# NASA Ignition and iMETRO

## The Integrated Mobile Evaluation Testbed for Robotics Operations (iMETRO) Facility

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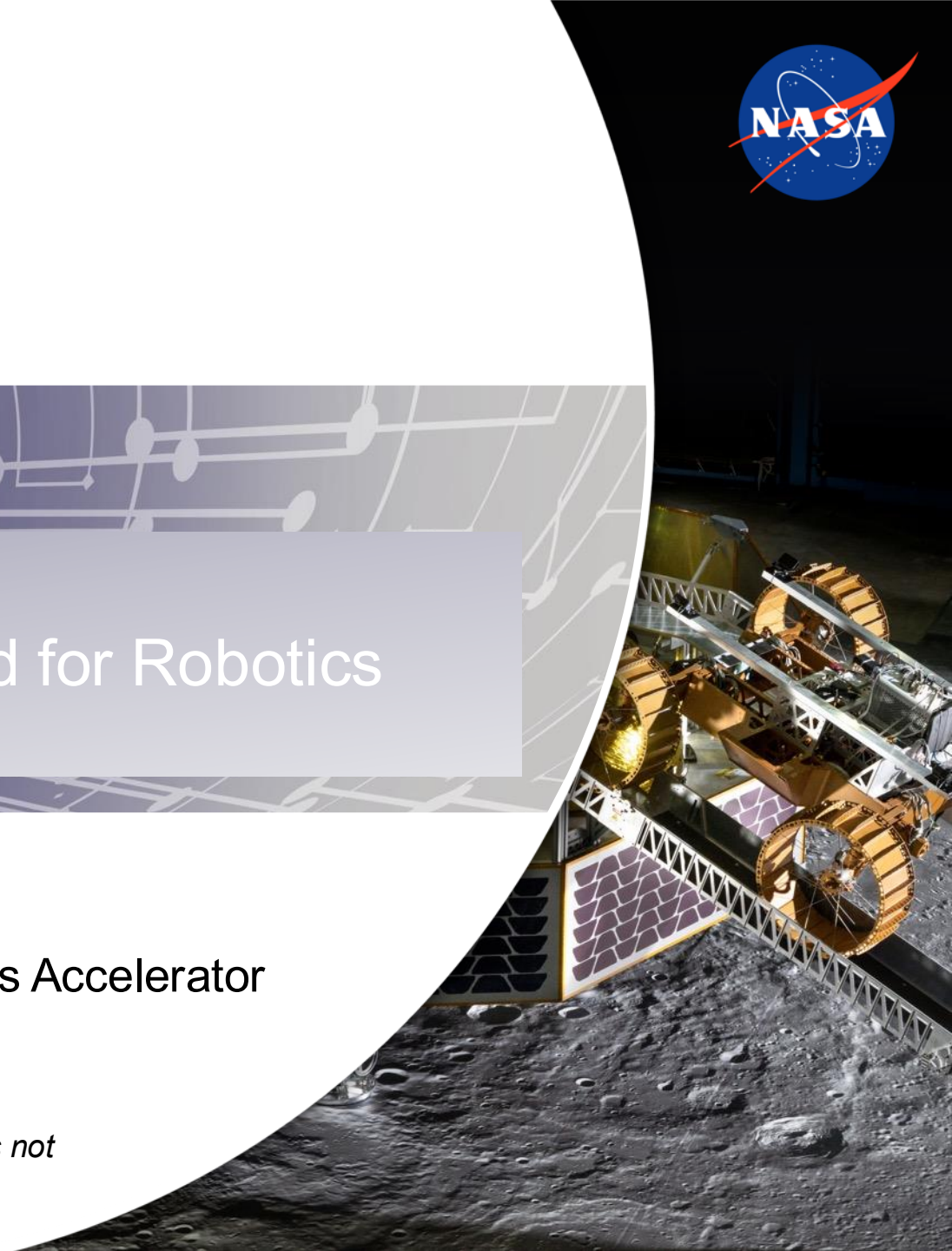


**Phase 1:**

Secure reliable access to the surface and experiment

**Starts now**

**Phase 2:**

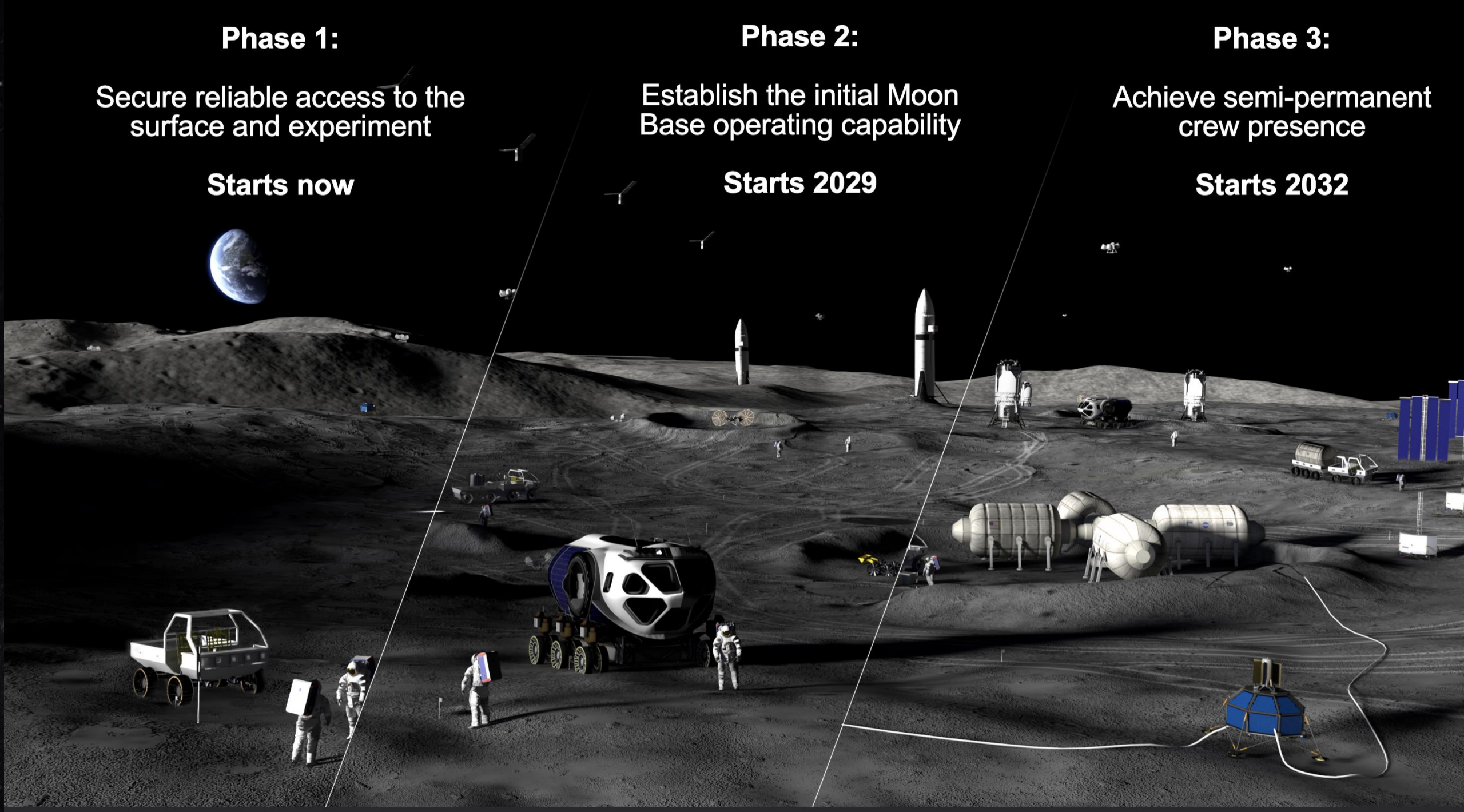
Establish the initial Moon Base operating capability

