



# Robot Technology Development

## Perception, User Interfaces and Architecture

**Terry Fong**

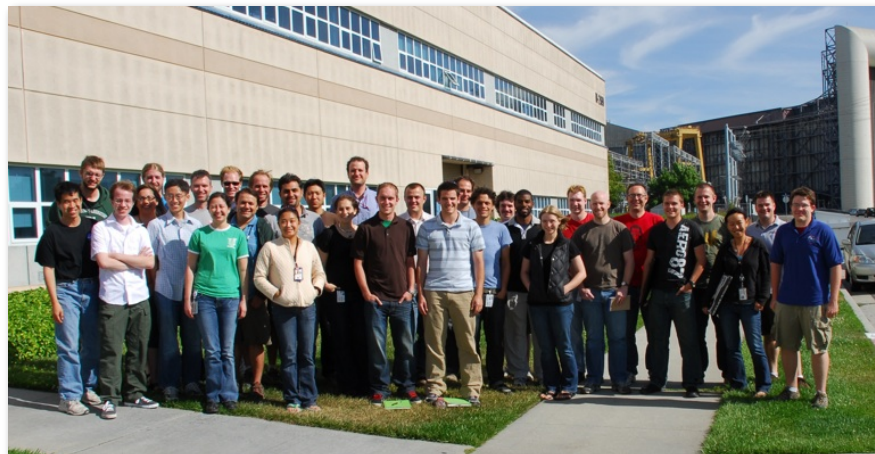
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[irg.arc.nasa.gov](http://irg.arc.nasa.gov)

# Intelligent Robotics Group (IRG)

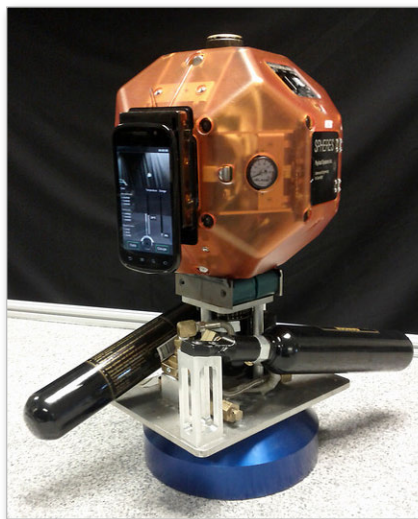
## Overview

- 31 researchers (14 Ph.D.'s)
- 20+ summer interns yearly
- 75% NASA work (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

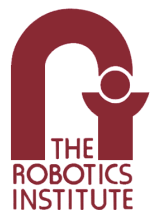


[irg.arc.nasa.gov](http://irg.arc.nasa.gov)



# IRG Collaborations (2010-2013)

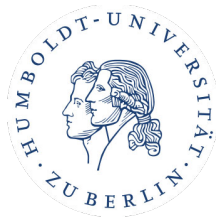
## Academic



Massachusetts  
Institute of  
Technology



ÉCOLE POLYTECHNIQUE  
FÉDÉRALE DE LAUSANNE



Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich



SETI INSTITUTE



Korea Advanced Institute of Science and Technology  
한국과학기술원

## Commercial



Smarter Software Solutions



HONEYBEE ROBOTICS



ProtoInnovations



## Government



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

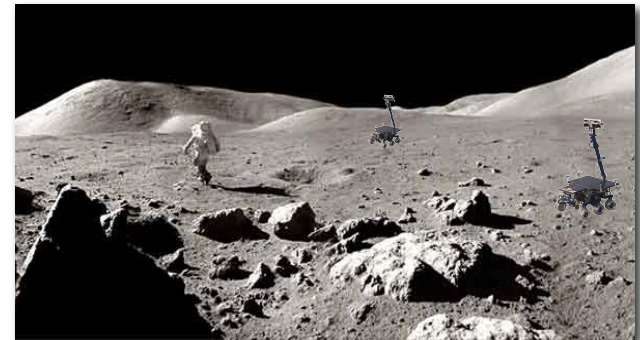
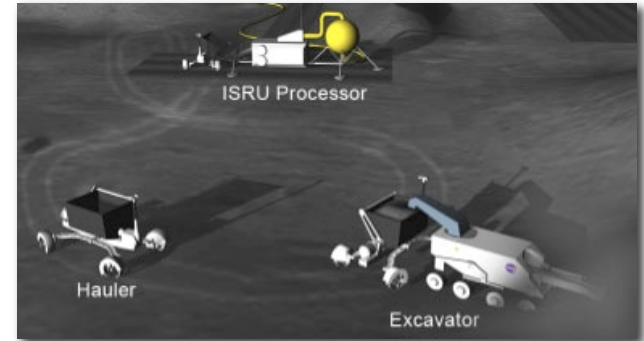
- Recon (scouting) & prospecting
- Site prep, deploy equipment, etc.

