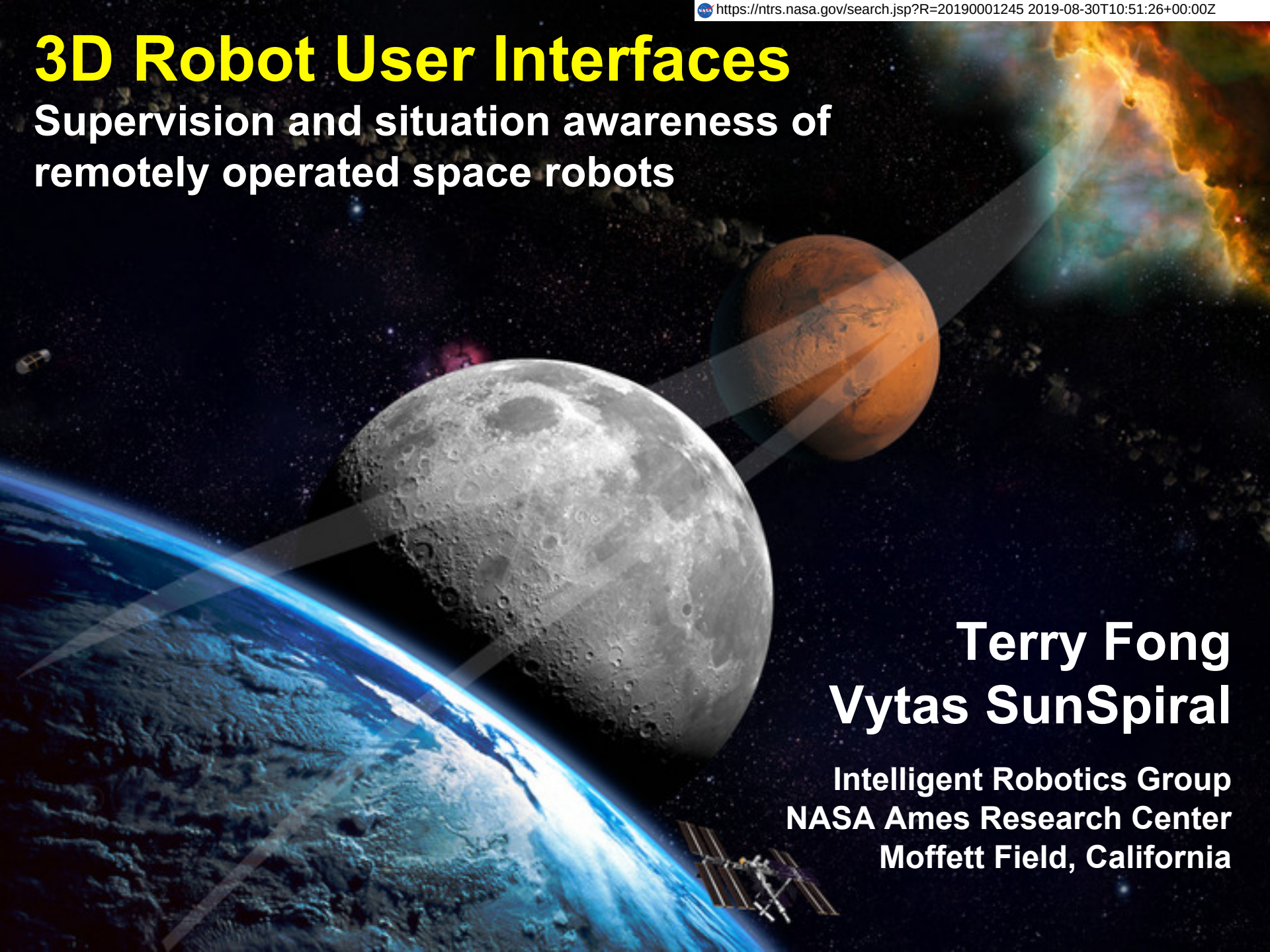
3D Robot User Interfaces

Supervision and situation awareness of remotely operated space robots



Terry Fong
Vytas SunSpiral

Intelligent Robotics Group
NASA Ames Research Center
Moffett Field, California

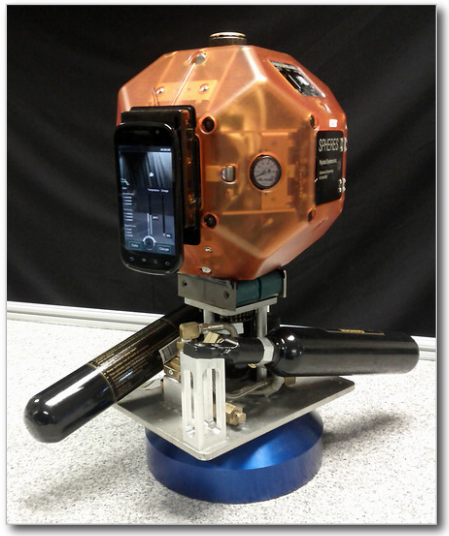
NASA Ames Intelligent Robotics Group

Overview

- 35 researchers (17 Ph.D.'s)
- 25+ student interns yearly
- 80% NASA work
- 20% non-NASA work
- SBIR-STTR (Phase 1, 2, 2E, & 3)

Research themes

- **Automated planetary mapping**
  - Base maps & terrain models
  - Geospatial data systems
- **Exploration user interfaces**
  - Robot & science operations
  - Accessible science data
- **Robots for human explorers**
  - Improve efficiency & productivity
  - Free-flyers, lake lander, & rovers



irg.arc.nasa.gov

IRG Collaborations (2015-2016)

