Robotic Technology Development at Ames

The Intelligent Robotics Group and Surface Telerobotics

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irg.arc.nasa.gov!

INTELLIGENT ROBOTICS GROUP OVERVIEW

Intelligent Robotics Group (IRG)

Overview

- 31 researchers (14 Ph.D.'s)
- 20+ summer interns yearly
- 75% NASA work (ARMD, HEOMD, STMD, SMD)
- 25% reimbursable (Google, etc.)
- SBIR / STTR (10 current proj.)

Research themes

- **Automated planetary mapping**
  - Base maps & terrain models
  - Geospatial data systems
- **Robots for human explorers**
  - Improve efficiency & productivity
  - Pre-cursor & "follow-up" work
- **Public service**
  - Disaster response & outreach

irg.arc.nasa.gov

IRG Collaborations (2010 – 2012)

Academic

The Robotics Institute
Stanford University
Massachusetts Institute of Technology
Arizona State University
University of Idaho
EPFL École Polytechnique Fédérale de Lausanne
Humboldt-Universität zu Berlin
ETH Eidgenössische Technische Hochschule Zürich, Swiss Federal Institute of Technology Zurich
SETI Institute
KAIST Korea Advanced Institute of Science and Technology 한국과학기술원

Commercial

Google
Microsoft Research
Aurora Flight Sciences
Microcosm Inc
Stottler Henke Smarter Software Solutions
ENERGID
HONEYBEE ROBOTICS
Optech
TRAC Labs
PI ProtoInnovations
PRCI

Government

SPAWAR

California Task Force 8 USAR
USGS science for a changing world

Robotics for Human Exploration

Purpose

- Increase human productivity
- Improve mission planning & execution
- Transfer **some** tasks to robots (tedious, repetitive, long-duration)

Before Crew

- Recon (scouting) & prospecting
- Site prep, deploy equipment, etc.

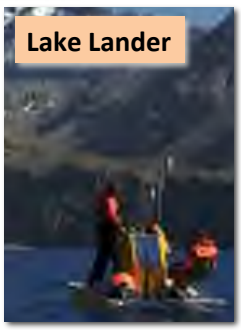
Supporting Crew

- Inspection, mobile camera, etc.
- Heavy transport & mobility

After Crew

- Follow-up & close-out work
- Site survey, supplementary tasks, etc.

IRG's Current Robots



K10 Robot at Haughton Crater, Canada

Sensing

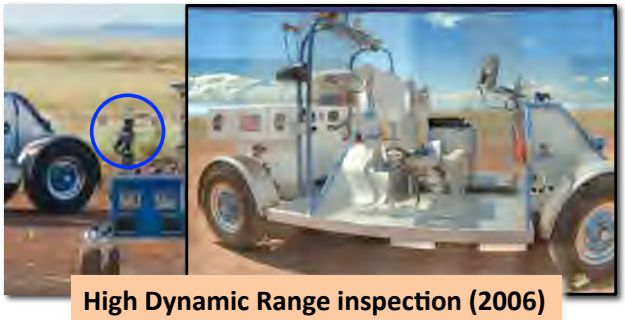
Position & orientation

Gas & vapor

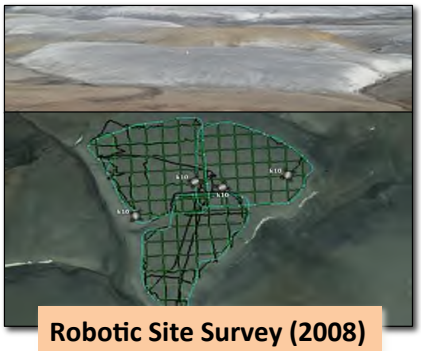
Force, torque, & tactile

Vision & distance

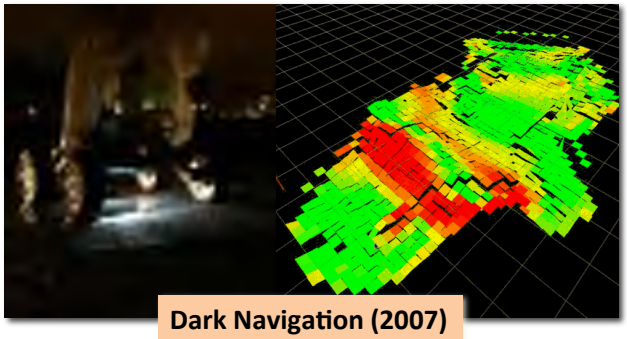
Perception



High Dynamic Range inspection (2006)