## Supporting Crew

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

## After Crew

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



# Robots



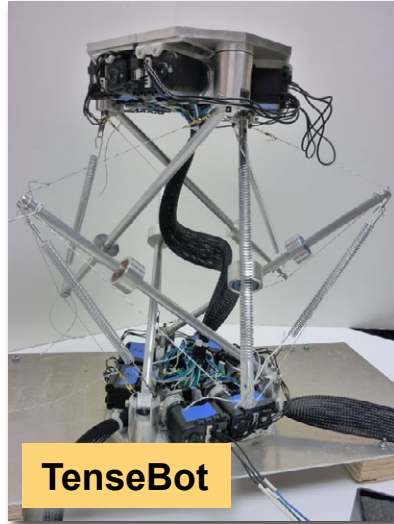
**K10 mini**



**K10**



**KREX**



**TenseBot**



**Modular Arm**



**Smart SPHERES**



**GigaPan**

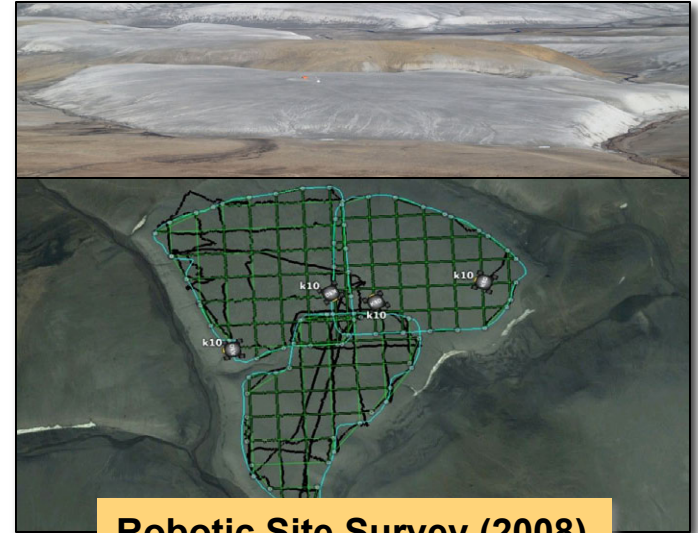


