Capabilities for Small-Scale and Commercial Spacecraft	DS
Entry Descent and Landing	181	1572: Performance-Optimized Low-Cost Aeroshells for EDL Missions	DS

- To obtain the full ranking results, visit: www.nasa.gov/civilspaceshortfalls

Entry Modeling & Instrumentation (EM&I) Capability

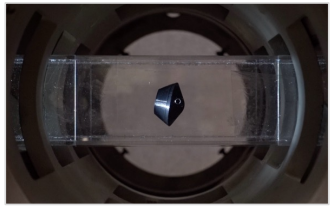
EM&I Shortfalls
- 1568: Entry Modeling and Simulation for Entry, Descent and Landing (EDL) Missions
- 1564: Aeroshell In-Situ Flight Performance Data During EDL
- 1574: Validated Performance Models for Planetary Parachutes

Envisioned Content



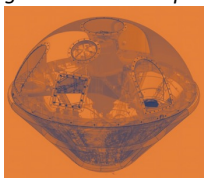
Multi-disciplinary Modeling

Advanced Numerics



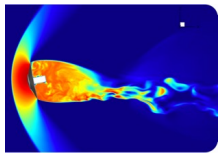
Advanced Ground Test Capabilities

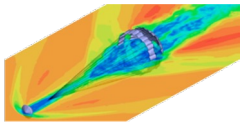
Image credit: Varda Space Ind.

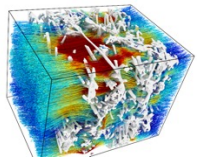


Validation through Hypersonic Testbeds

Existing Content



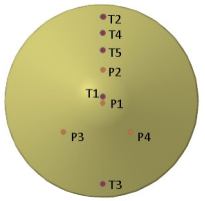


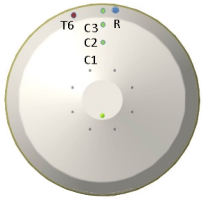


Entry Systems Modeling
- Aerosciences
- TPS material response/failure
- Parachutes
- Validation through ground and flight test

ACCESS STRI

Dragonfly Entry Aerosciences Measurements (DrEAM)
- Instrumenting the aeroshell for Titan entry model validation





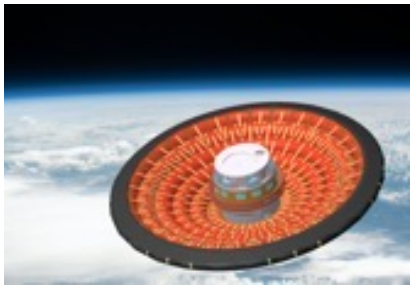
SciFli ACOs: Airborne observation to obtain reentry data
- Sierra Space
- SpaceX

DAVINCI Instrumentation (VISTA)
- Instrumenting the probe for Venus entry model validation

Deceleration Systems (DS) Capability

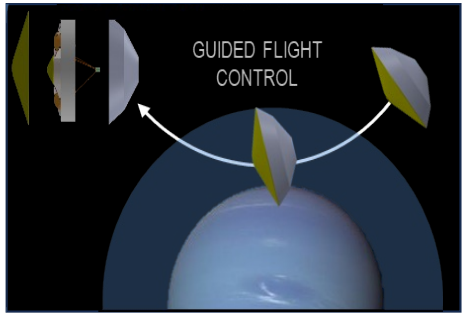
DS Shortfalls
- 1566: High-Mass Mars Entry and Descent Systems
- 1572: Performance-Optimized Low-Cost Aeroshells for Entry, Descent & Landing Missions
- 1563: Aerocapture for Spacecraft Deceleration and Orbit Insertion
- 1567: Entry Capabilities for Small-Scale and Commercial Spacecraft

Existing Content

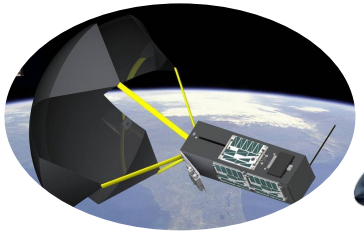


HIAD Development/Application
- Vulcan Engine Reuse System TP (ULA)