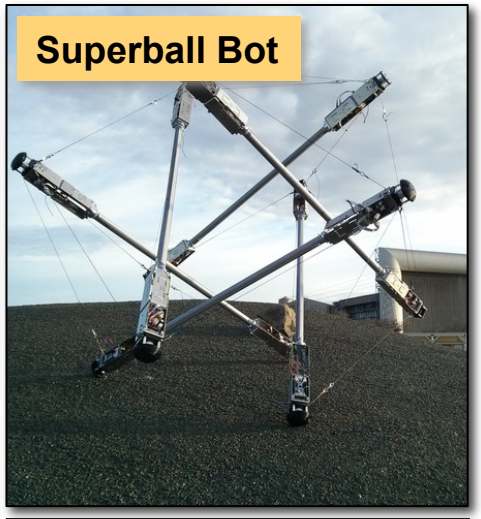
Academic

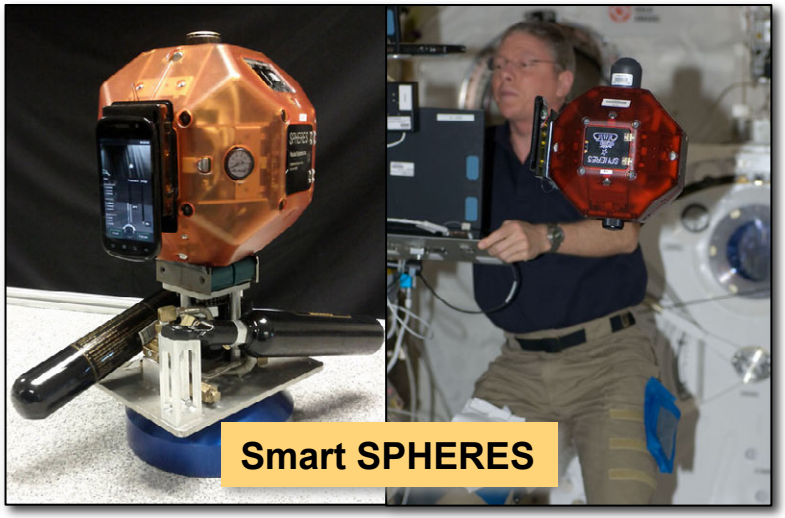
Commercial

Government

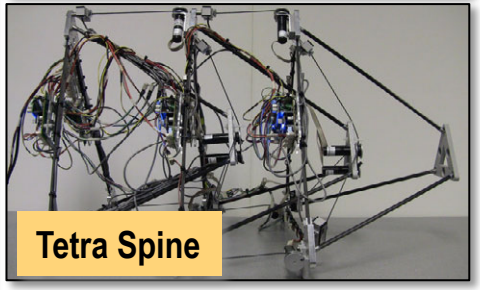
Robots


K10


Superball Bot


Smart SPHERES


KREX


Tetra Spine


K10 mini


GigaPan
Voyage


Lake Lander

Viz

Interactive 3D UI

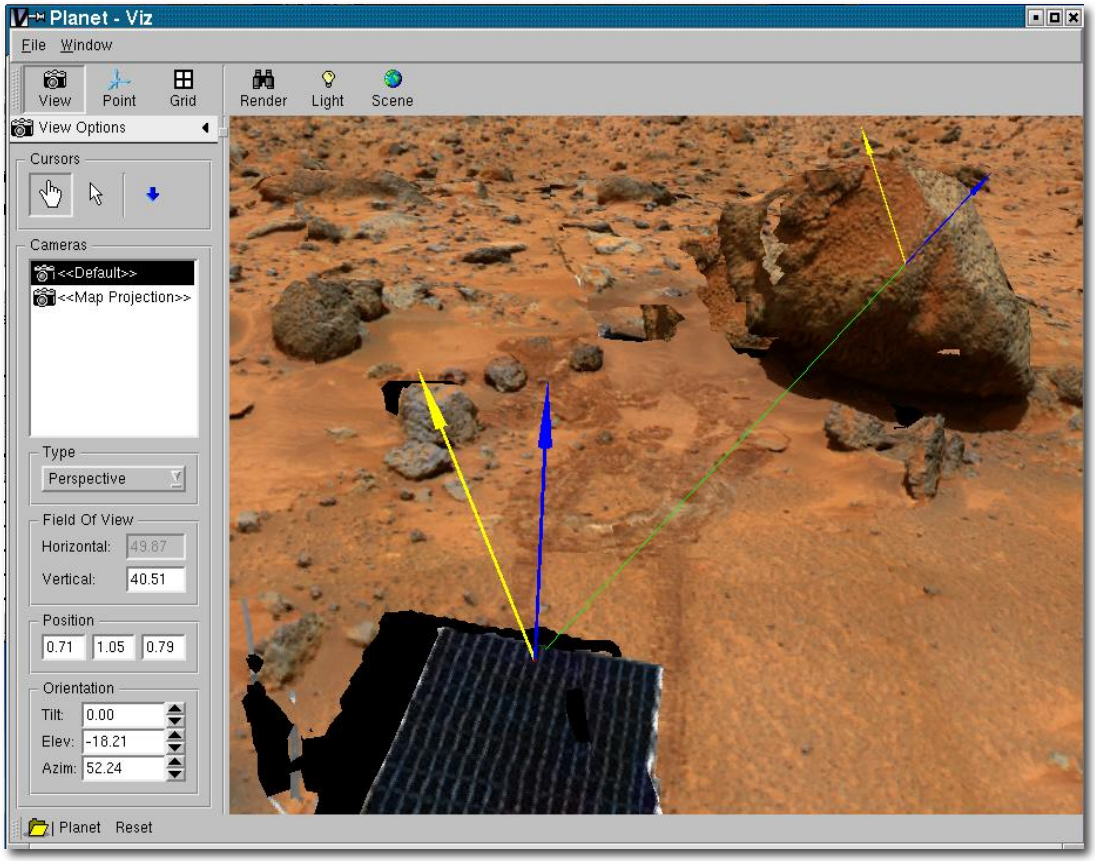
- Stereo viewing
- Background image

Simulation

- Time of day lighting
- Viewpoint + pose
- Object kinematics

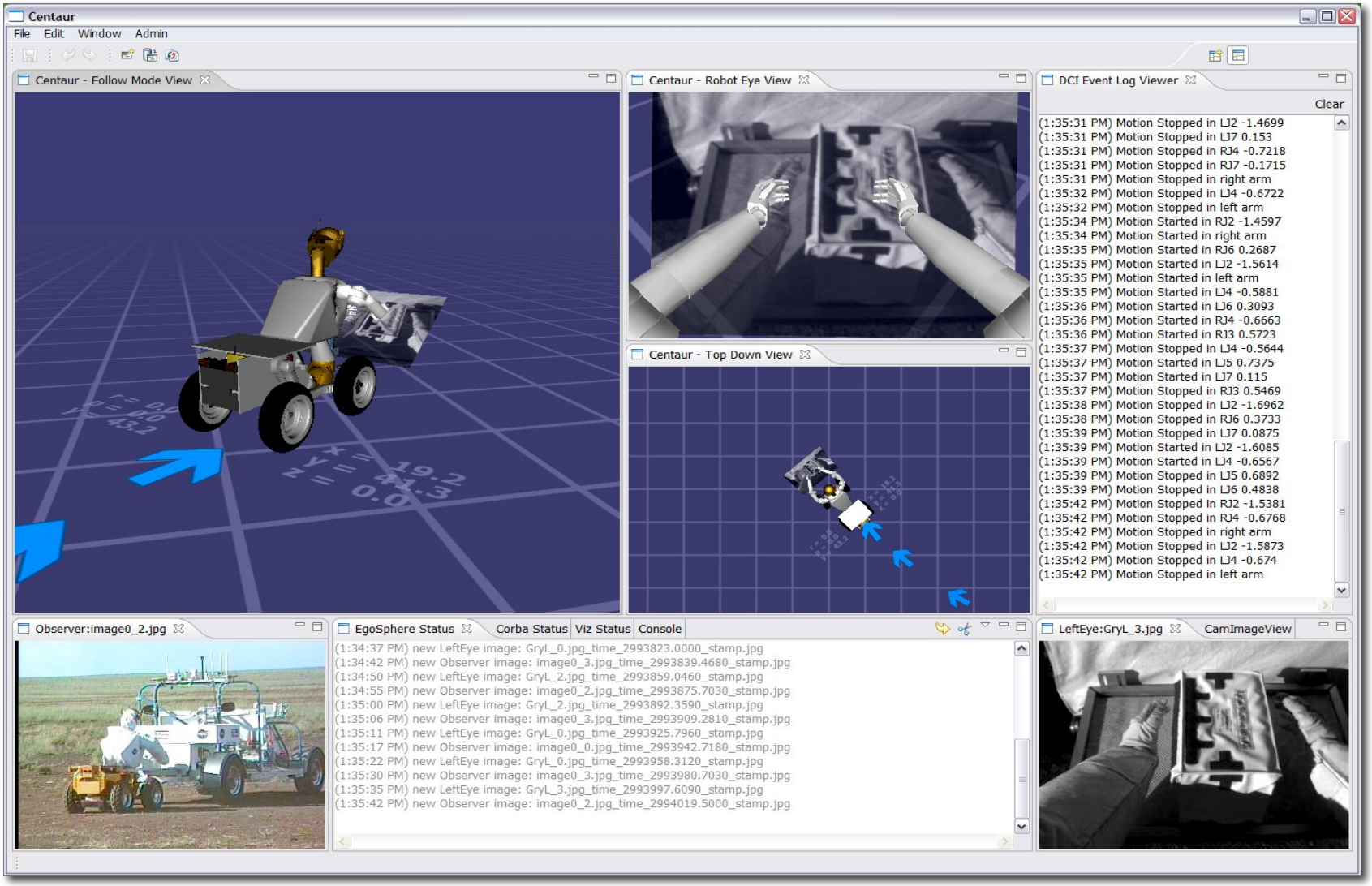
Site understanding tools

- Point, distance, azimuth measure
- Elevation + slope maps
- Sun + planet vectors
- Surface area measure
- Terrain cross-section
- Markers + ancillary data