**Starts 2029**

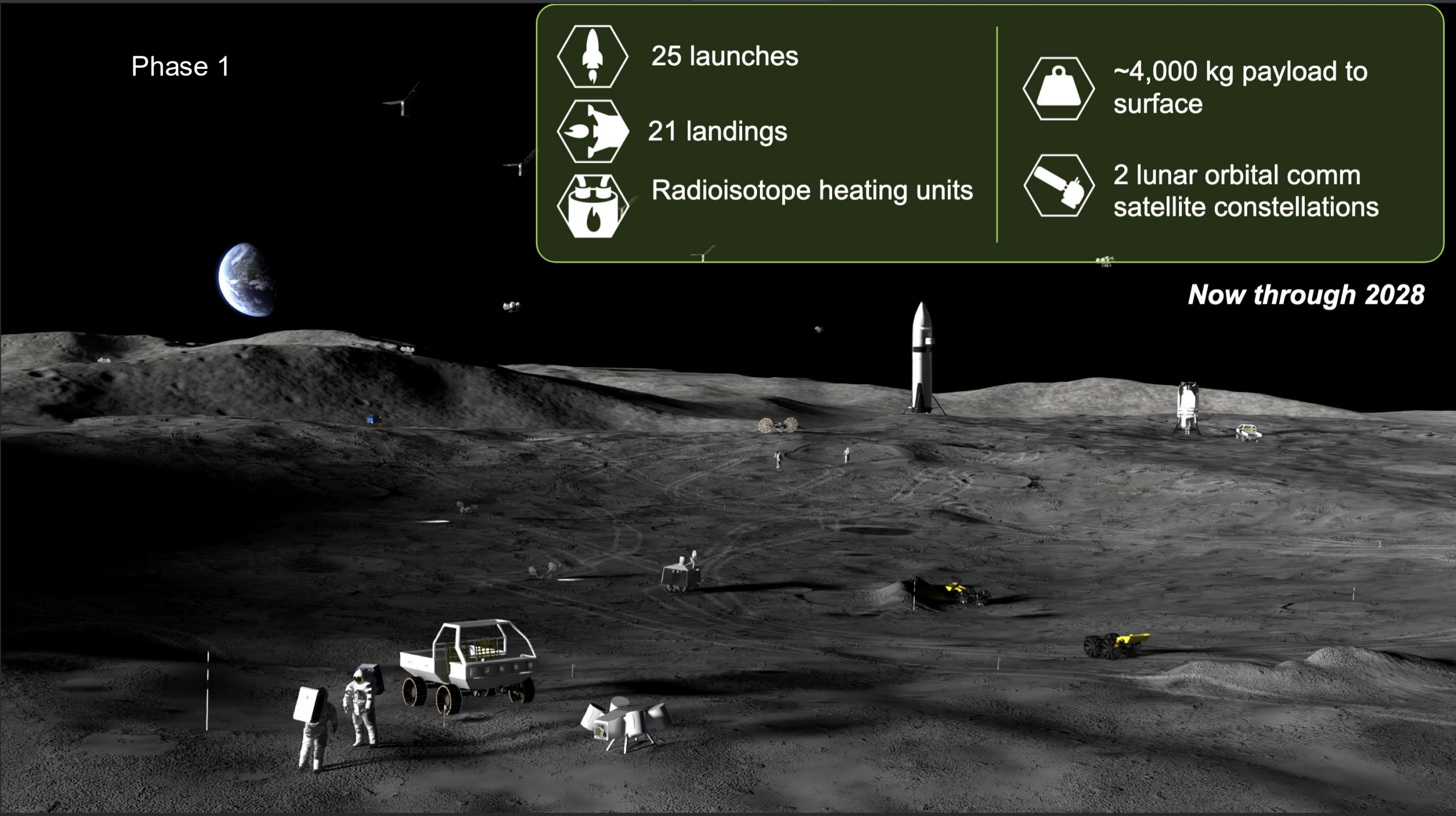
**Phase 3:**

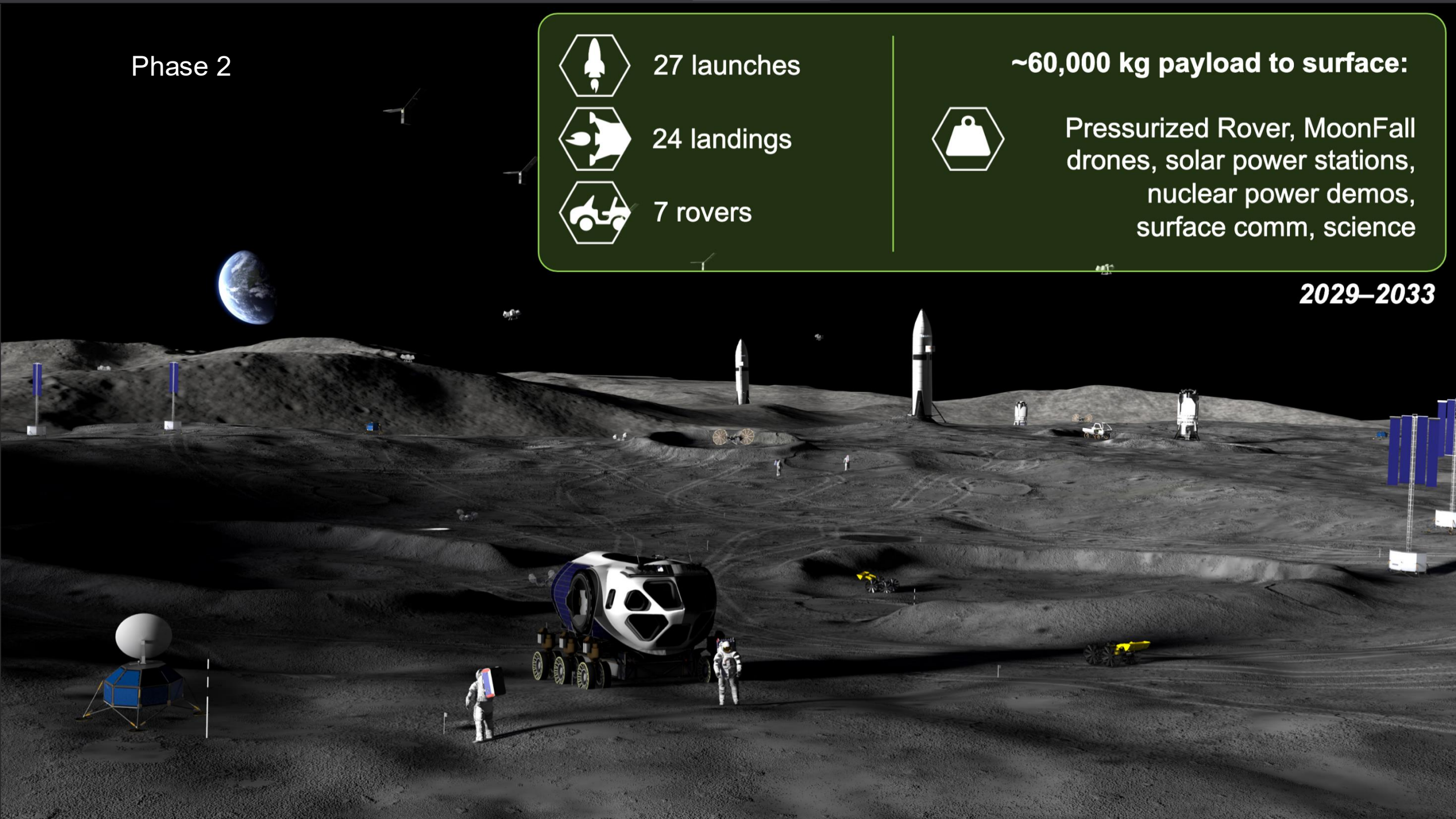
Achieve semi-permanent crew presence

**Starts 2032**




Cargo Return
Fission Surface Power
Logistics
ISRU
Habitats
Habitats
Power Distribution

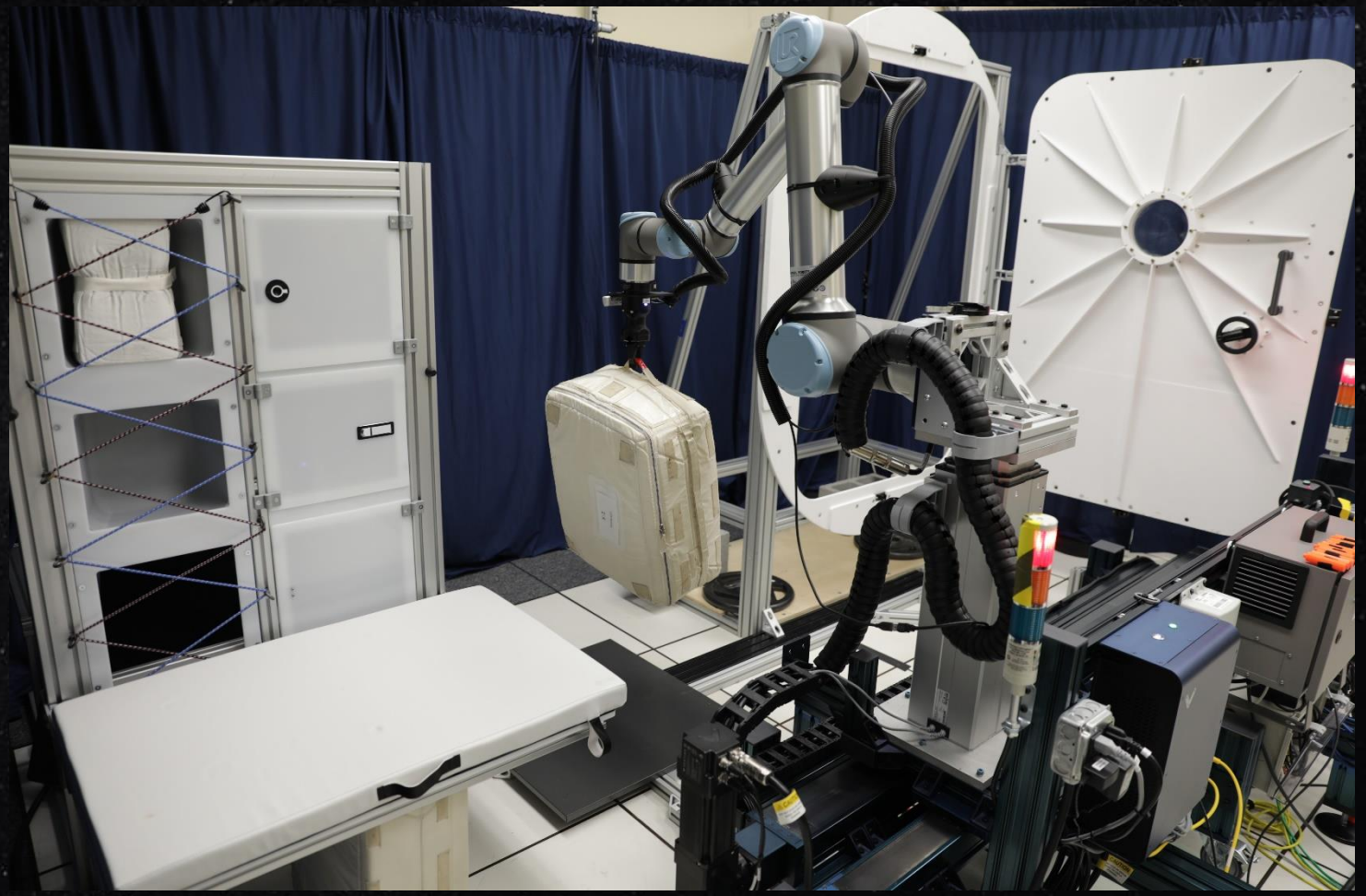

Phase 1
25 launches
21 landings
Radioisotope heating units
~4,000 kg payload to surface
2 lunar orbital comm satellite constellations
Now through 2028