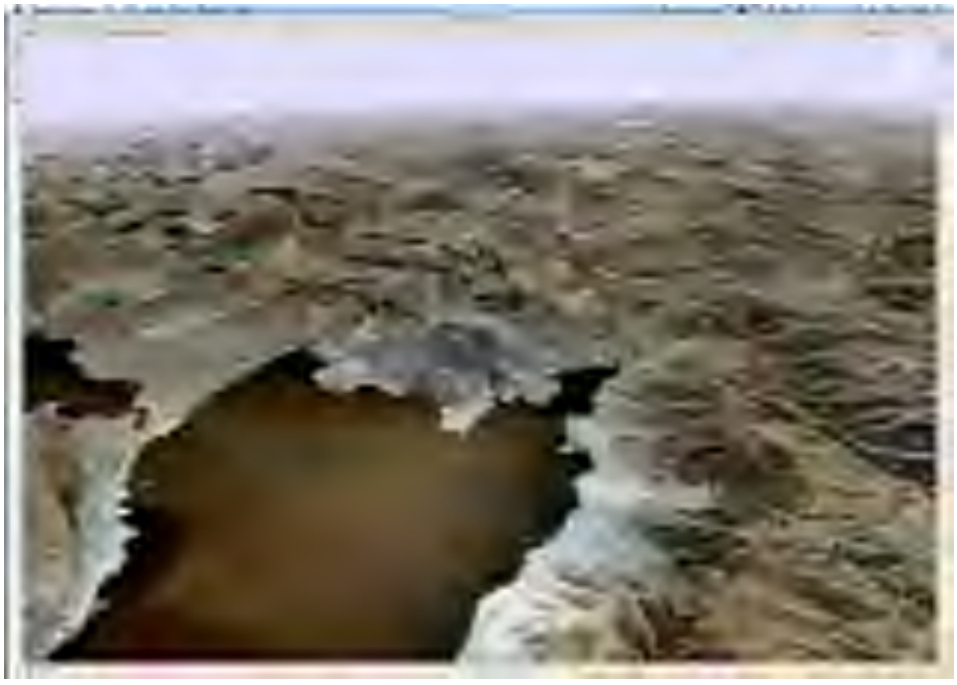
Robotic Site Survey (2008)



Dark Navigation (2007)

GigaPan Voyage (2009 - 2011)

Rover driving, Basalt Hills, California (2012)



Smart SPHERES robot, ISS (2012)

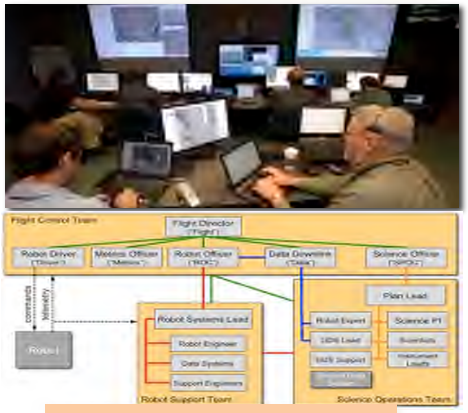
2x speed

User Interfaces

VERVE (2007 - 2013)

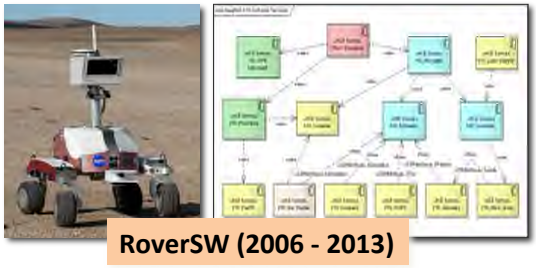
K10 Data Browser (2010 - 2011)

