TOWARDS AUTONOMOUS OPERATIONS OF THE ROBONAUT 2 HUMANOID ROBOTIC TESTBED

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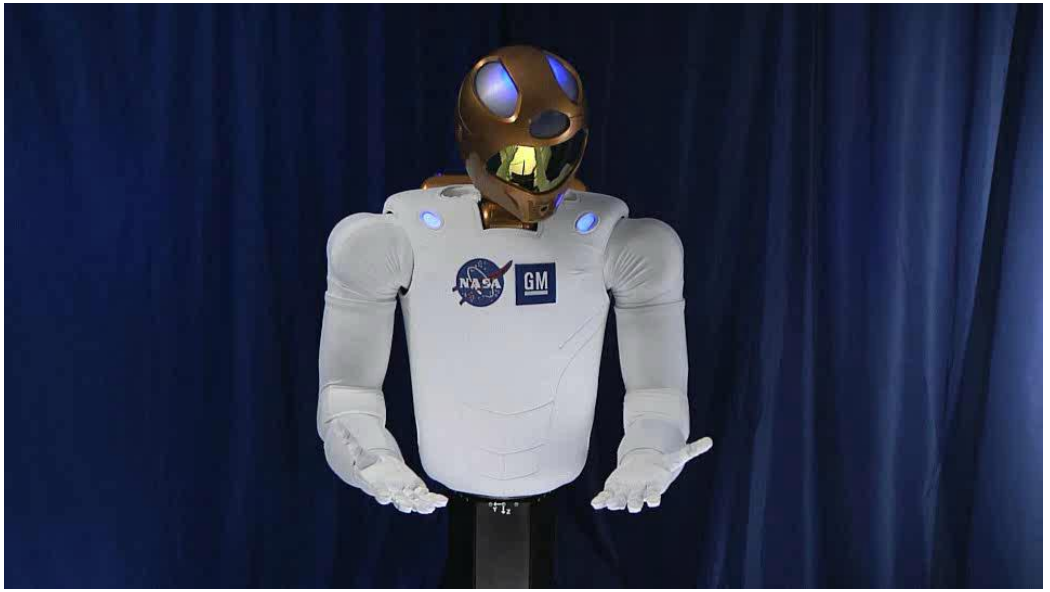
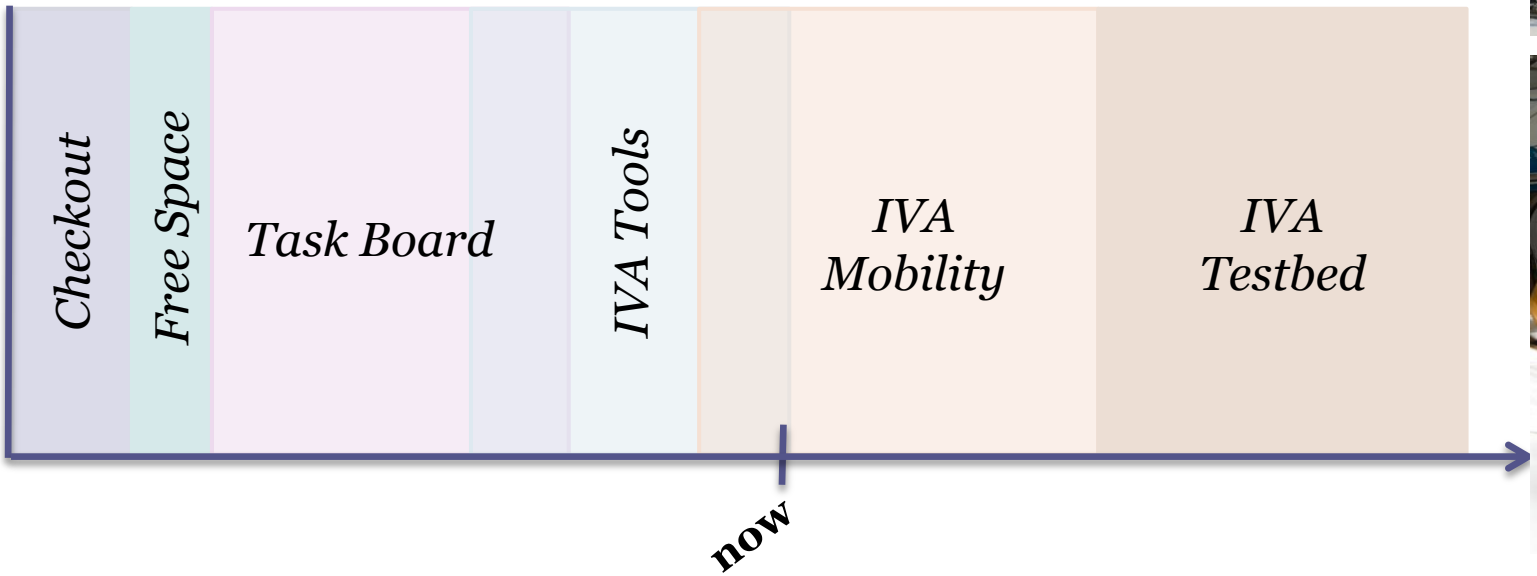
Robonaut 2 (R2)

