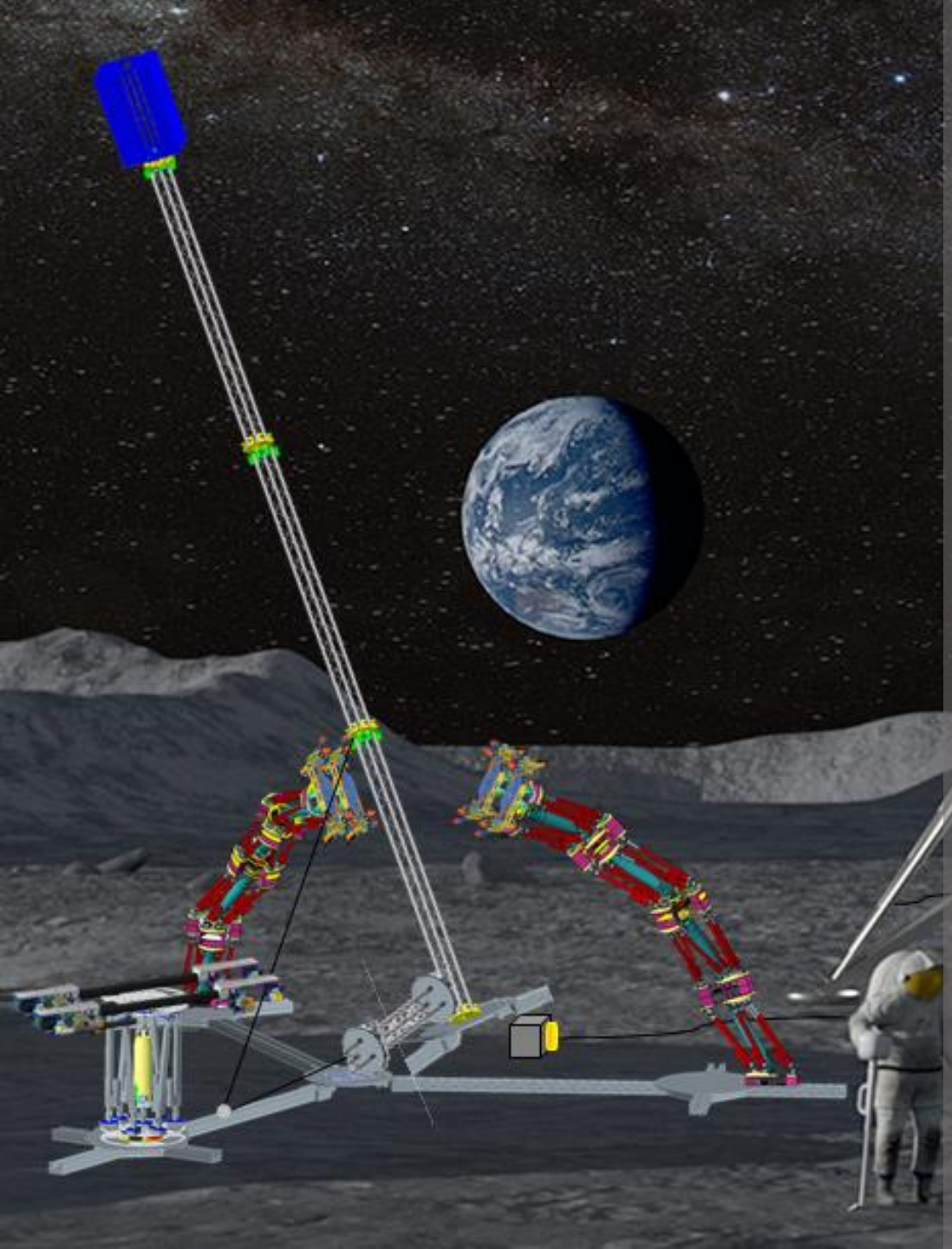


Autonomous In-Space Assembly at NASA LaRC

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7/27/22

Outline

1. NASA Autonomous Systems Capability Taxonomy
2. Baseline infrastructure at NASA Langley
3. Active research and projects
4. Gaps remaining