Google Earth Ops (2008 - 2011)

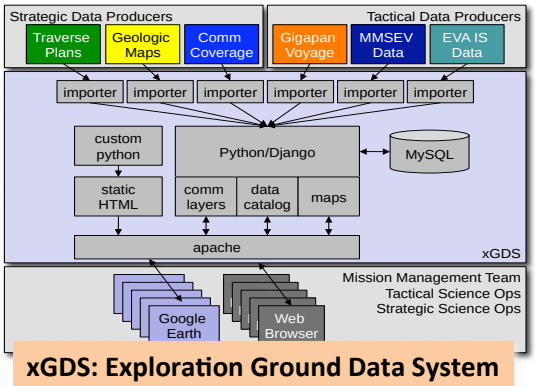


Interactive Ground Control (2008 - 2010)

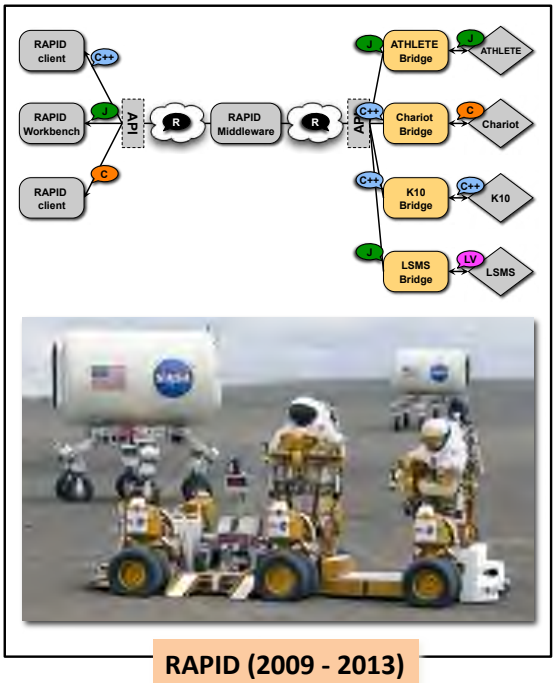
System Software



RoverSW (2006 - 2013)



xGDS: Exploration Ground Data System (2009 - 2013)



RAPID (2009 - 2013)

Mars in Google Earth

Explore Mars in 3D

- Released Feb. 2, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, infrared, historical, etc.
- Imager footprints & overlay (HiRISE, CTX, MOC, …)
- Mars rover tracks & color panoramas
- Tours (Bill Nye & Ira Flatow)
- Live from Mars: THEMIS
- And much more …

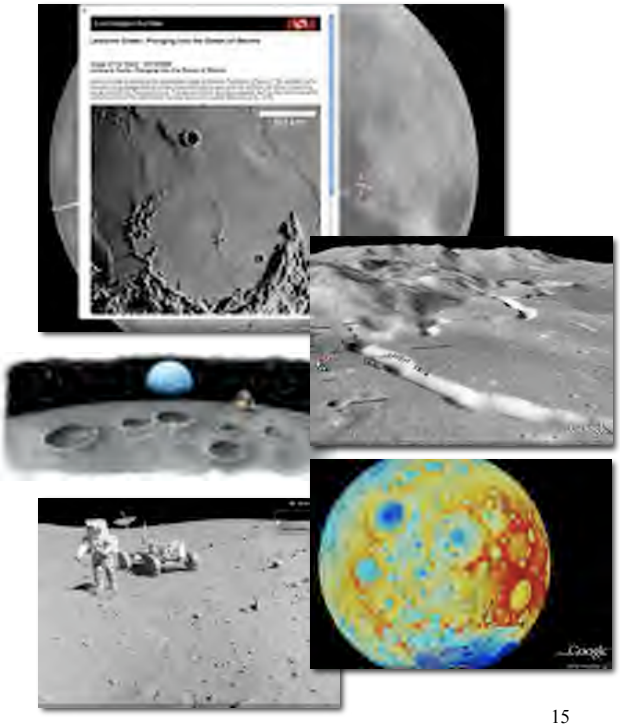
Moon in Google Earth

Explore the Moon in 3D

- Released July 20, 2009
- Co-developed with Google
- NASA Ames created content & processing scripts

