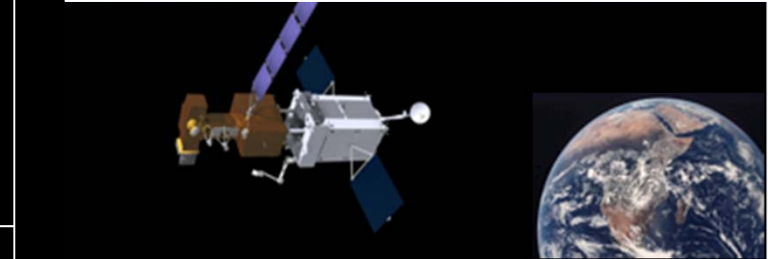


# Excitement of In Space Robotic Servicing

## Ground System Architecture Workshop

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<https://sspd.gsfc.nasa.gov>





# Overview



- The Satellite Servicing Capabilities Office is responsible for overall management, coordination, and implementation of satellite servicing technologies and capabilities for NASA. To meet these objectives it:
  - Conducts studies
  - Fosters technology development
  - Conducts demonstration experiments in orbit and on the ground
  - Manages satellite servicing missions
  - Advises and designs cooperative servicing elements and subsystems
- We use over a dozen 6- and 7-DOF industrial and flight-like robots to
  - Provide motion platforms to determine envelope of sensor performance
  - Provide platform for teleoperation and autonomous operations
    - Tool engineering development
    - Procedure development
    - Training
    - On-orbit robot support
  - Simulate robot-satellite contact dynamics
  - Simulate on-orbit robot kinematics/dynamics



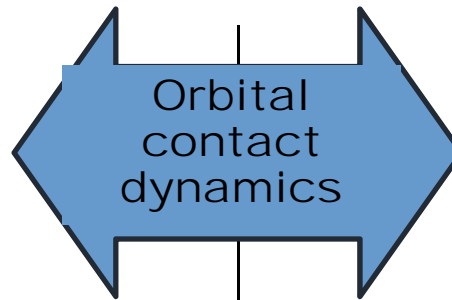
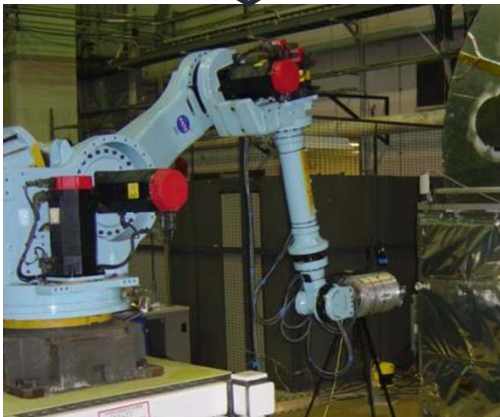
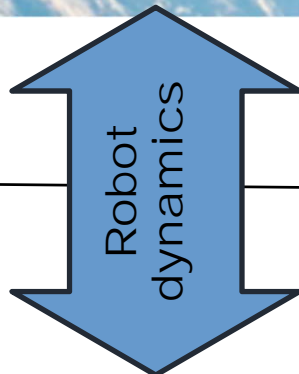
# Ground simulations



Space robot

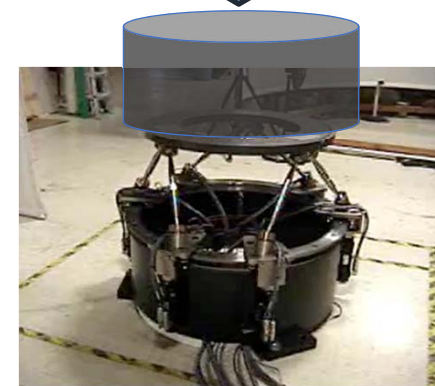
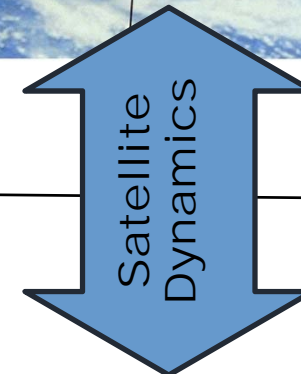
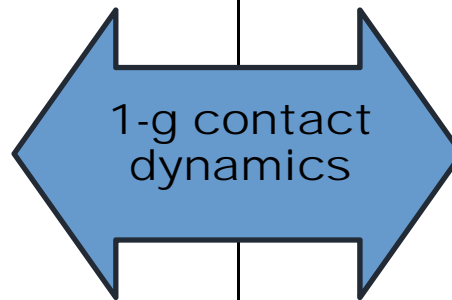


Satellite interface



**HIGH VELOCITY  
LARGE WORKSPACE**

**HIGH FORCE/STIFFNESS  
FAST RESPONSE**



Motion-based platform





# Challenges



- Synchronizing data across multiple sources (sensors, robots, metrology, etc.)
- System lag
- Simulating zero-g and on-orbit lighting on the ground
- Accurately simulating space kinematics and dynamics
  - Using stiff industrial robot systems to simulate flexible systems
  - Software-based kinematic and dynamic simulation
  - Compliment with tests using Dextre Ground Trainer and flight-like robot
- Validating contact dynamics models (2-D air bearing table, zero-g, impact tests, computer models, etc.)
- Simulating compliance controller of space robot
  - In some cases, can not command joint torques of industrial robot
  - In other cases, details of the space robot controller are proprietary
- Developing flight algorithms on flight processors
- Planning the mission (both before and during)
- Performing tasks in presence of 4 to 6 seconds of time delay
- Displaying large amounts of data effectively
- Use of augmented and virtual reality
- Unknown unknowns



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