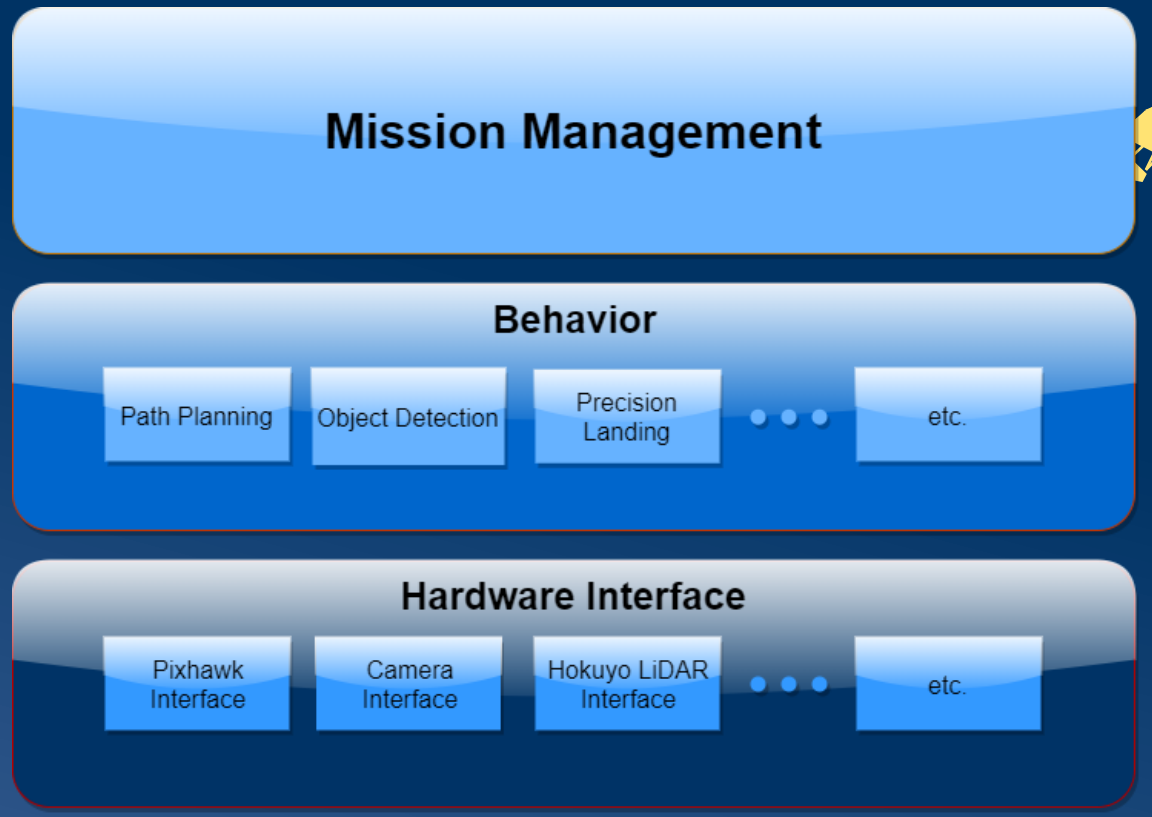
Autonomous Systems Capability Taxonomy



- **1.0 Situation and Self Awareness**
  - 1.1 Sensing and Perception
  - 1.2 State Estimation and Monitoring
  - 1.3 Knowledge and Model Building
  - 1.4 Hazard Assessment
  - 1.5 Event and Trend Identification
  - 1.6 Anomaly Detection
- **2.0 Reasoning and Acting**
  - 2.1 Mission Planning
  - 2.2 Activity and Resource Planning and Scheduling
  - 2.3 Motion Planning
  - 2.4 Execution and Control
  - 2.5 Fault Diagnosis and Prognosis
  - 2.6 Fault Response
  - 2.7 Learning and Adapting
- **3.0 Collaboration and Interaction**
  - 3.1 Joint Knowledge and Understanding
  - 3.2 Behavior and Intent Prediction
  - 3.3 Goal and Task Negotiation
  - 3.4 Operational Trust Building
- **4.0 Engineering and Integrity**
  - 4.1 Verification and Validation
  - 4.2 Test and Evaluation
  - 4.3 Operational Assurance
  - 4.4 Modeling and Simulation
  - 4.5 Architecture and Design

Autonomous Entity Operations Network (AEON)

- Publish/subscribe communication framework for autonomous systems
- Uses Data Distribution Service (DDS) protocol
- Built-in data types for common information
  - Pose
  - Trajectory
  - Sensor signals
    - IMU
    - GPS
    - LIDAR
- Plug-and-play architecture for rapid software iteration