**Lake Lander**

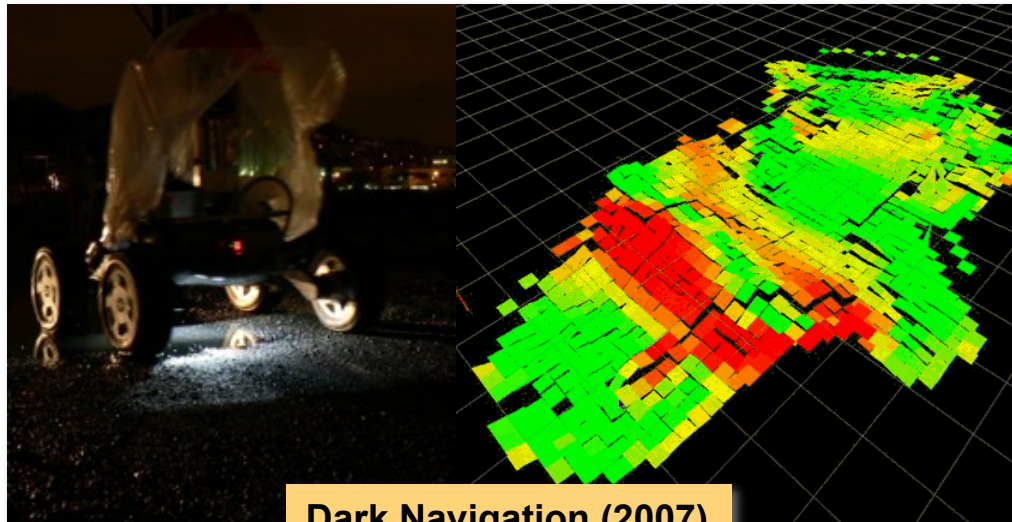
# Perception



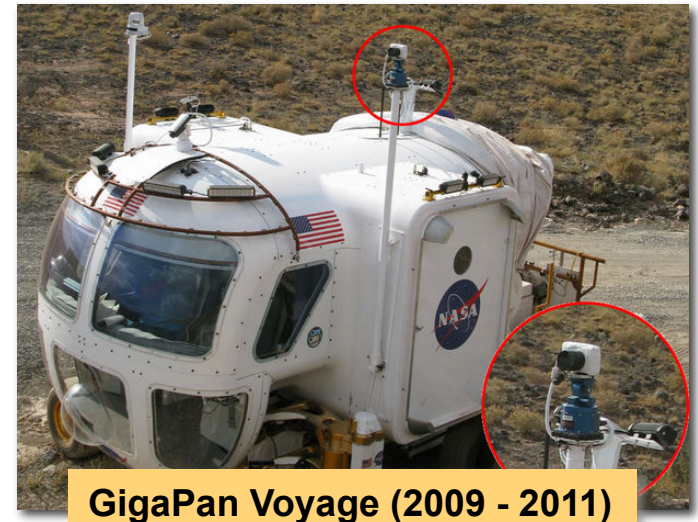
High Dynamic Range inspection (2006)



Robotic Site Survey (2008)



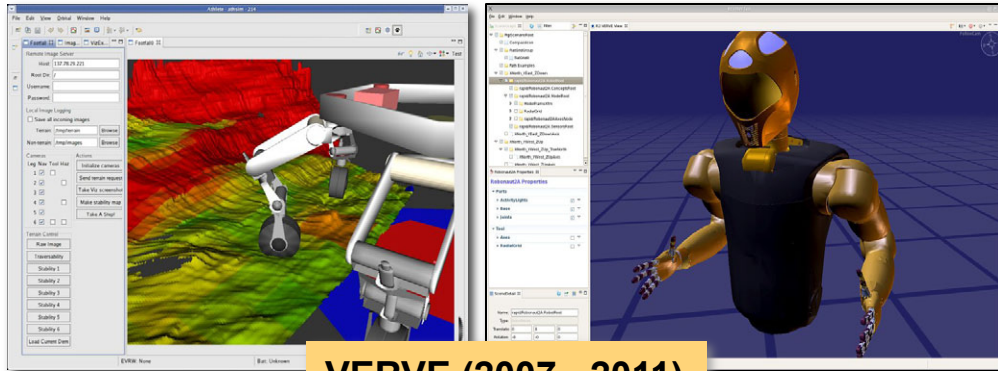
Dark Navigation (2007)



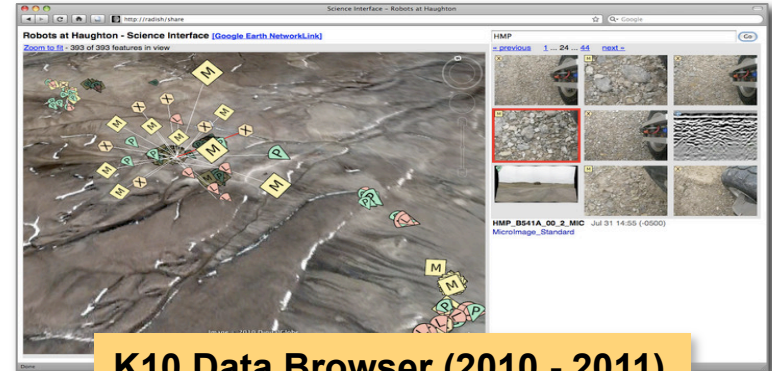
GigaPan Voyage (2009 - 2011)