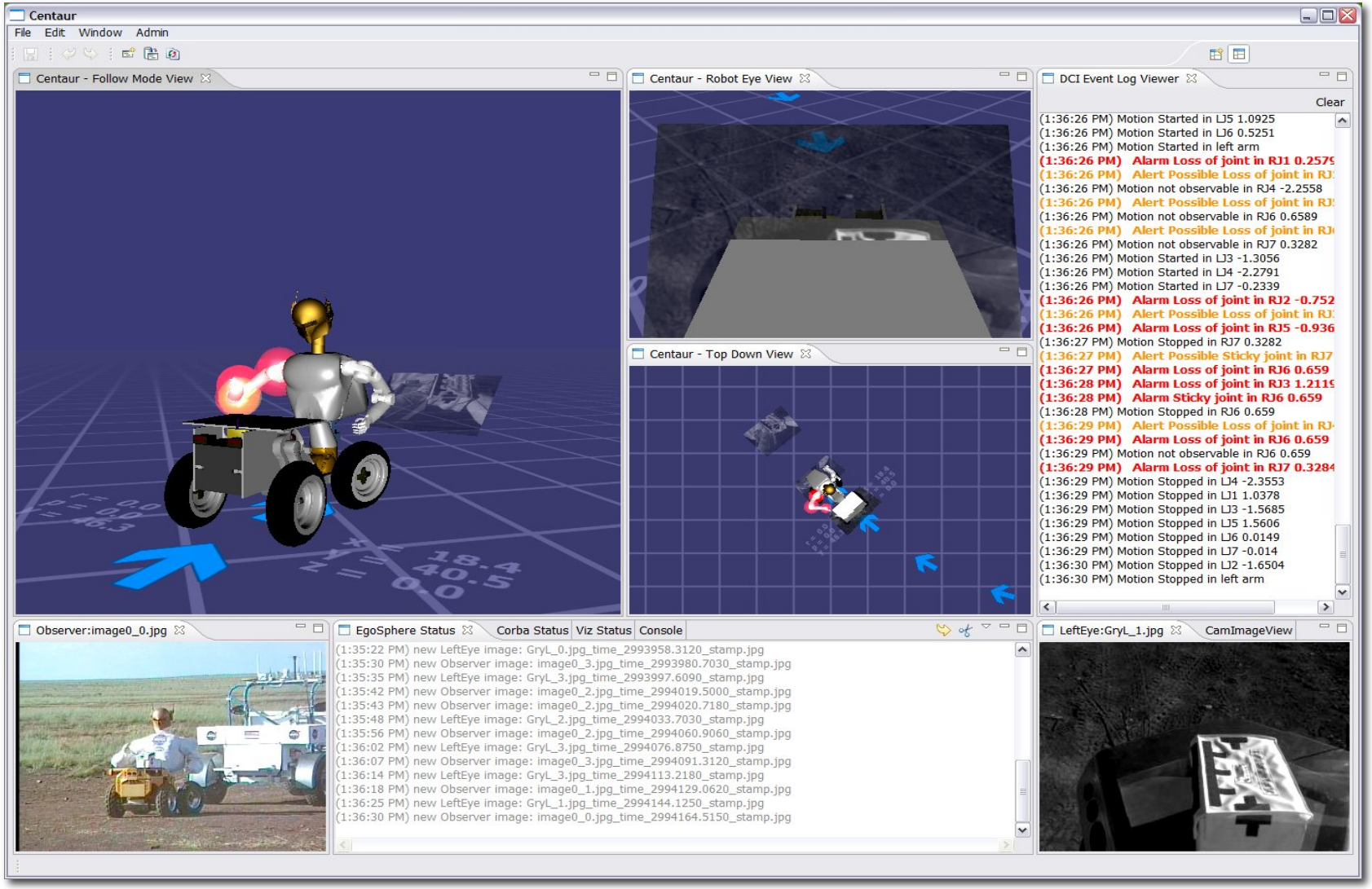


Missions: MPL, MER, Phoenix, MSL
Field Tests: K9/Mojave, IS Level 1, CDS

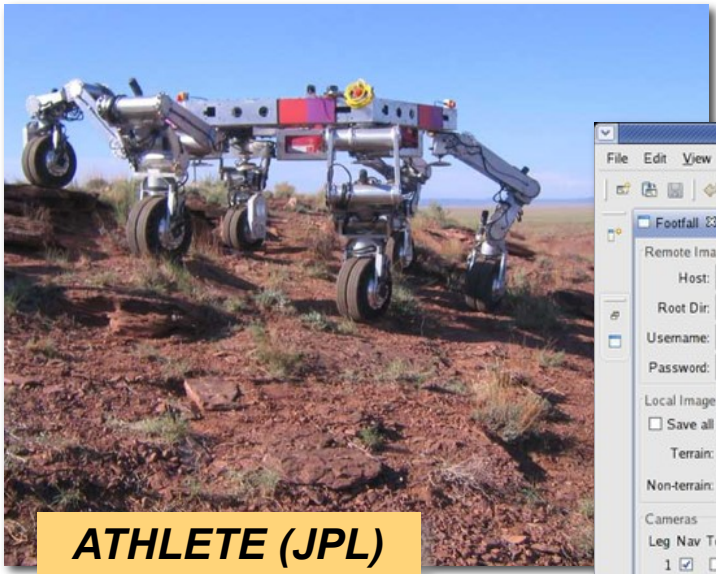
Centaur (Robonaut): Grasping Tools



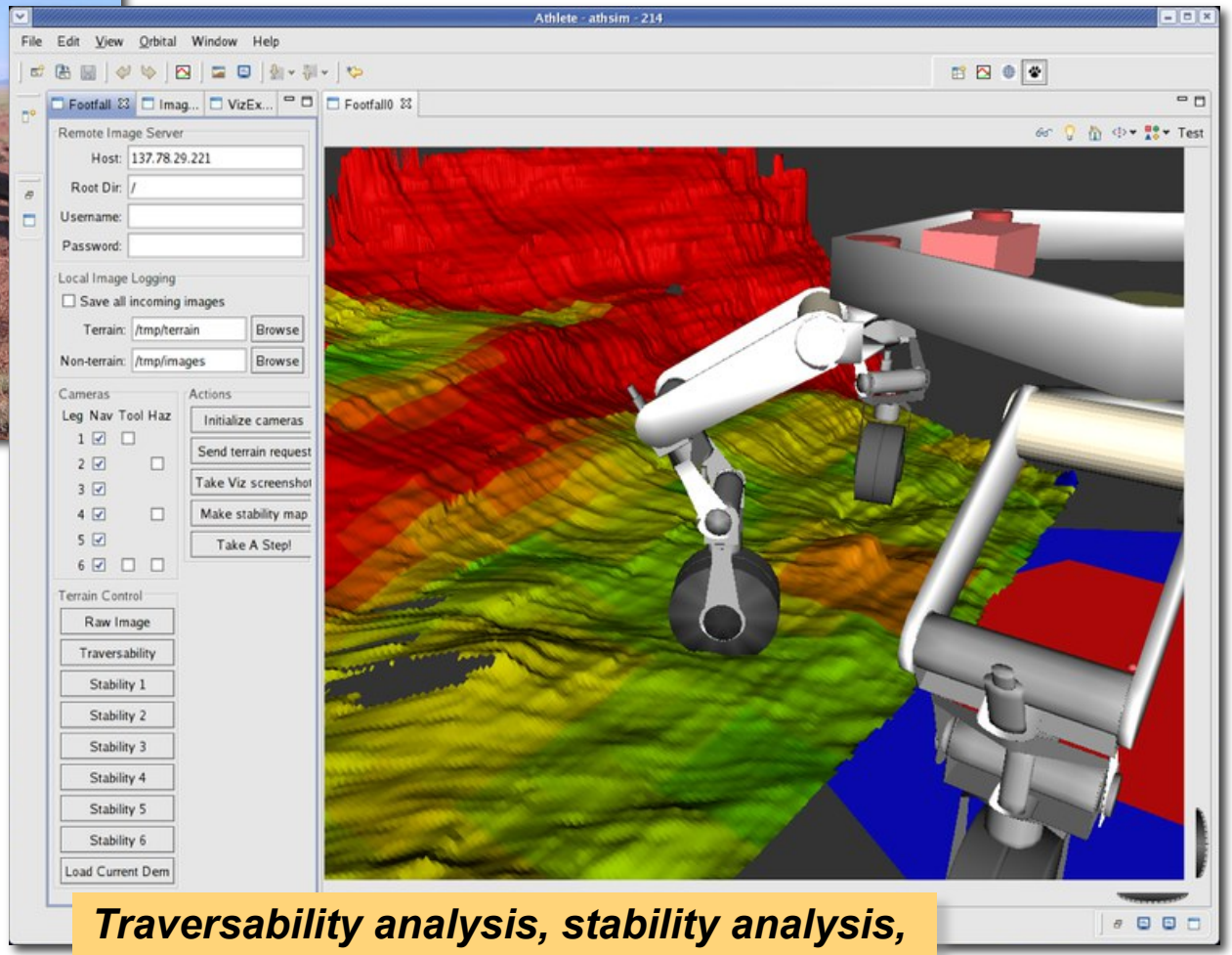
Centaur (Robonaut): Hardware Faults



ATHLETE Footfall Planning

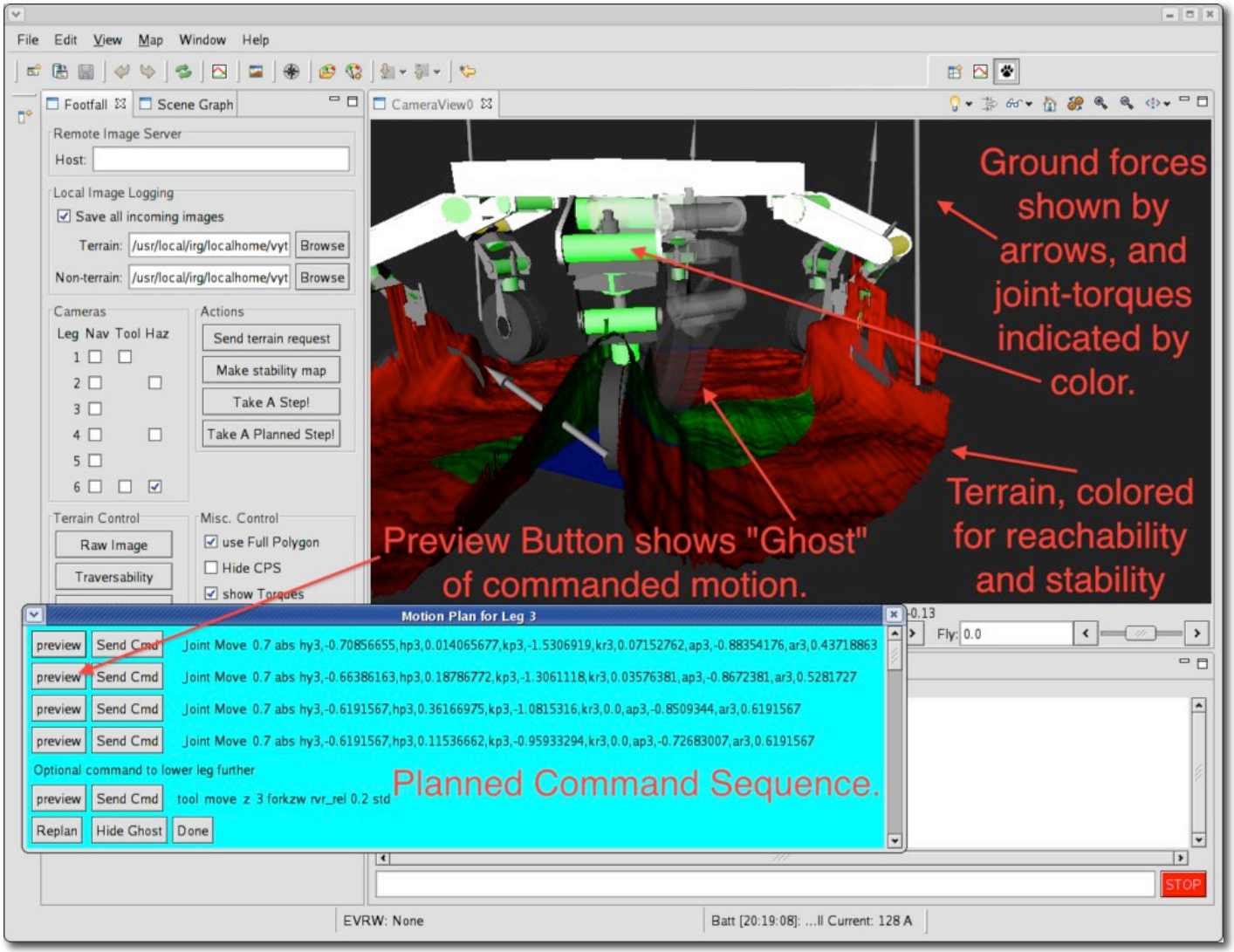


ATHLETE (JPL) at Meteor Crater

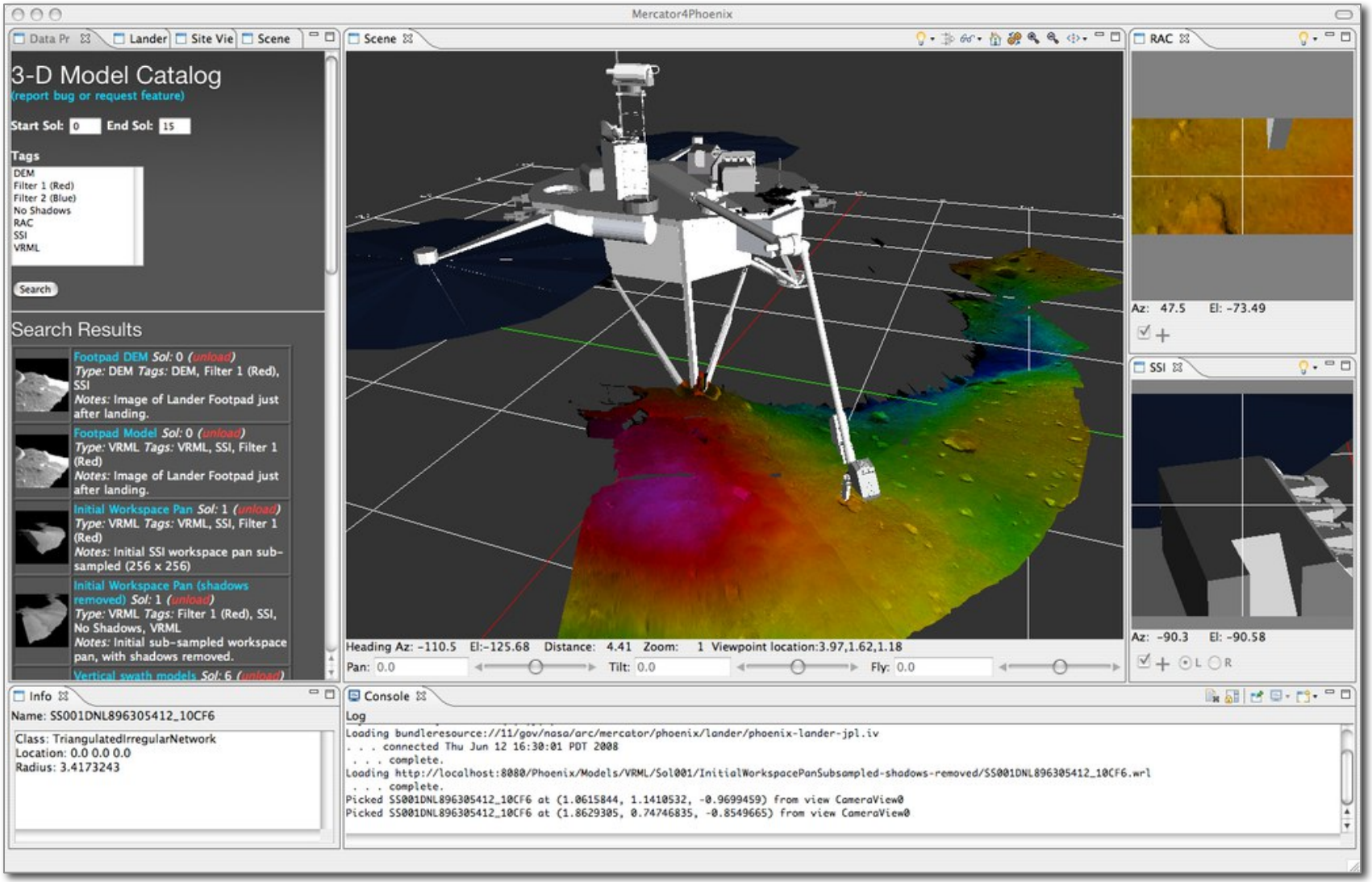


