National Aeronautics and Space Administration

iMETRO (Integrated Mobile Evaluation Testbed for Robotics Operations) Facility

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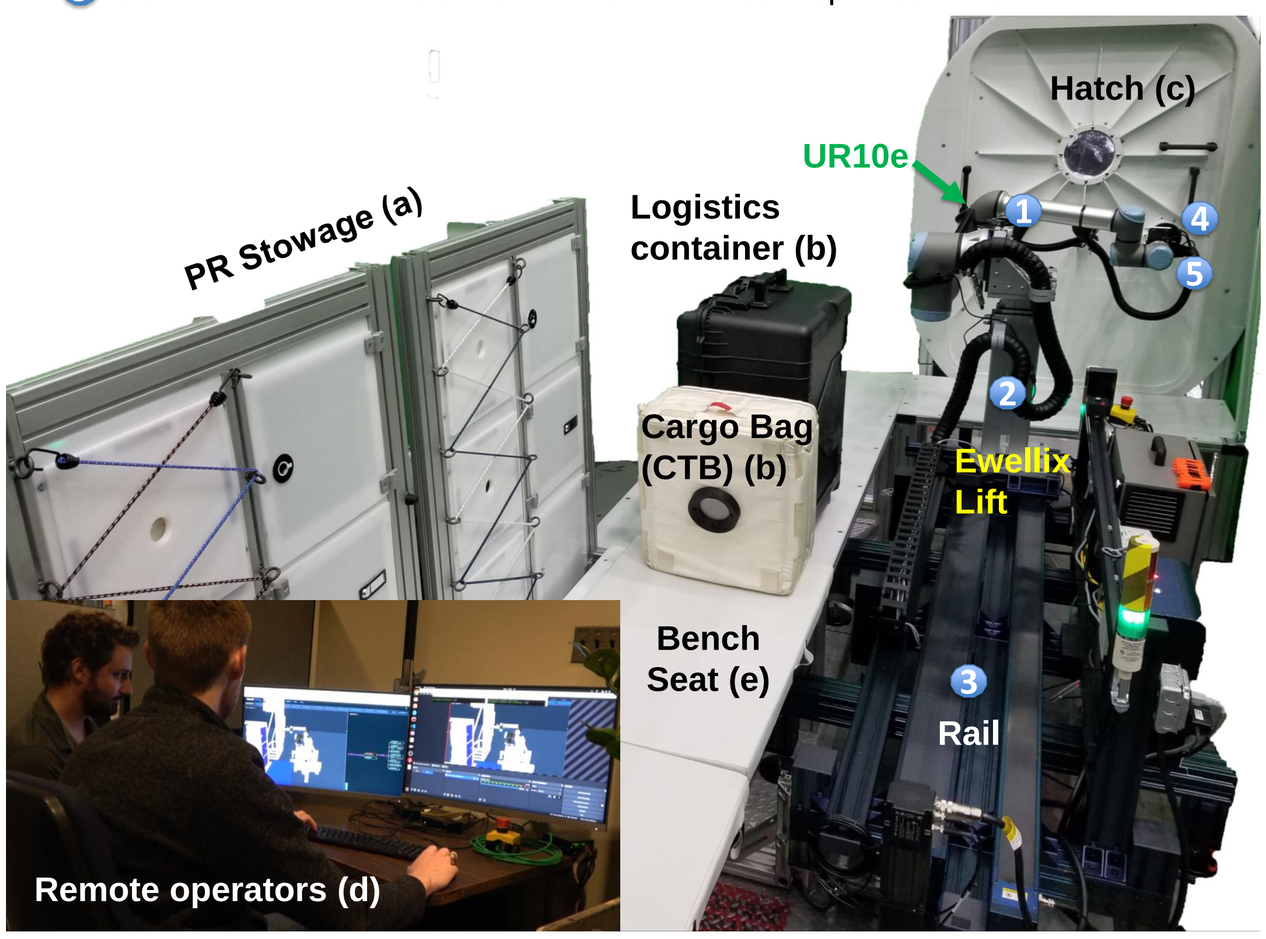
EXECUTIVE SUMMARY

Exploration crew time in space is precious – every hour could yield immense scientific discovery. However, overhead tasks such as logistics, maintenance, and assembly greatly limit crew time available for science and exploration. Robotic remote operations capabilities offer a solution, but operating mobile dexterous robots in human centered environments presents many unknowns and challenges, therefore testing is needed. **iMETRO is a NASA JSC robotics test facility** for terrestrial robotic technology adaptation for space exploration use cases, including logistics, maintenance, and science utilization. iMETRO focuses on Intra-Vehicular task 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 remote space robot operations systems with Earth supervision.

INNOVATION

The first innovation from this project is hardware integration (9 DOF) with open source software (ROS2) and remote station operation (below):

1. Robot Arm: Universal Robots UR10e
2. Vertical Lift: Ewellix Telescoping Lift Kit with 700mm Stroke
3. Linear Rail: Vention Horizontally Mounted 2.0m
4. Gripper: Robotiq Hand-E parallel jaw w/ customizable fingers
5. Sensor: Intel® RealSense™ Wrist-Mounted Depth Camera



iMETRO facility with remote operation (d) of the 9 DOF system for cargo transfer (b), Pressurized Rover stowage (a), and hatch (c). The robot and components are also movable for collaboration with other robotic systems.

The second innovation is hardware and software packages (ROS2) for pressurized rover mockups including, **PR stowage (a), hatches (c), and bench seats (e)**. These hardware mockups allow testing with IVR and EVR systems. More importantly, their release will **foster collaborations** with universities, companies, and international partners on standardized mockups to speed the adaptation of terrestrial robotics and new technology development for **non-terrestrial robotics**.

COLLABORATION

1. ER5 – Extra-Vehicular Robotics (EVR)
2. SF3 – Pressurized Rover Mockup Development
3. PickNik (https://picknik.ai/)
4. Hardware partners: Vention, Ewellix, Clearpath, Universal Robotics

OUTCOMES & INFUSION

The major outcomes of this project are the hardware demonstration showing the transfer and stowage in the bench seat of cargo transfer bags, and a **demonstration of an Extra-Vehicular Robotics (EVR) transfer** of a logistics container through a hatch. The demonstrations were also completed using PickNik's MoveIt Studio software built on top of ROS2. These efforts also supported several programs:

1. Conducted **Lunar Architecture Team** (LAT) robotics logistics feasibility studies for **Artemis Use Cases & Functions** (UC&F)
2. Demonstrated automated robotic CTB handling technologies for **Mars Campaign Office Logistics Reduction** project
3. Demonstrated small business partner's commercial remote robotic operations software (**PickNik, MoveIt Studio** SBIR)
4. Performed a Merlin Freezer seal wipe down for **Integrated System for Autonomous and Adaptive Caretaking** (ISAAC) with a UR5

FUTURE WORK

The next iMETRO demonstration will be opening an ISS freezer mockup and **cleaning the seal** using the nine DOF system. This demonstration will involve a high fidelity / complex latching mechanism and end effector force control. Then, the group will implement **latency and bandwidth limitations** to simulate a lunar environment more accurately.

The next major step will be receiving and integrating a dual arm mobile system (below) which will increase iMETRO capabilities for testing:

- Dual arm manipulation
- Integration with other robotic systems
- Navigation and mapping
- Gripper refinement
- Remote estop

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