Phase 2
27 launches
24 landings
7 rovers
~60,000 kg payload to surface:
Pressurized Rover, MoonFall drones, solar power stations, nuclear power demos, surface comm, science
2029–2033


Phase 3
29 launches
28 landings
4 rovers
~150,000 kg payload to surface:
Rovers, habitats, logistics,
fission surface power, science
2033–2036

# Integrated Mobile Evaluation Testbed for Robotic Operations (iMETRO)

- For Space Robotics to be successful – we must advance the Technology Readiness Levels (TRL) of integrated technologies for missions requiring remote space robotics operations.
- iMETRO is a test facility at JSC for NASA, Industry, and Academia to develop these technologies



- iMETRO provides:
  - COTS robots
  - Space Applications
  - Core open source software for all
  - Remote operator consoles (test like you fly)

# Components of iMETRO Facility

Partners can choose which components to include to meet their testing needs


Robot

Application

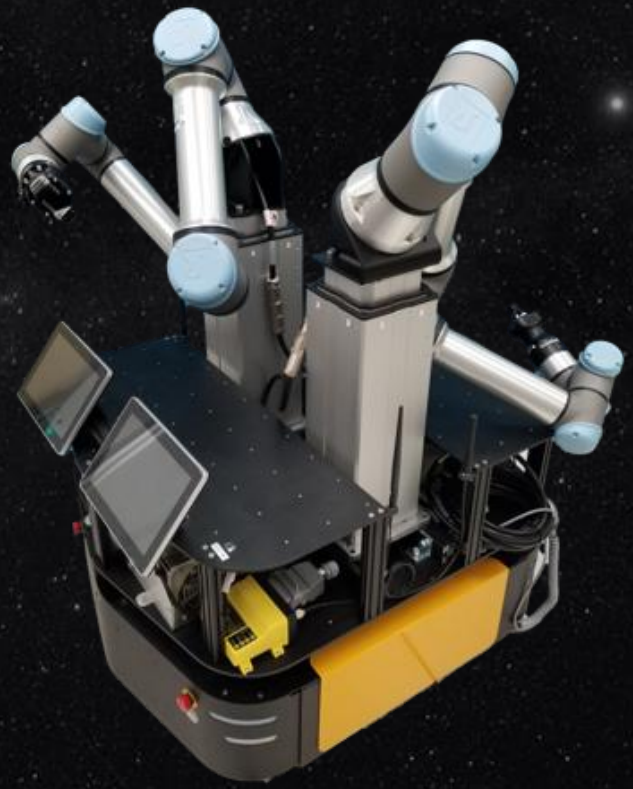
Software

ROS

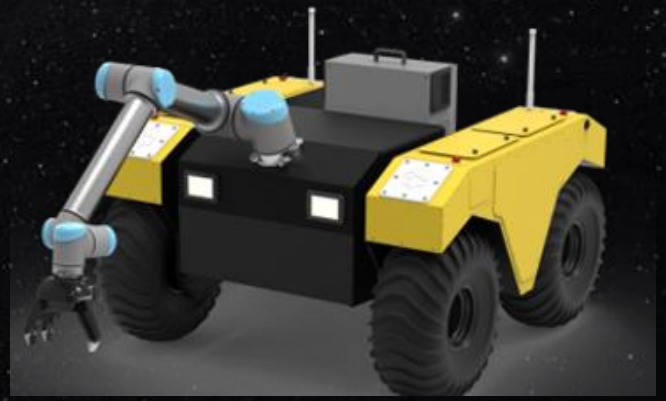
# iMETRO Robots

- Single Arm on a Rail

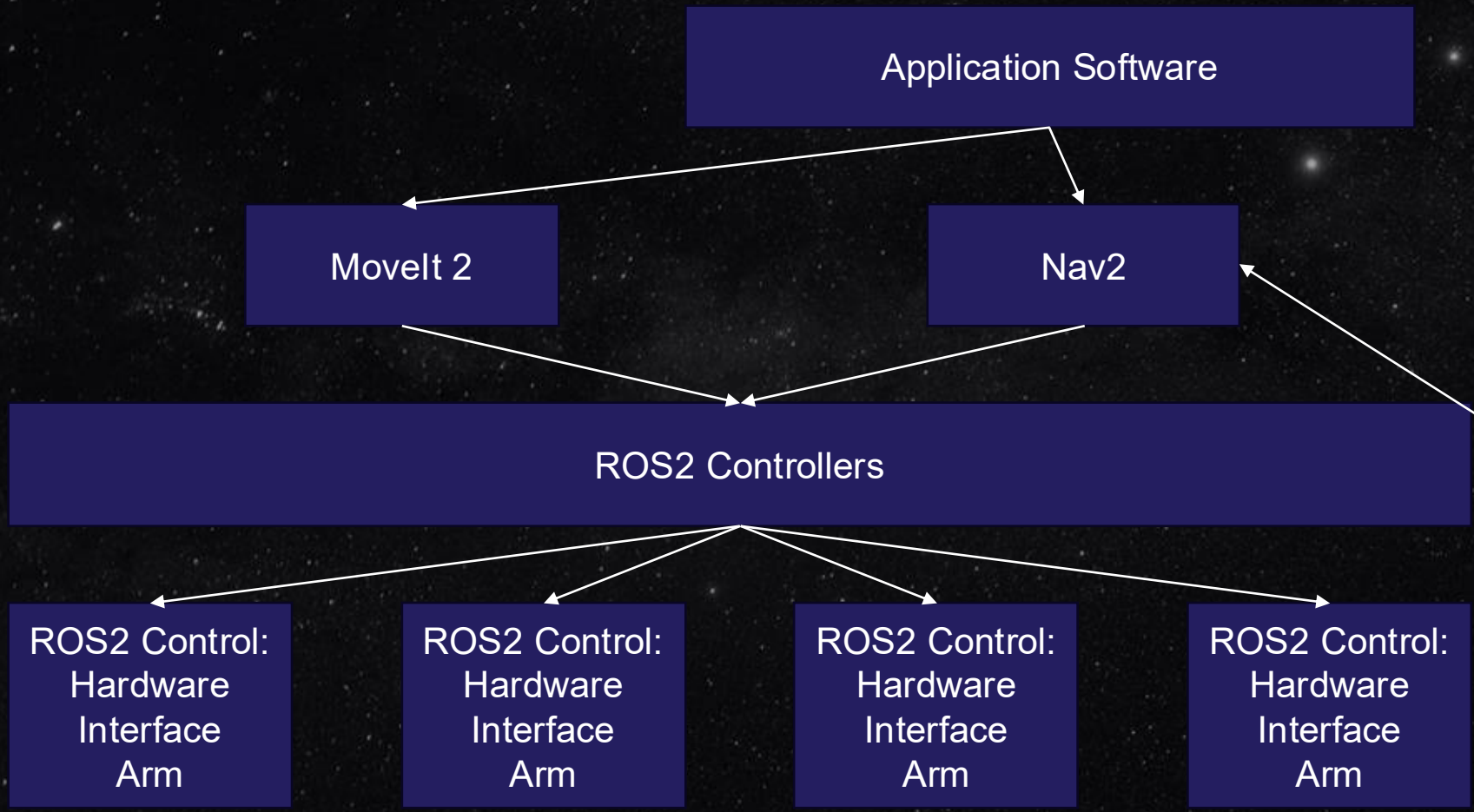
- IVR Mobile Dual Arm System



- EVR Mobile Single Arm System



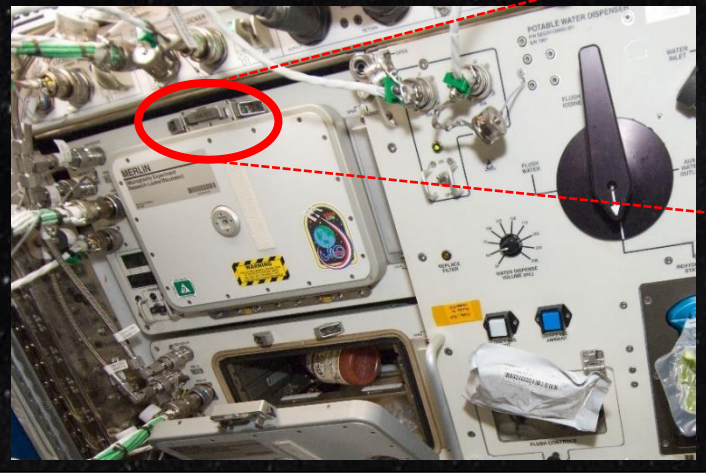
# ROS2 Software Stack




- Uses standardized ROS interfaces
- Ability to pick and choose layers in the software stack

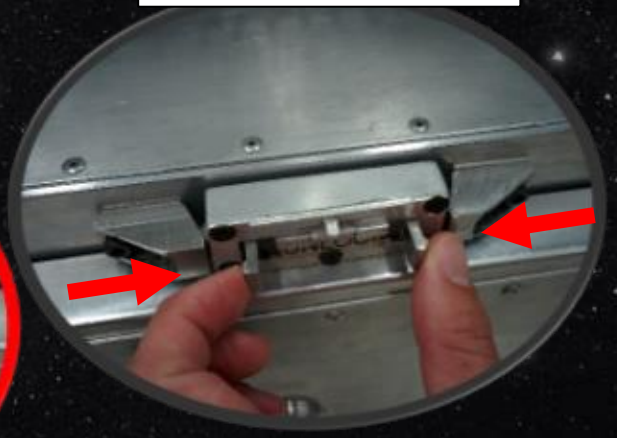
# iMETRO Applications: ISS MERLIN Freezer Example

