LANDO: Developing autonomous operations for planetary surfaces

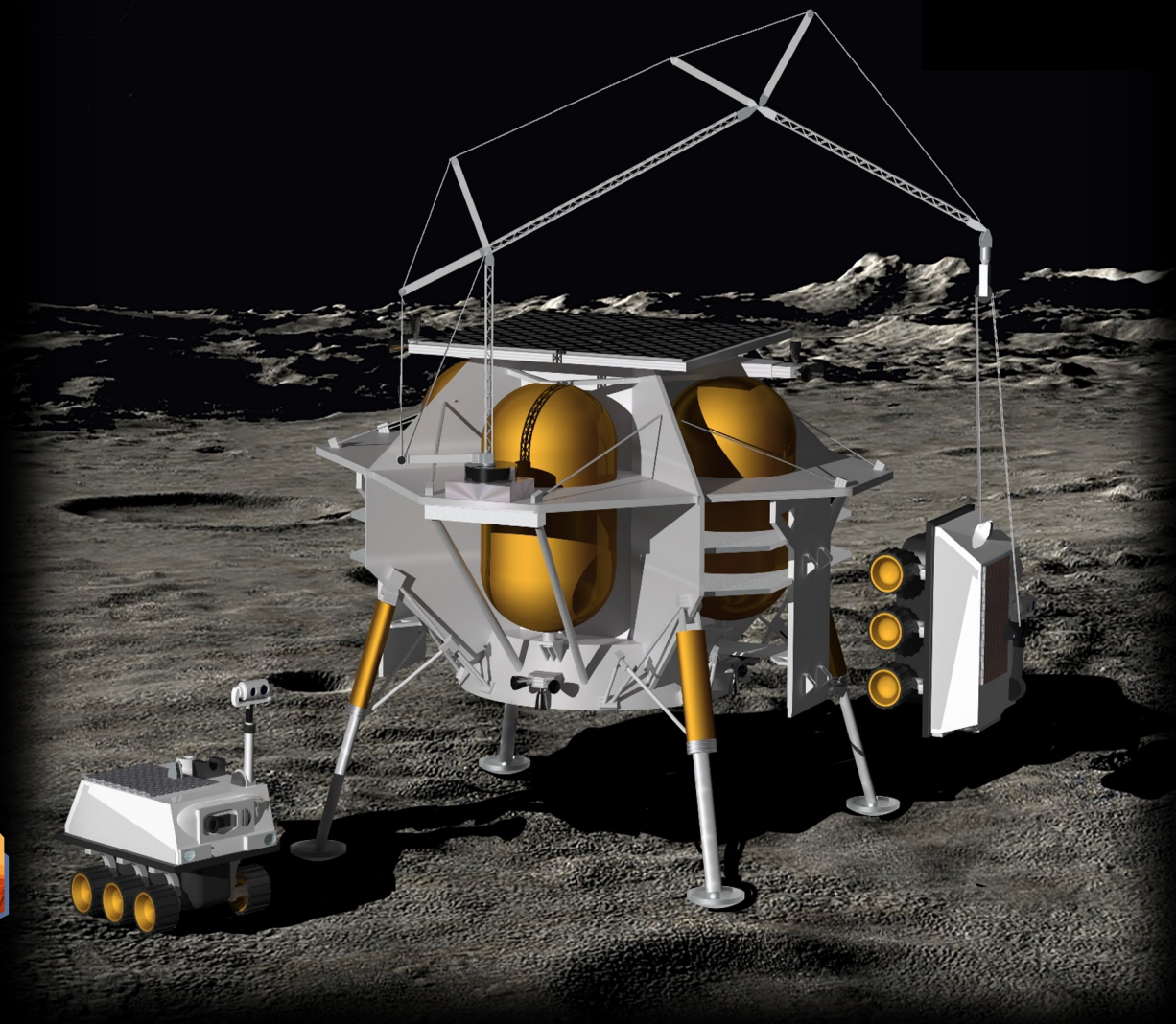
NASA Advisory Council

Technology, Innovation, and Engineering Committee

Walter Waltz, PhD

LANDO ECI Autonomy Lead

November 30, 2023

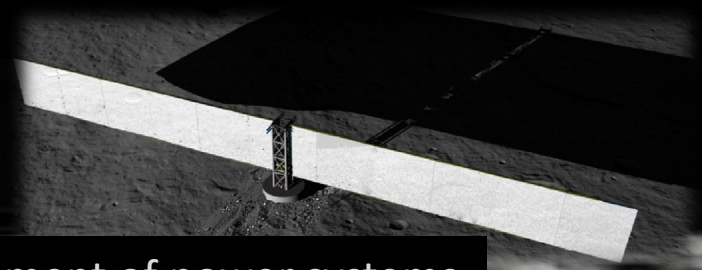


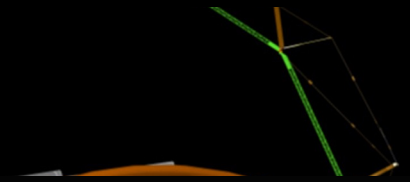
Outline

- High-level overview
- Management
- ECI Lessons Learned
- Engagements
- Next Steps

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

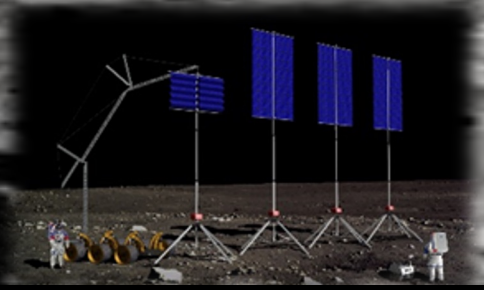
Moon To Mars (M2M) Lunar Infrastructure LI-4^{L} autonomous construction capabilities, extensible to Mars Infrastructure M2M Operations OP-10^{LM} operate robotic systems to support crew on lunar or Martian surface, autonomously or remotely…



