LANDO: Developing autonomous surface operations for planetary surfaces

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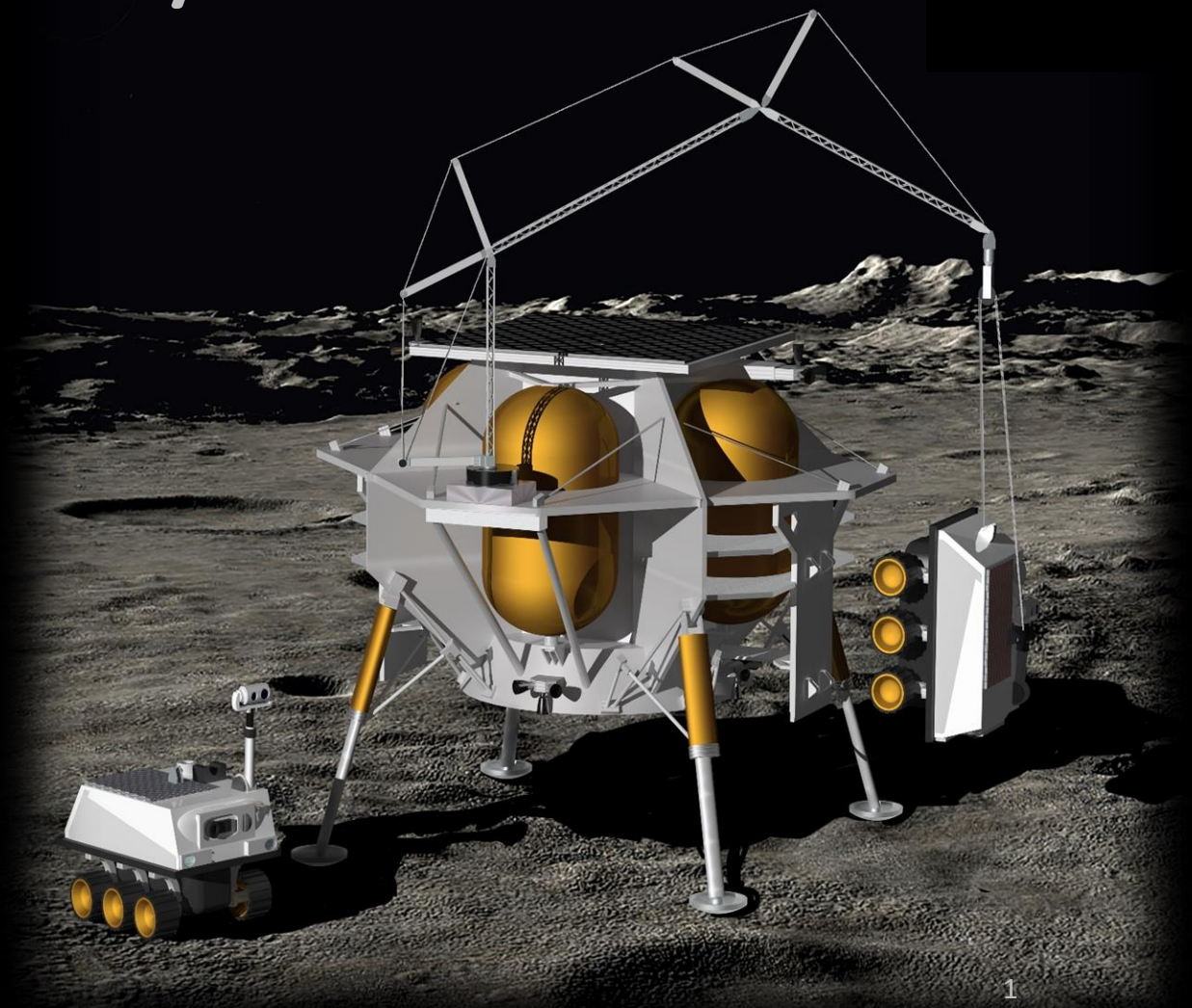
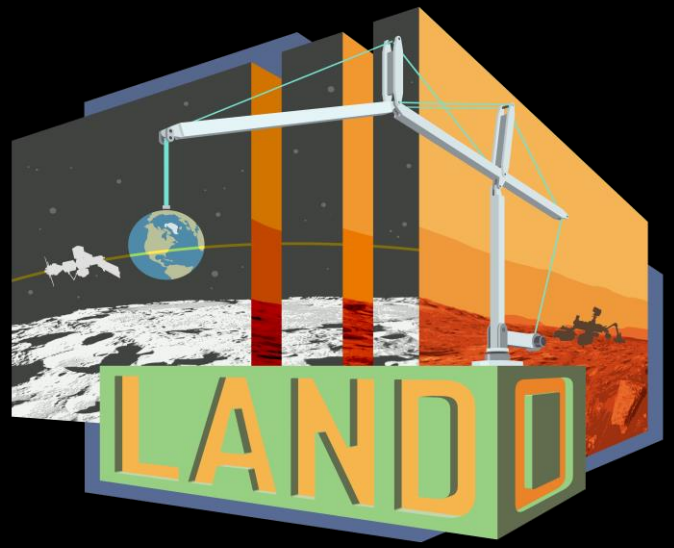




Lightweight Surface Manipulation System (LSMS)