- Started in 2007 with GM
  - Leveraged Robonaut 1 technology (1998-2006)
- Common goals
  - Use humans' tools
  - Safely share humans' workspace
  - Do real (useful) work
- Launched on STS-133 in Feb 2011

Robonaut 1, Units A & B

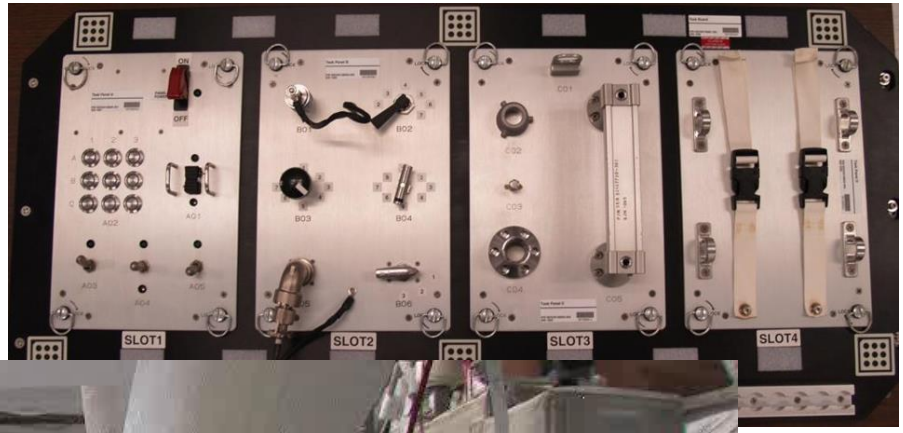