Traversability analysis, stability analysis, single/multi-step planning

ATHLETE Footfall Planning



Phoenix Lander: Manipulator Monitoring



VERVE

3D robot user interface

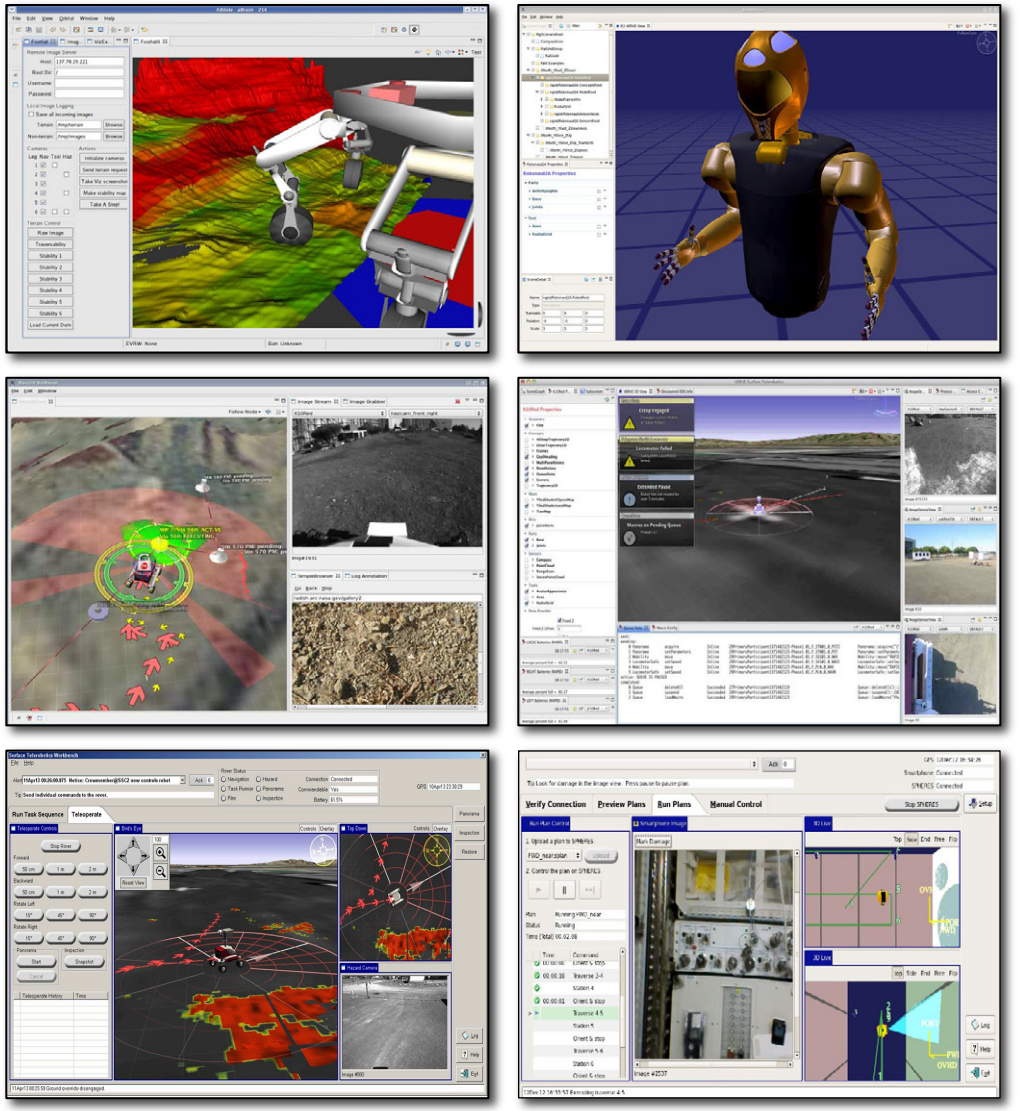
- Interactive planning and monitoring of space robots
- Facilitates situation awareness
- Multiple control modes

Technologies

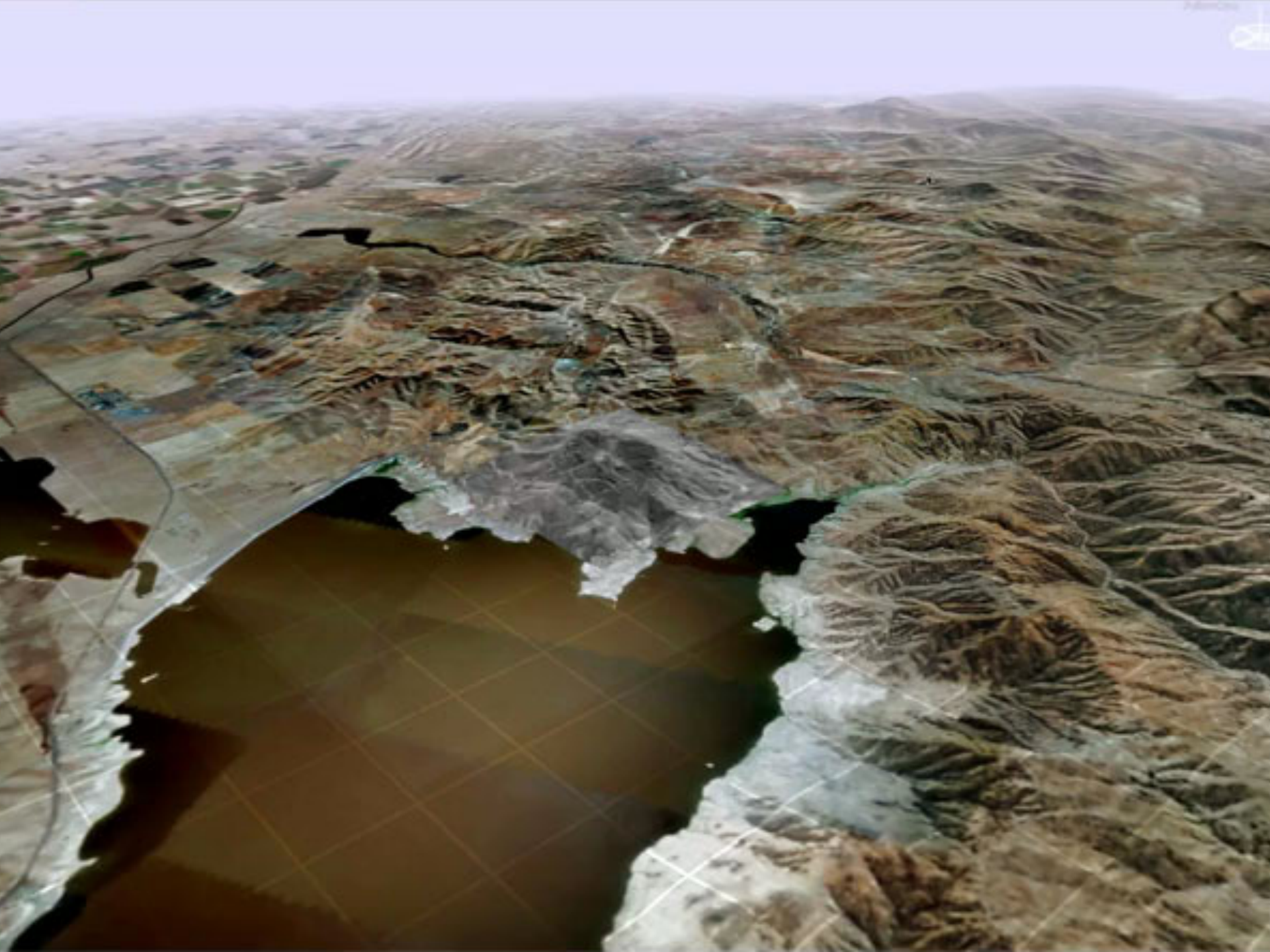
- Java & Eclipse RCP
- Ardor 3D
- NASA RAPID/DDS messaging

Applications

- ATHLETE, Robonaut, K10, K-REX
- ISS: Smart SPHERES and Surface Telerobotics
- Resource Prospector mission



KREX Robot at Basalt Hills



Surface Telerobotics Project

Summary

- Demo **crew-control** surface telerobotics (planetary rover)
- Test **human-robot conops** for future exploration mission
- Obtain **baseline engineering data** (robot, crew, data comm, task, etc)