- Goal: Provide non-proprietary, realistic, and current space use cases
- Focus on:
  - High fidelity manipulation interfaces
  - Low fidelity body/secondary interfaces

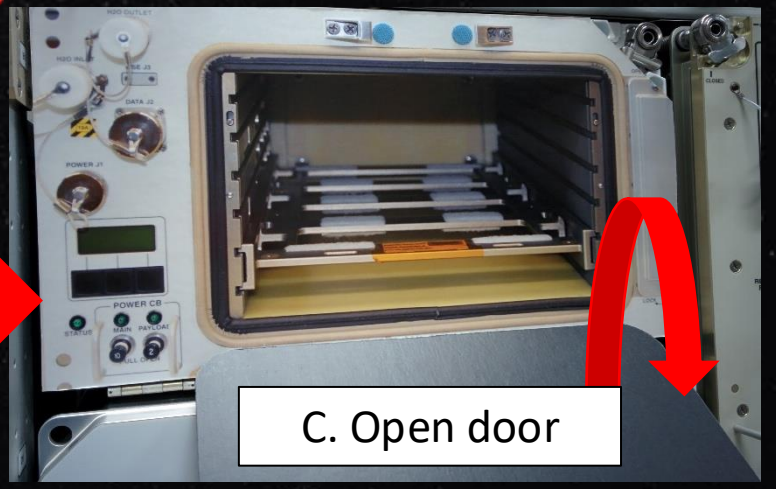


**Actual freezer on ISS**

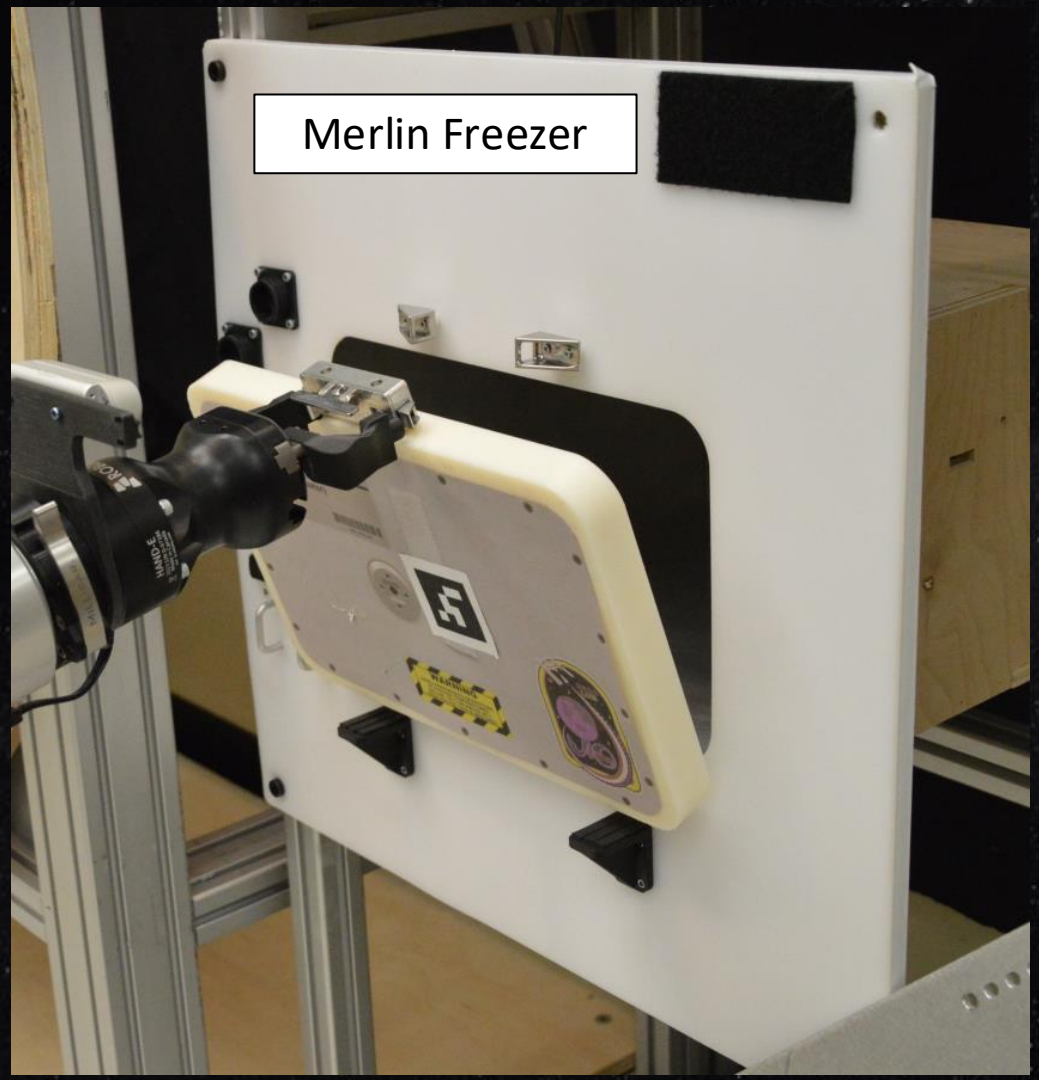
**(Current lab demo uses mockup hardware with relevant components built-to-drawing from active ISS payload design)**