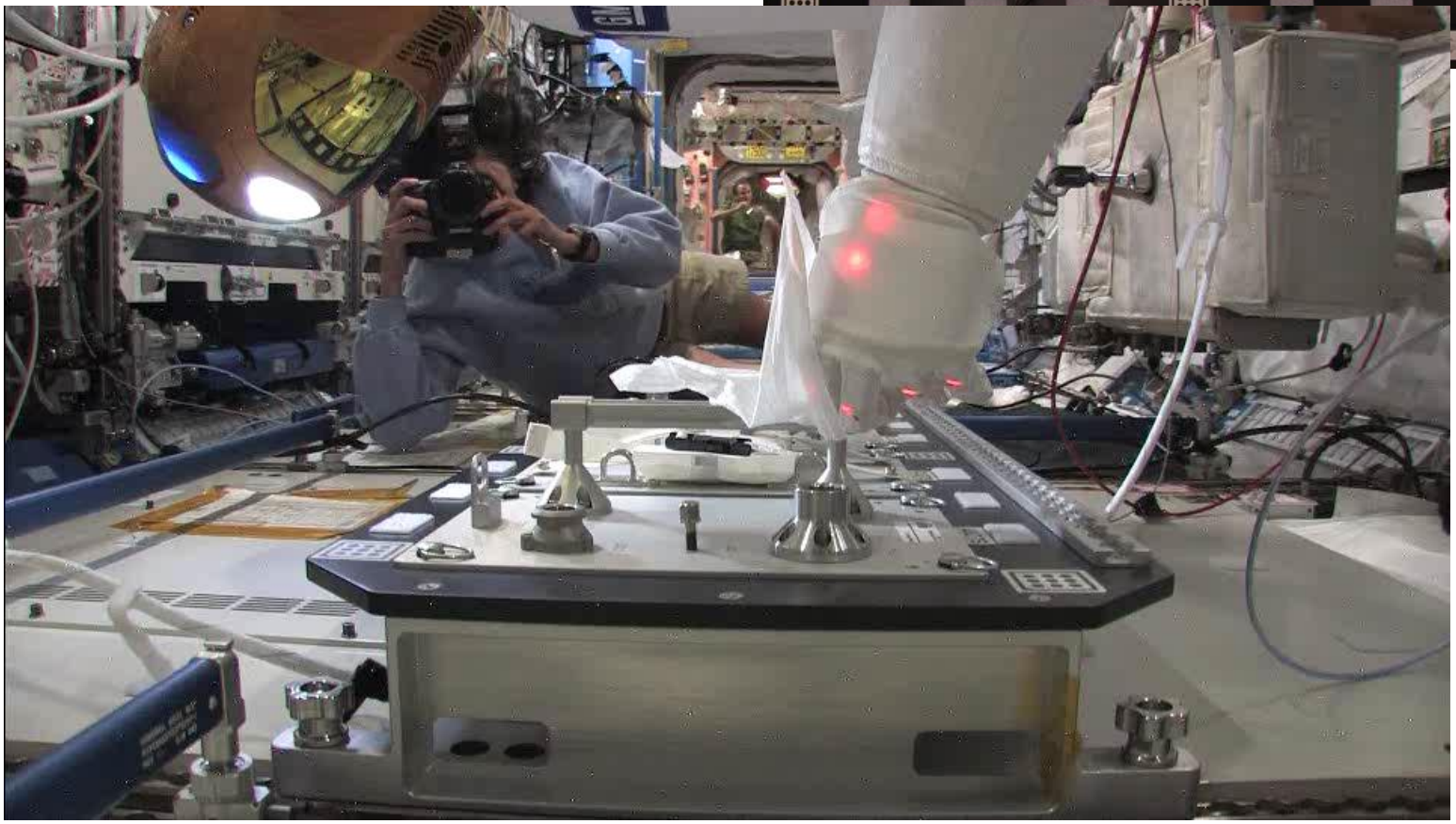
R2 ISS Task-Level Timeline



Tasks: Taskboard

Edited version of R2's wipe manipulation and handrail cleaning





Tasks: IVA Tools

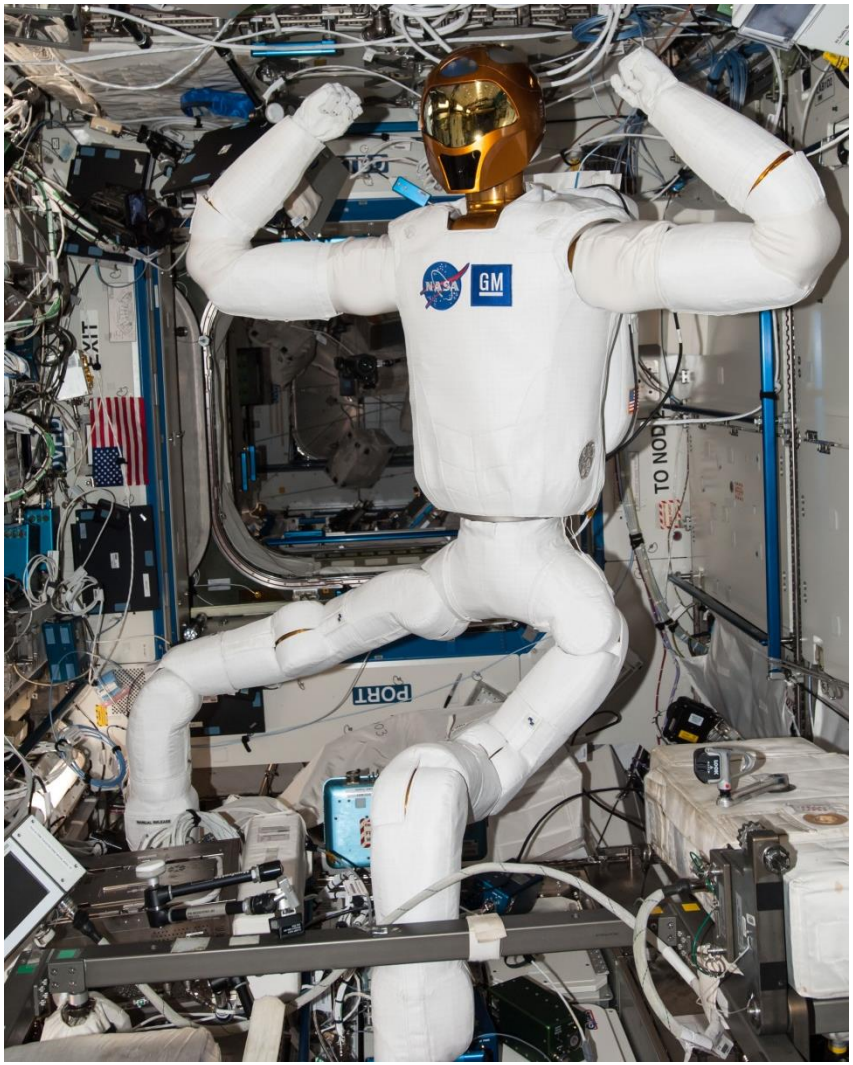
R2 using the VelociCalc tool to measure air flow from a vent