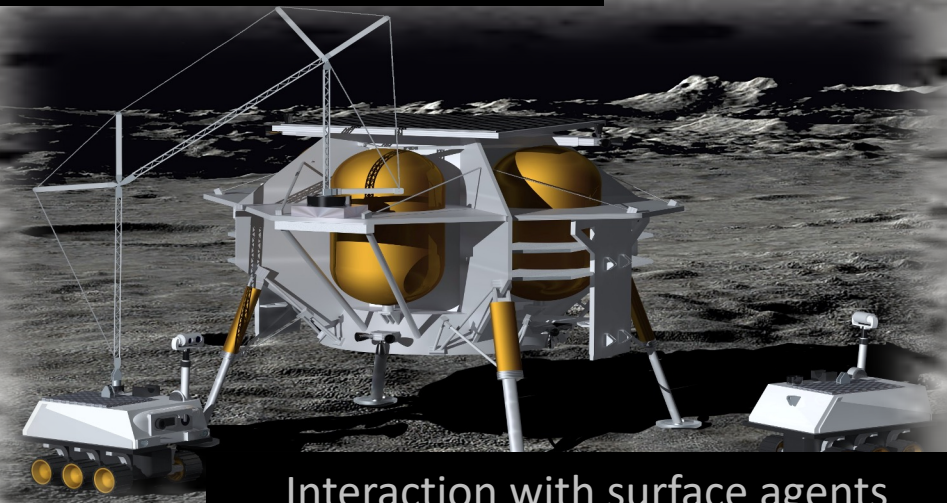


Emplacement of power systems

Payload offloading



Deploying structures

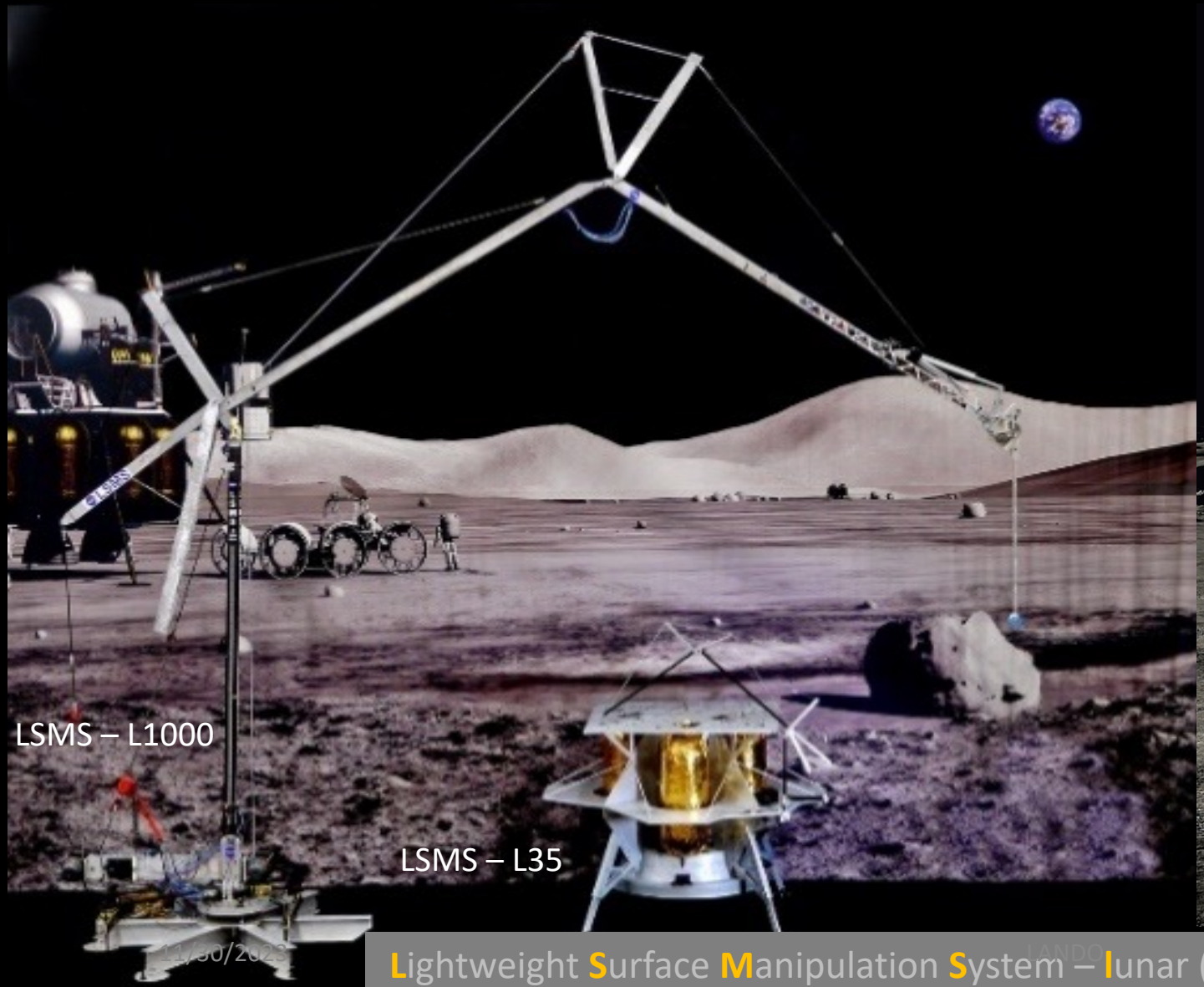


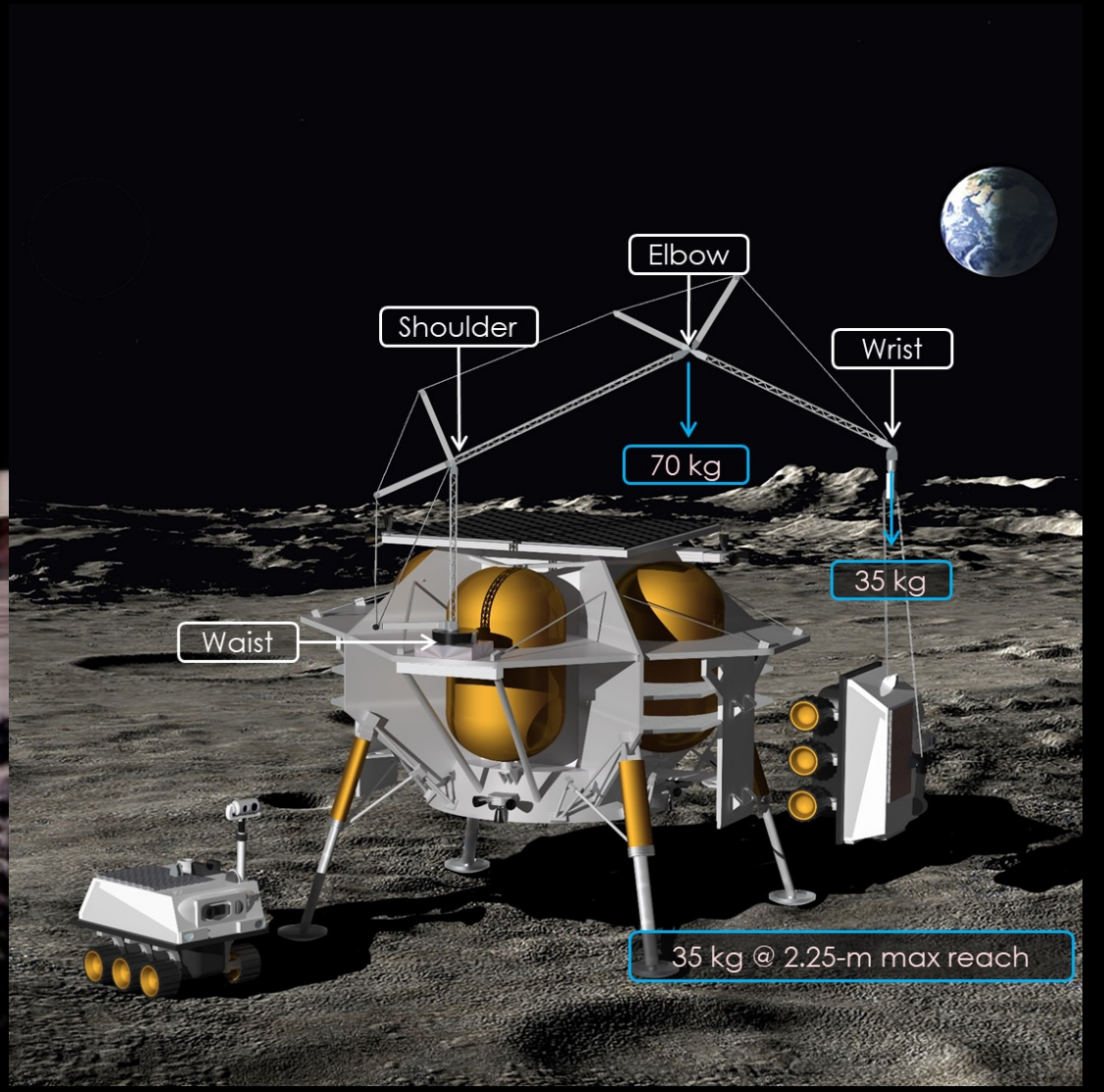
Interaction with surface agents

Construction of berms, shelters

Handling regolith

