iMETRO (Integrated Mobile Evaluation Testbed for Robotics Operations) Facility

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EXECUTIVE SUMMARY

Crew time in space is precious – every hour could yield immense scientific discoveries and exploration milestones. However, overhead tasks such as logistics, maintenance, and assembly take a large portion of crew time.
Remotely operated robotics capabilities offer a way to free the crew from many overhead tasks, but operating mobile dexterous robots in human-centered environments presents many unknowns and challenges for potential technology providers, limiting adoption for flight missions.

iMETRO is a NASA JSC robotics test facility for terrestrial robotic technology adaptation to space exploration use cases, including logistics, maintenance, and science utilization. iMETRO focuses on Intra-Vehicular (IVA) environments, such as surface habitats, pressurized rover cabins, and space station modules (both Gateway & LEO). Its goal is to **advance the Technology Readiness Levels (TRL)** of integrated technologies for missions requiring remote space robotics operations.

INNOVATION & BENEFITS

The iMETRO facility provides both NASA internal and external partners access to multiple robots, robot simulations, and space use-case mockups, developed to represent current interfaces under development by NASA Moon to Mars exploration architecture. iMETRO provides the ability to test **remote robotic operations** using any combination of user-provided robots or iMETRO robots and mockups.

iMETRO provides open-source ROS2 kinematic simulations of:
• A dual-arm mobile manipulation robot
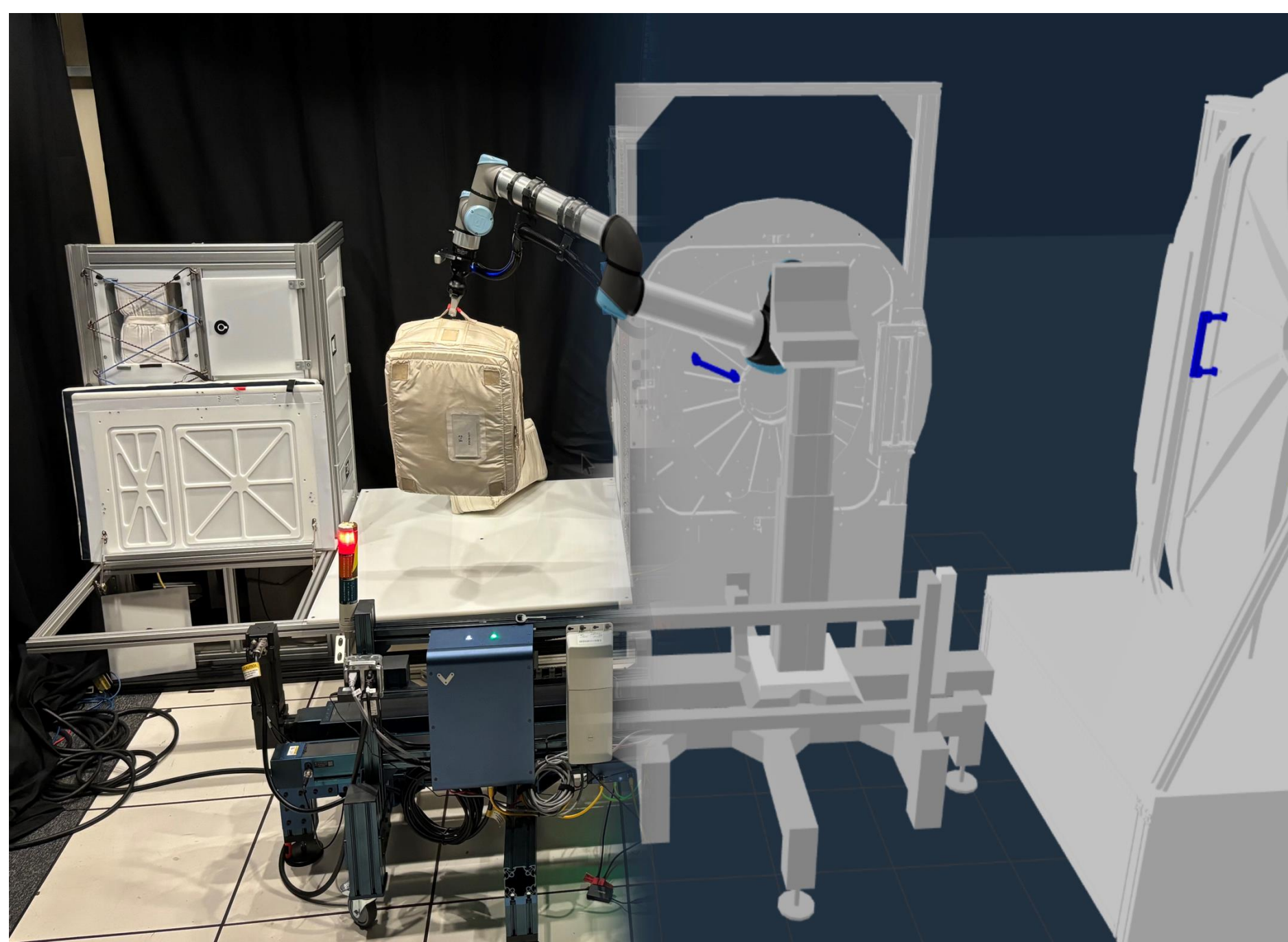• A manipulator with a lift on a rail robot
• Mockups