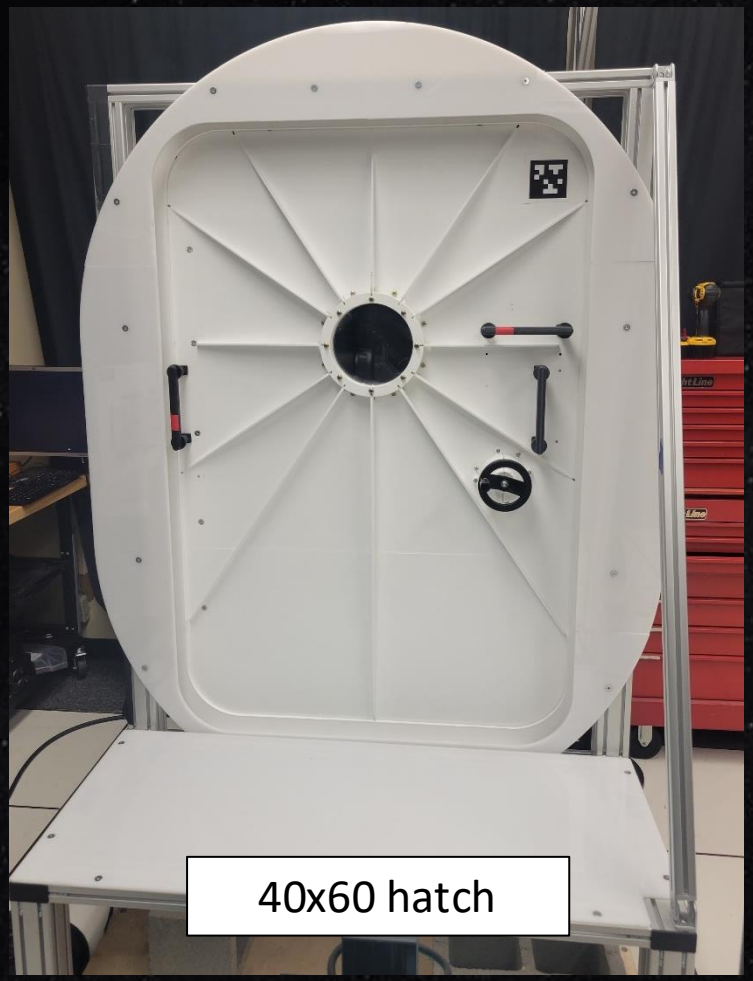




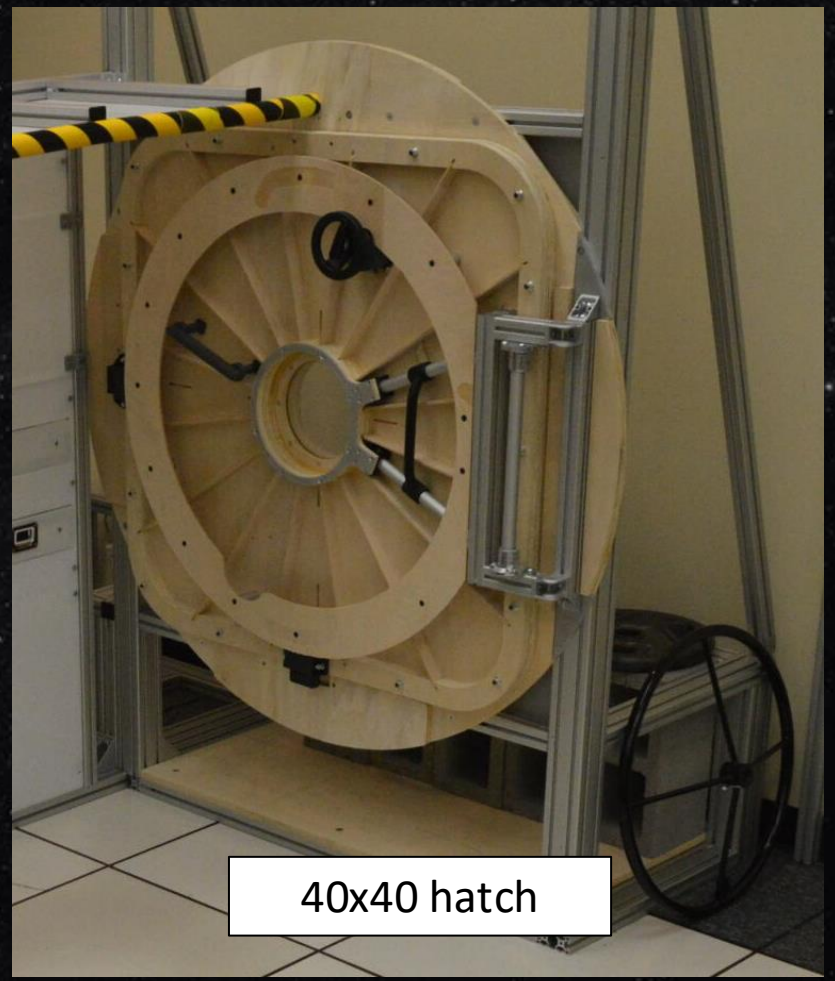
# iMETRO Applications




# iMETRO Applications: Surface Vehicle Hatch Mockups

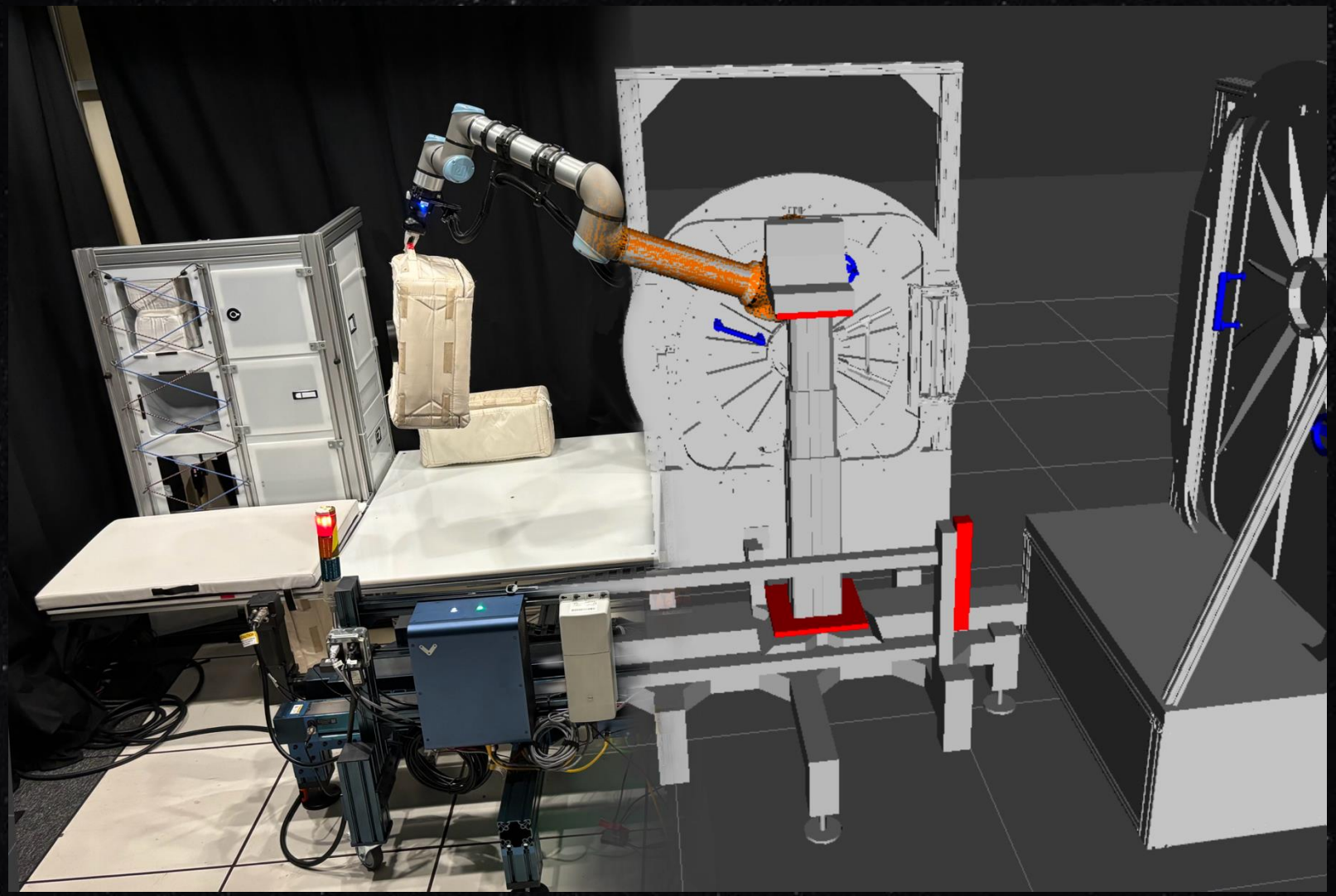


40x60 hatch



40x40 hatch

# True Digital Twin: Simulation + Hardware in the Loop



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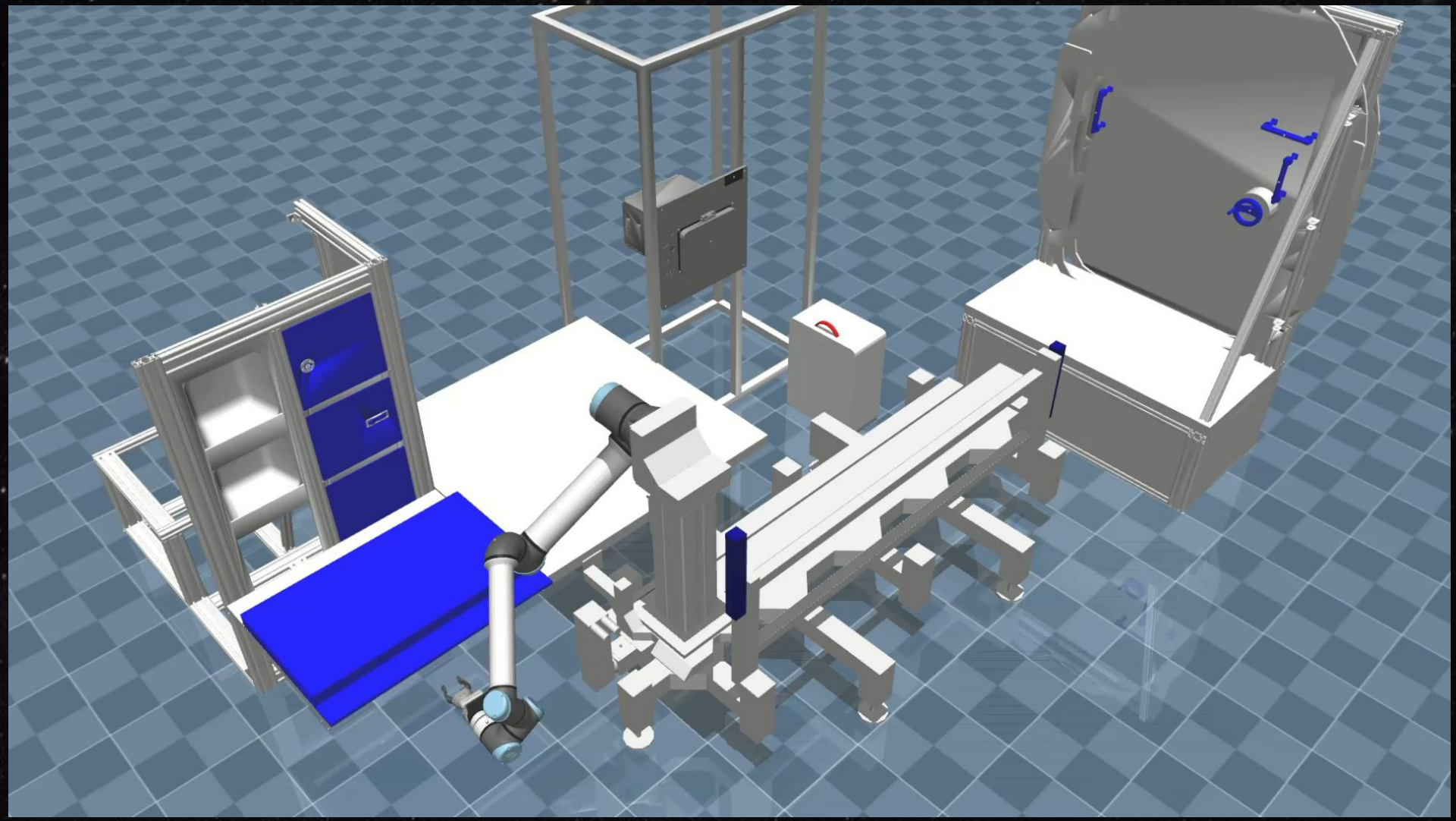