Baseline Environment for Autonomous Modeling (BEAM)

- Multi-agent simulation and mixed reality environment based on Unity
- Integrated with AEON
- Software-in-the loop simulation
- Easy to develop mods for new autonomous agents

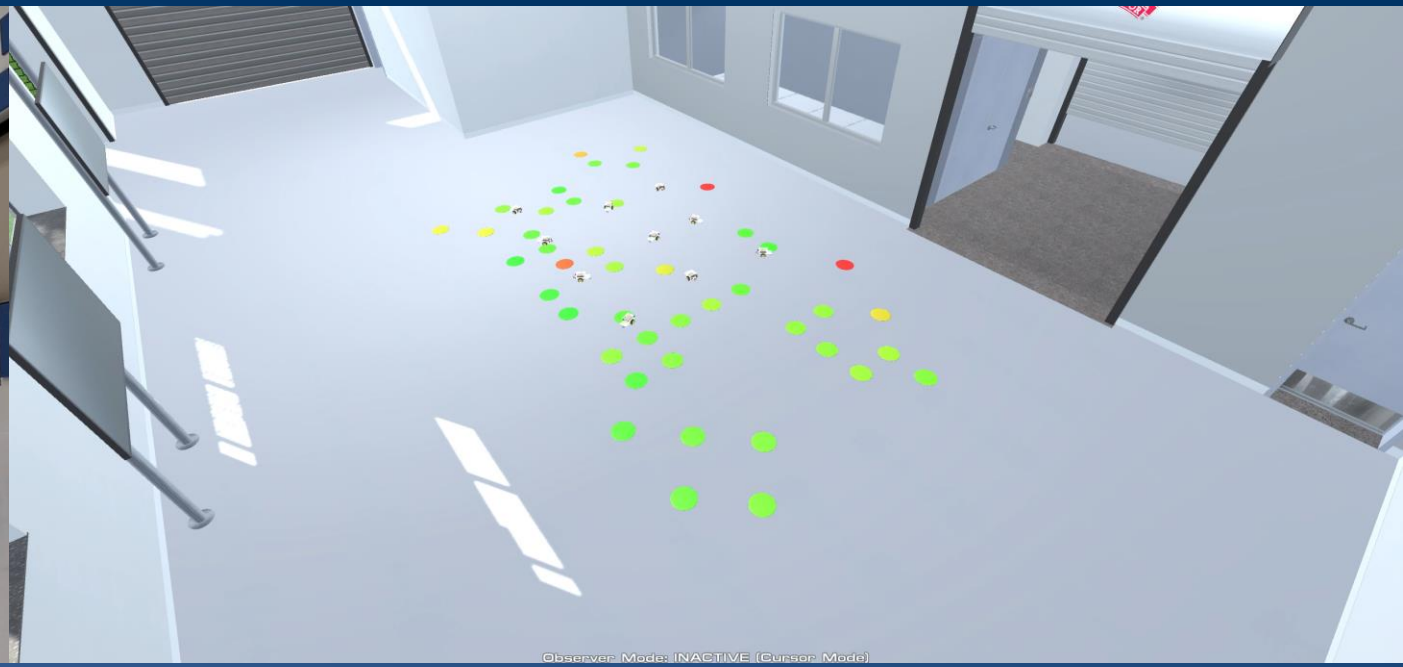


BEAM as a Visualization Tool

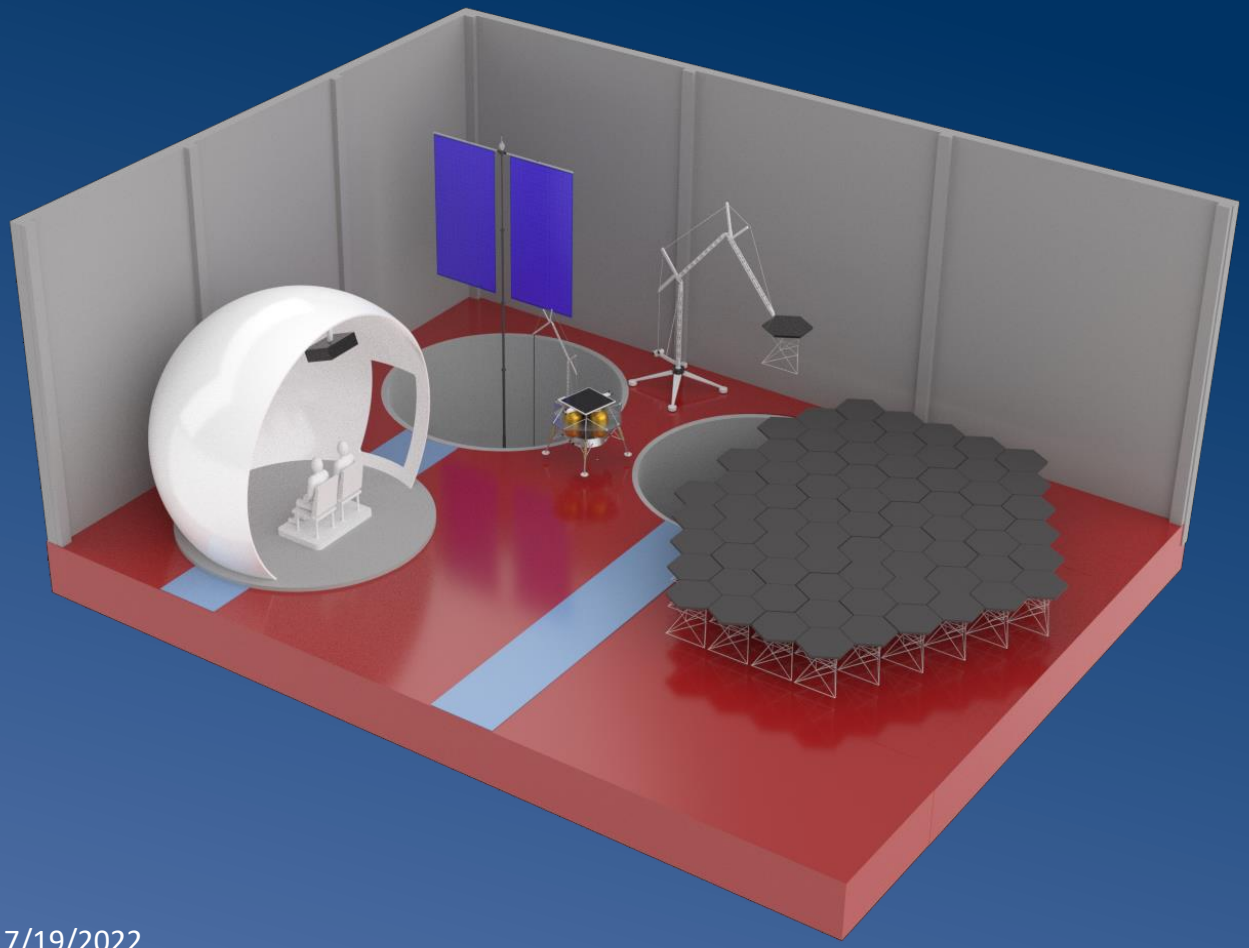
Real vehicles



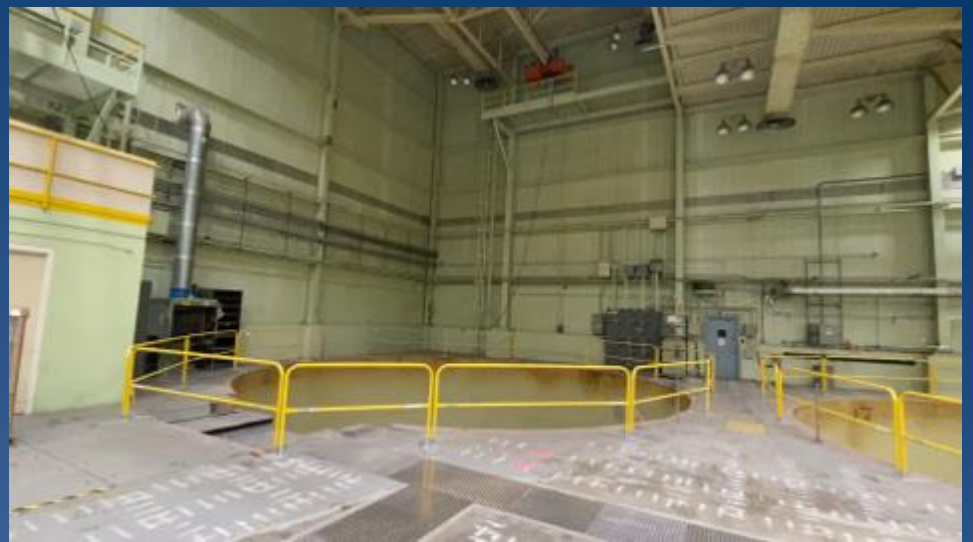
State information communicated to BEAM via AEON to render with additional visual aids