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

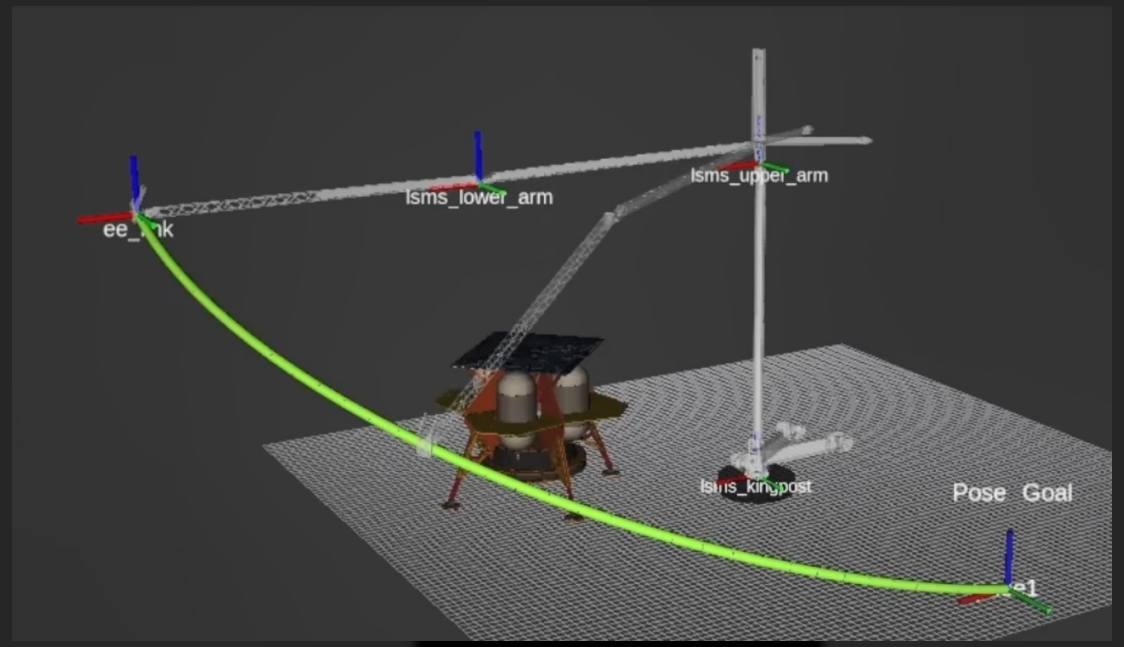


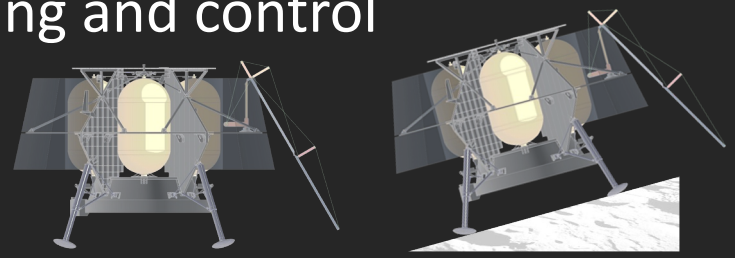


Lightweight Surface Manipulation System – lunar (or Mars) XXXX kg capacity (LSMS-LXXXX)

LANDO will develop the integrated autonomy framework for the LSMS, enabling payload offloading