The mockups provided by iMETRO:
• MERLIN cold stowage freezer
• 40x60 pressurized rover hatch
• 40x40 pressurized rover hatch
• Bench seat for a pressurized rover
• Stowage cabinet for a pressurized rover
• Cargo Transfer Bags

iMETRO is in process of open-sourcing a ROS2 dynamic simulation of:
• A dual-arm mobile manipulation robot
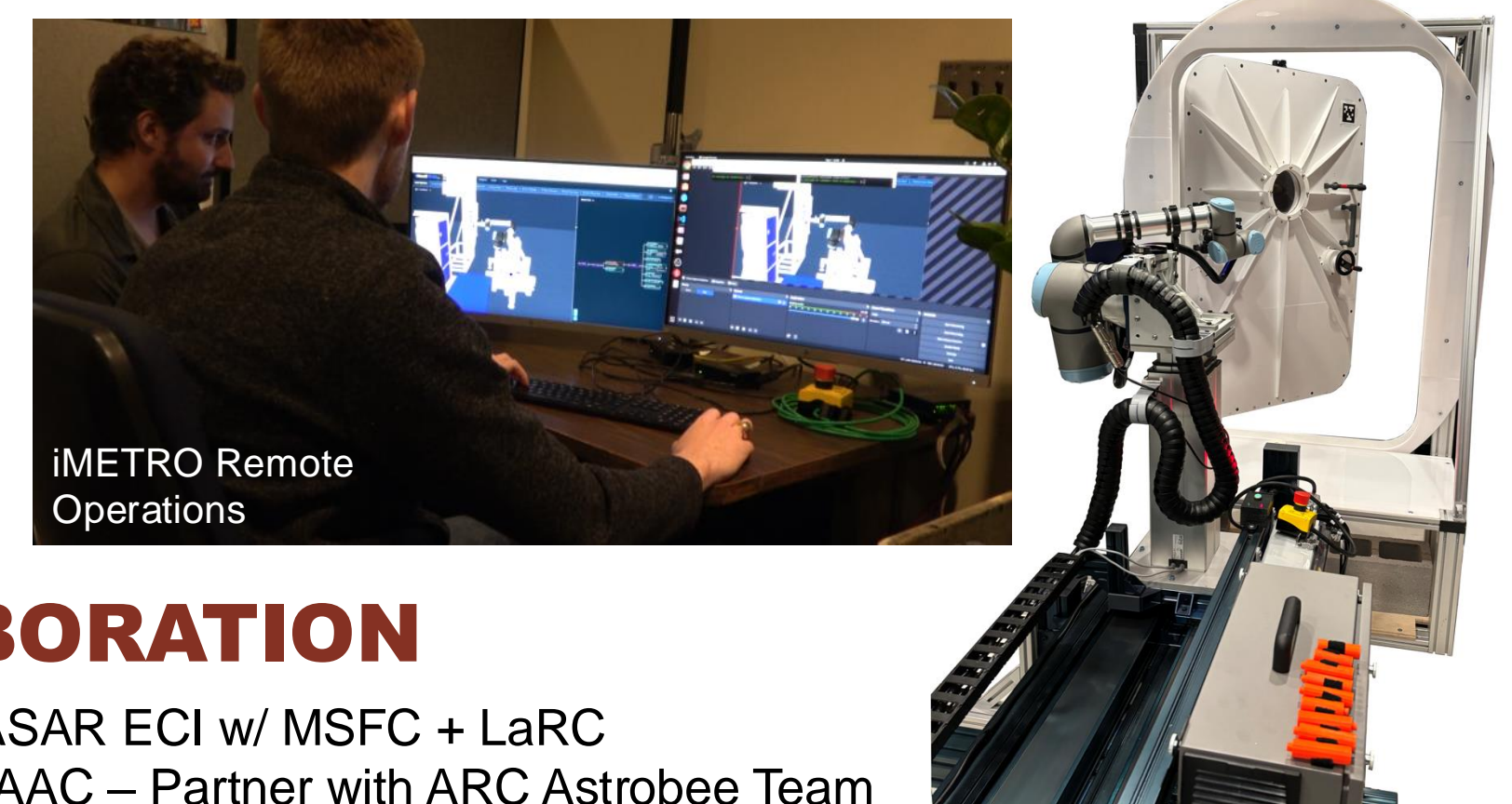• A manipulator with a lift on a rail robot
• Mockups