R2 using the an RFID reader to take inventory of items in a cargo bag

IVA Mobility Upgrade

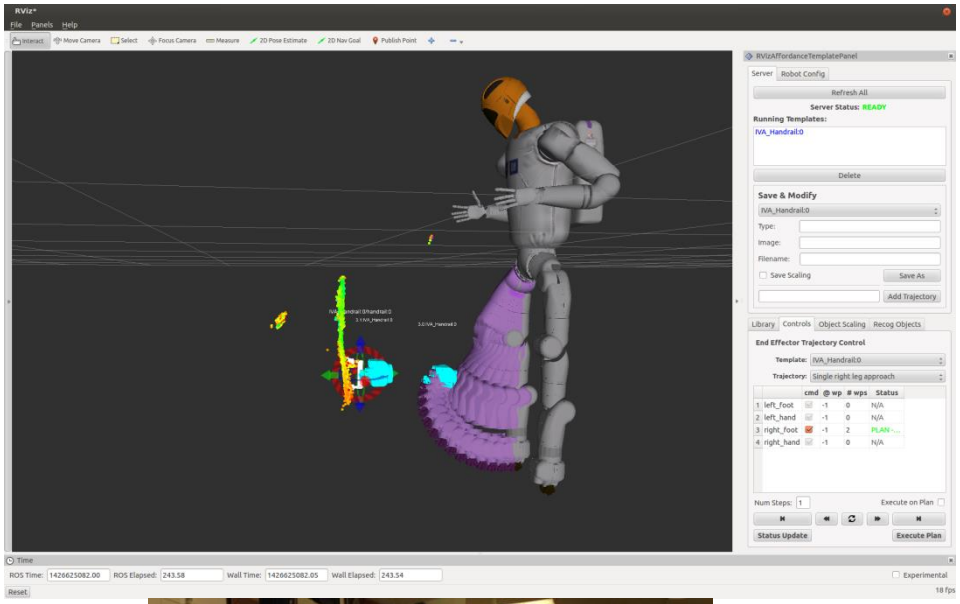
Upgrades included:

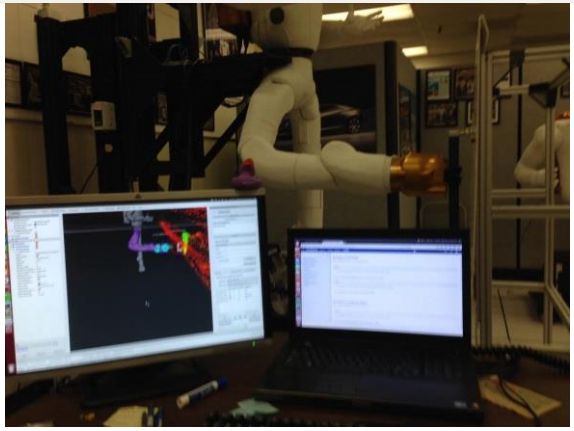
- Robotic "legs"
  - 7 DOF each + gripping end effector
  - Vision package (camera + TOF sensor) in each end effector
- New helmet for increased vision capabilities
- 3 Core i7 Processors for control and safety system