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

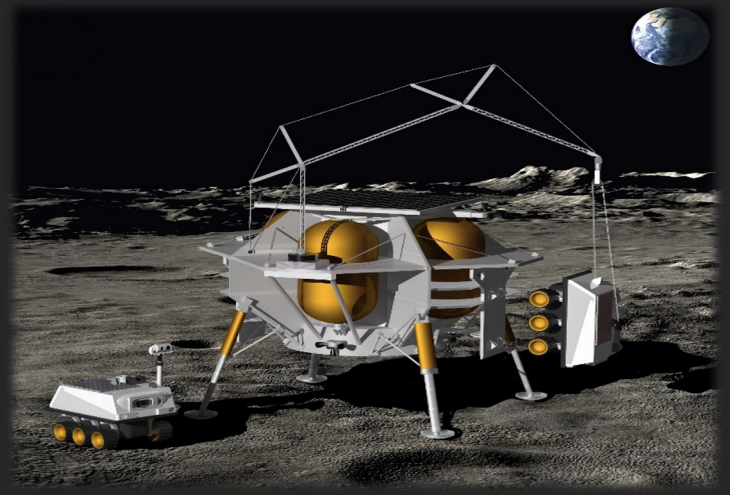


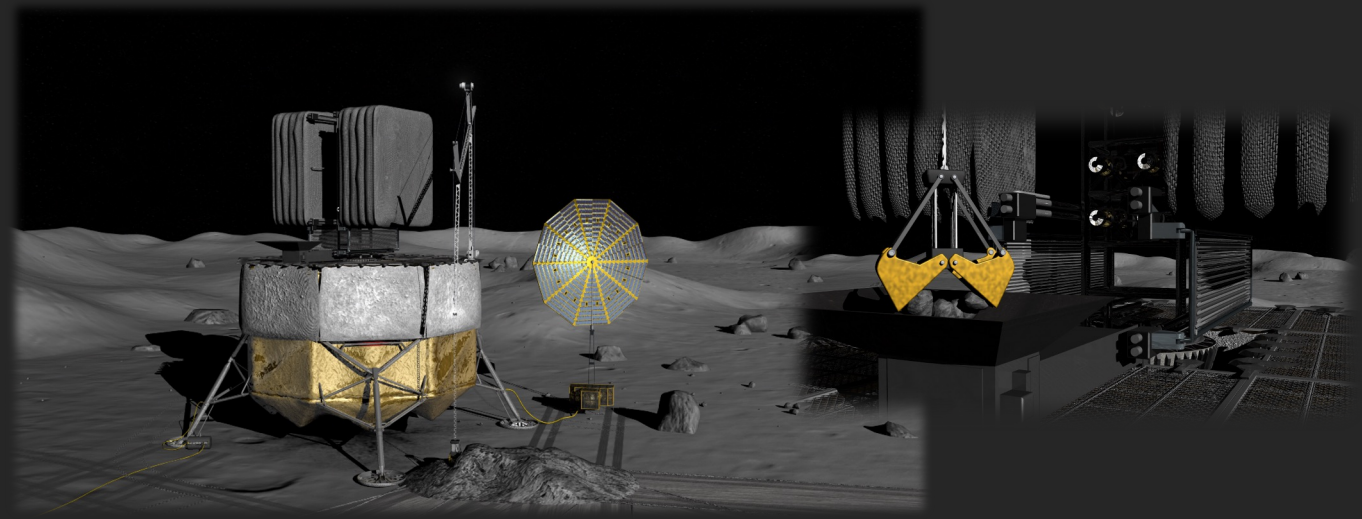


Sense lander orientation and align king post with gravity vector

Is payload mass safe to lift?

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



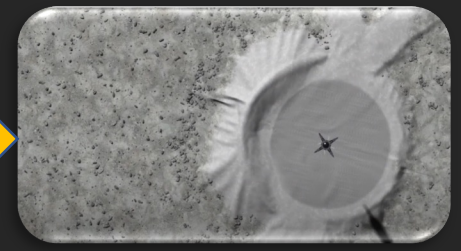


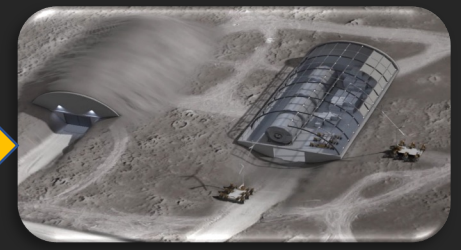
Structured Payloads

- 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

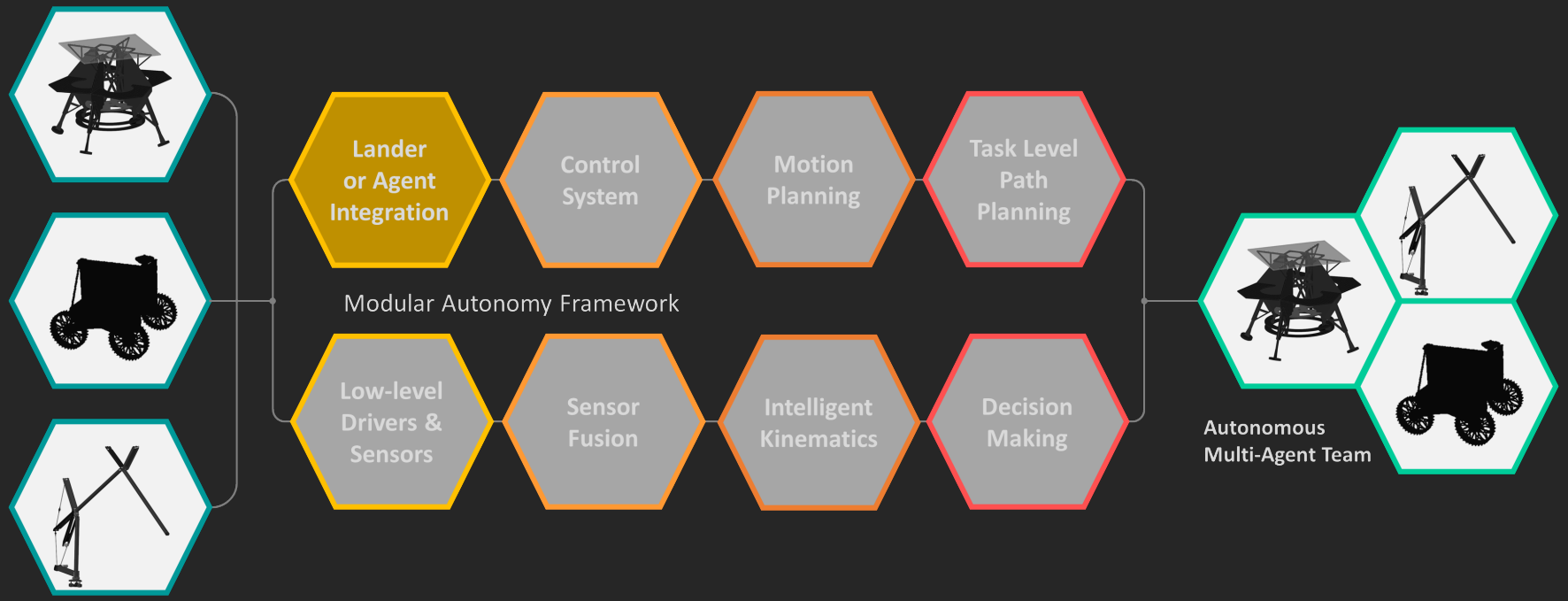




The autonomy software framework is modular and focuses on interoperability

Modular autonomy software refers to segments of software separately named and addressable that are integrated with well-defined message interfaces to satisfy problem requirements

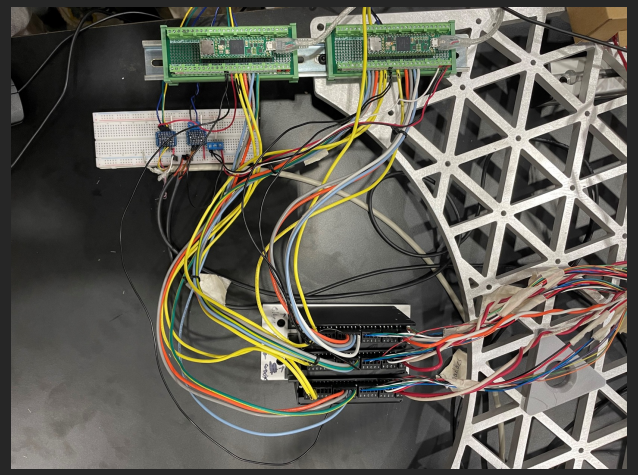
- Reduces system complexity compared to monolithic designs
- Node diagrams double as a road-map
- Develop components in parallel
- Incremental development relying at first on strong assumptions that are relaxed as system matures
- Increase autonomous operations as new components are written