Content

- Global maps: topography, geologic, historical, etc.
- Spacecraft imagery: Apollo, Lunar Orbiter, etc.
- 3D models of spacecraft, landers, and crew rovers.
- Tours (Andy Chaikin, Buzz Aldrin & Jack Schmidt)
- And much more …



WorldWide Telescope | Mars

Complete HiRISE Mosaic

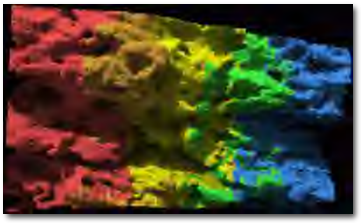
- Mars Reconaissance Orbiter HiRISE imager
- 74,000 images
- Each image: 20K x 50K pixels (> 1 GB / image)

Mosaic stats

Tile Dimensions	256 x 256 pixels
Root Tiles / Image	15,000
Tile Space	25 KB
Tiles Total	229 million
Total Mosaic Size	5.7 TB

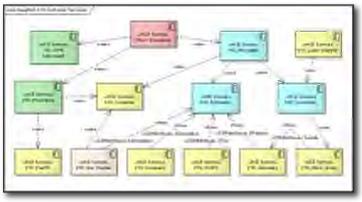
IRG Open Source Software

Vision Workbench



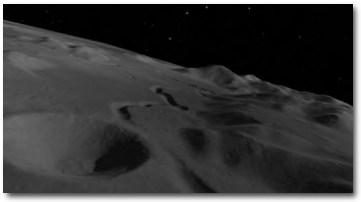
GeoCam

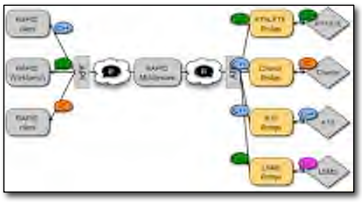
RoverSW



Vehicle Detection

Neo Geography Toolkit



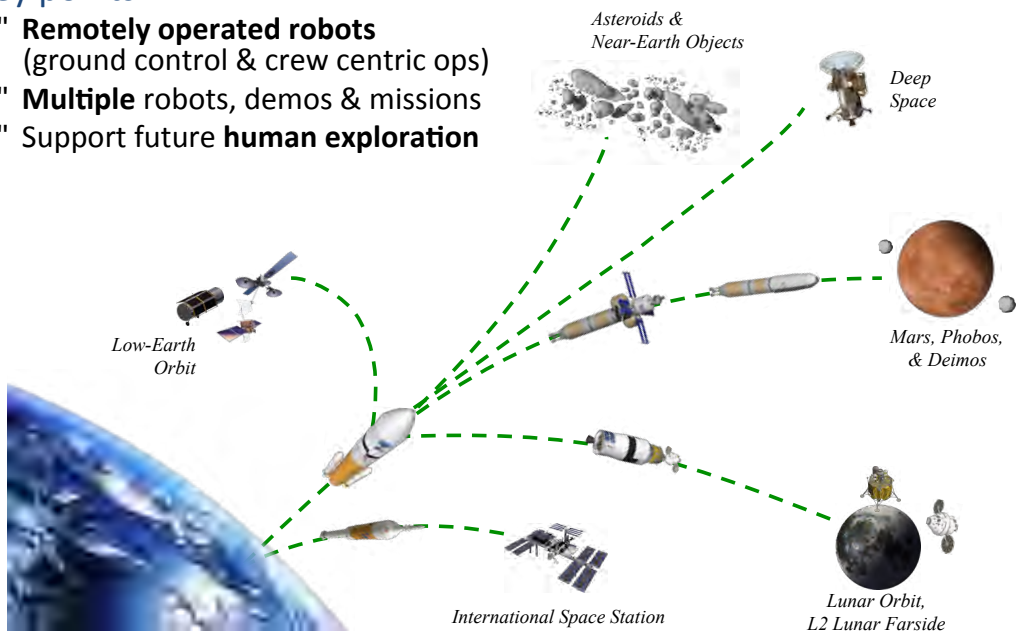


RAPID

Human Exploration Telerobotics (HET)