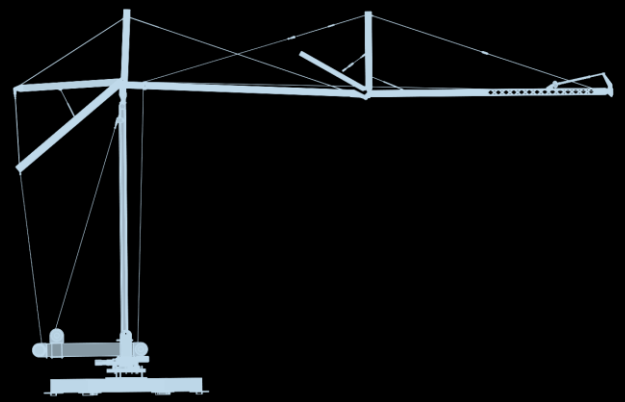
AutoNomy capabilities

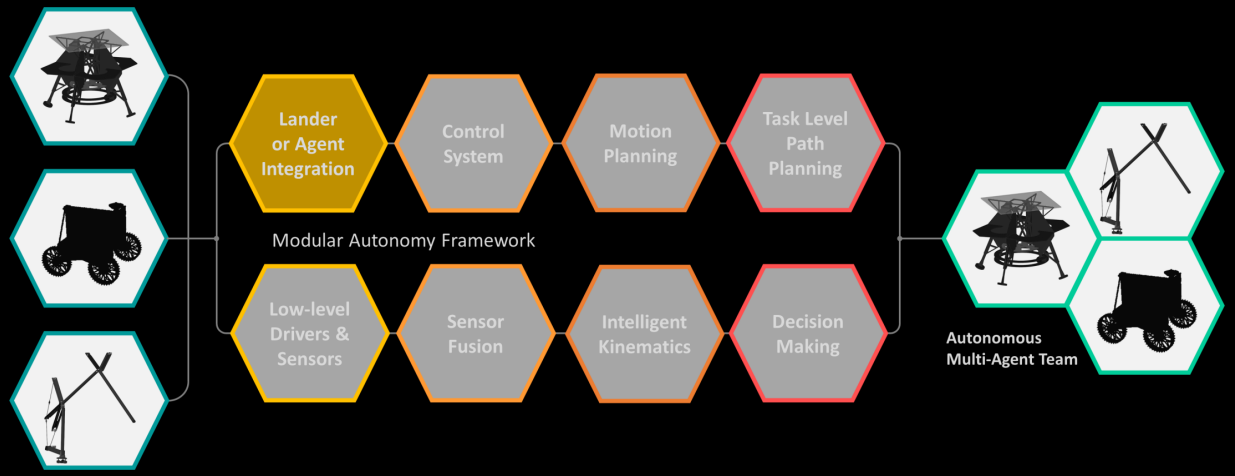
Development for surface

Operations and construction

(LANDO)

This talk will be an overview of the two-year LANDO Early Career Initiative project selected for funding start in October 2021





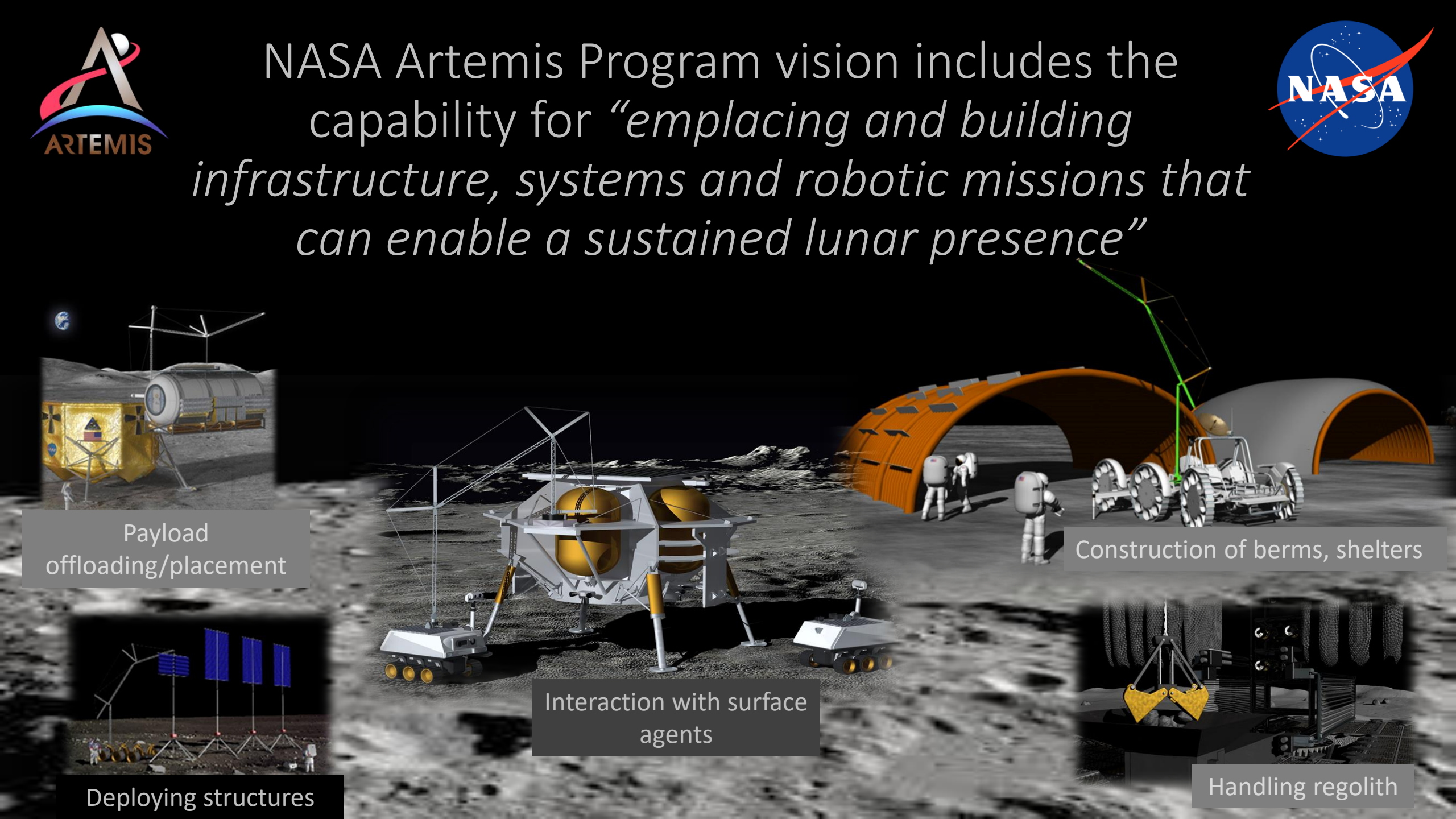
Motivation **Surface operations and construction – focus on payload handling**