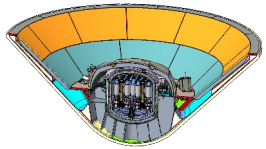
Envisioned Content



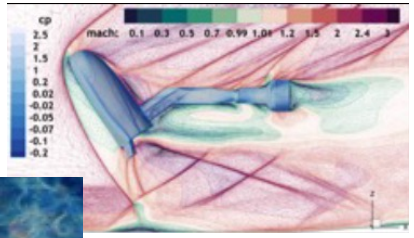
Aerocapture
Demonstration & Infusion

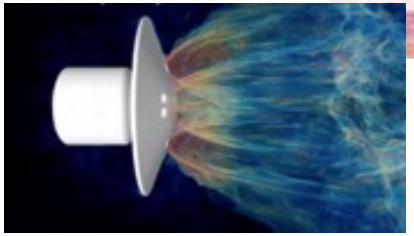


Advanced Deceleration
Devices



Robust, Low-Cost
Structures & TPS



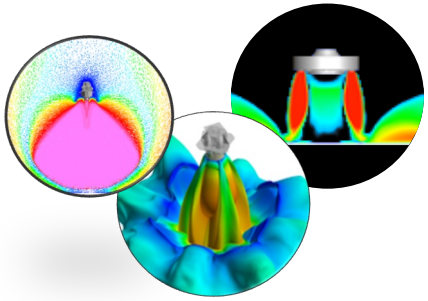


Retropropulsion
- Supersonic wind tunnel testing
- Use of GPUs for CFD/visualization (w/DoE)

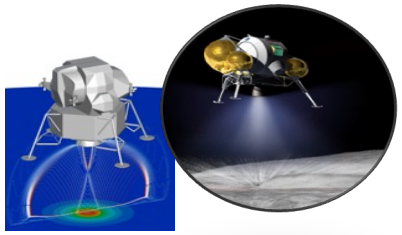
Landing Systems & Environments (LS&E) Capability

LS&E Shortfalls
- 1562: Characterization of Plume Surface Interaction (PSI)
- 1570: Lander Capabilities for Soft Touchdown

Envisioned Content

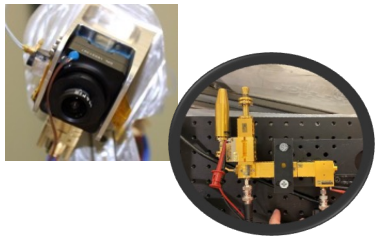


PSI Fundamental Modeling, Simulation & Validation



Mission PSI Assessment & Prediction

Touchdown Attenuation Systems & Assessments

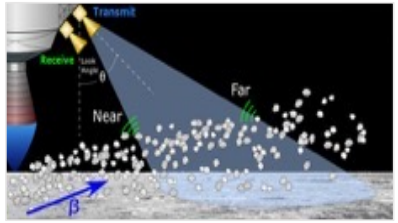


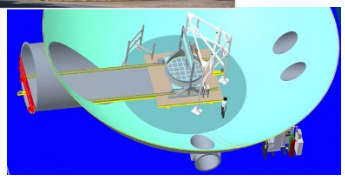
Test & Flight Instruments for PSI Characterization & Mitigation

Existing Content

SCALPSS
- Evolving stereo camera systems to measure PSI on Commercial Lunar Payload Services (CLPS) and other landers

PSI Instrumentation
- Sensor(s) for time-evolving surface topography for erosion
- Sensor(s) for ejecta velocity and energy flux for near-field and far field damage and site alteration





PSI Ground Testing (HLS funded)
- Scaled PSI testing at 100 Pa using lunar regolith simulant for large lunar landers
- Evaluating requirements for a Mars-relevant PSI test

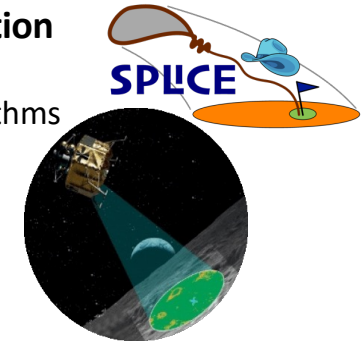
Guidance & Navigation Systems (G&NS) Capability