Key points

- **Remotely operated robots** (ground control & crew centric ops)
- **Multiple** robots, demos & missions
- Support future **human exploration**



HET Telerobotic Systems

Robonaut 2

- **Humanoid robot** (42 DOF, human-scale/safe)
- Perform dexterous IVA/EVA **manipulation** tasks
- Share **astronaut tools** and **workspaces**

Smart SPHERES

- **Free-flying robot** (6 axis, cold-gas propulsion)
- Perform IVA/EVA remote **mobile sensor** tasks
- Improve **ground control** situation awareness

Surface Telerobotics

- **Mobile robot on surface** (Moon, asteroid, Mars)
- Perform **surface activities** before/support/after crew
- **Crew centric operations** from inside flight vehicle

Surface Telerobotics

Surface Telerobotics is an engineering test of a human-robot "opscon" for future deep-space human exploration missions

Candidate Missions

- **L2 Lunar Farside**. Orion crew module test flight (~2020) to Earth-Moon L2 point
- **Near-Earth Asteroid**. NEA dynamics and distance make it impossible to manually control robot from Earth
- **Mars Orbit**. Crew must operate surface robot from orbit when circumstances (contingency, etc.) preclude Earth control

(NASA GSFC)

What will the test achieve?

- Obtain baseline engineering data
- Validate & correlate prior ground simulations
- Reduce the risk that mission planning is based on inaccurate assumptions

L2 Lunar Farside (Waypoint) Mission Concept

Orion at Earth-Moon L2 Lagrange point

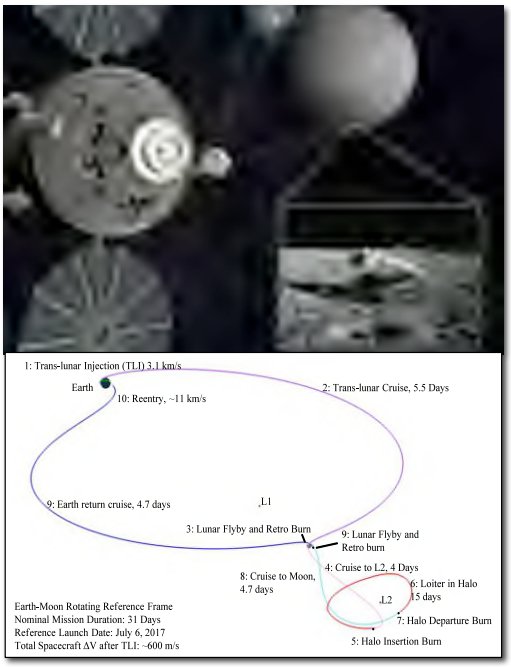
- 60,000 km beyond lunar farside
- Allows station keeping with minimal fuel
- Crew remotely operates robot on lunar farside
- Less expensive than human surface mission
- Does not require human-rated lander

Primary objective: lunar telescope

- Use telerobot to setup radio telescope
- Requires surface survey, antenna/receiver deployment, and inspection/documentation
- Lunar farside provides radio quiet zone for low-freq measurements cosmic dawn

Secondary objective: sample collection

- Use telerobot to perform field geology
- Requires scouting, sampling (possibly subsurface), and sample caching/return
- South Pole Aitken (SPA) basin sampling is the highest priority lunar science objective