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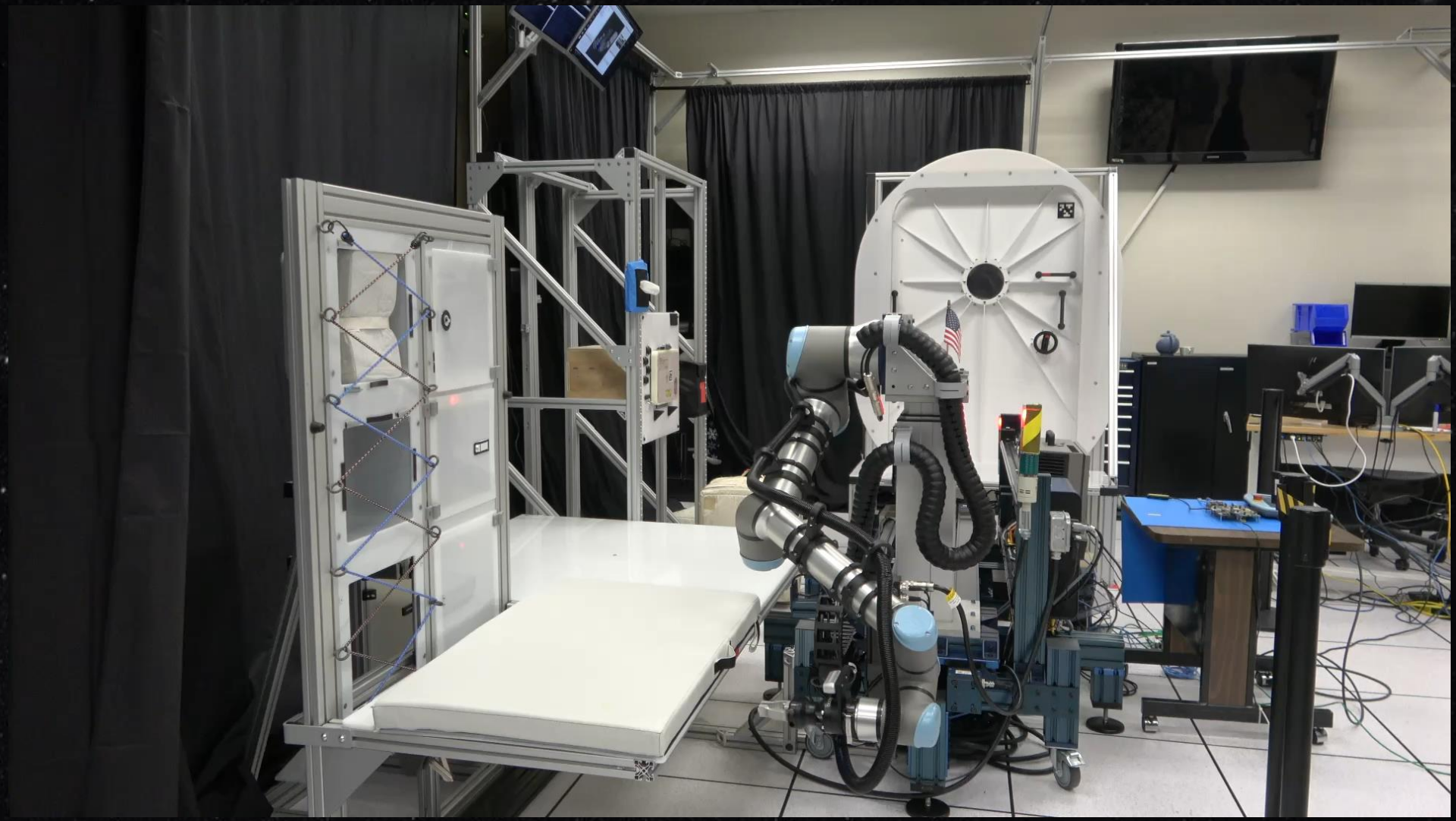
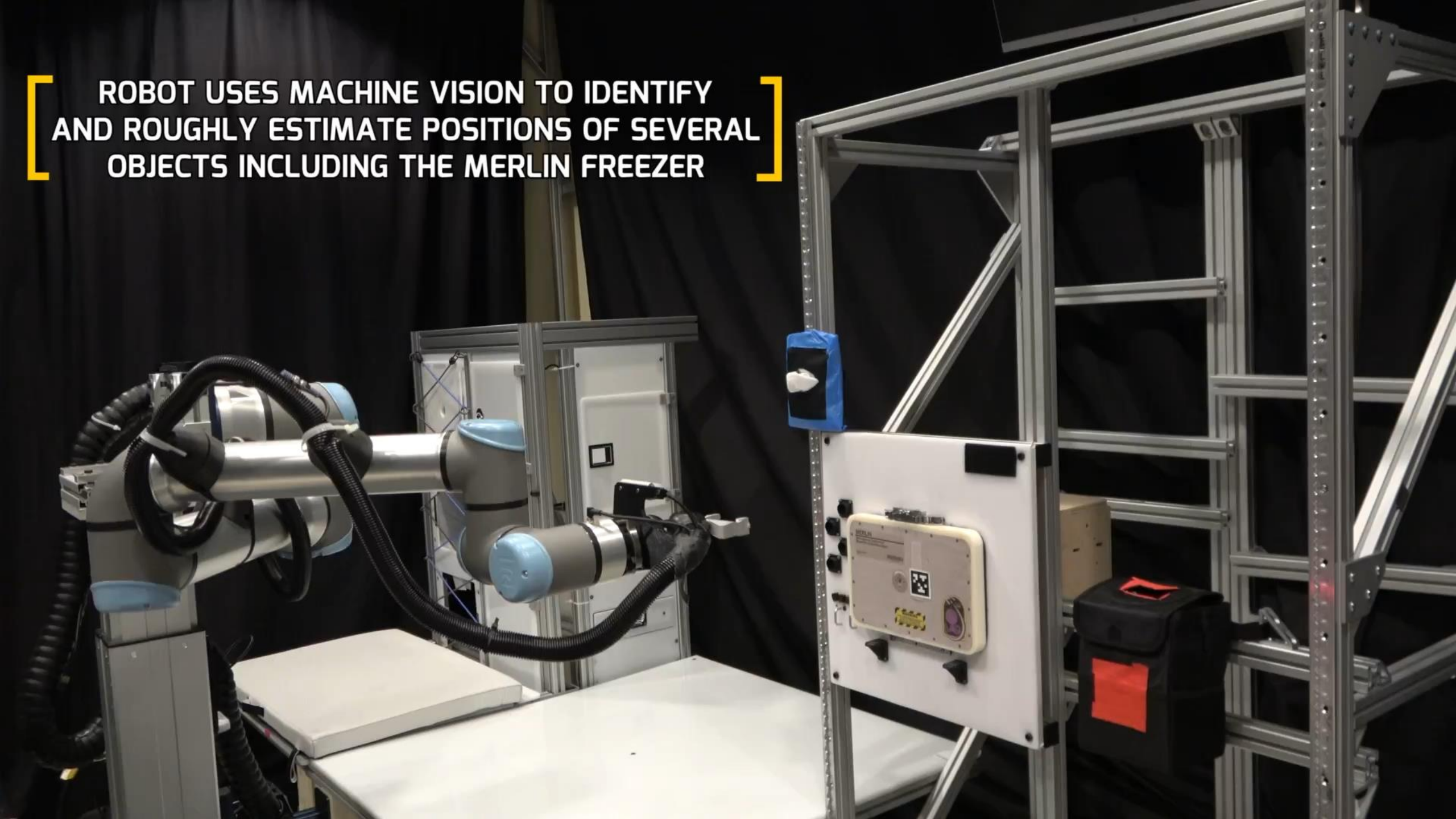
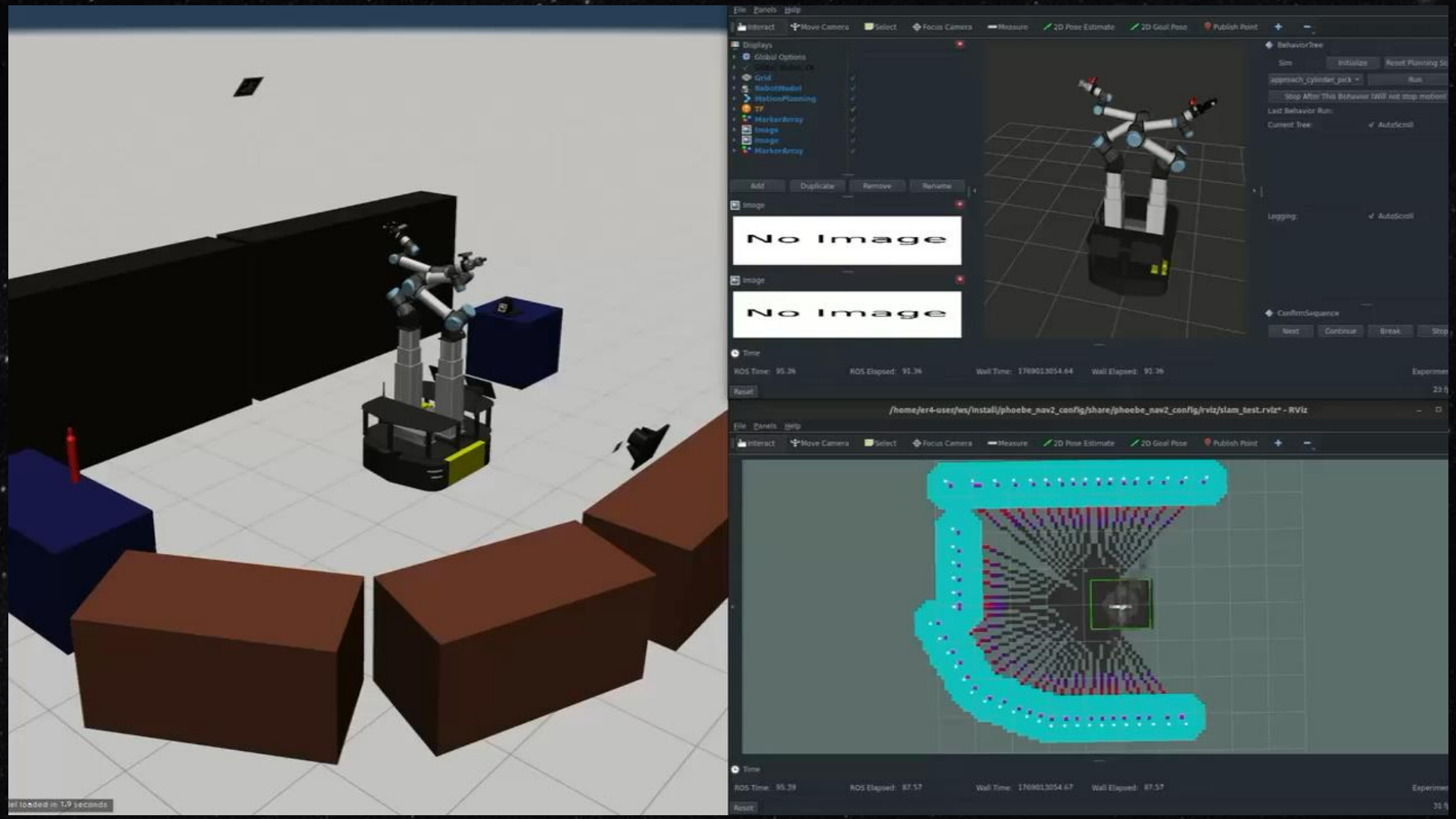