Overview of the **Lightweight Surface Manipulation System (LSMS)**

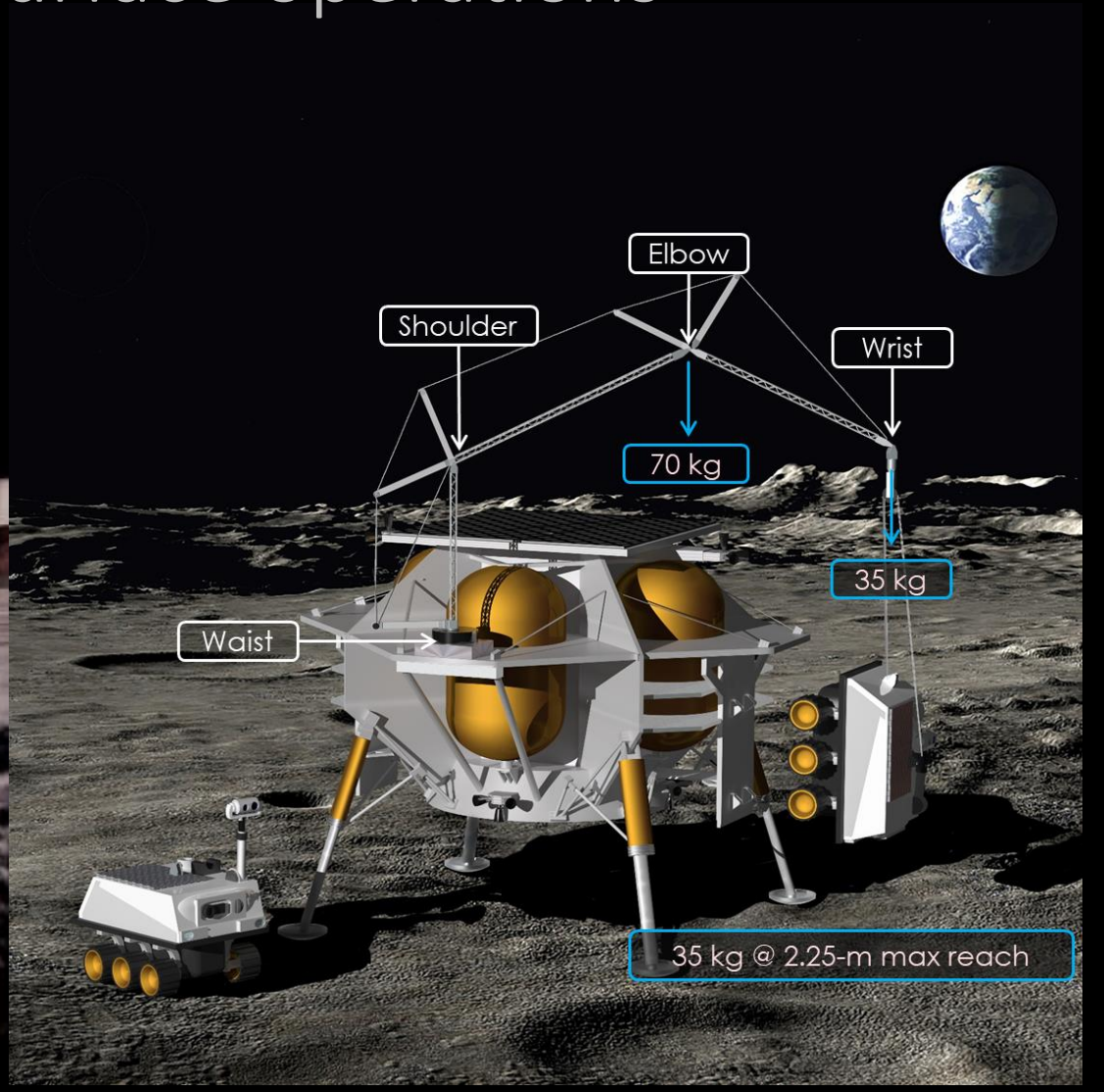
Autonomy capabilities development

- Modular plug-and-play interface
- Human-on-the-loop

NASA Artemis Program vision includes the capability for *"emplacing and building infrastructure, systems and robotic missions that can enable a sustained lunar presence"*



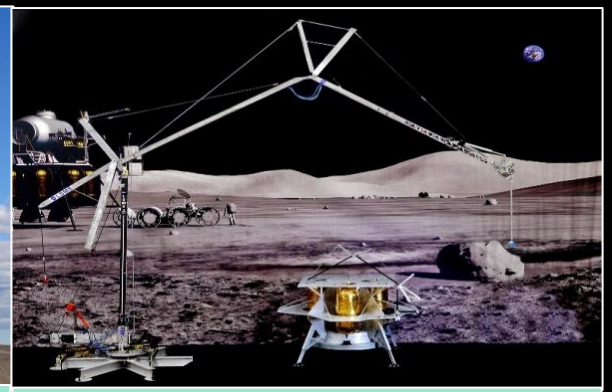
LSMS is a lightweight, reusable, robust, versatile, and scalable robot designed for surface operations



Lightweight **S**urface **M**anipulation **S**ystem – **l**unar (or **M**ars) **XXXX** kg capacity (**LSMS-LXXXX**)

Desired future surface operations require an autonomous LSMS capable of human-on-the-loop control

LSMS – L1000 at Moses Lake



LSMS – L1000 and LSMS – L35

Why autonomy?