In-Space Assembly Laboratory



- New lab under development at LaRC
- Enables full scale in-space robotic assembly demonstrations
- Multi-level facility with recessed floors and elevated ceilings allows for variety of operations



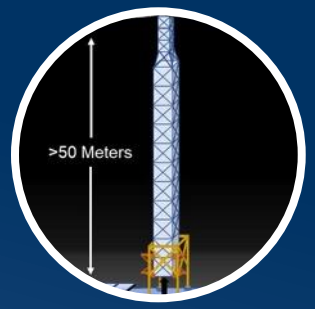
In-Space Servicing, Assembly, and Manufacturing

- **Grand vision**: heterogenous teams of robotic agents assembling large structures
  - Task allocation
  - Motion planning
  - Sensing and perception
  - Modular robotics

Enabled Technologies



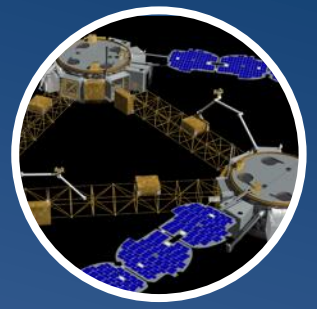
Nuclear Powered Transit Vehicles



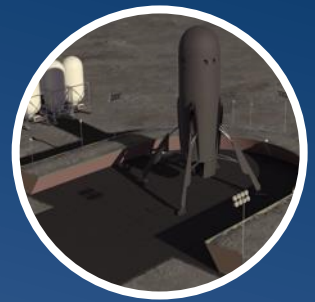
Tall Power Towers



Shelters



Persistent Platforms

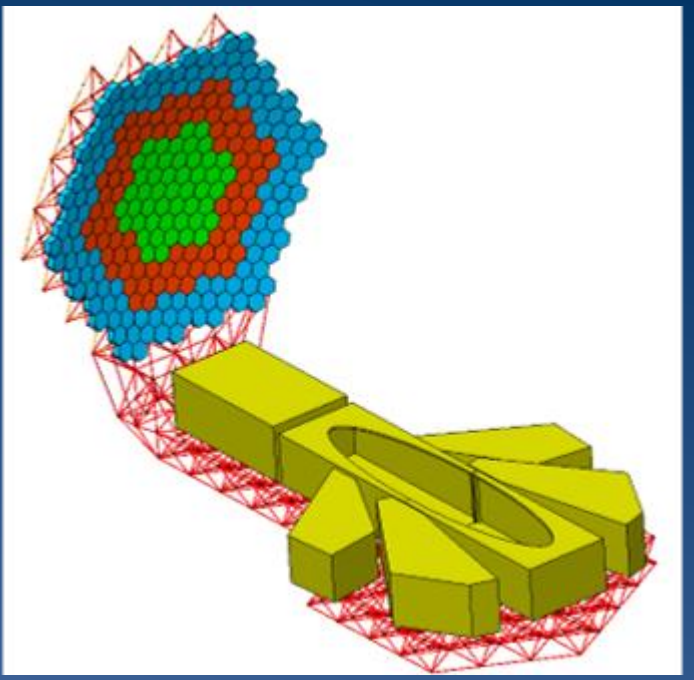


Blast Containment Shields



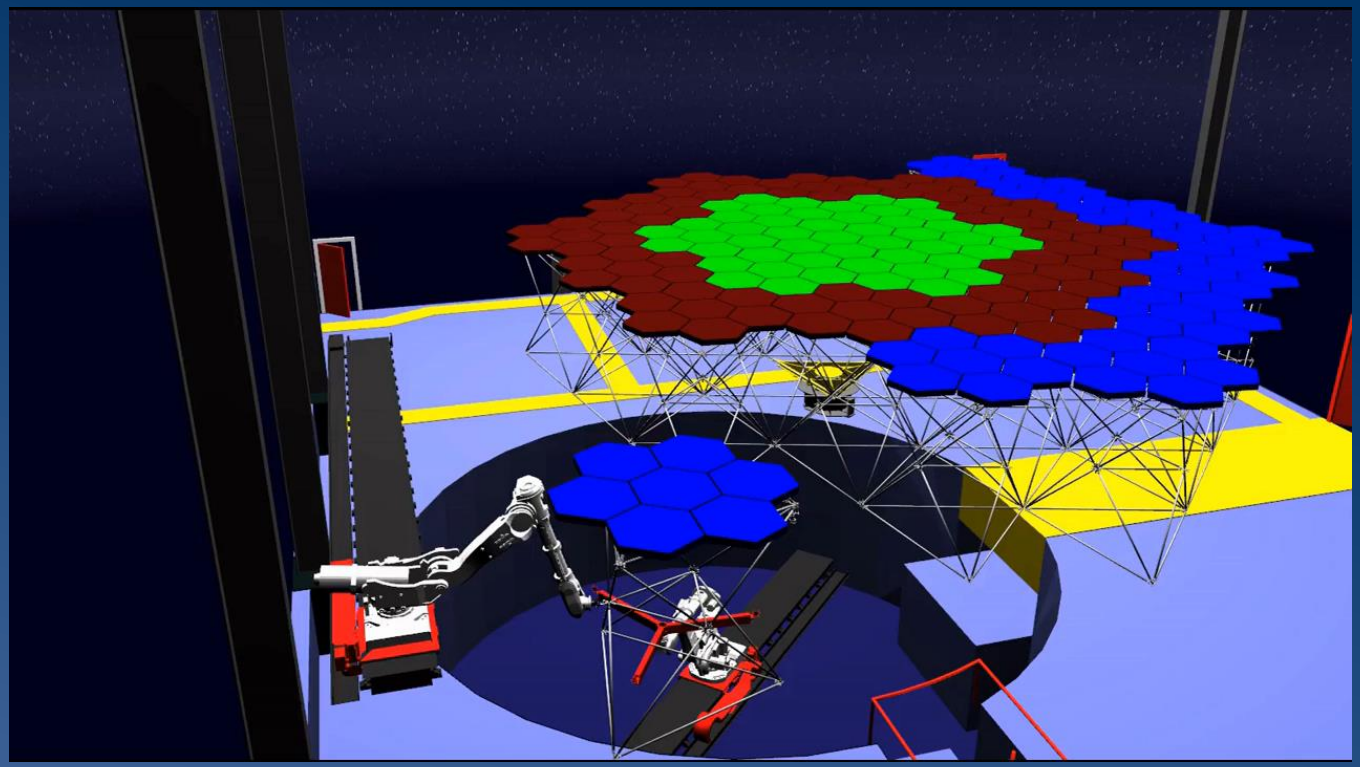
Telescopes

Precision Assembled Space Structure (PASS)

