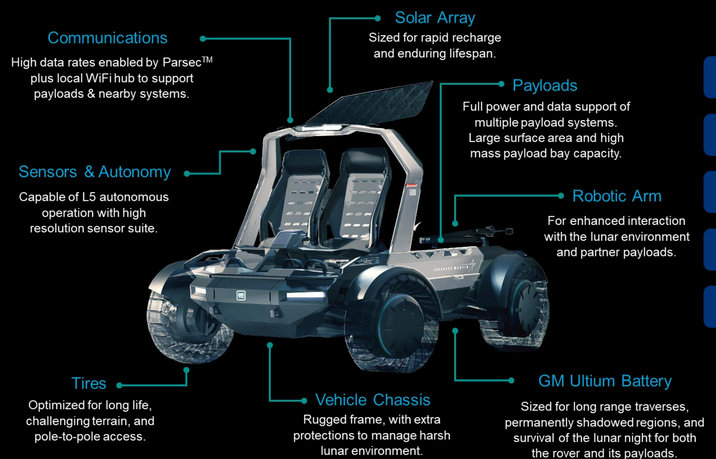
Enabling Science and Exploration Objectives with Lunar Services

C. M. Edwards, A. Marcinkowski, M. Yant, T. Cichan
Lockheed Martin Space. 12257 S Wadsworth Blvd, Littleton, CO 80127
Contact: adam.marcinkowski@lmco.com

Mobility Services

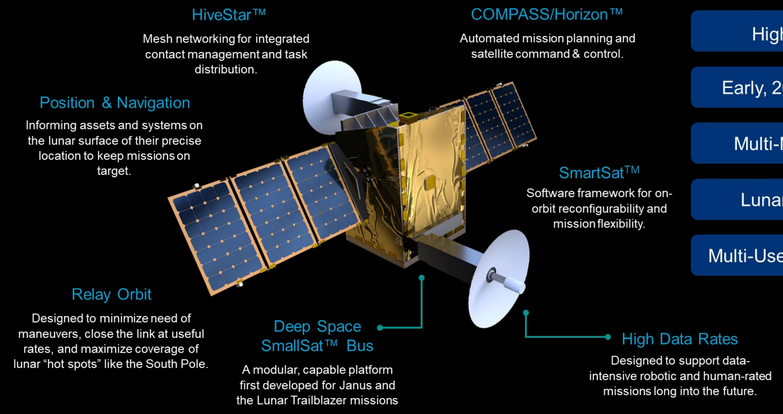
Lunar Mobility Vehicle (LMV) Offering commercial services for a broad and diverse range of partners including NASA, Industry, and International customers



- L5 Autonomy & Sensors
- Ruggedized Design
- Long Life
- Paradigm Shifting Mobility
- Evolvable and Scalable

Communication Services

Parsec™ Commercial Service Relay Network

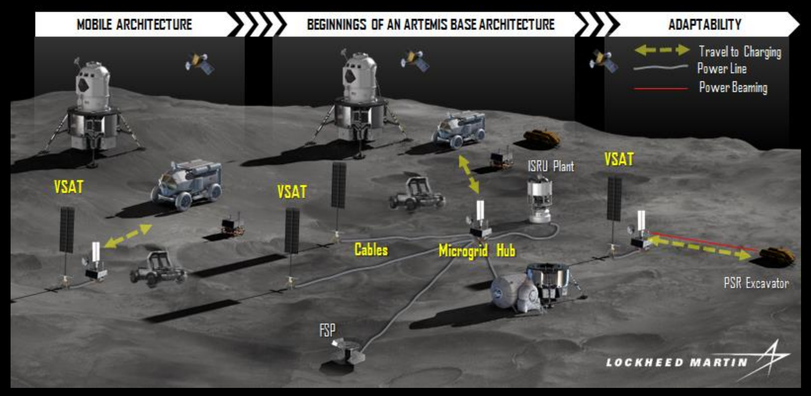


- High Data Rates
- Early, 2024 Deployment
- Multi-Node Evolution
- Lunar Surface PNT
- Multi-Use Satellite Platform