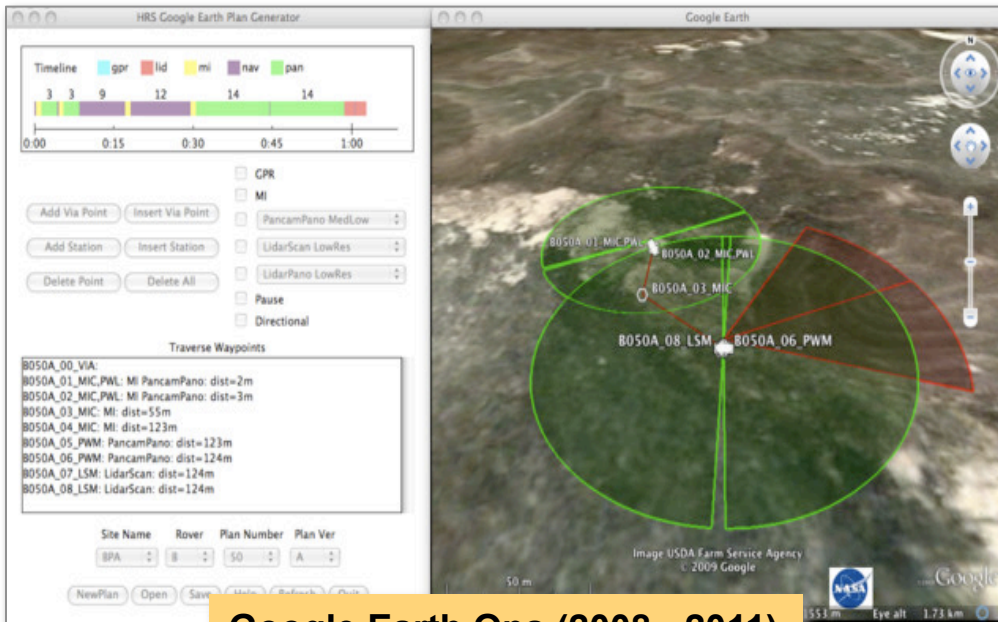
# User Interfaces



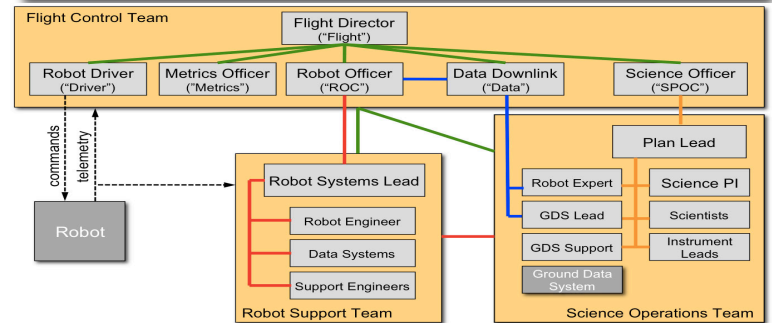
**VERVE (2007 - 2011)**



**K10 Data Browser (2010 - 2011)**

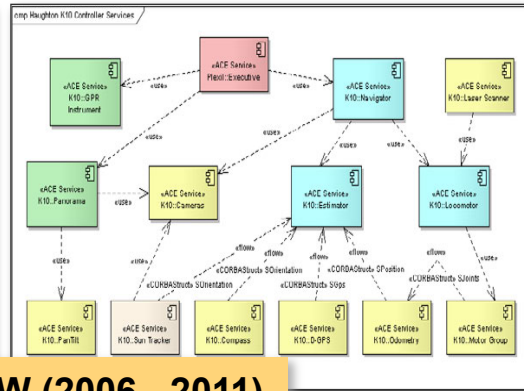