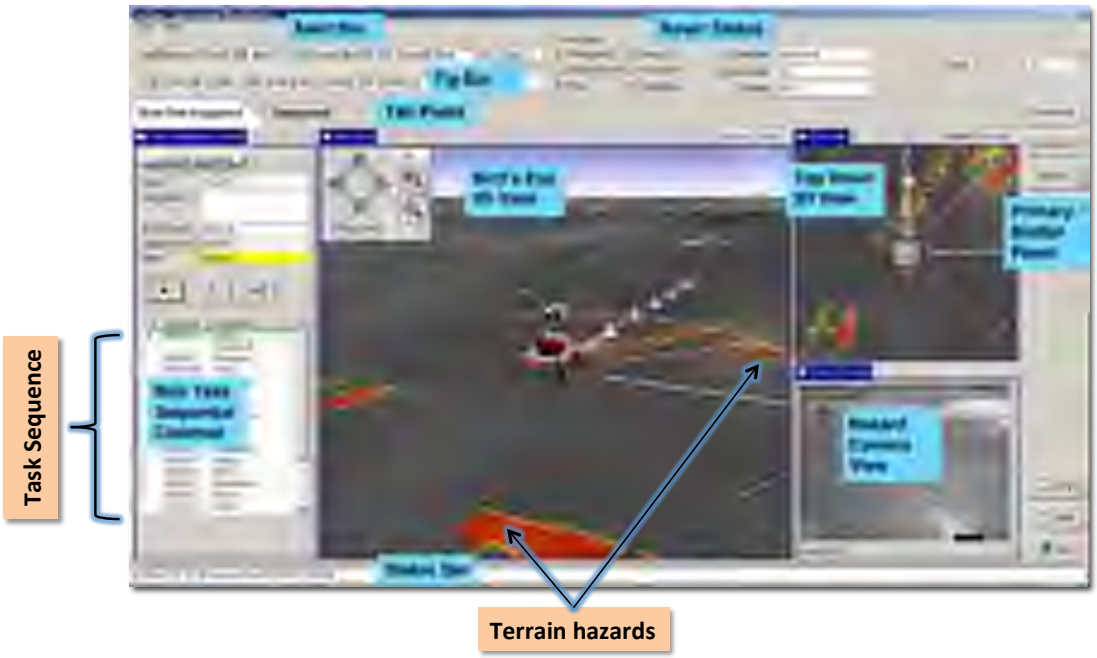


(Lockheed Martin / LUNAR)

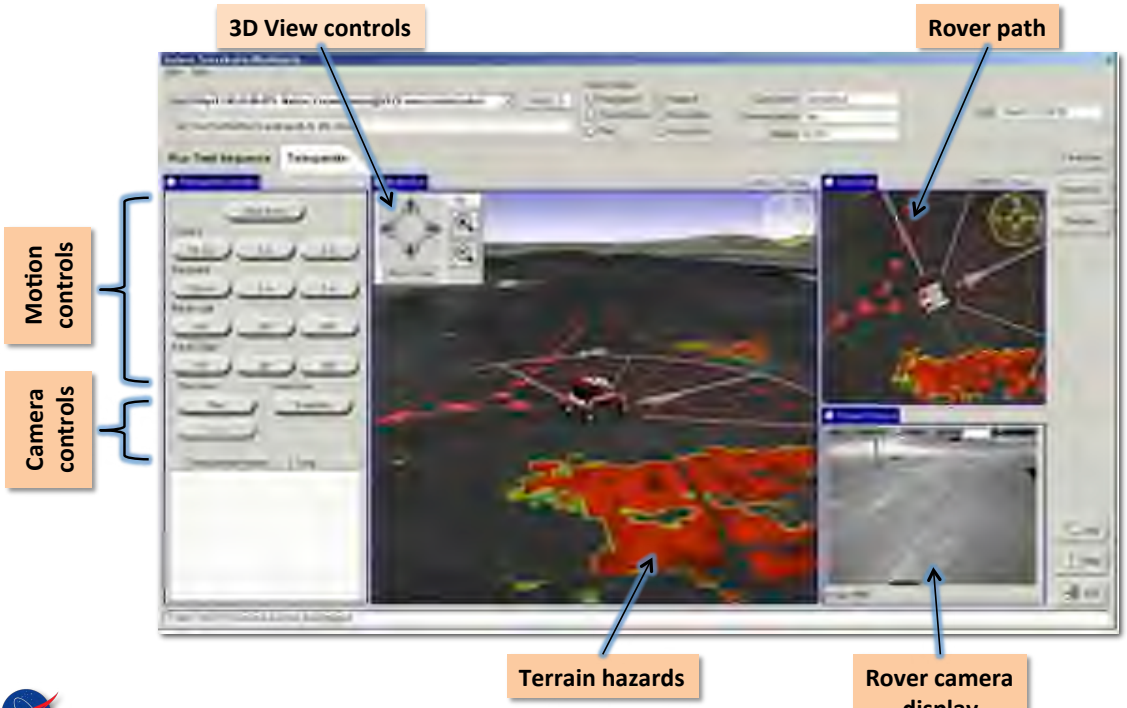
Waypoint Mission Simulation (2013)