Power Services

Vertical Solar Array Technology (VSAT)

- Reducing barrier of entry for lunar surface assets by providing a mobile power station
- Catalyzing commercial services by reducing environment risk for long-term lunar surface assets
  - Dust mitigation, surviving lunar night



Fission Surface Power (FSP)

- Enabling higher power levels to support increasing habitation and in-situ resource utilization (ISRU) needs
- Providing power generation that is steady through the lunar night

Science Objectives Enabled by Mobility Services

- Performed study of how mobility aids several science objectives
- Investigated activities and equipment that would support these science objectives
- Compared how supportable those activities and equipment would be with a fixed habitat versus a pressurized rover

Science Objective	Activity	Equipment	Fixed Habitat (FH)	Pressurized Rover (PR)
Sample Gathering and Transportation	• Regolith from craters and slopes • Sub-surface water ice and dry ice • Sample storage in a controlled environment • Transportation of cached samples to ascent element for delivery back to Earth • Conduct cryogenic sample return	• Sample collection equipment • Sample return equipment	Supportable with LMV 	Supportable: enables better sample range than fixed habitat and has higher volume capacity per trip than LMV

Sample Characterization	• Sample analysis
	  • Composition
	  • Age
	  • Physical characteristics
	  • Volatile investigation
		• Glove box
		• Geology tools
			Significant mass addition, maybe feasible	Characterization is unlikely to be performed on PR, but can have cold stowage to preserve a diversity of samples

Surface Dust Environment Characterization	• Dust impact studies on electrical and mechanical assemblies (e.g., mechanisms, regenerative power systems, controls) both on the surface and internal vehicle systems • Study electrical properties of lunar dust • "Dust mapping" studies to track dust transport into habitable environment	• Filtration • Air monitoring • Scientific payloads to study dust • Tools to measure dust build up on seals and surfaces both internal and external to habitable volume	Supportable, enhanced by LMV	Supportable: enables better sample range, more variety of locations to observe terminator plasma interaction with dust
Characterization of EVA Sites	• Document EVA site characteristics, sampling, and instrument deployment • Real-time transmission of data from in situ science instrumentation that provides real-time science collaboration and documentation for site characteristics	• Cameras, sensors • High bandwidth communication that is capable of real-time data transmission	Supportable with LMV 	Supportable: enables ability to consider more variety of locations for EVA
Surface Survey/Mapping	• Imagery of regolith, crater rims, sloped regions, lava channels/tubes, high-albedo regions • Surveys of regolith and resources (identification, characterization and localization) • Topographic, gravitational and thermal (for shadowed regions) surface maps • Sub-surface maps of lava channels and tubes	• Cameras • Sensors	Supportable with LMV 	Supportable: has better range over fixed habitat
General Surface Environment Characterization	• Measurements of transient phenomena, including day to lunar night transitions, response to time-varying solar wind and chemical-species migration • Sub-surface temperature and seismological measurements	• Sensor suites	Supportable, enhanced by LMV 	Supportable: both PR and LMV enable more variety of locations to observe solar wind and other phenomena, and enables crew to assist with deployment
Long Term Temperature Sensing	• Measurement of surface and subsurface (ground) temperature via deployment of long-lived instrument packages on moon • Temporal sampling over a lunar day/night cycle is ideal but temporal spacing over one lunar rotation requires more time than is available by the crew on the lunar surface (for HLS time durations)	• Capability to transport and deploy temperature sensing packages	Supportable, enhanced by LMV 	Supportable: both PR and LMV have better range over fixed habitat when deploying long-duration sensor packages and enable crew to assist deployment
In-situ Sample Characterization	• Inclusion of in-situ measurement tools to characterize rock samples and take volatile measurements to characterize volatile losses	• Additional instrumentation required beyond sample collection, return and IVA analysis equipment	Supportable, enhanced by LMV 	Supportable: has better range over fixed habitat