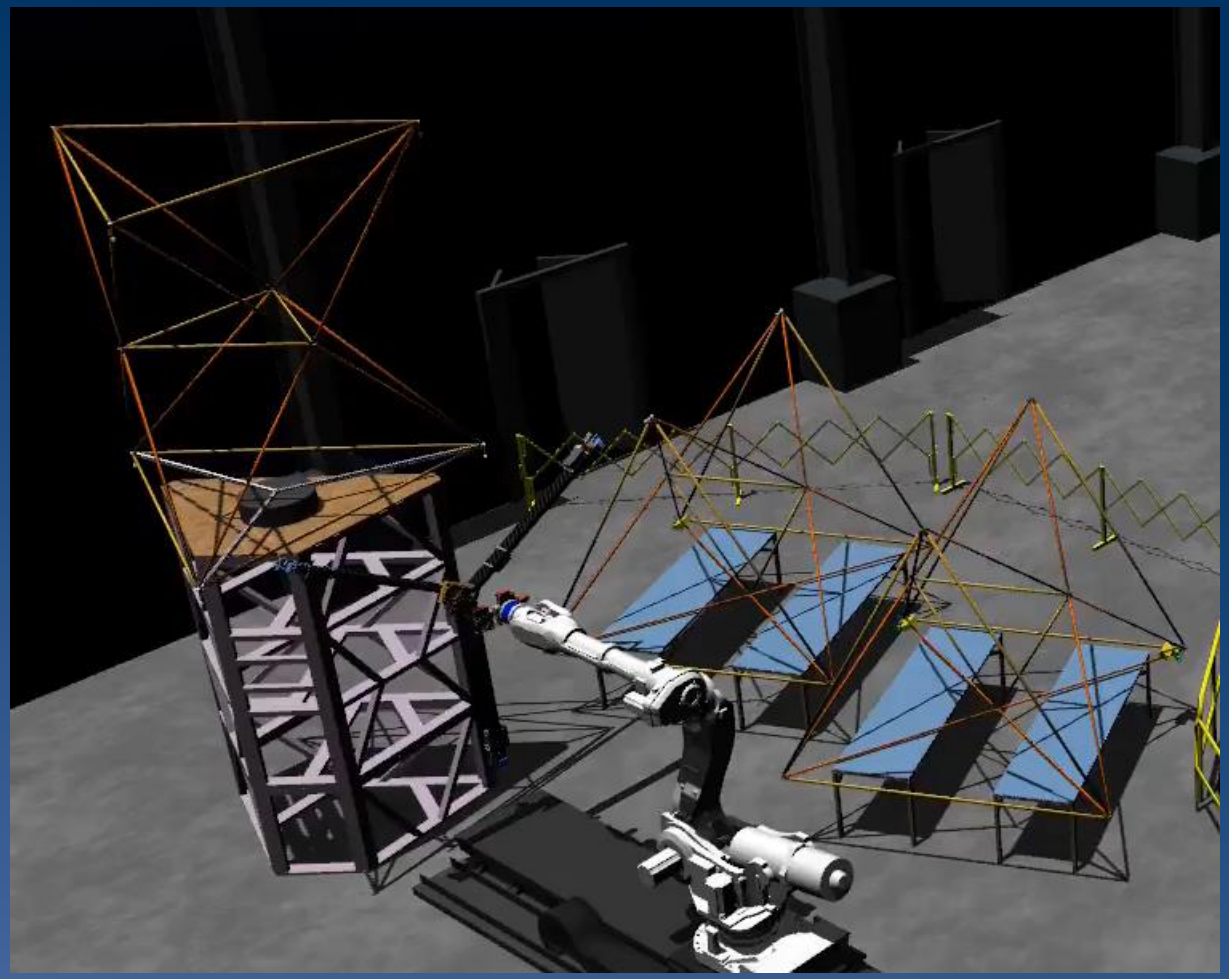


In Space Assembled Telescope Concept

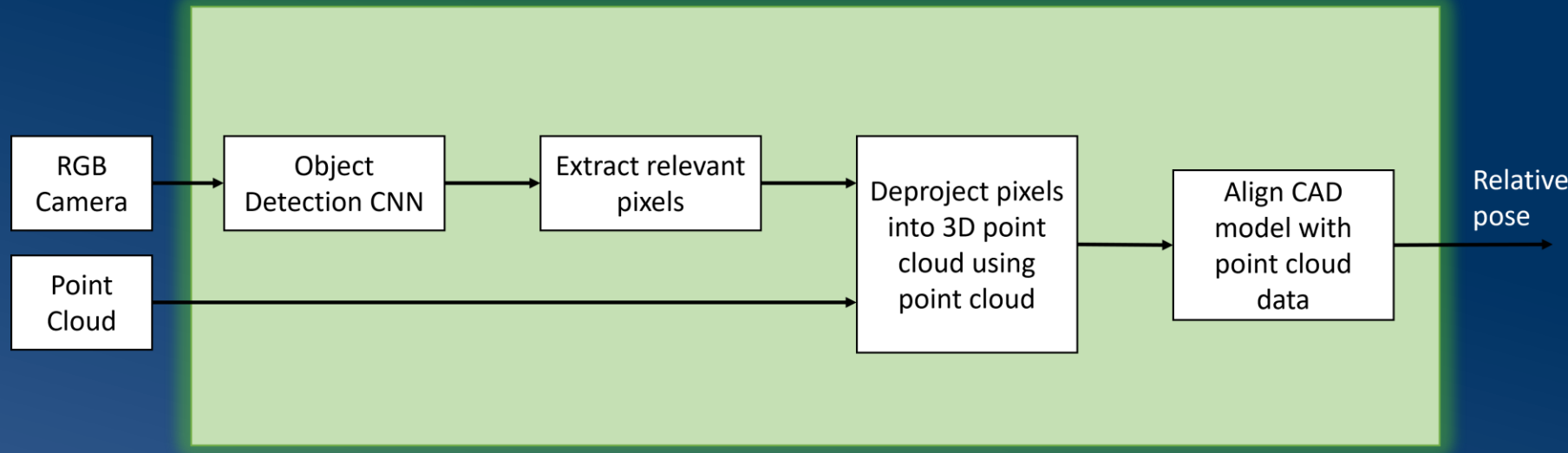
- Developing technologies to demonstrate an In-Space Assembled Telescope