Implementation

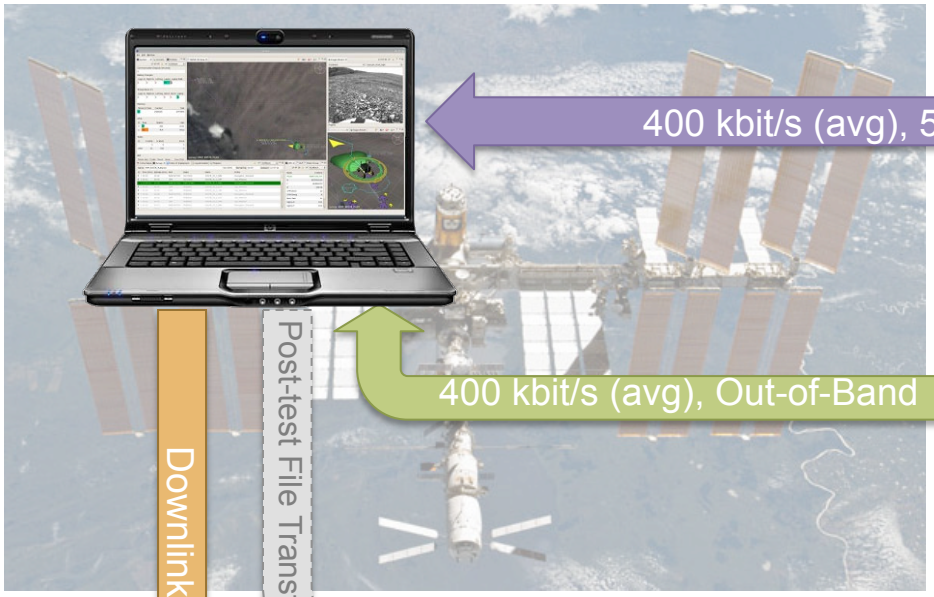
- Lunar libration mission simulation
- Astronaut on Space Station
- K10 rover in NASA Ames Roverscape

ISS Testing (Expedition 36)

- 17 June 2013 – **C. Cassidy**, survey
- 26 July 2013 – **L. Parmitano**, deploy
- 20 August 2013 – **K. Nyberg**, inspect

- **Human-robot mission sim**: site survey, telescope deployment, and inspection
- **Telescope proxy**: Kapton polyimide film roll (no antenna traces, electronics, or receiver)
- **3.5 hr per crew session** ("just in time" training, system checkout, ops, & debrief)
- **Robot ops**: manual control (discrete commands) and supervisory control (task sequence)

ISS Test Setup



400 kbit/s (avg), 500 msec delay (max)

"Live" Rover Sensor and Instrument Data (telemetry)

400 kbit/s (avg), Out-of-Band

Rover/ Science Data (e.g. imagery)

Uplink, data transfer to laptop storage

Uplink

Downlink

Post-test File Transfer

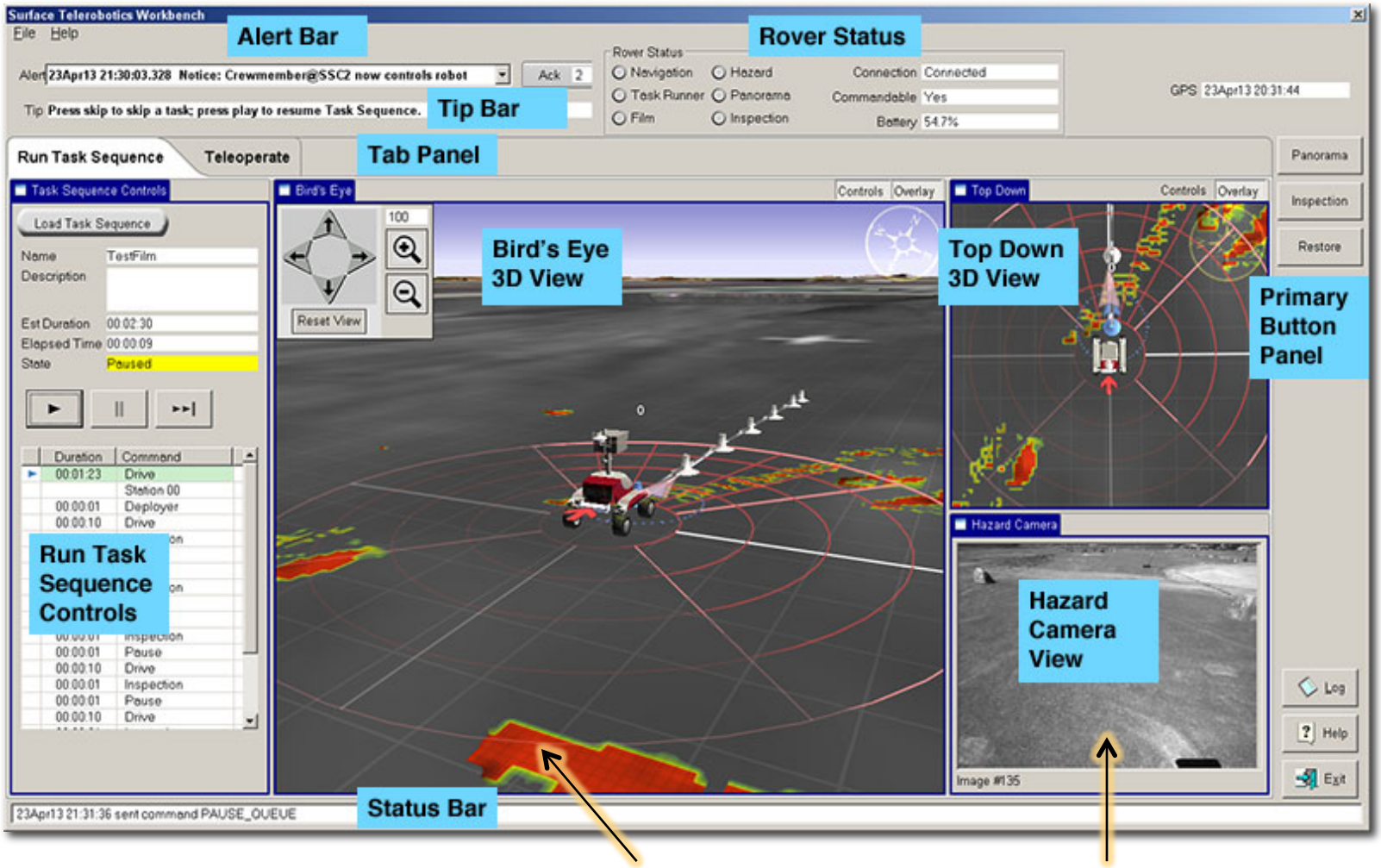
Interface Instrumentation & Evaluation Data

Rover Plan (command sequence)

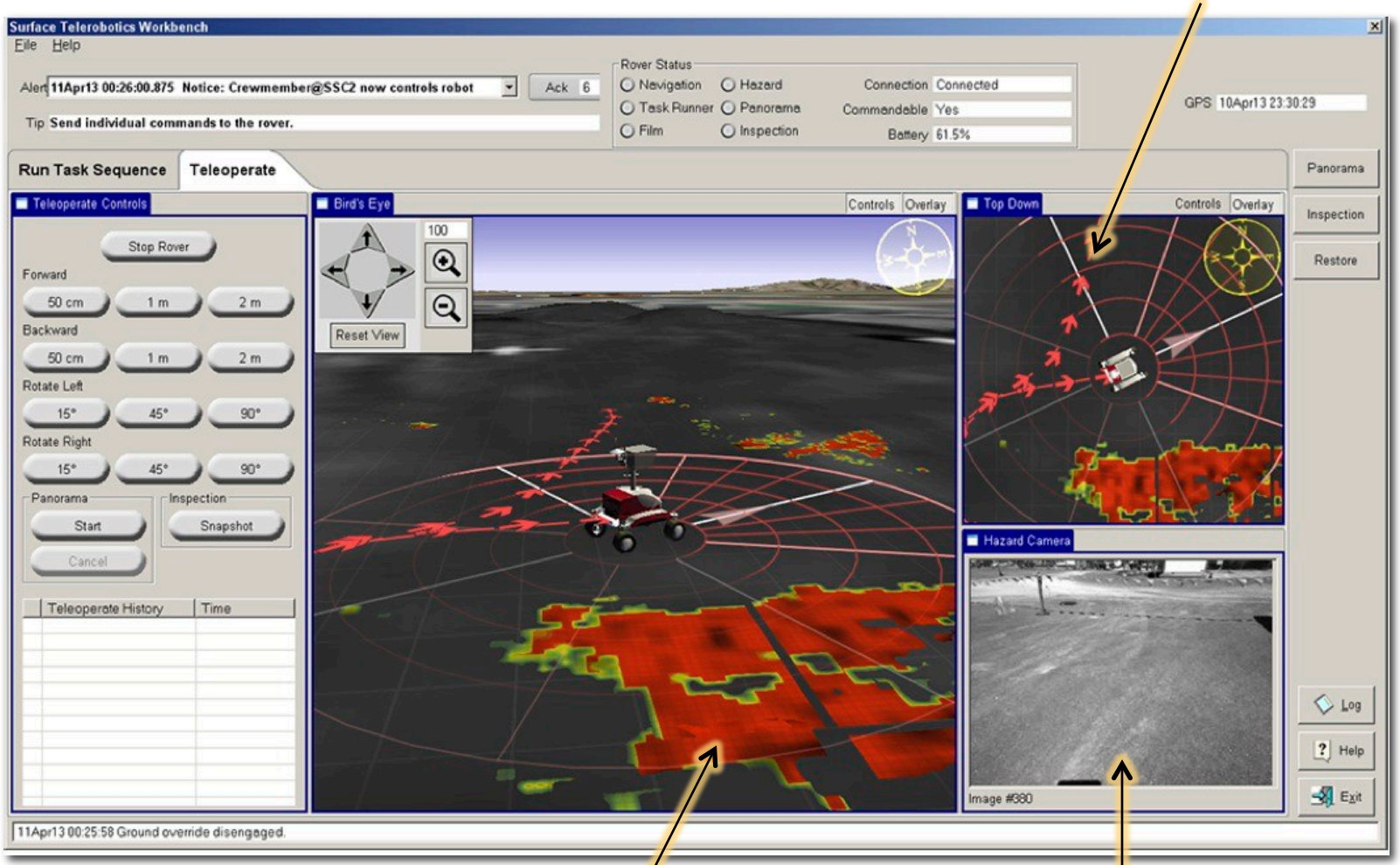
3 kbit/sec (avg), 500 msec delay (max)