ROBOT USES MACHINE VISION TO IDENTIFY
AND ROUGHLY ESTIMATE POSITIONS OF SEVERAL
OBJECTS INCLUDING THE MERLIN FREEZER

# IVR Mobile Dual Arm System Digital Twin



# LUNAR HABITAT SUPERVISED AUTONOMY - LAB DEMONSTRATION

## Lunar Command and Control Interoperability (LuCCI)


# Open Source Software

- All NASA-developed iMETRO software is released as open source
  - Releases are containerized using Docker

MuJoCo

ROS 2™

docker

# iMETRO Contact Information

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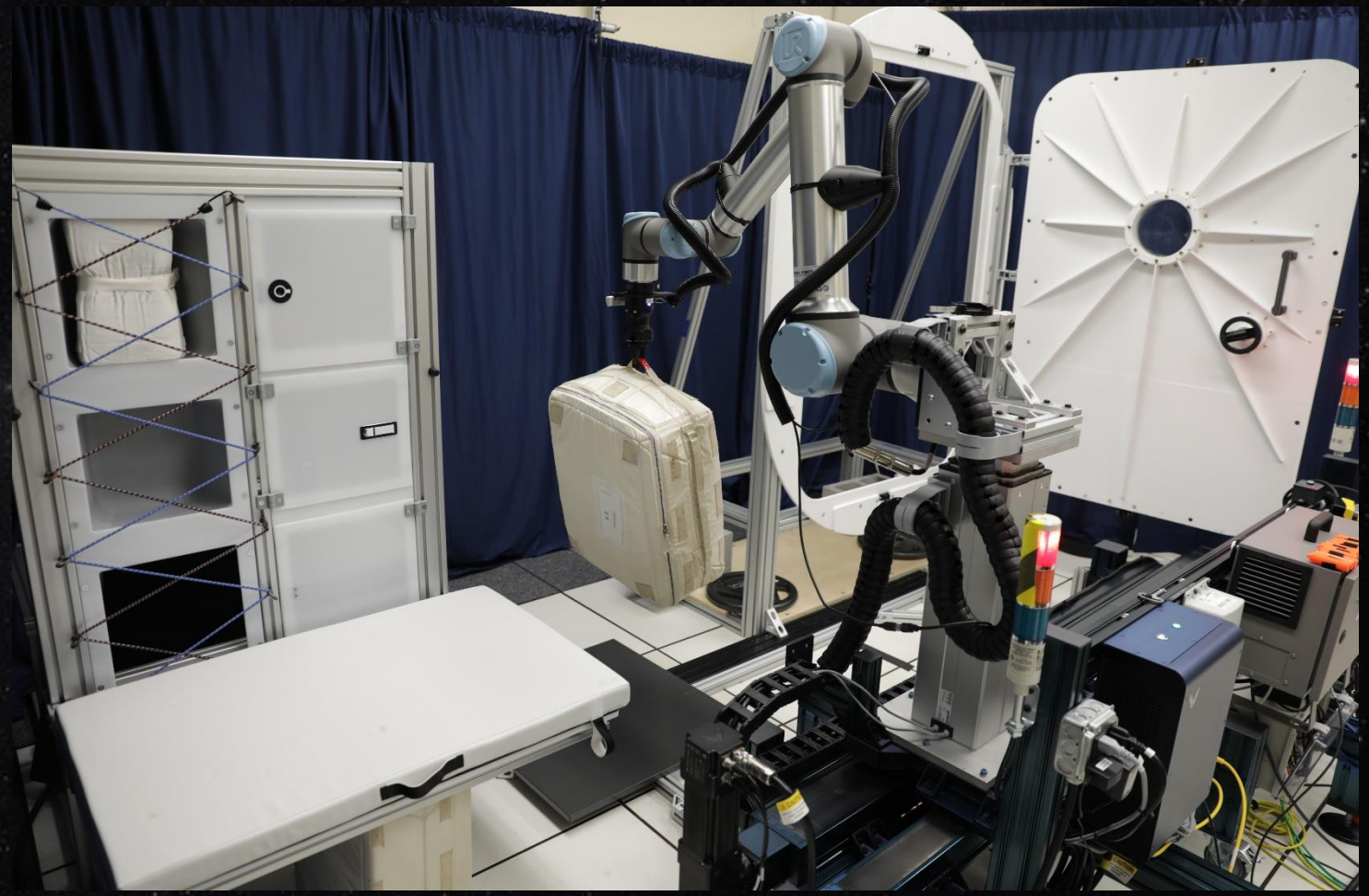
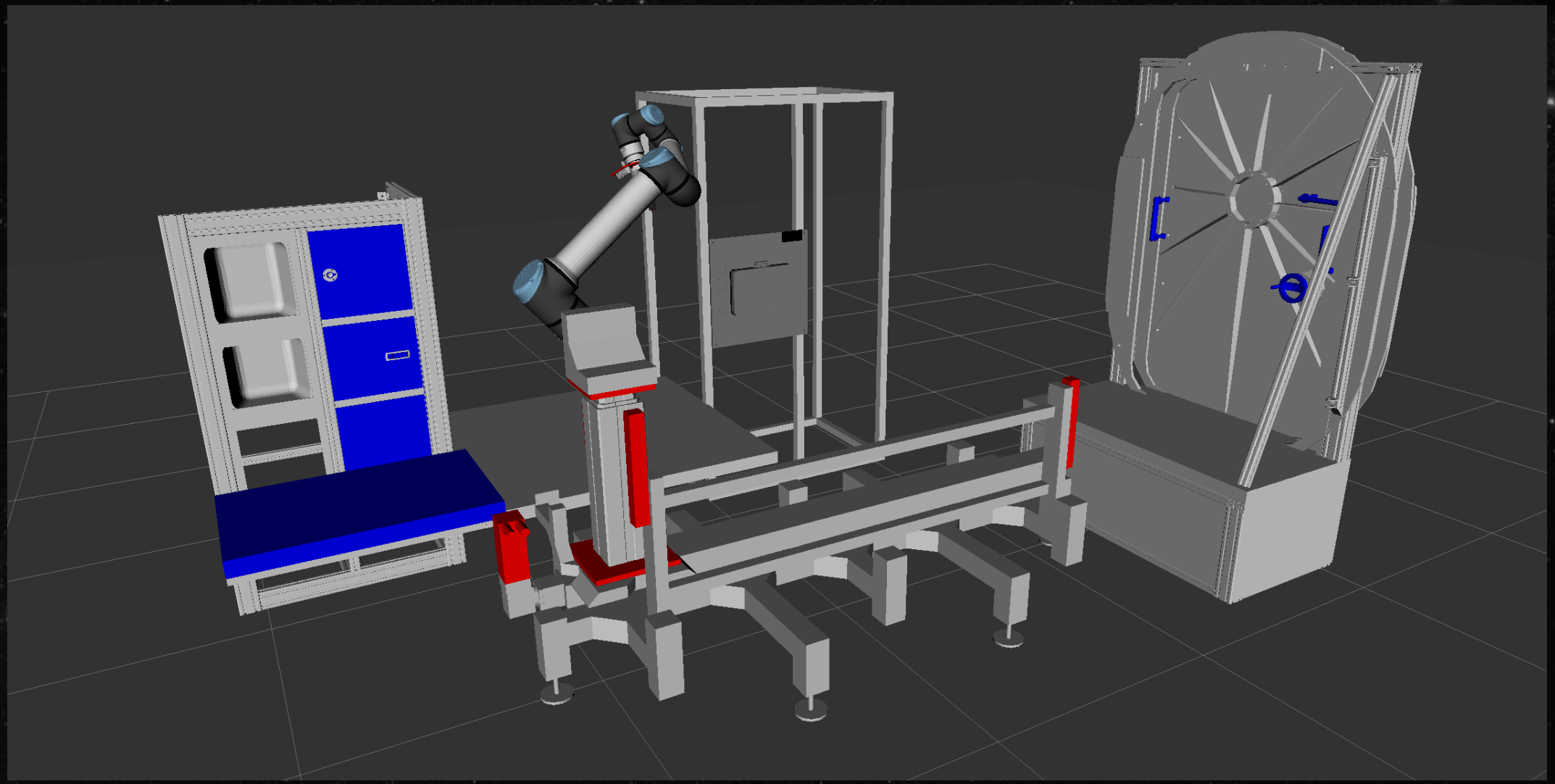
  - emma.zemler@nasa.gov