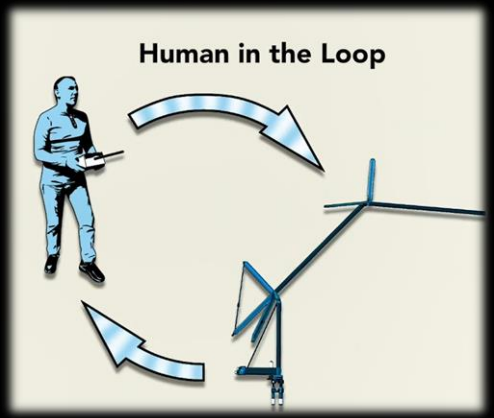
- Intelligent pose configuration
- Latency (to Martian surface)
- Reduce human operator workload
- Safer operations

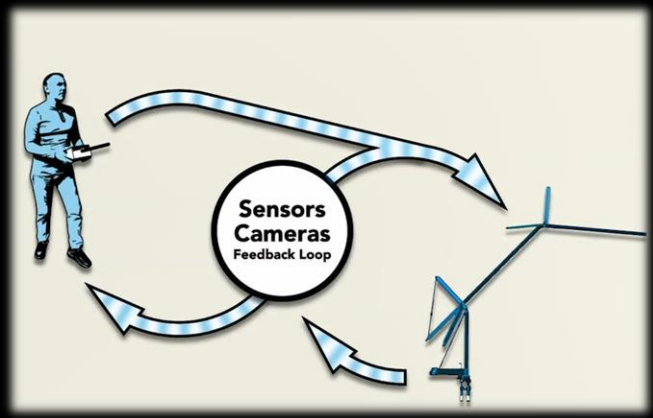
Current LSMS operations

- Joystick tele-operated
- Some low-level scripted commands
- Human-in-the-loop
- No hardware/software interface for landers or surface agents

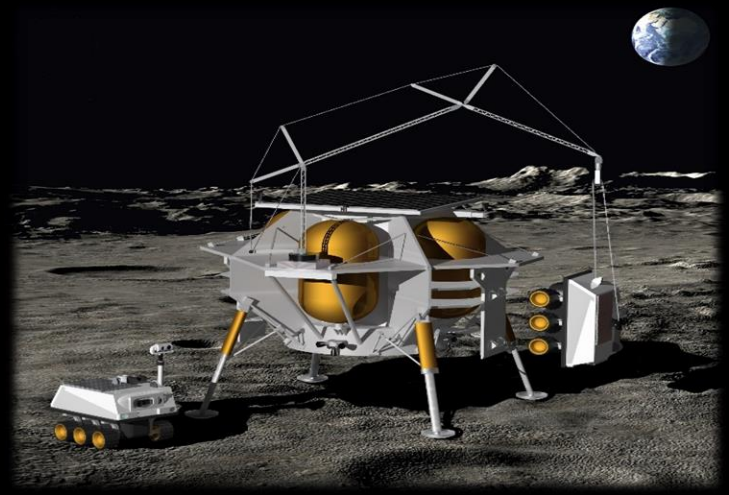
Future LSMS capabilities required for surface operations

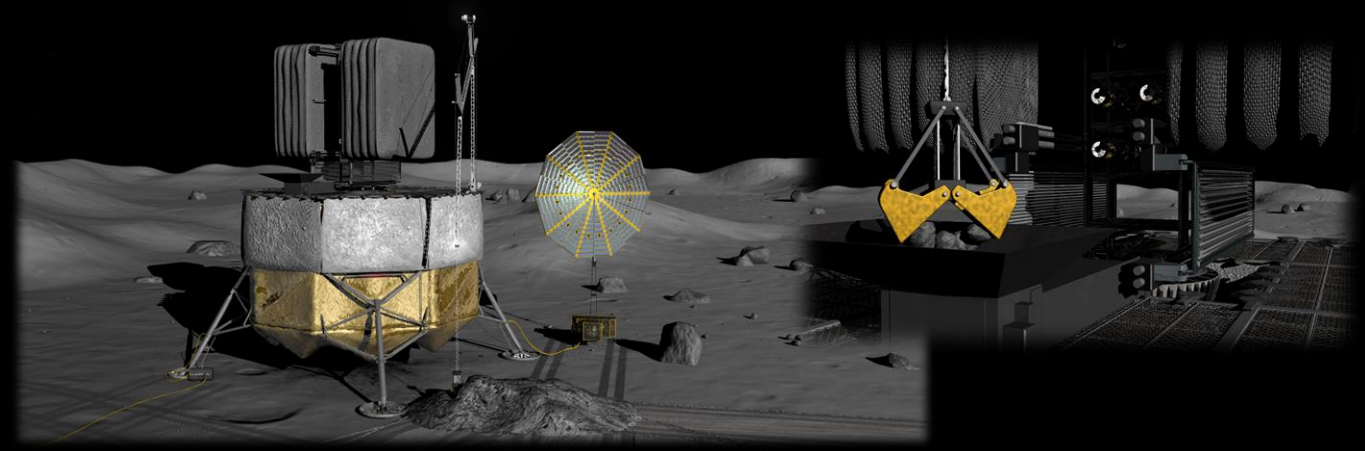
- Autonomous operations with situational awareness and feedback to software control system during operation
- Supervised human-on-the-loop technology
- Modular plug-and-play interface specifications for landers or surface agents