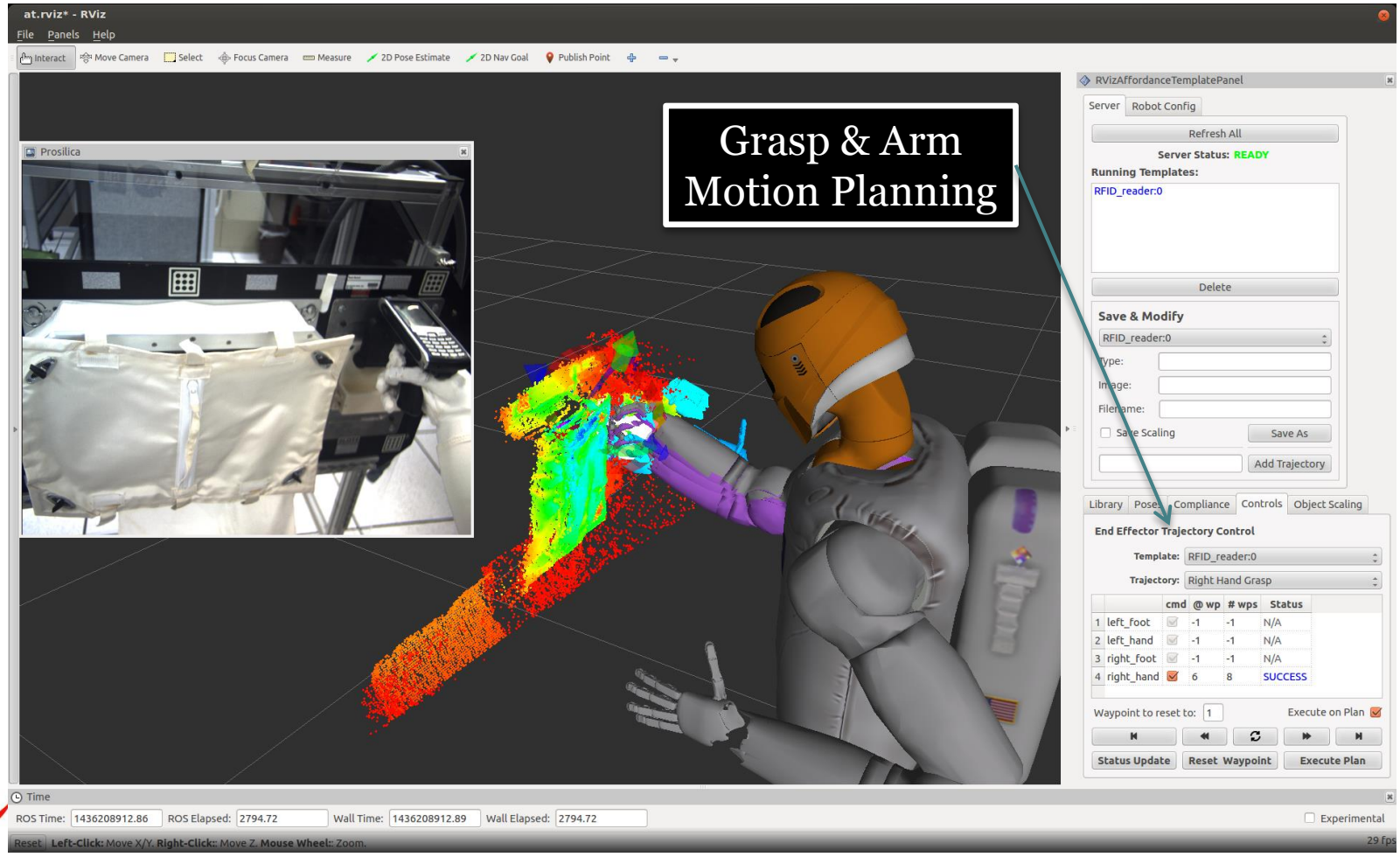
Affordance Templates

- Adopted this approach to move from supervised control to autonomous robotic behaviors
- Adapted from concept attempted during first DARPA Robotics Challenge
- Several upgrades and semi-autonomous functionalities introduced for successful IVA task demonstration