Simulation + Hardware in the Loop Testing

iMETRO serves as a facility for collaborators to test remote operations. Testing with iMETRO remote operations benefits participants by providing scalable test constraints to identify architectural and fundamental design barriers to remote operations with limited bandwidth, high latency, and comm. outages which may not be evident during locally operated lab feasibility demonstrations.

iMETRO offers the following for remote operations:
• Operator station that is not co-located with the facility
• Three PTZ overhead network cameras for operator awareness
• Adjustable bandwidth/latency connections with the Linux Traffic Control (TC)

iMETRO Remote Operations

COLLABORATION

1. STMD – LASAR ECI w/ MSFC + LaRC
2. STMD – ISAAC – Partner with ARC Astrobee Team
3. Lunar Architecture Team - Integrated Logistics Working Group
4. JSC SF3 - Space Habitability Design Center (HDC)
5. JSC ER5 – Extra-Vehicular Robotics (EVR) "Heavy Lift" Robotics Facility
6. JAXA Robotics – ISS Mobile Robot Tech Demo "PORTRS"
7. PickNik Robotics (https://picknik.ai/) – Commercial Robotic Control Software
8. Motiv Robotics - xWalker SBIR Sequential Contract
9. Rice – Kavraki Lab – High Efficiency Robot Motion Planning Software
10. Purdue University - CoMMA Lab
11. Hardware providers: Vention, Clearpath, Universal Robotics

OUTCOMES & INFUSION

"Technology Infusion" has been disrupted and redefined by the commercial services model, creating a gap where technologies previously infused into NASA-directed programs now face an uncertain path to adoption with commercial and international partners. Proprietary data, export restrictions, and other barriers currently inhibit space exploration commercialization by American small businesses and university labs.

NASA JSC's iMETRO lab helps to fill these gaps by providing non-proprietary, realistic, and current space use cases which lower the barriers to entry for innovators, while also providing a shared platform for NASA's unique experience and technical leadership role. No single provider can or should supply all robotics technology needs – iMETRO acts as a bridge between specialists in sensors, hardware, and software to develop integrated capabilities which are more likely to succeed in commercial adoption and infusion with element partners.

FUTURE WORK

For FY25, iMETRO will be focusing on reducing the sim-to-real gap by upgrading the lunar surface robotic digital twin. We will be adding physics/dynamic simulations of the robotic systems and the mockups, all of which will be open-sourced.

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