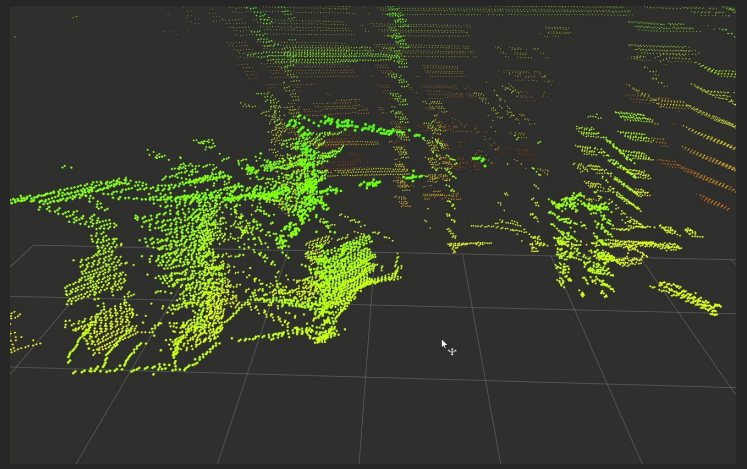
Benefits

- Increases versatility
- Promotes efficiency
- Enables extensibility
- Testable design
- Hardware agnostic

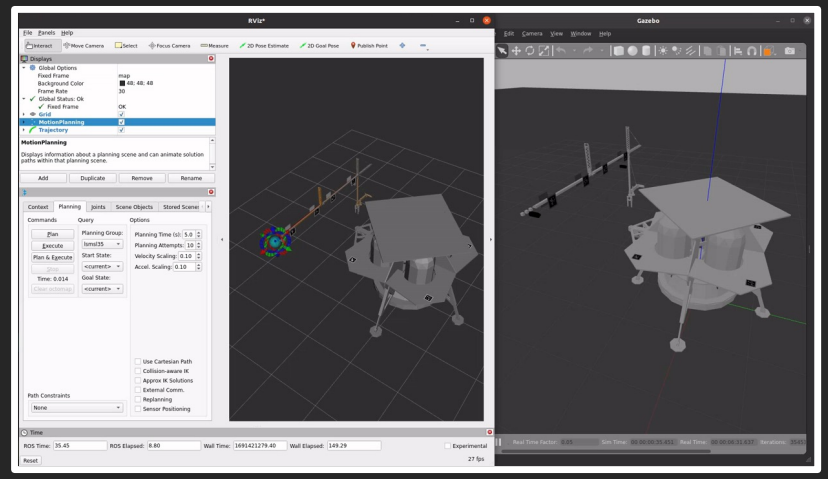
Project Elements



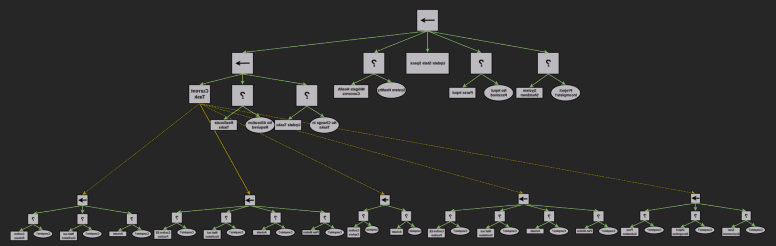
Low-Level



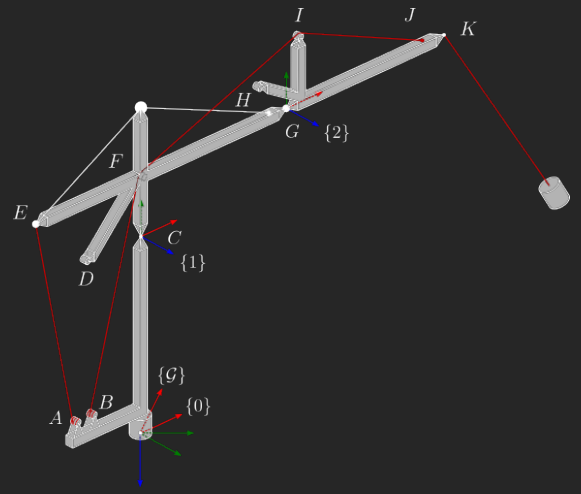
Perception



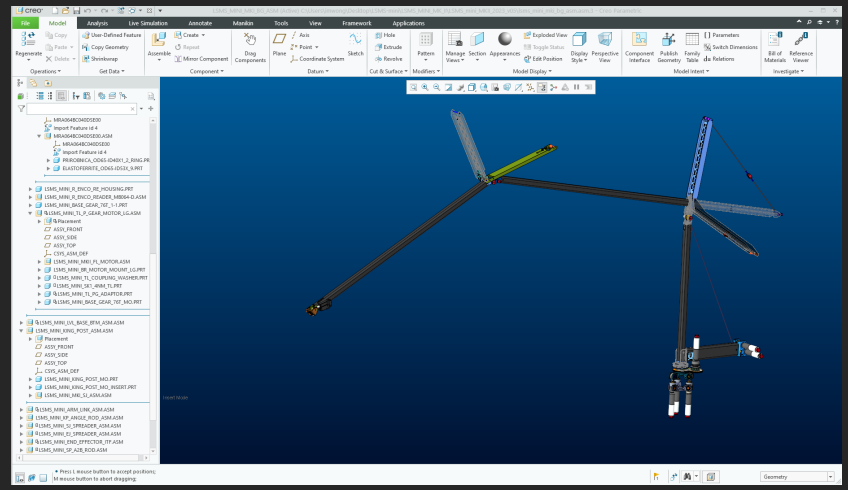
Simulation



Intelligent Capabilities



Mathematical Modeling