LANDO is focused on addressing **safe** autonomous payload handling using the LSMS



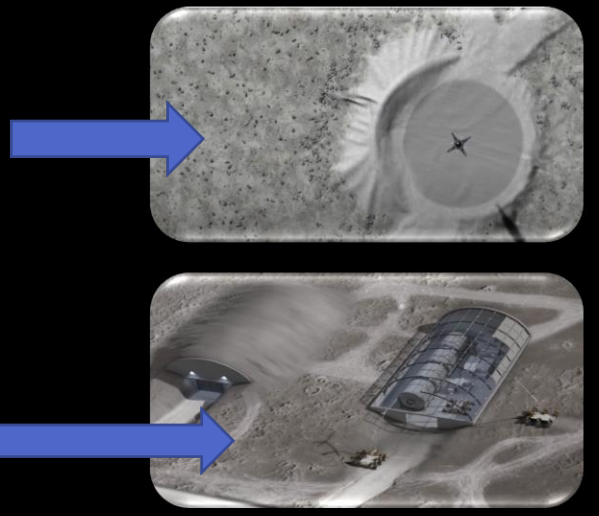


Structured Payloads

- Addresses Commercial Lunar Payload Services (CLPS) partners' immediate need for payload offloading
- Addresses long-term need for payload handling capabilities on lunar/Martian surface enabling a permanent presence

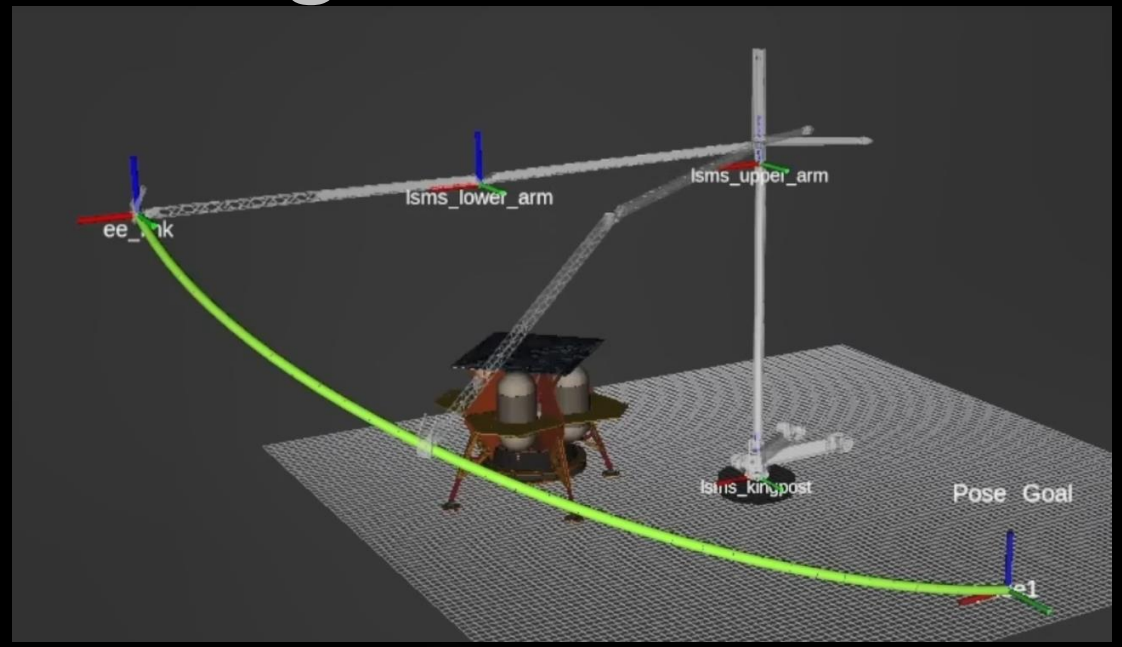
Unstructured Payloads

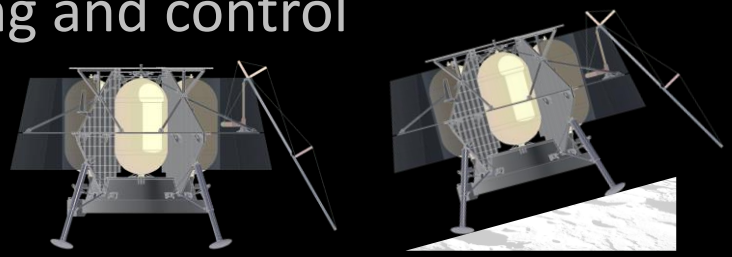
- Addresses surface construction gaps in rock relocation in preparation for 3D printing of landing pad via sintering
- Transport payloads to sites away from the lander; prepare placement site; offload
- Scoop and pile regolith on shelter as a radiation shield



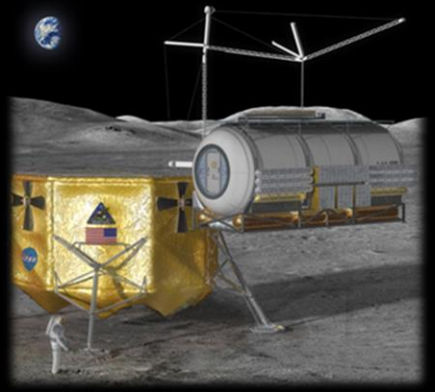
LANDO will develop the integrated autonomy framework for the LSMS that integrates:

- Object recognition
- Environmental sensing
  - LSMS pose
  - Lander position
- Fault detection and recovery
- Path/motion planning
- Payload manipulation
  - Tool hardware interfacing and control
  - Payload identification
  - Grasp planning



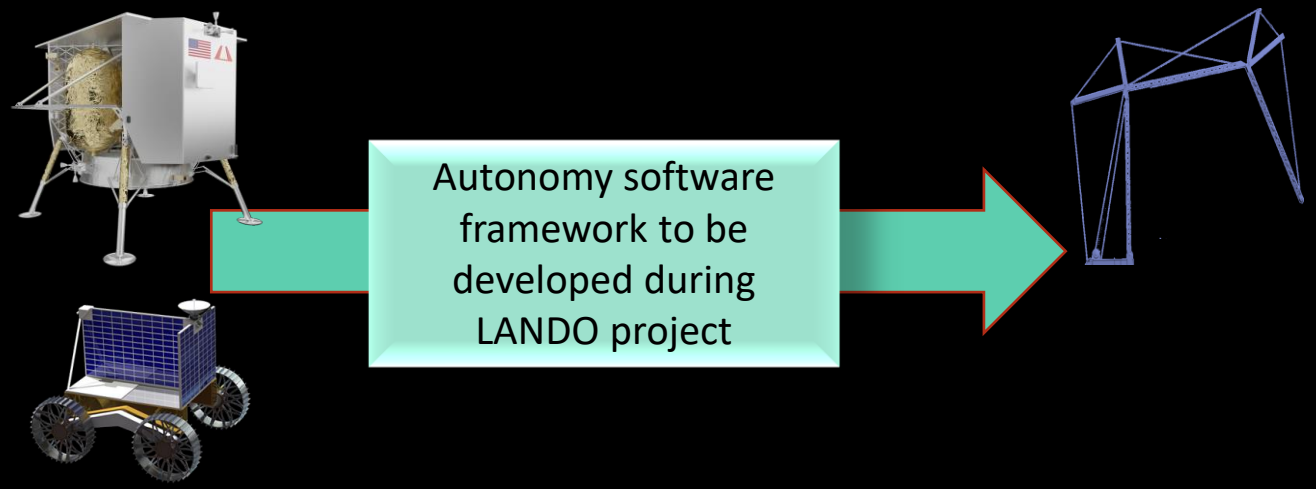


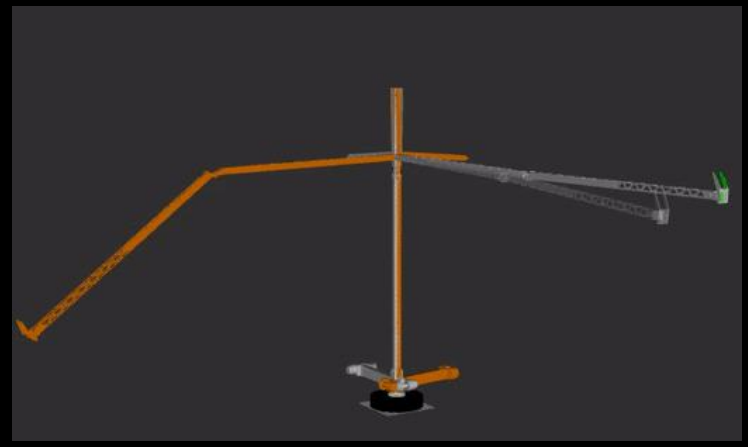
Sense lander orientation and align king post with gravity vector



Is payload mass safe to lift?

LANDO leverages the in-house autonomy and robotics expertise at NASA Langley Research Center (LaRC)