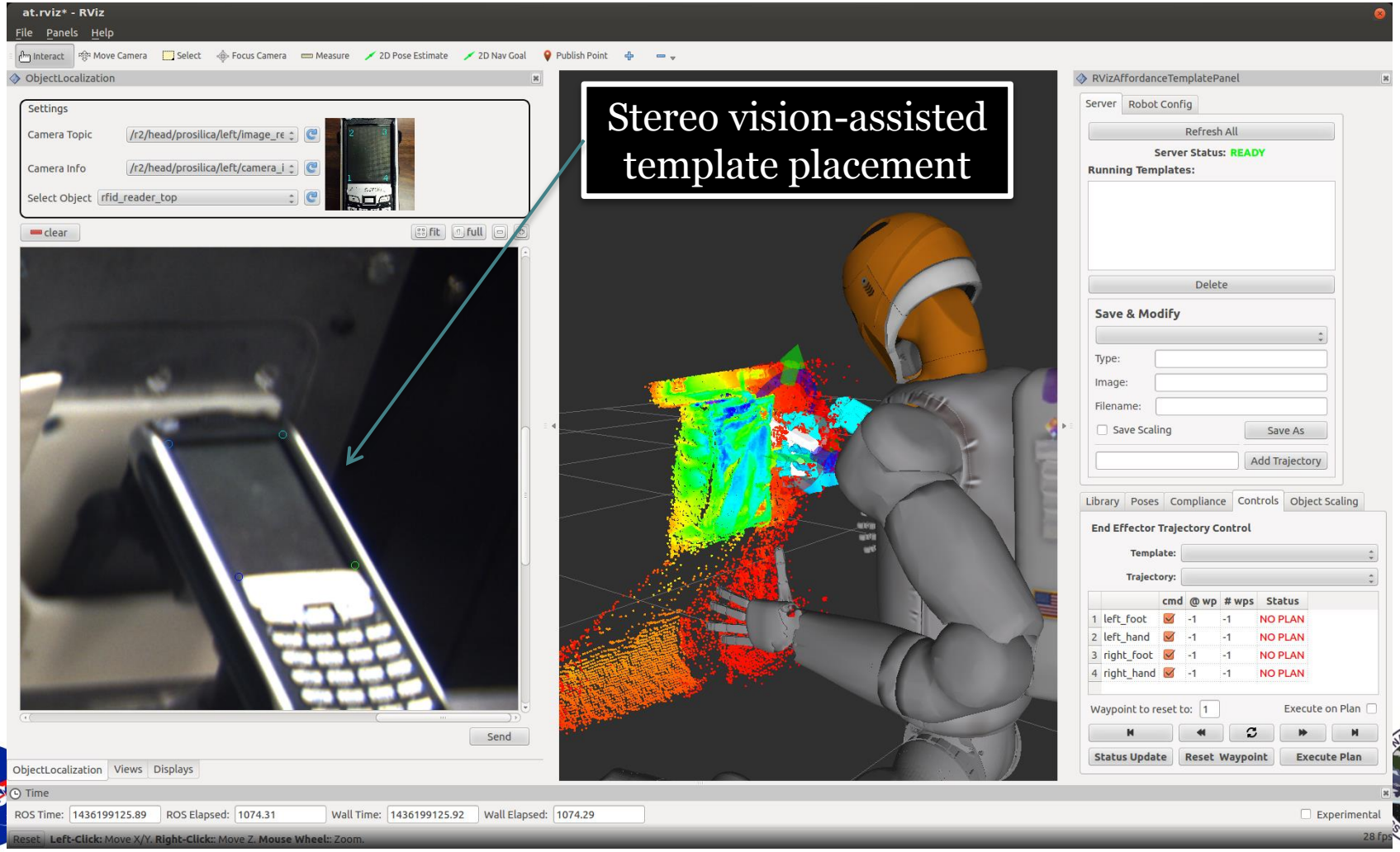




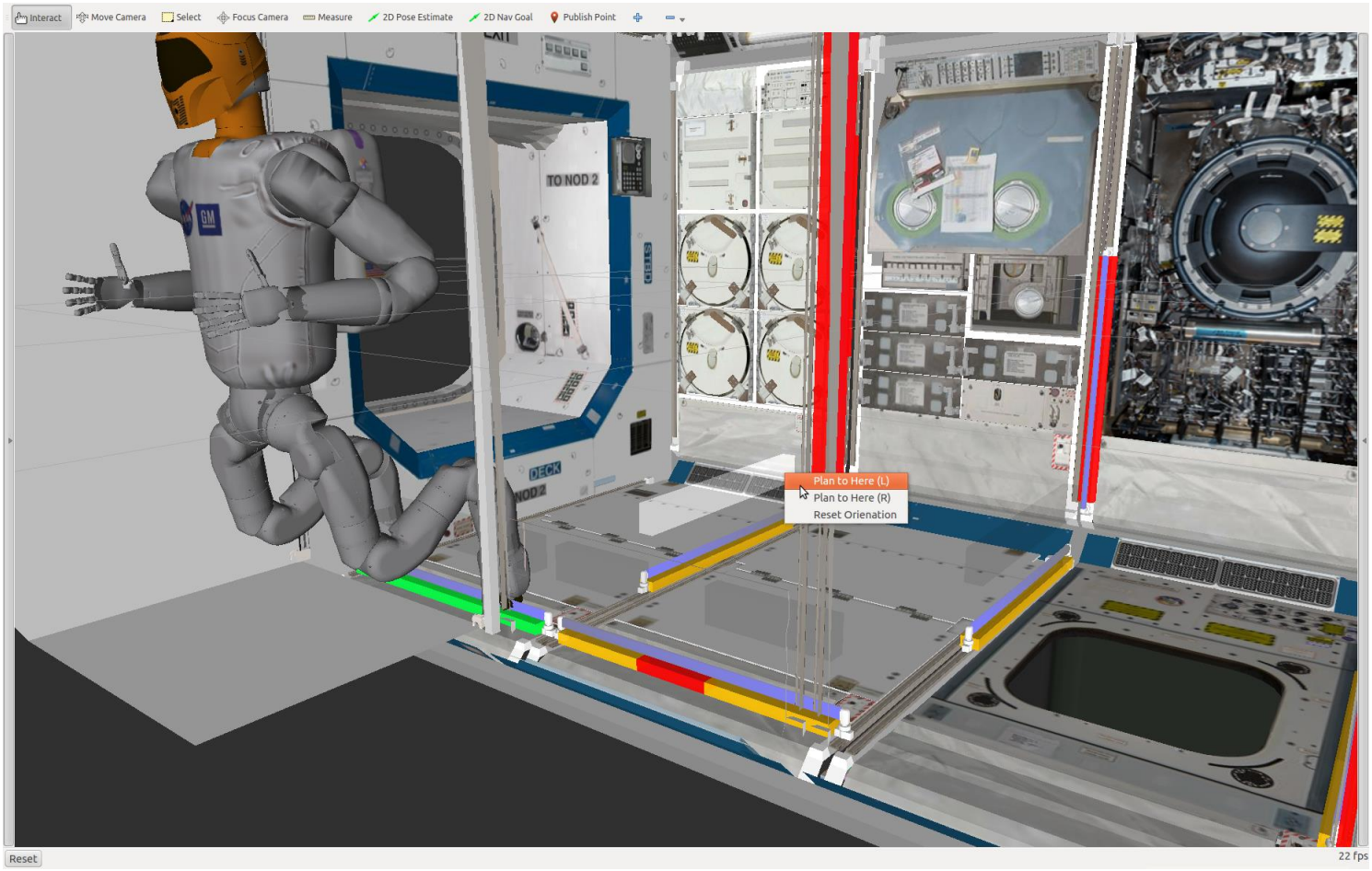
Grasp Planning Library



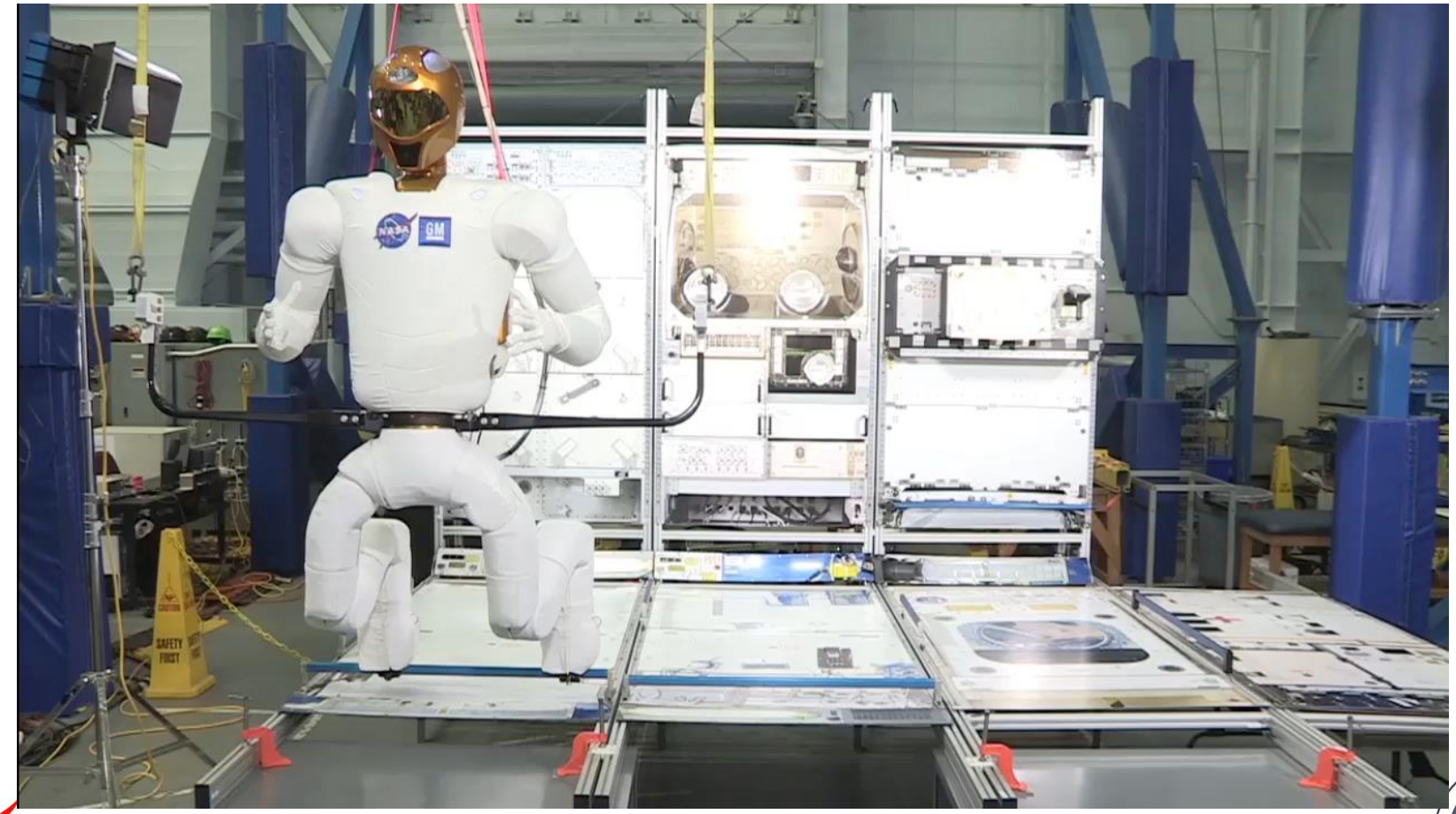
Supervised Template Placement



Path Planning Integration



IVA Task Demonstration



Affordance Templates 2.0

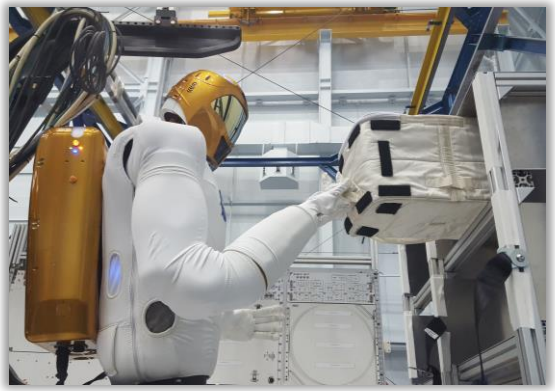
Framework upgrades and improvements:

- Embedded collision data & checking
  - Allowable Collision Matrix
  - Obstacle Avoidance
- Planner Plugins
  - Customizable planners and trajectory generators
- Active supervisors
  - QR Code Detection
  - Automatic Object Recognition
  - Handle-Like Shape Detection[1]

[1] Andreas ten Pas and Robert Platt. **Localizing Handle-Like Grasp Affordances in 3-D Points Clouds Using Taubin Quadric Fitting.** International Symposium on Experimental Robotics (ISER), Morocco, June 2014.