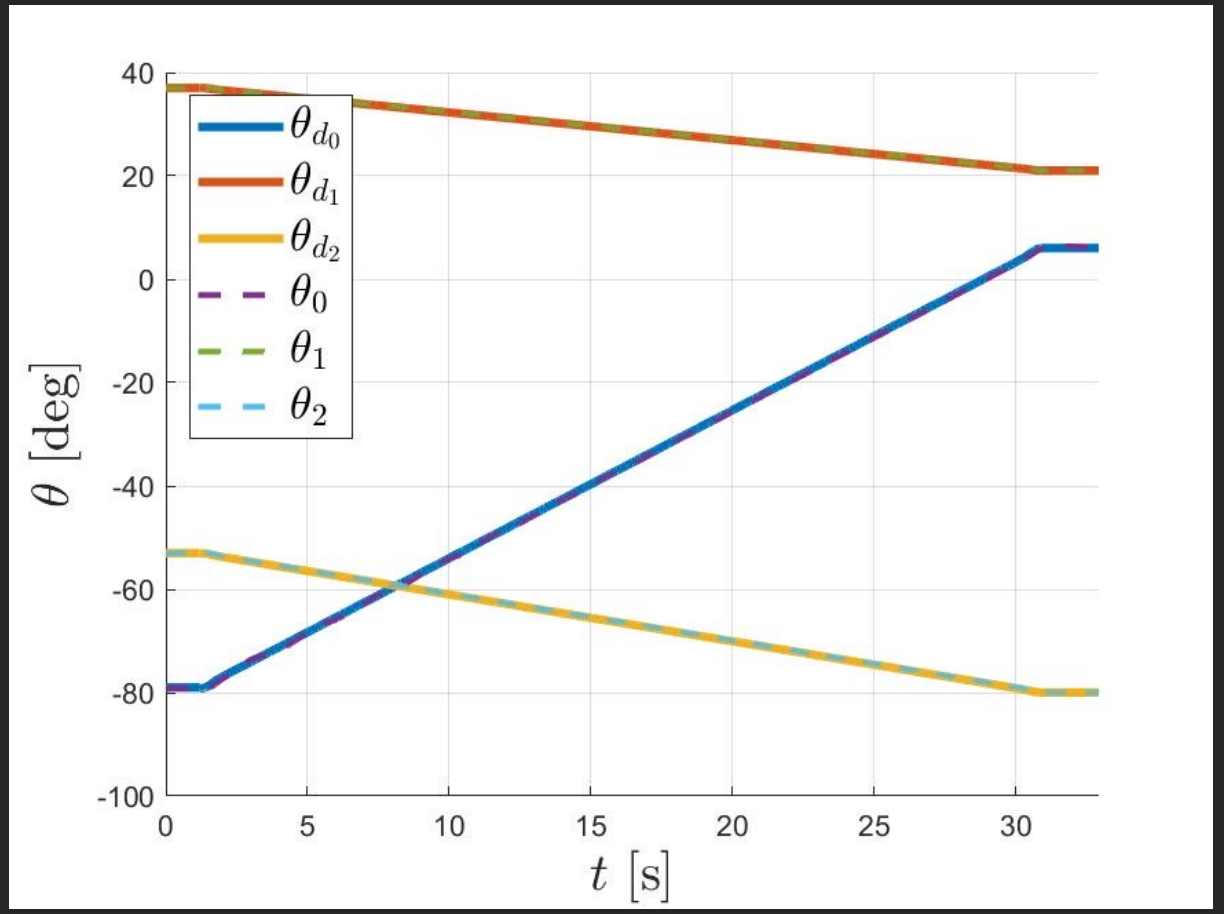
Hardware Design

System Integration Testing

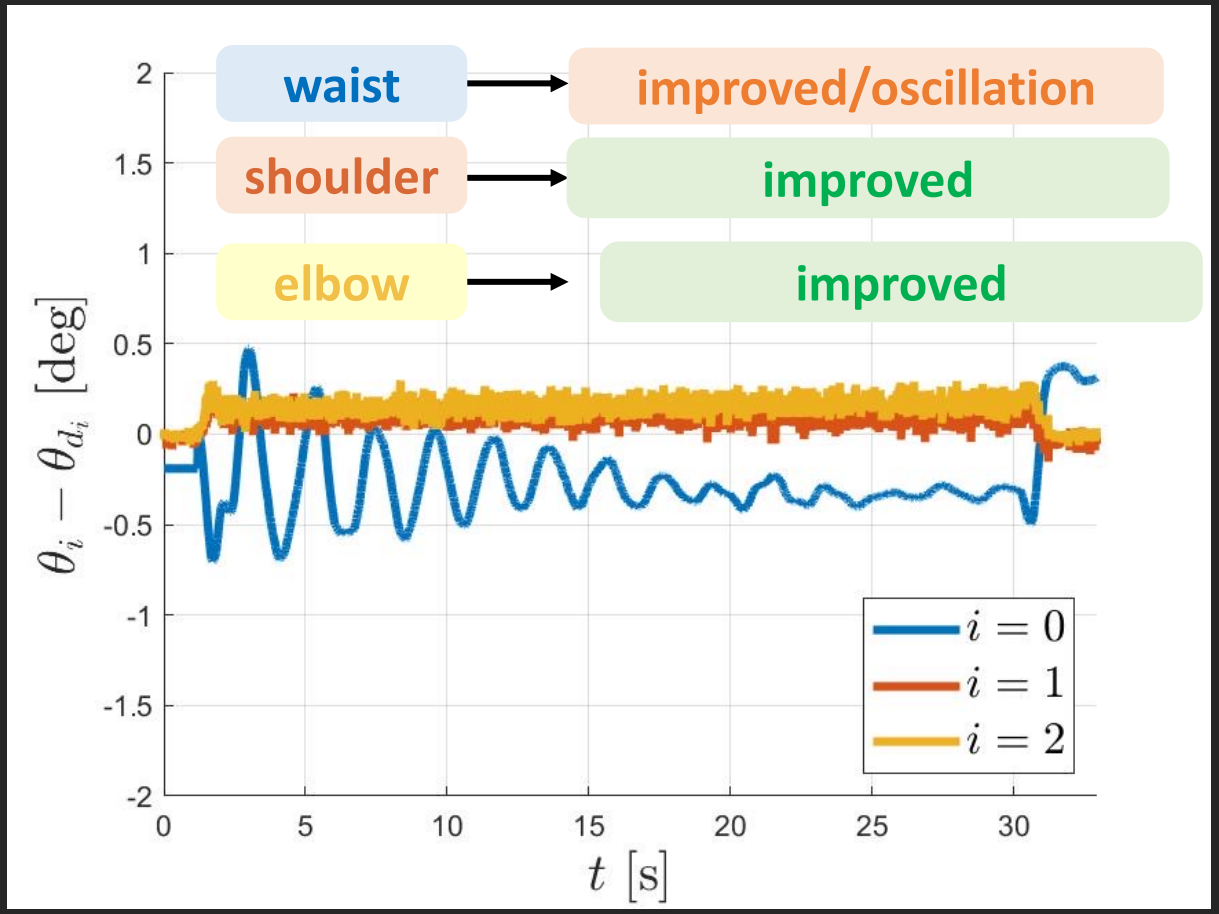
Experimental Results

with payload

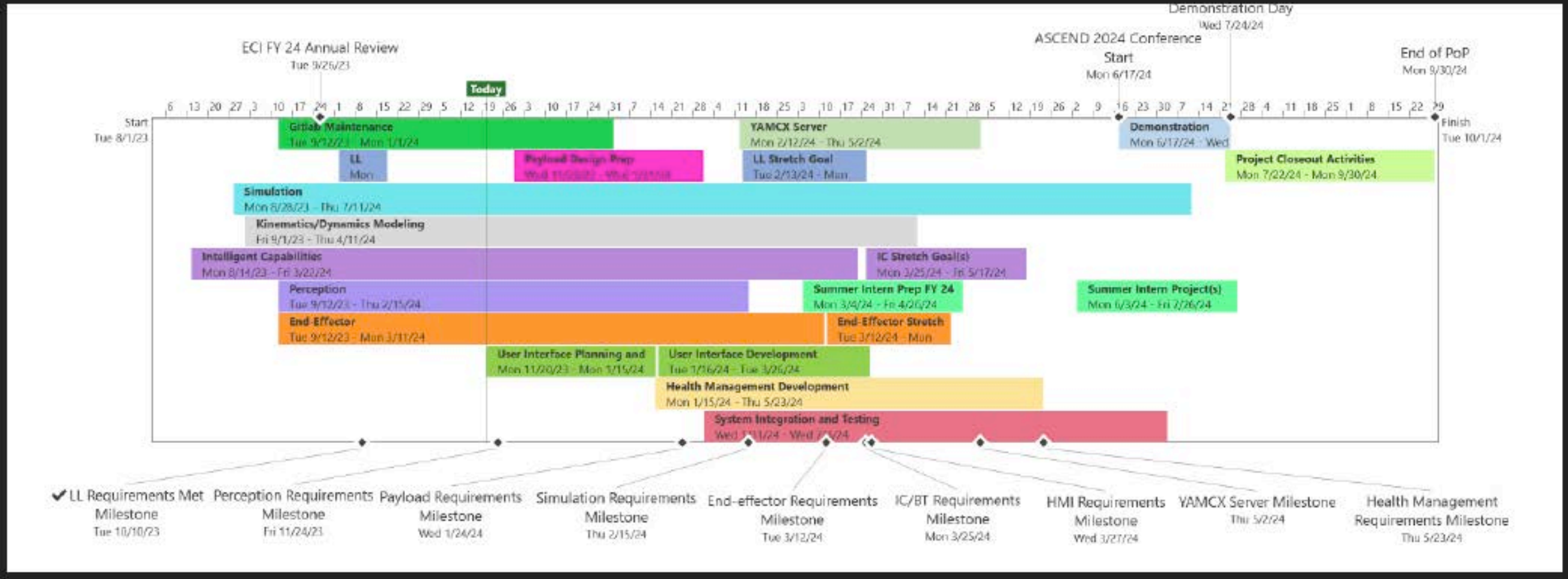
Desired & actual angles



Trajectory tracking errors



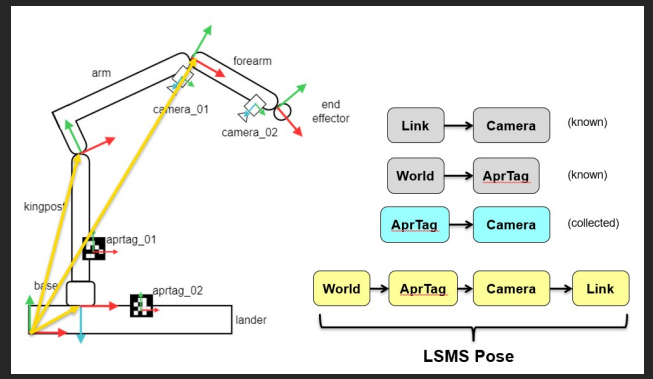
Updated FY 2024 LANDO Schedule



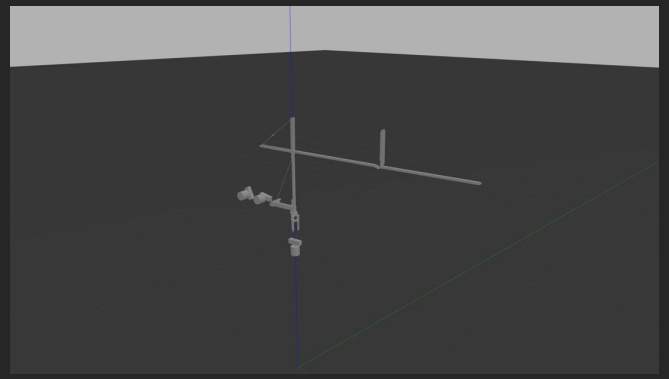
ECI Lessons Learned

- COVID
  - The team had to adapt to hybrid teaming and the utilization of new tools for communication
  - Had complications with procurement, notably with supply chain issues
- Learning the contracting process
  - COR designation
  - Reporting

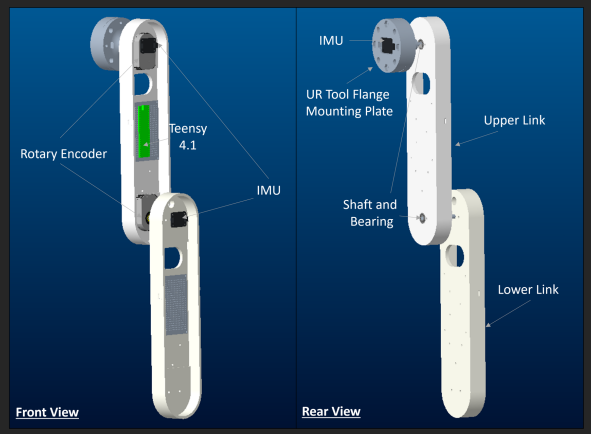
- LANDO has brought on board 6 interns, working on different parts of the project
- The team experienced new challenges and learned a lot about processes, helpful for their career at NASA