G&NS Shortfalls
- 1571: Navigation Sensors for Precision Landing
- 1562: Advanced Algorithms and Computing for Precision Landing
- 1573: Terrain Mapping Capabilities for Precision Landing and Hazard Avoidance
- 1565: Assessment & Validation Capabilities for Integrated Precision-Landing Systems

Existing Content

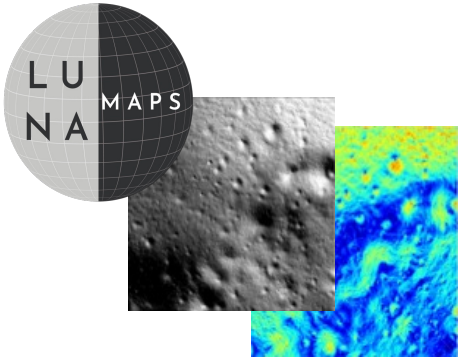
Safe & Precise Landing – Integrated Capabilities Evolution

- Developing lidars for active terrain sensing in all lighting
- Implementing convex optimization-based guidance algorithms for real-time trajectory planning
- Flight testing integrated technologies
- Supporting technology transfer and commercialization



Lunar Navigation Maps

- Developing mapping capabilities for lunar missions that feed forward to Mars
- NASA Tech Transfer underway

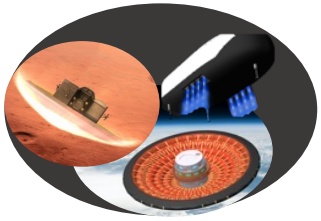


Xogdor Tipping Point (Astrobotic)

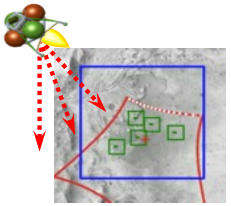
- Next-generation suborbital rocket for flight demonstrating payloads to higher altitudes and velocities
- Closed-loop capability

Image Credit: Astrobotic

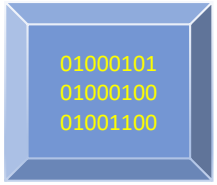
Envisioned Content



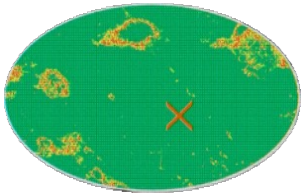
Guidance, Navigation & Control Systems Studies