Spring 2013 *June 17* *July 26* *August 20*

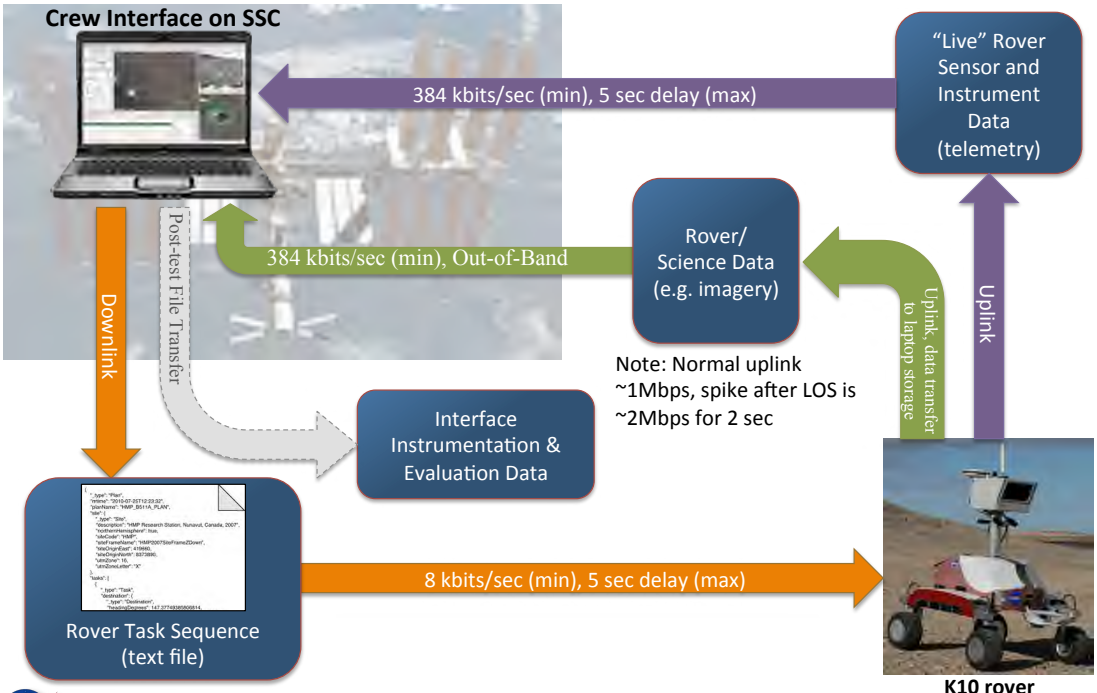
Crew Interface (Task Sequence Mode)