**Google Earth Ops (2008 - 2011)**

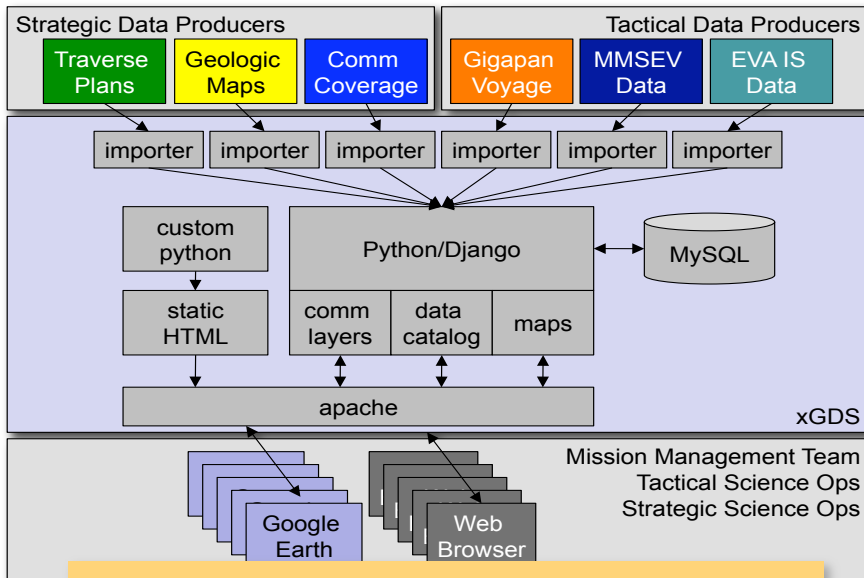


**Interactive Ground Control (2008 - 2010)**

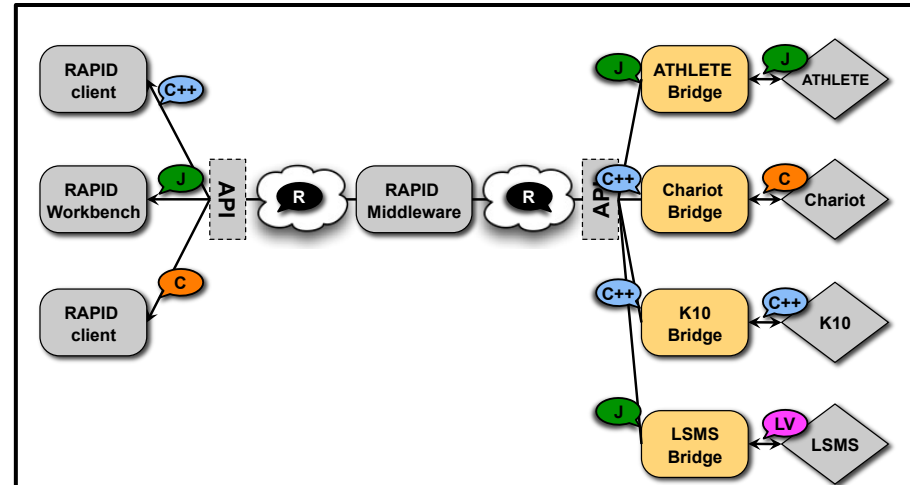
# Architecture



**RoverSW (2006 - 2011)**



**xGDS: Exploration