AGENDA

- ISS Robotics Systems Overview
- Robotics Research and Technology Demonstrations on ISS
- Future Concepts
ISS Robotic Systems Overview

- Mobile Servicing System (CSA)
  - 57 ft, 7 DoF Space Station Remote Manipulator System
  - 11.4 ft, 2 armed - 6 DoF Special Purpose Dextrous Manipulator “Dextre”
  - Mobile Base System on ISS Truss
- Kibo External Facility (JAXA)
  - 32.5 ft 6 DoF Remote Manipulator System
  - 6.2 ft Small Fine Arm
- European Robotic Arm (ESA)
  - Stowed on orbit, to be installed on Multipurpose Laboratory Module (RSA) in 2013
Robotics Research and Technology Demonstrations

Robotic Component Verification on the ISS (ROKVISS)

20 inch, 2 joint robotic element installed in 2005 on the exterior of Zvesda to demonstrate integrated light weight hinge elements and telerobotic control procedures

Joint Roscosmos /DLR project

Returned to ground in 2011
Robonaut 2

Robonaut 2 is the first anthropomorphic ISS crew member. Designed to demonstrate humanoid robotic technology and applications to assist human crew members on future exploration missions.

Joint NASA/General Motors project
Synchronous Position Hold Engage Reorient Experimental Satellites (SPHERES)

3 bowling ball sized free-flying satellites inside the pressurized ISS provides the opportunity to develop and test and iterate multi-body formation flying algorithms and concepts.

Originally a DARPA/MIT/Aurora Flight Sciences development, SPHERES is now managed by NASA ARC as an ISS facility.

Diameter | 8 inches each
Mass     | 7 pounds each
Power    | AA batteries
Propulsion| CO₂ gas
Communications and Control | 900 MHz link to onboard laptop
Position knowledge | 5 infrared/ultrasound beacons
Crew     | setup/monitoring/stow
First launch | 2006
International Space Station SPHERES Integrated Research Experiments (InSPIRE)

- DARPA/NASA follow-on to SPHERES
  - Advanced satellite R&D using SPHERES
  - Mods for ISS wifi compatibility
  - STEM Education

- 2010 DARPA BAA
  - Vision Based Navigation with addition of stereo cameras for 3-D inspection (MIT/Aurora Flight Sciences/NRL/Lockheed-Martin)
  - Electromagnetic Formation Flight/Coupled Power Transfer (Univ. of Maryland/Aurora Flight Sciences/MIT)
  - Exo-SPHERES concept study (Univ. of Maryland)
Zero Robotics
NASA/DARPA/MIT

- InSPIRE competition for high school students using SPHERES on ISS based on FIRST Robotics
- Student develop algorithms and flight code for a set test objective
- Code tested in space with students interacting with crew on ISS

- Initiated with pilot program in 2009
- 142 teams (24 international) participated in 2011
- Over 200 students (27 teams) attended finals held in Jan 2012 at MIT with an additional 9 teams participating at ESA/ESTEC
SPHERES SLOSH

- Uses SPHERES to study spacecraft propellant fluid dynamics
- 2 transparent tanks containing simulated propellant
- OCT funded, KSC lead
Robotic Refueling Mission (RRM)

- Launched to ISS on STS-135 (July 2011)
- Joint NASA/CSA effort
- Demonstrates capability for telerobotic servicing of legacy spacecraft
- Uses Dextre with Goddard developed tools and task boards
RRM Tools and Task Boards

- Task boards simulate legacy spacecraft not designed for on-orbit servicing
- Fill & drain valves configured to replicate satellite close-outs
- Refueling transfer of representative fluid
- MLI cutting and manipulation
- Opening coolant valves
- Removing SMA caps
- Torque tasks
- Vision tasks
RRM Video
RRM Tools

Safety Cap Tool (SCT)

EVR Nozzle Tool (ENT)  
*For Spacecraft Refueling*

Multi-Function Tool (MFT)

Wire Cutter Tool (WCT)
RRM Tools

Fill/Drain Valve
Safety Cap Tool
Robotic Refueling Mission Payload
Tool Vision Support Structure
Dextre ORU Tool Change-Out Mechanism (OTCM)
Develop tools and techniques for future in-space human/robotic assembly of large segmented aperture optical astronomical telescope
OPTIIX
InSPIRE Exo-SPHERES

Concept designs for small external free-flying satellite capable of providing inspection and EVA astronaut assistance

Image courtesy University of Maryland Space Systems Laboratory
Future Human/Robotic Collaboration
ISS Robotics is moving forward for operations, exploration, science, commerce and education.