K10 rover at NASA Ames

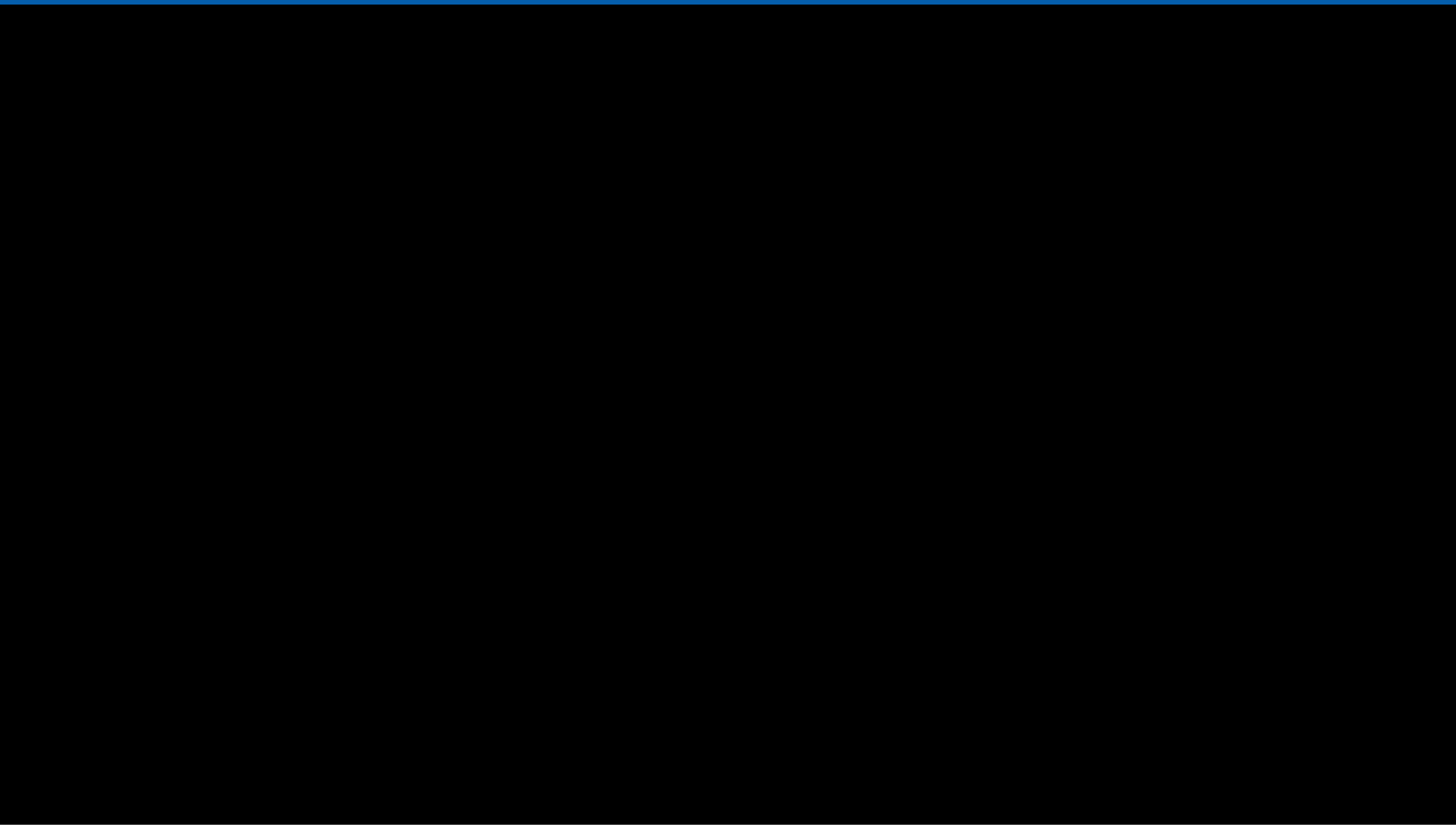
Robot Interface (Supervisory Control)



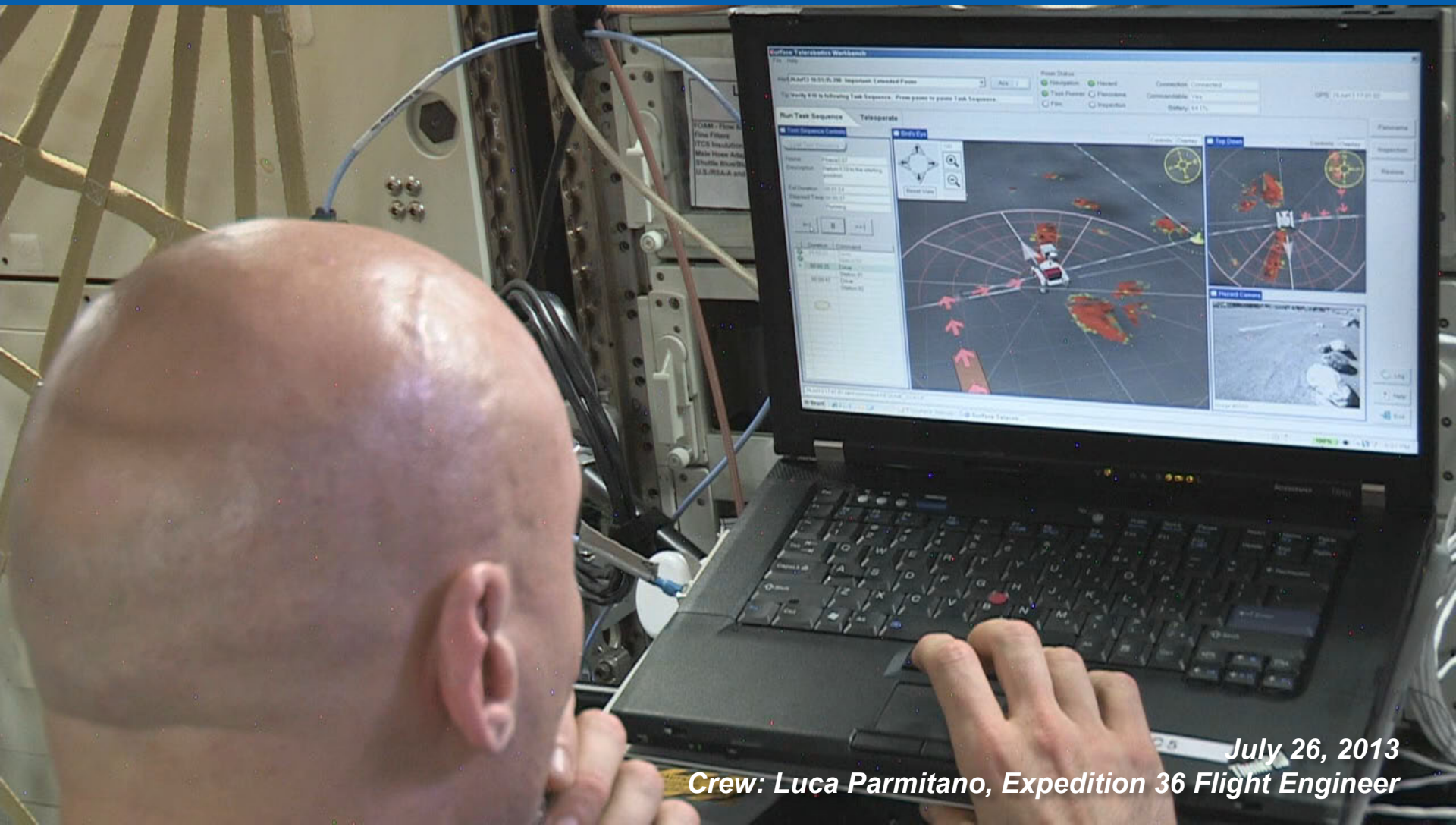
Robot Interface (Manual Control)