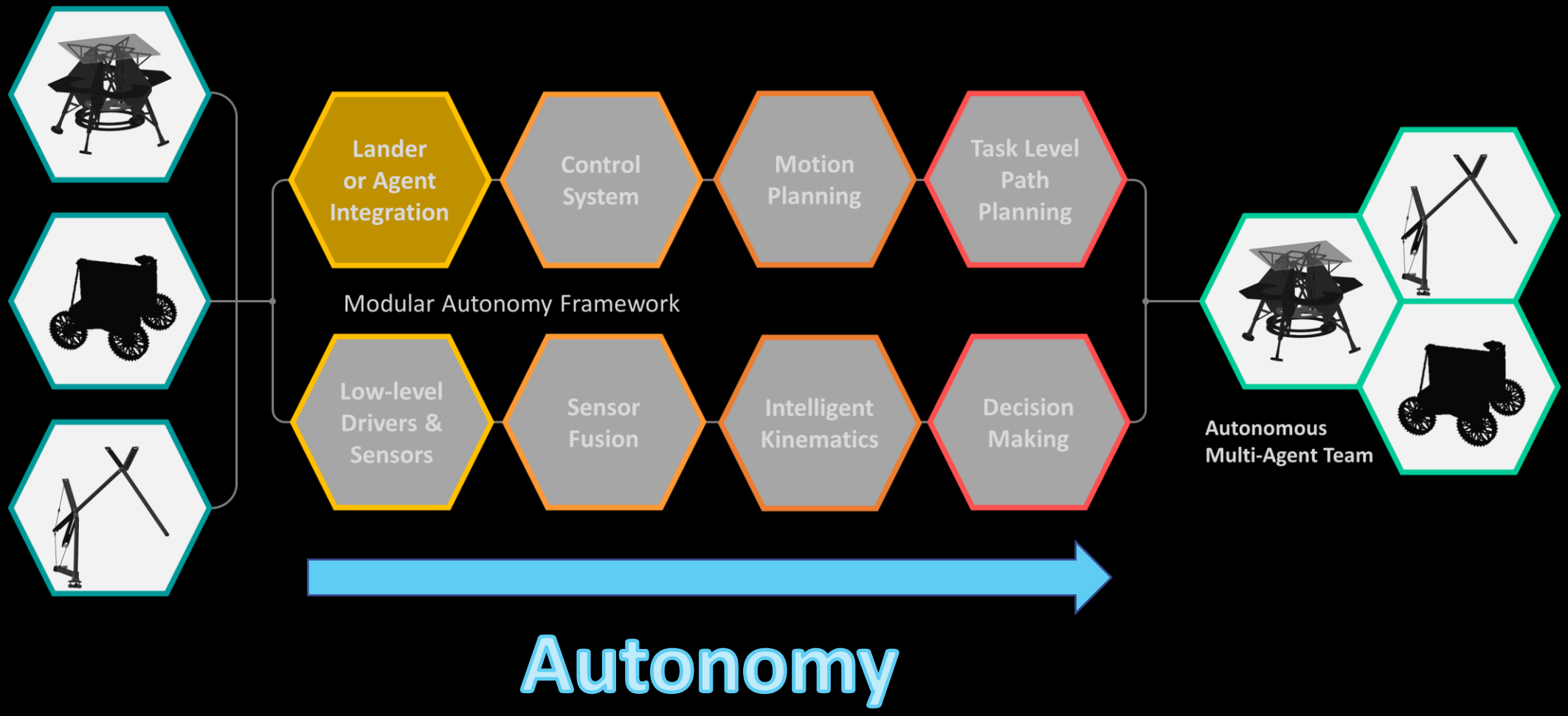




Visualized motion plan trajectory for the LSMS provides initial and desired poses

- Existing autonomy and robotics expertise at LaRC
  - Baseline Environment for Autonomous Modelling (BEAM), Autonomous Entity Operations Network (AEON), Robotic Operating System (ROS2), Data Distribution Services (DDS)
  - Autonomy Teaming and Trajectories for Trusted Operational Reliability (ATTRACTOR), In-Space Assembly (ISA), Robotic Assembly of Modular Space Exploration Structures (RAMSES), Precision Assembled Space Structure (PASS)
- Modular autonomy packages are standalone programs with well-defined message interfaces
  - Develop components in parallel
  - Incremental development relying at first on strong assumptions that are relaxed as system matures
  - Increase autonomous operations as new components are written
- Plug-and-play software and hardware interface

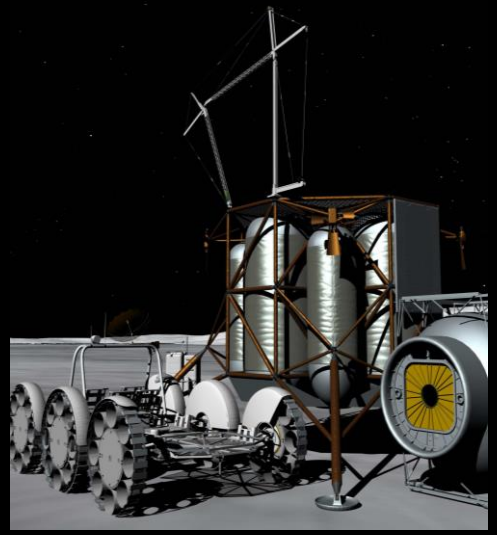
The autonomy software framework is modular and focuses on interoperability



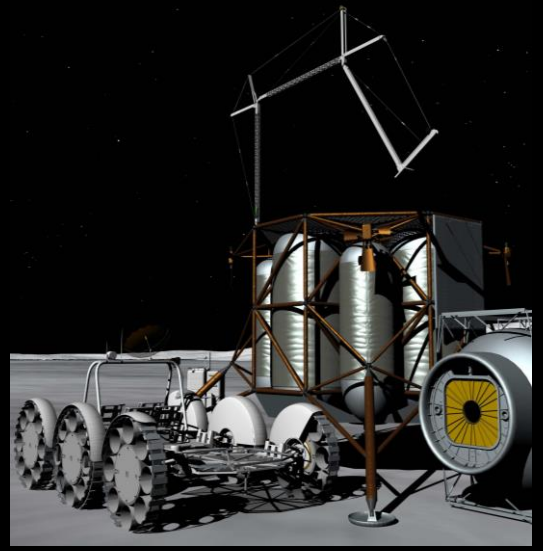
Modular plug-and-play interfaces turn the LSMS into a “commodity device” for surface operations

Commodity Device:

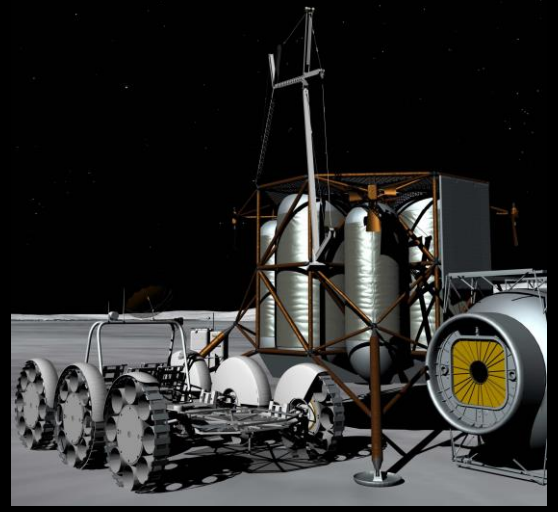
- Plug-and-play interface with landers or surface agents
  - “LSMS on every lander and rover” requires straightforward integration
  - Ability to self-offload from lander to rover (shown below)
- Operational versatility for performing surface construction tasks
  - Reduces design of unique devices
  - Design a tool for LSMS wrist and software module