Autonomous Resupply Demonstration

- Resupply manipulation
  - Cargo Transfer Bag
  - Restraint System
- Automatic template placement
  - Template servoing
- Task-state monitoring



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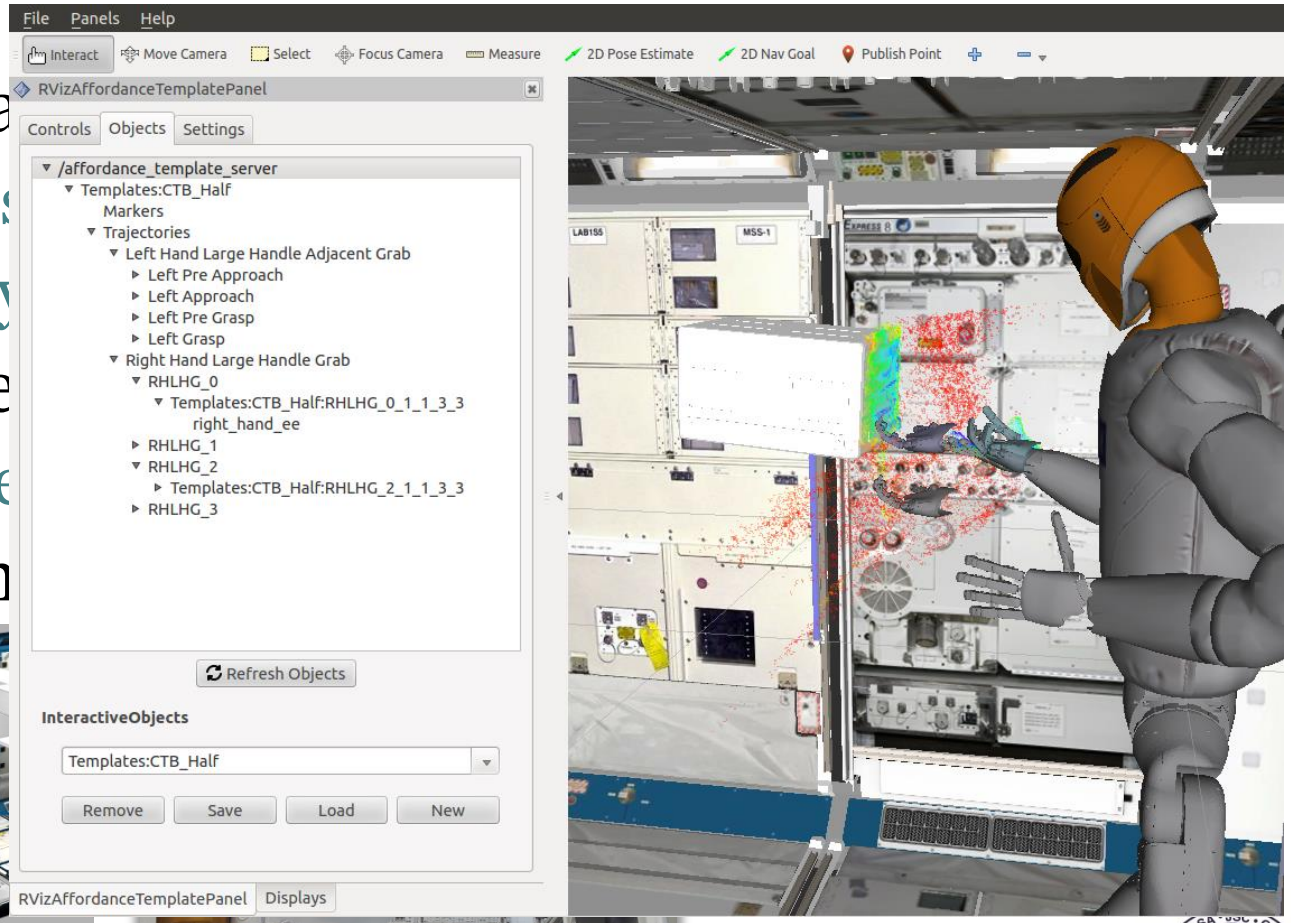

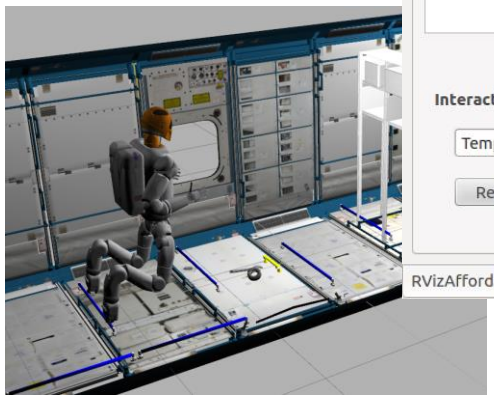

Conclusions and Future Work

- Efforts continue to develop the R2 on ISS into a semi-autonomous robotic testbed
  - Sophisticated manipulation strategies
  - Integrated path planning features
- Future work includes both on orbit and ground testing
  - Further development of several IVA tasks
  - Advanced path planning
  - Autonomous manipulation
  - EVA tasks and tools