Surface Telerobotics

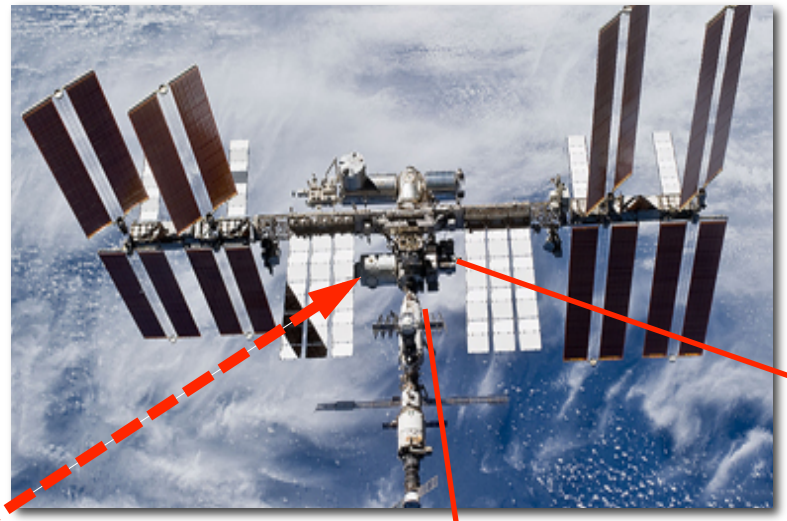


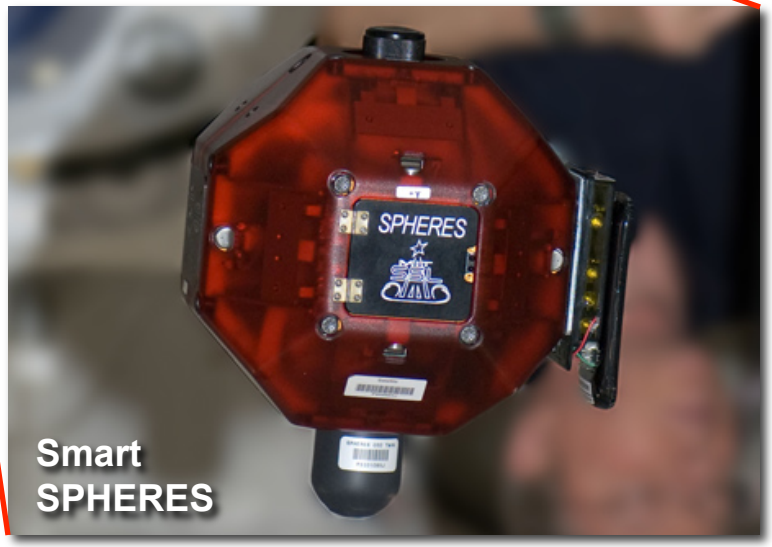
Surface Telerobotics



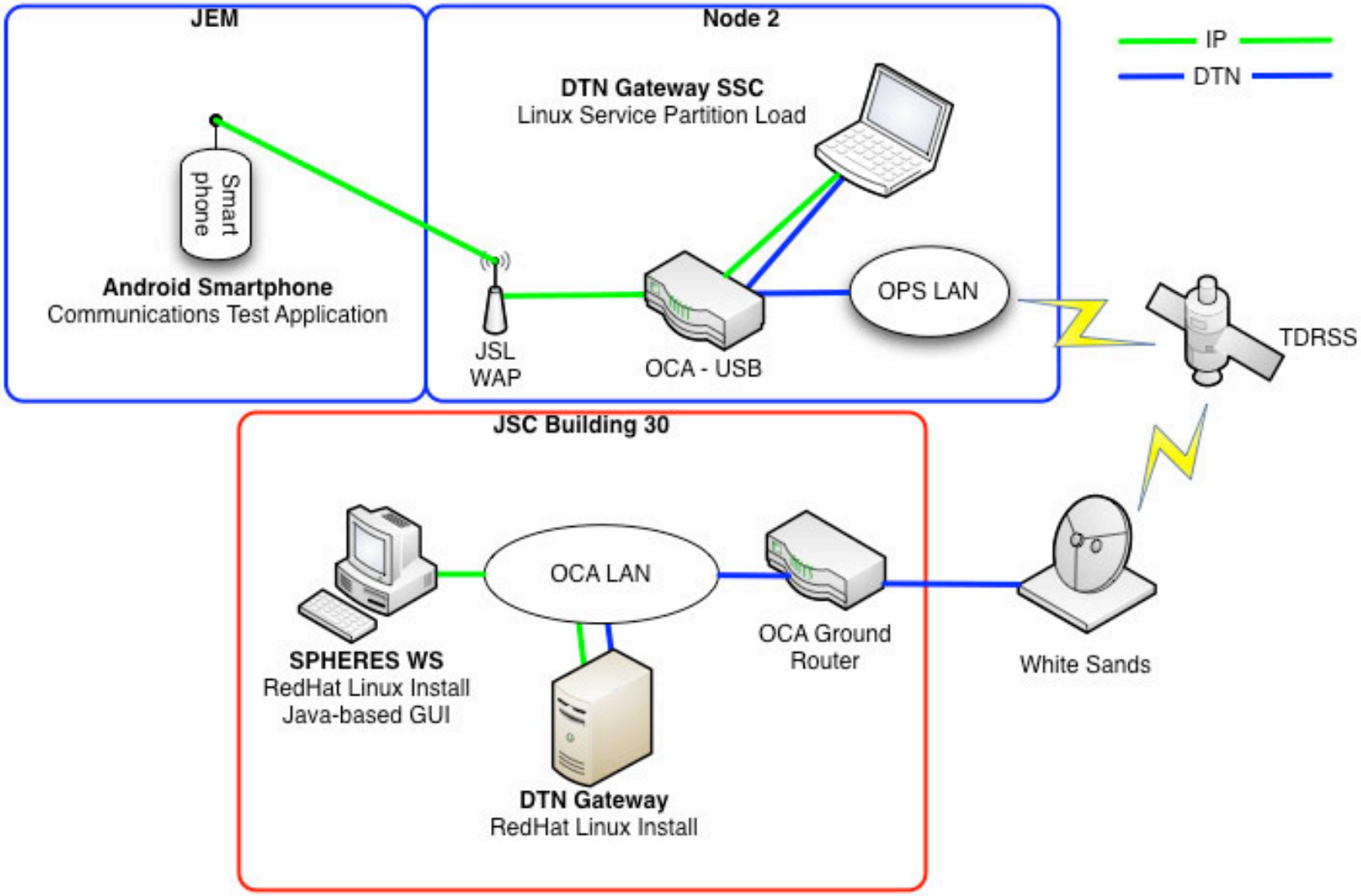
July 26, 2013
Crew: Luca Parmitano, Expedition 36 Flight Engineer

Smart SPHERES





Smart SPHERES Network Setup



ISS Interior Survey with SmartSPHERES

Questions?

Intelligent Robotics Group

irg.arc.nasa.gov