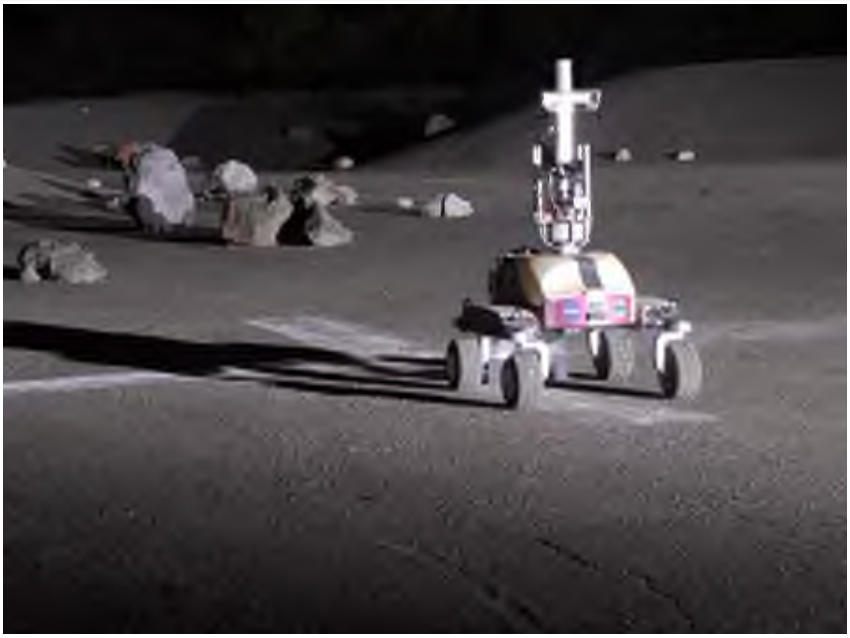
Crew Interface (Teleop Mode)



Data Communications (Upside-down Payload)



K10 rover before dawn in the ARC “Roverscape”

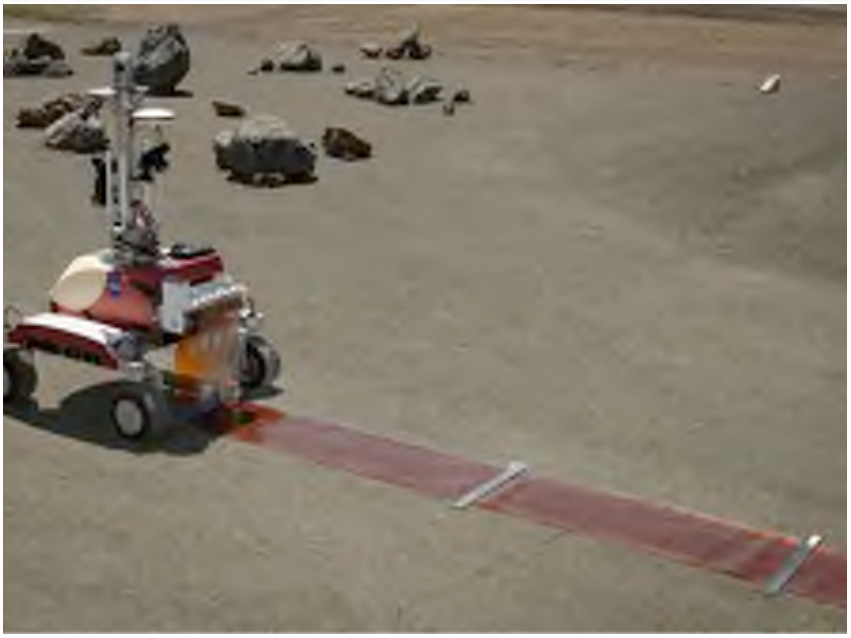


K10 Planetary Rover @ NASA Ames

K10 Specifications
- "4-wheel drive, 4-wheel steer
- "Split rocker chassis
- "Size: 1.3 x 0.9 x 1.0 m (HxWxL)
- "Speed: 0.9 m/s (on 10 deg slope)
- "Power: 1900 W (Li-ion batteries)
- "Weight: 100 kg (with 25 kg payload)

NASA Ames Roverscape

Telerobotic Lunar Telescope Deployment



K10 deploying simulated polyimide antenna.

K10 Deploys Kapton Film in Marscape

Chris Cassidy uses the “Surface Telerobotics Workbench”

Astronaut remotely operates K10 from the ISS (2013-06-17)

Astronauts Parmitano & Nyberg Operate K10 from ISS

ISS Mission Control (MCC-H) during Surface Telerobotics test (2013-08-20)

View of robot interface (top left) and K10 at ARC (top right)

"PLUTO" Multi-Purpose Support Room at JSC

Provides data comm & crew laptop support

Multi-Mission Operations Center (MMOC) at ARC

Manages Surface Telerobotics test sessions

K10 support team at ARC

Provides rover engineering & test logistics

Questions?

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