Ground Data System (2009 - 2011)**



**RAPID (2009 - 2011)**

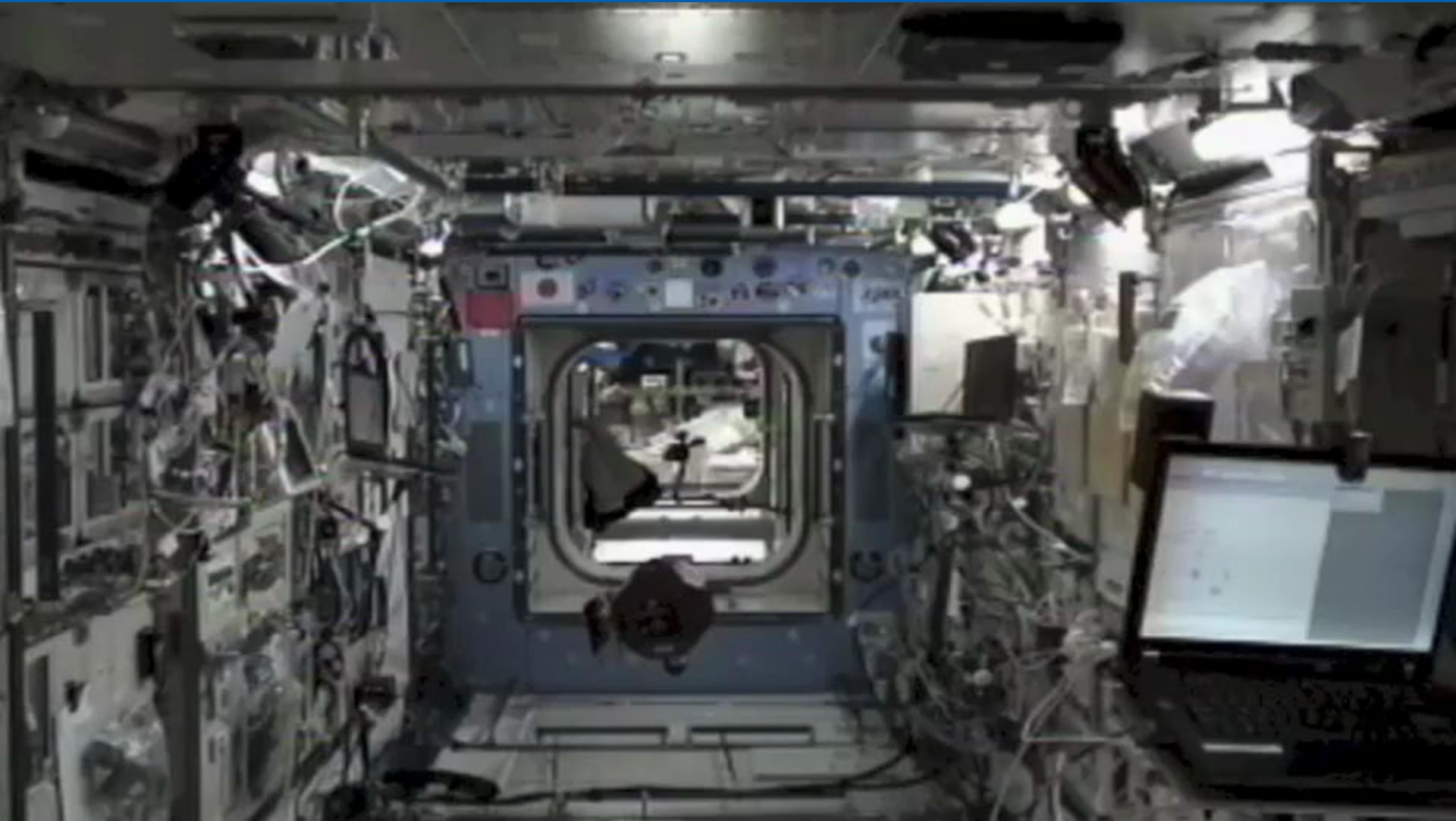




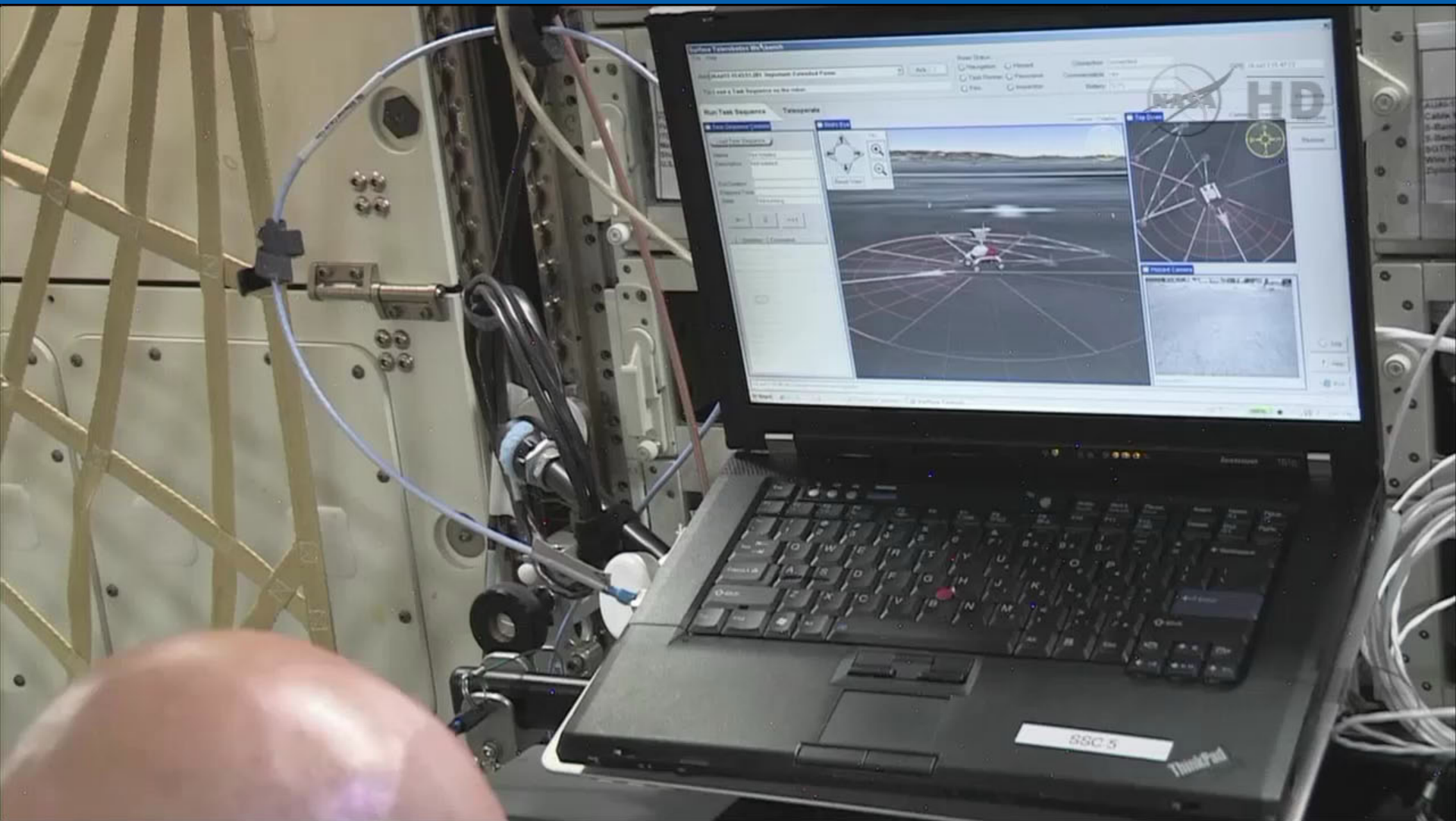
# K10 Robot at Haughton Crater, Canada



# SmartSPHERES on ISS