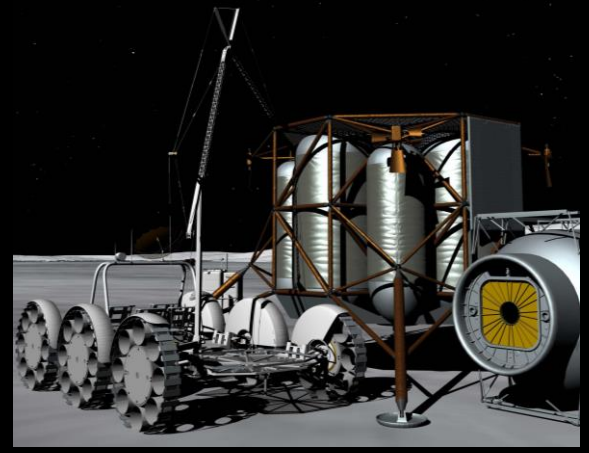
LSMS wrist grasps support rail



LSMS base detaches from lander

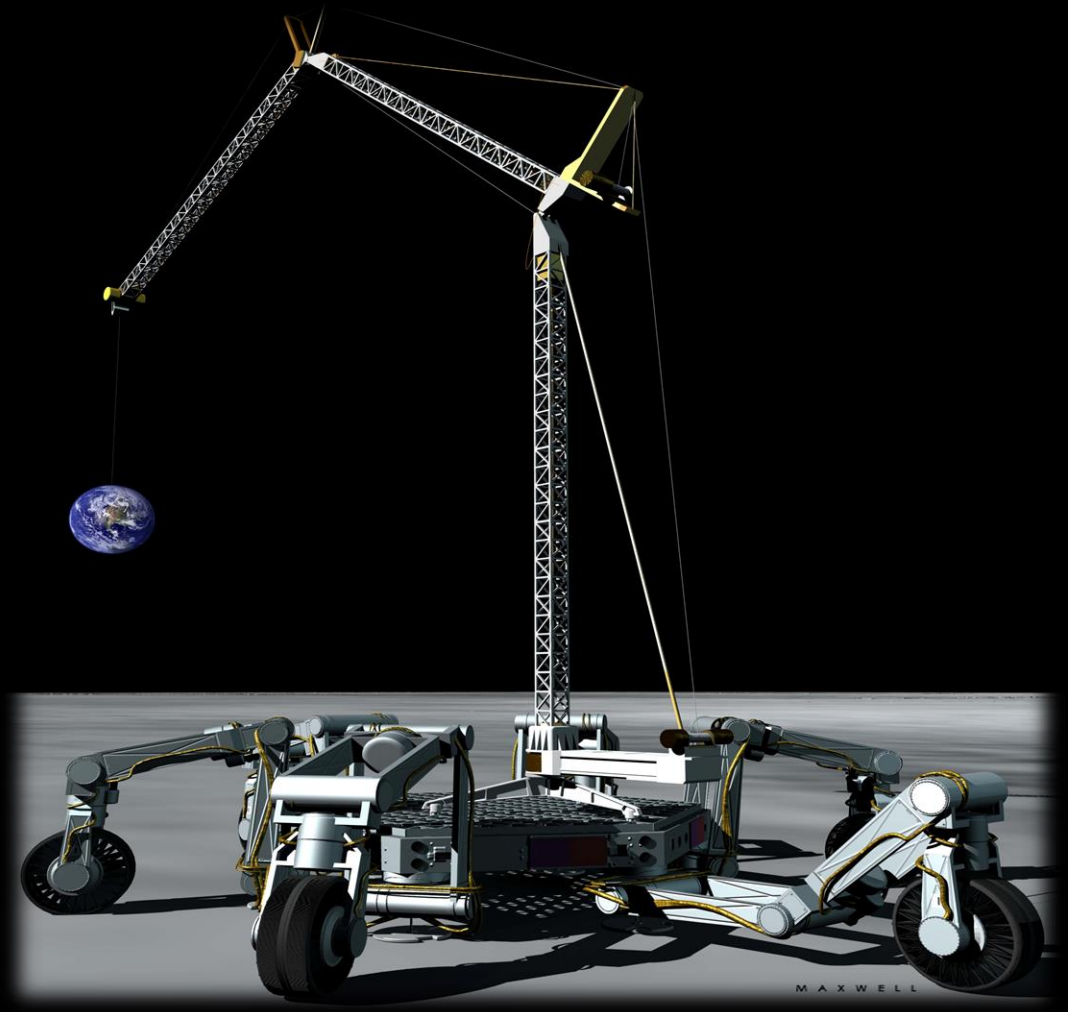


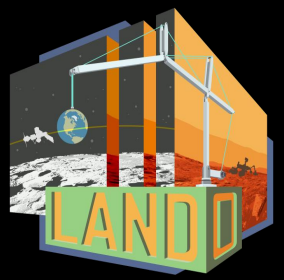
LSMS base is relocated to mobile asset



LSMS wrist detaches from support rail

LANDO will take the first steps in transitioning Earth-based construction to lunar surface operations and future Mars missions





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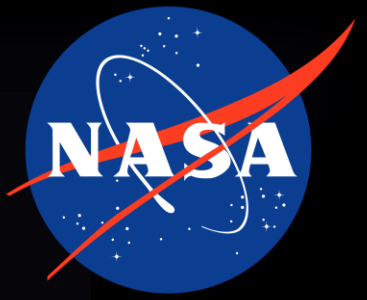

Looking forward to the discussions at
AIAA SciTech 2022!

For questions, please contact:
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