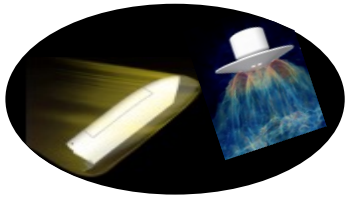
Surface-Relative Sensing



Advanced Algorithms



High-Resolution Surface Hazard Mapping

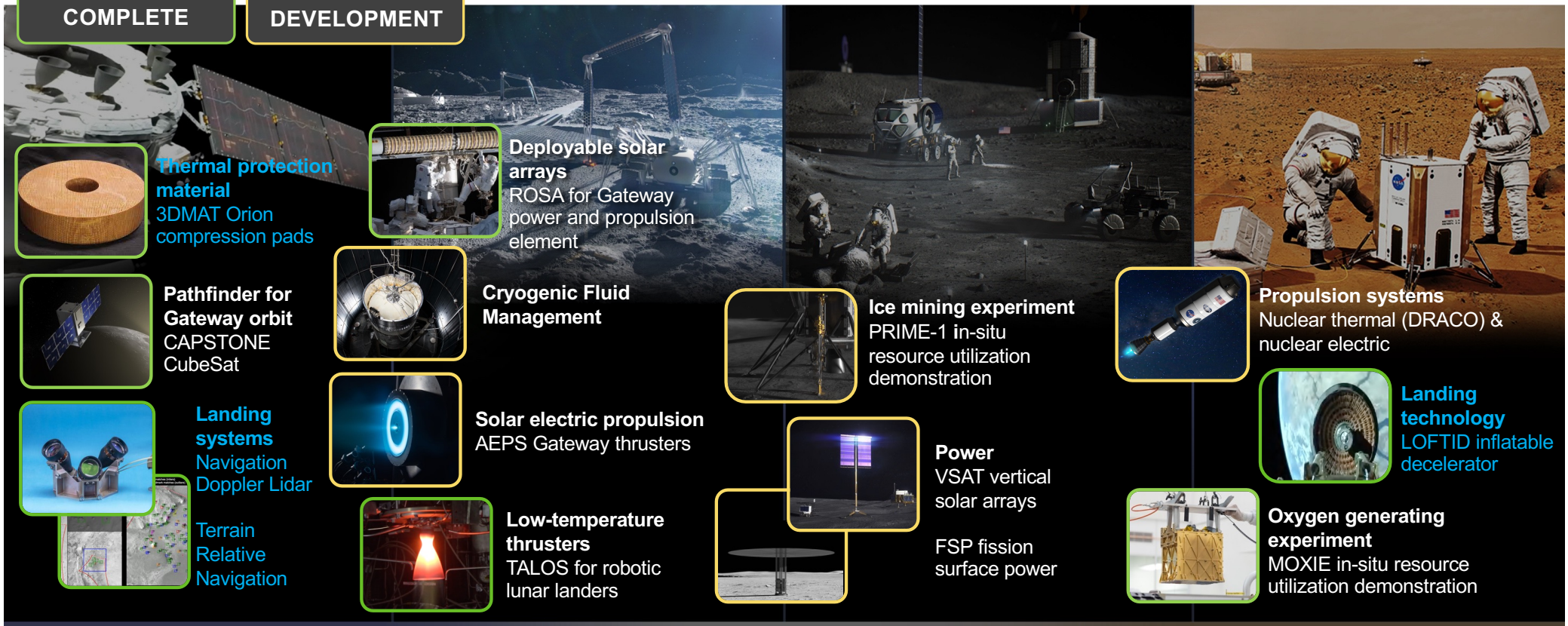


High-Mach Entry Sensing

STMD Contributions to Moon & Mars Exploration

EDL Content in blue

COMPLETE | DEVELOPMENT



Thermal protection material
3DMAT Orion compression pads

Pathfinder for Gateway orbit
CAPSTONE CubeSat

Landing systems
Navigation Doppler Lidar

Terrain Relative Navigation

Deployable solar arrays
ROSA for Gateway power and propulsion element

Cryogenic Fluid Management

Solar electric propulsion
AEPS Gateway thrusters

Low-temperature thrusters
TALOS for robotic lunar landers

Ice mining experiment
PRIME-1 in-situ resource utilization demonstration

Power
VSAT vertical solar arrays

FSP fission surface power

Propulsion systems
Nuclear thermal (DRACO) & nuclear electric

Landing technology
LOFTID inflatable decelerator

Oxygen generating experiment
MOXIE in-situ resource utilization demonstration

HUMAN LUNAR RETURN | FOUNDATIONAL EXPLORATION | SUSTAINED LUNAR EVOLUTION | HUMANS TO MARS

Catalysts: Mechanisms to Advance Technologies and Address Shortfalls

LAND will use a variety of tools and mechanisms to address capability shortfalls and nurture the knowledge and talent base for civil space

Contracts

Grants and Cooperative Agreements

Internal Awards

Challenges

Flight Tests

Funded / Unfunded Space Act Agreements

Cross-cutting activities (Inclusive Innovation, NASA I-Corps) and other tools

NASA Innovative Advanced Concepts	Center Innovation Fund / Early Career Initiative	Space Technology Research Grants	Prizes, Challenges, and Crowdsourcing	Tipping Point	Announcement of Collaboration Opportunity	Small Business Innovation Research / Small Business Technology Transfer	Flight Opportunities	Technology Transfer

Explore opportunities to work with us: techport.nasa.gov/opportunities

Summary

- The new STMD **Land** domain will address entry, descent and landing capabilities by maturing technologies along the TRL spectrum
  - 4 capability areas included
  - multi-NASA Center leadership
  - Utilizing academia, industry, NASA Centers, and international collaborations
- We have an exciting technology portfolio that will continue to make impacts on the Artemis architecture
- EDL will continue to be a needed capability, supporting human exploration, science missions, and industry endeavors


Thank you!
Best wishes for a successful IPPW 2025!