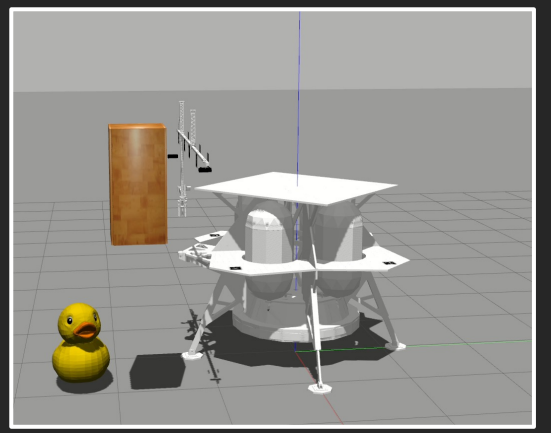
Eliya Pelton



Yotam Granov



Gabby Conard



Luay Jawad

NASA Early Career Team

Dr. Julia Cline
Project Lead

Iok Wong
Prototype Design

Matt Vaughan
Autonomy Developer

Dr. Josh Moser
Autonomy Developer

Dr. Javier Puig Navarro
Autonomy Developer

Dr. Walter Waltz
Autonomy Lead

Dominic Bisio
Autonomy Developer

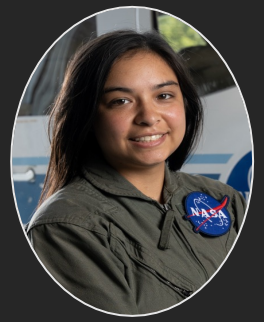
Amelia Scott
Autonomy Developer

Jessica Friz
Modeling/Simulation

Ryan Bowers
Autonomy Developer

Gabrielle Conard
Intern

Luay Jawad
Intern



Eliya Pelton
Intern

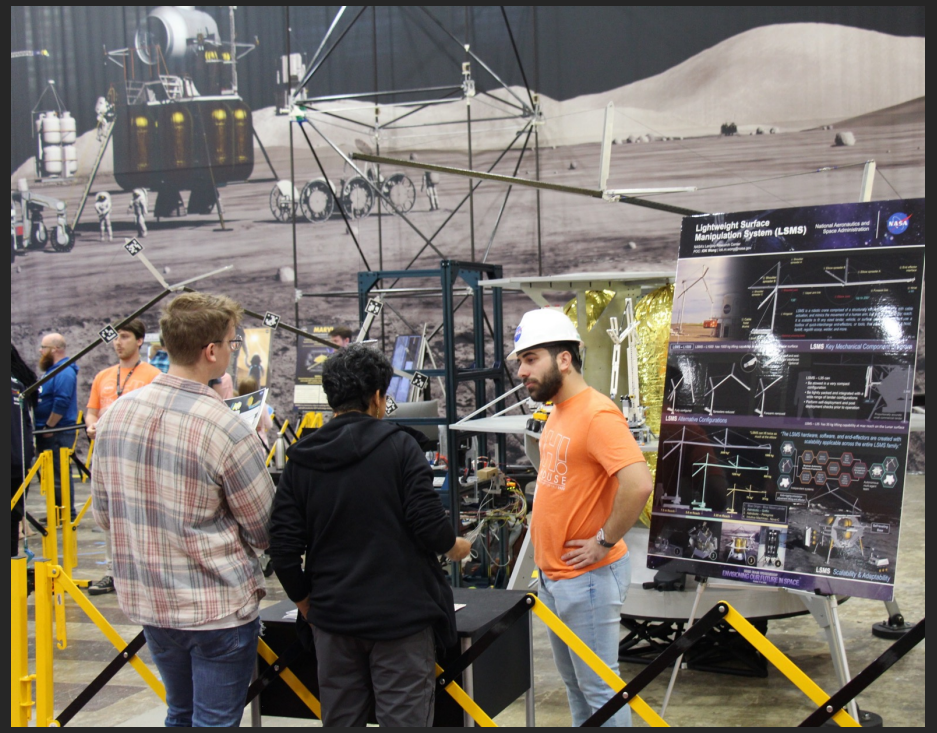
Yotam Granov
Intern

Skyle Close-arzon
Pathways Intern

Paula Coe
Intern

Open House

STAFF


Lightweight Surface Manipulation System (LSMS)
National Aeronautics and Space Administration

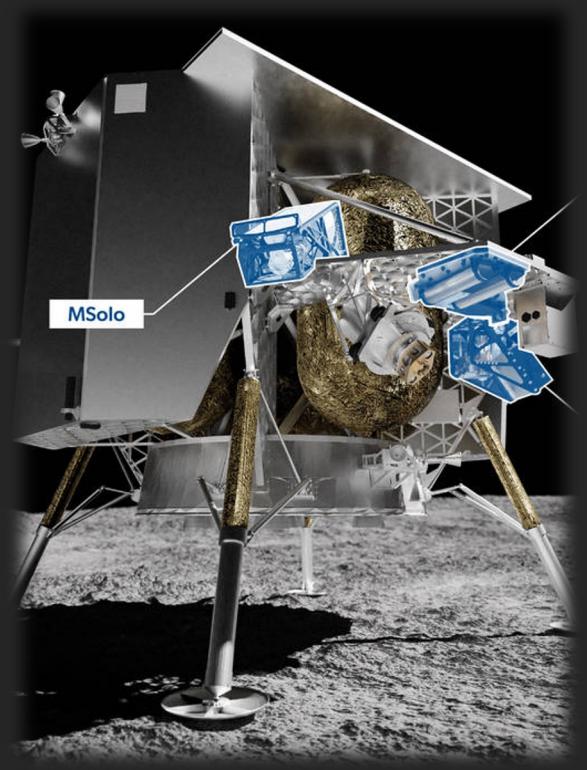
External Partnership: Astrobotic

- Astrobotic Technologies, Inc., Pittsburgh, PA
  - Founded in 2007 by Carnegie Mellon Professor Red Whittaker
  - Manifested Commercial Lunar Payload Services (CLPS) lander provider
    - Launching December 24th, 2023, delivering 28 payloads
    - Delivery of NASA's VIPER lunar prospecting rover in late 2024
    - (2) classes of CLPS lander: Peregrine and Griffin
  - CLPS payload developer (autonomous MoonRanger rover)
  - Member of the Blue Origin Human Landing System (HLS) team
  - 50+ past or ongoing contracts with NASA to advance space robotics technologies

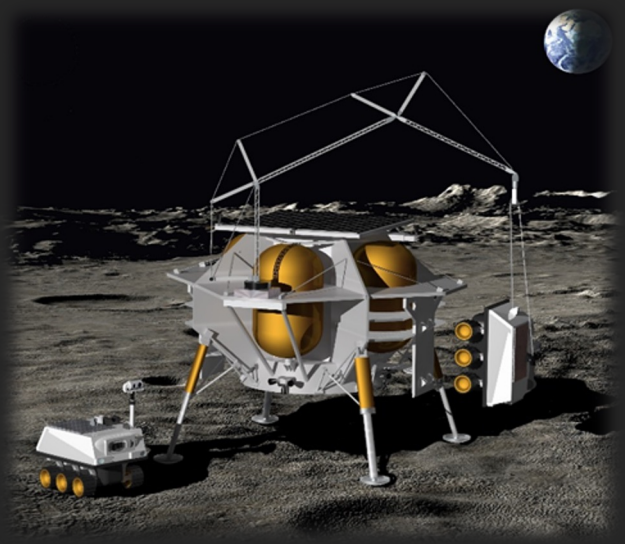
"Critically, Astrobotic and our customers have ample real use cases for autonomous lunar surface manipulation. LANDO applications that are of direct commercial interest to Astrobotic include grappling and offloading of payloads from the decks to the surface….as we look to expand our service offerings beyond just lander delivery."

Astrobotic's Role with LANDO

Lander integration needs



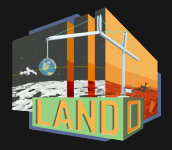
Payload definitions and handling/offloading requirements

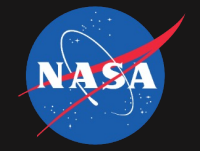


Operational concepts for providing enhanced services on the lunar surface

Next Steps

- Integrated Design Collaboration Center (IDC2)
  - Identified gaps and steps toward flight demonstration
- Proposal development:
  - STMD Game Changing Development, Tipping Point, and announcement of collaboration opportunities within STMD
  - Center Innovation Fund (CIF)/Internal Research and Development (IRAD)
- Commercialization and Commercial Interest
  - Working with Astrobotic to determine potential follow-on work
  - Blue Origin, Lockheed Martin, Boeing
  - Tours





Questions?