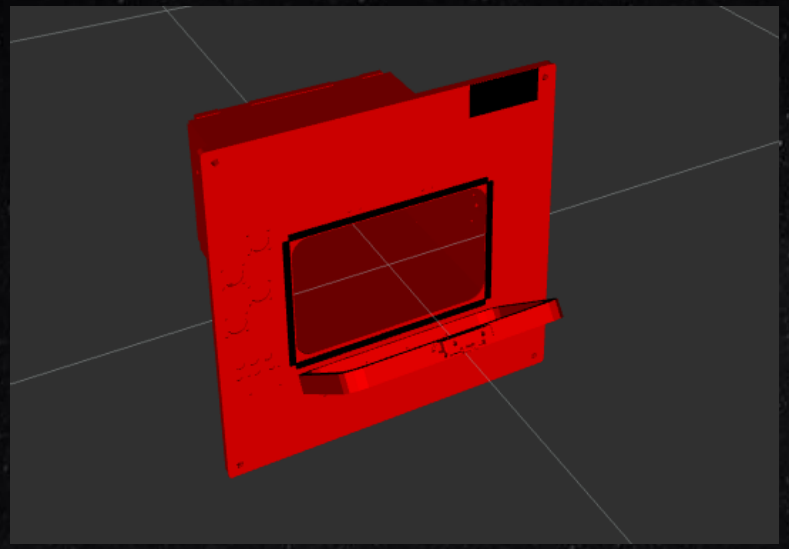


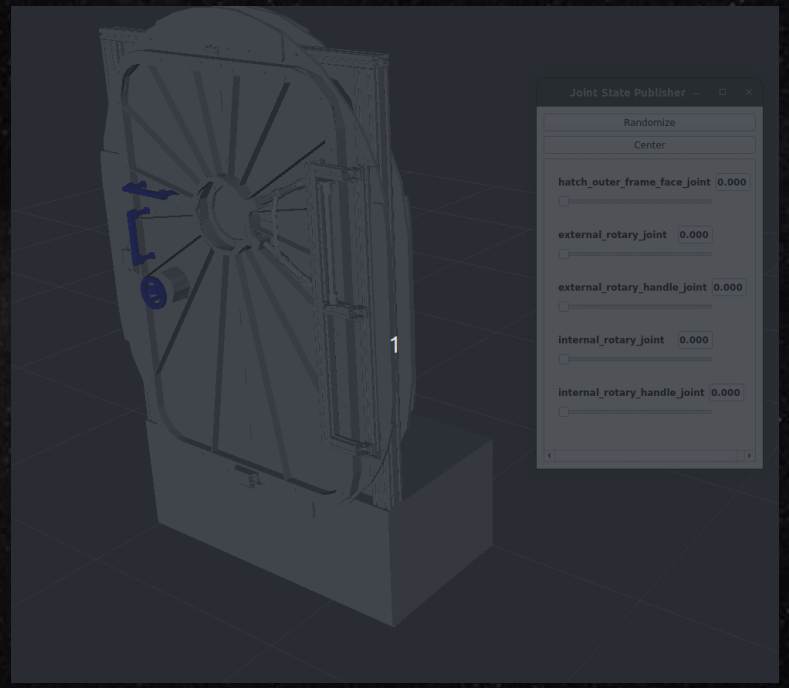
# Backup Slides

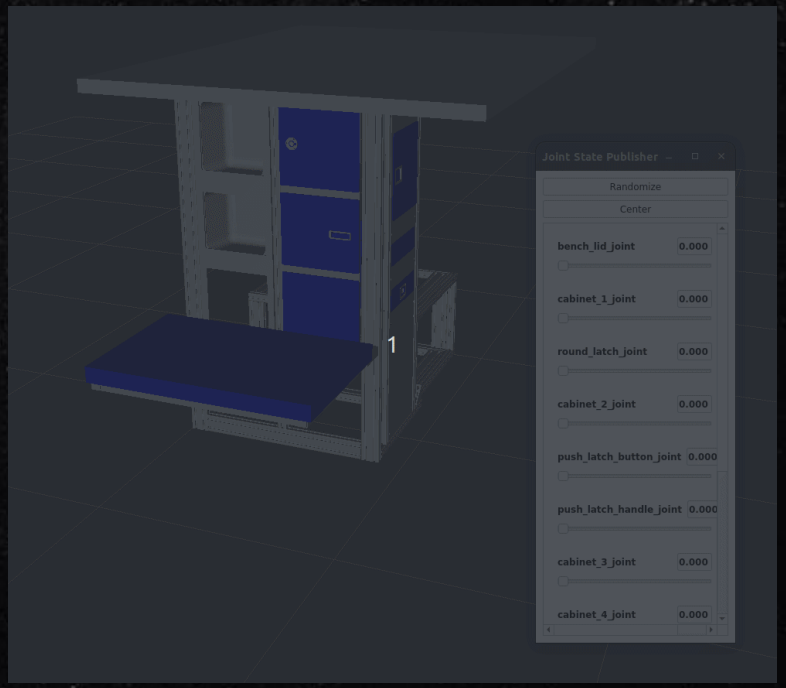
# Kinematic Simulation



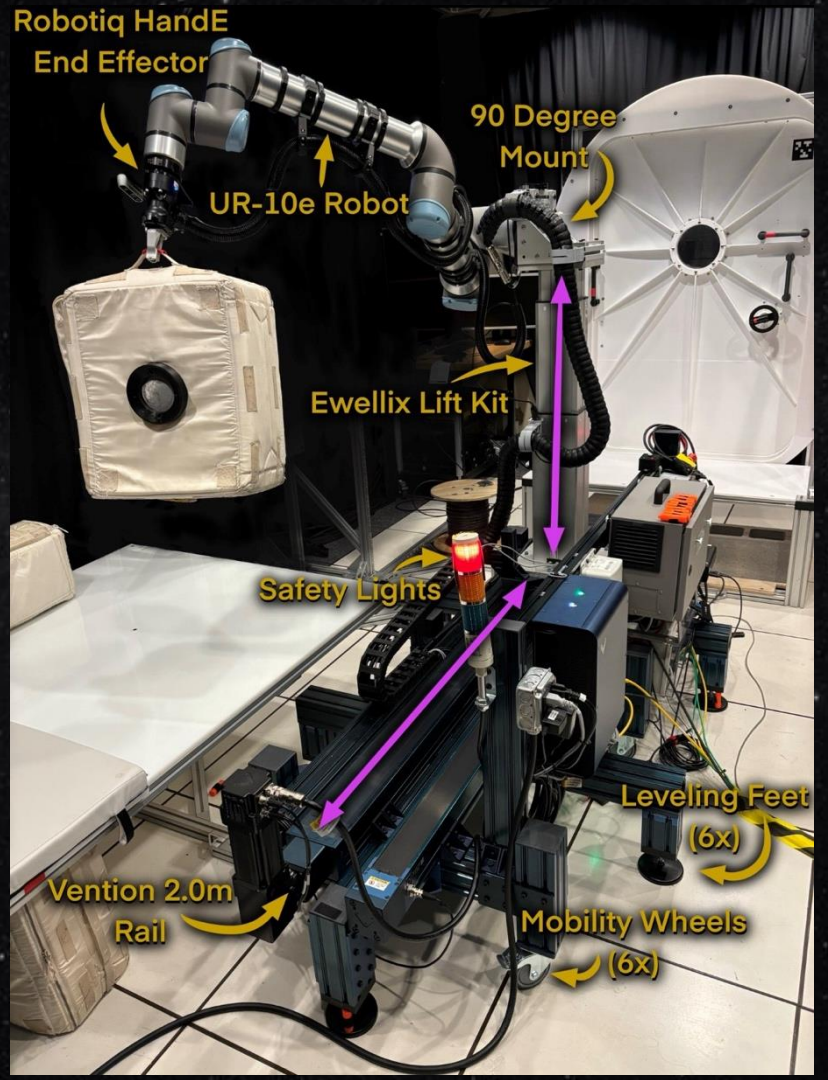
# Mockups described via URDF





# Single Arm on a Rail



# IVR Mobile Dual Arm System

- Clearpath ridgeback
- X2 Ewellix Liftkit 500mm stroke
- X2 UR5e
- X2 Robotiq Hand-E

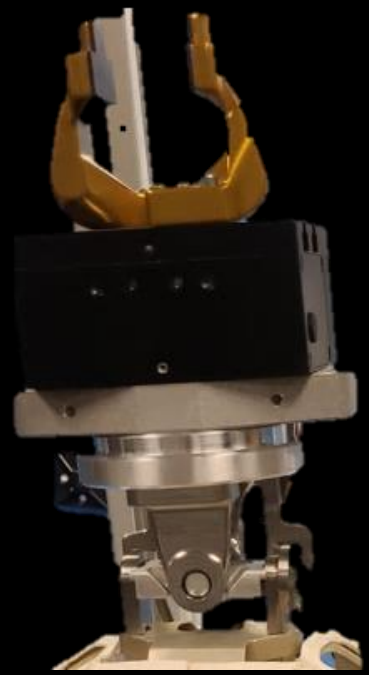
# Modular End Effectors

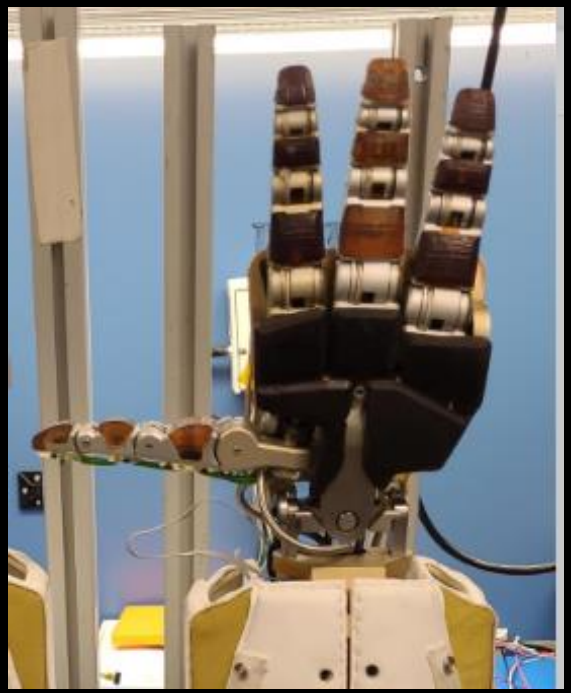
**Parallel Jaw Grippers**

- Non-backdrivable
- More common for iMETRO applications
- Higher pinch force maximum
- Custom fingers

**Dexterous Hands**

- Backdrivable and underactuated
- More compliant
- Force Controlled
- Lower pinch force capability



More Robust

Less Robust