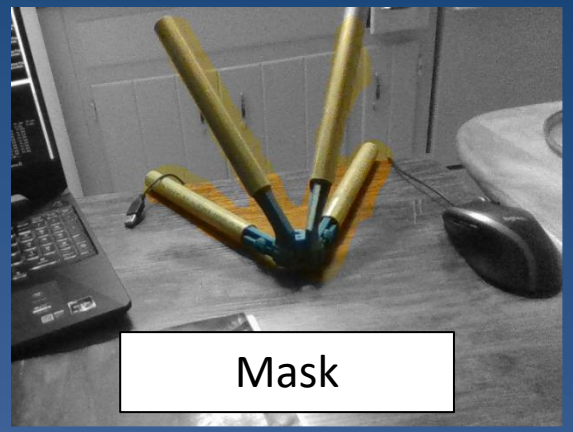
Phase I Assembly Demonstration

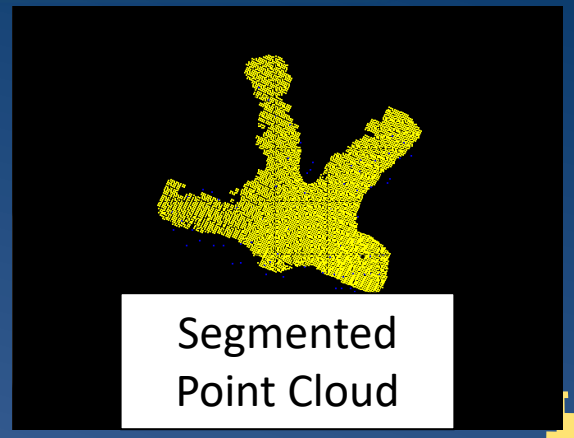


Object Pose Estimation



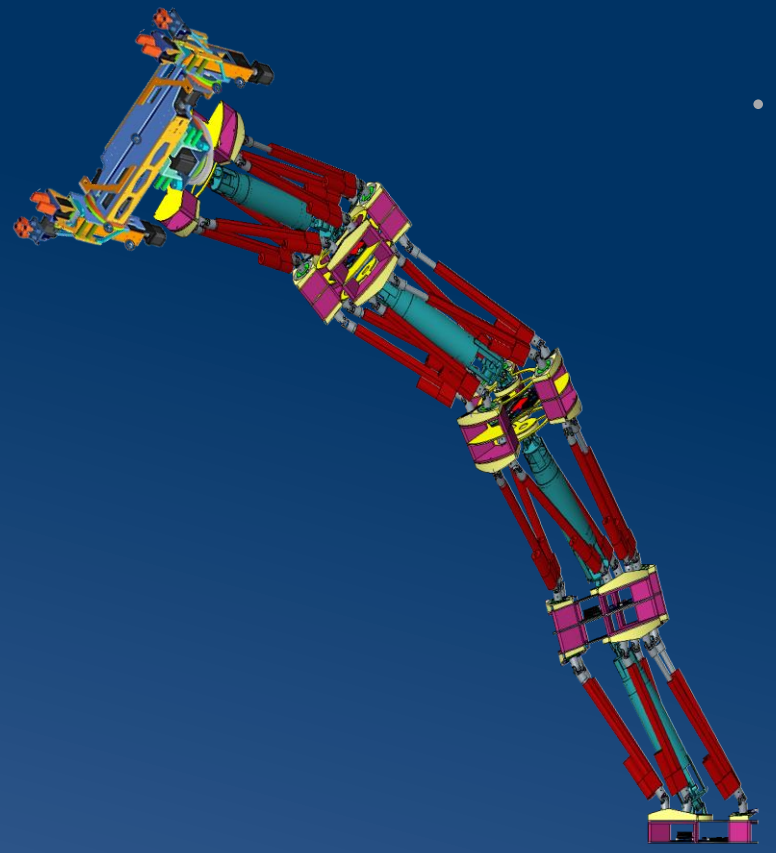






Current Research Gaps

- Autonomous multi-agent task allocation
- Modular robotics and structures
- Semantic environment mapping
- Unstructured grasping









Thanks

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