# K10 Remotely Operated from ISS





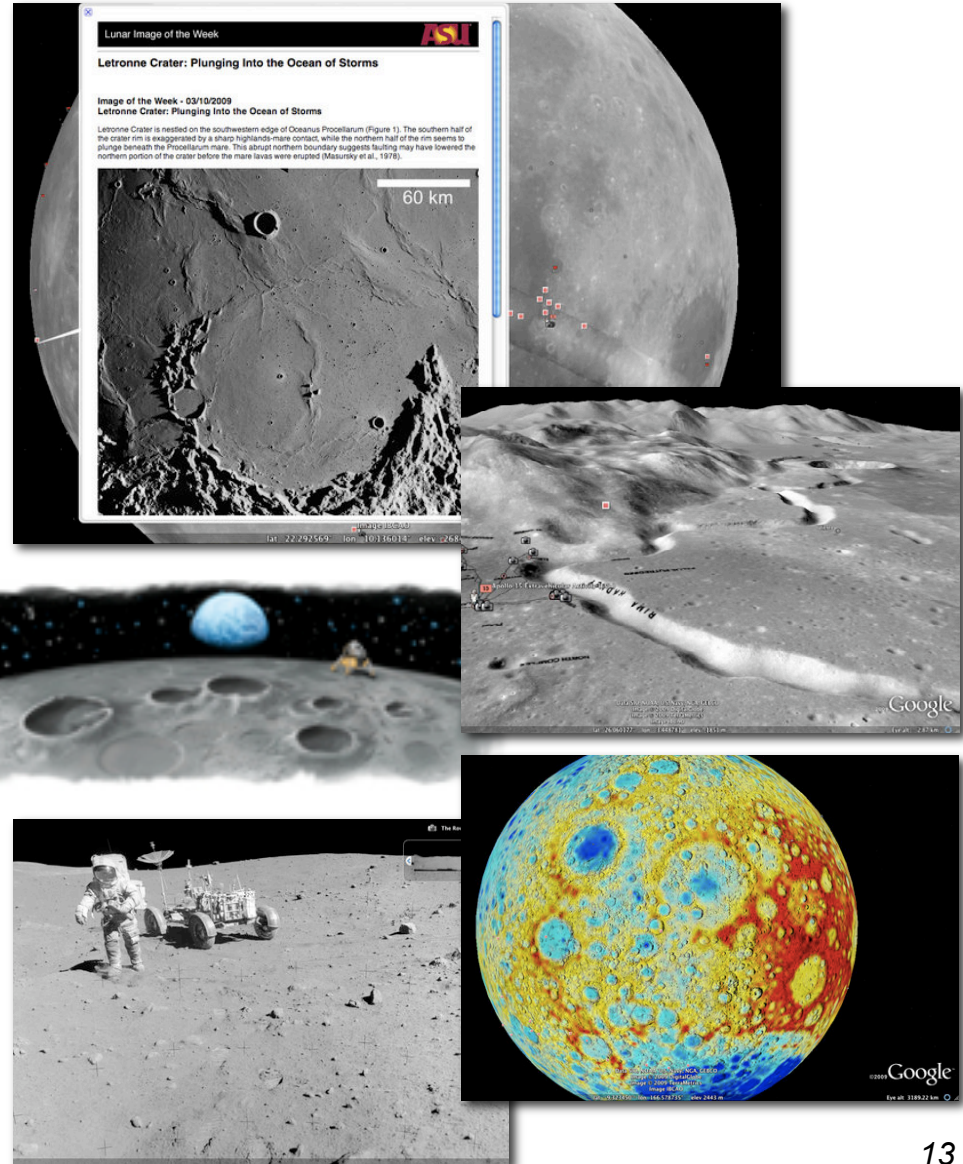
# Moon in Google Earth

## 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 ...



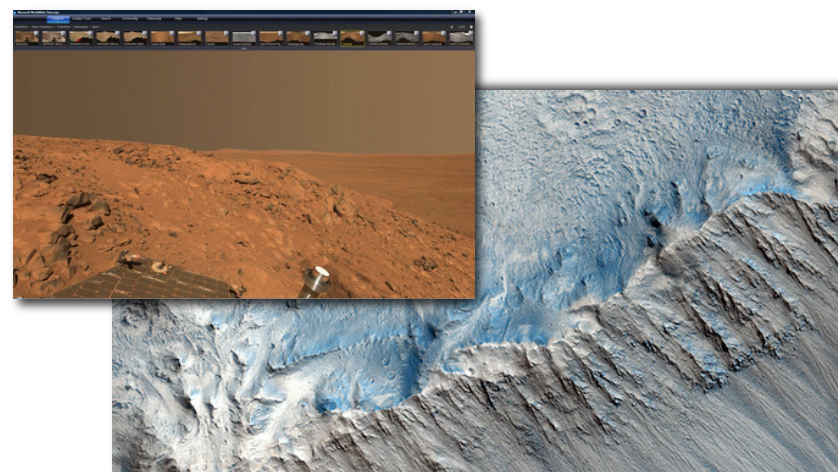
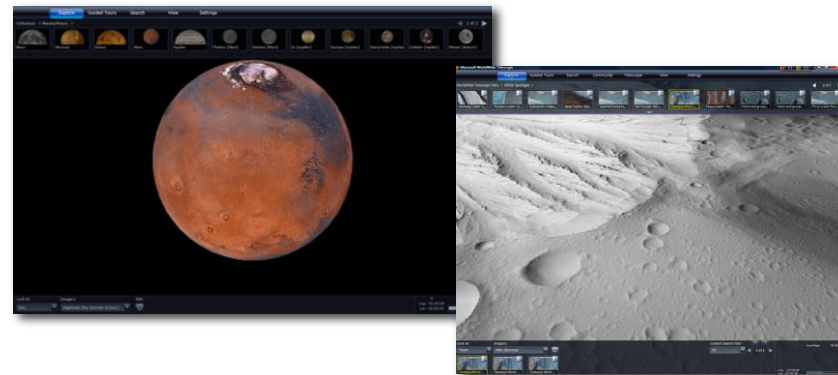
# WorldWideTelescope | Mars

## Complete HiRISE Mosaic

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

## Mosaic stats

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



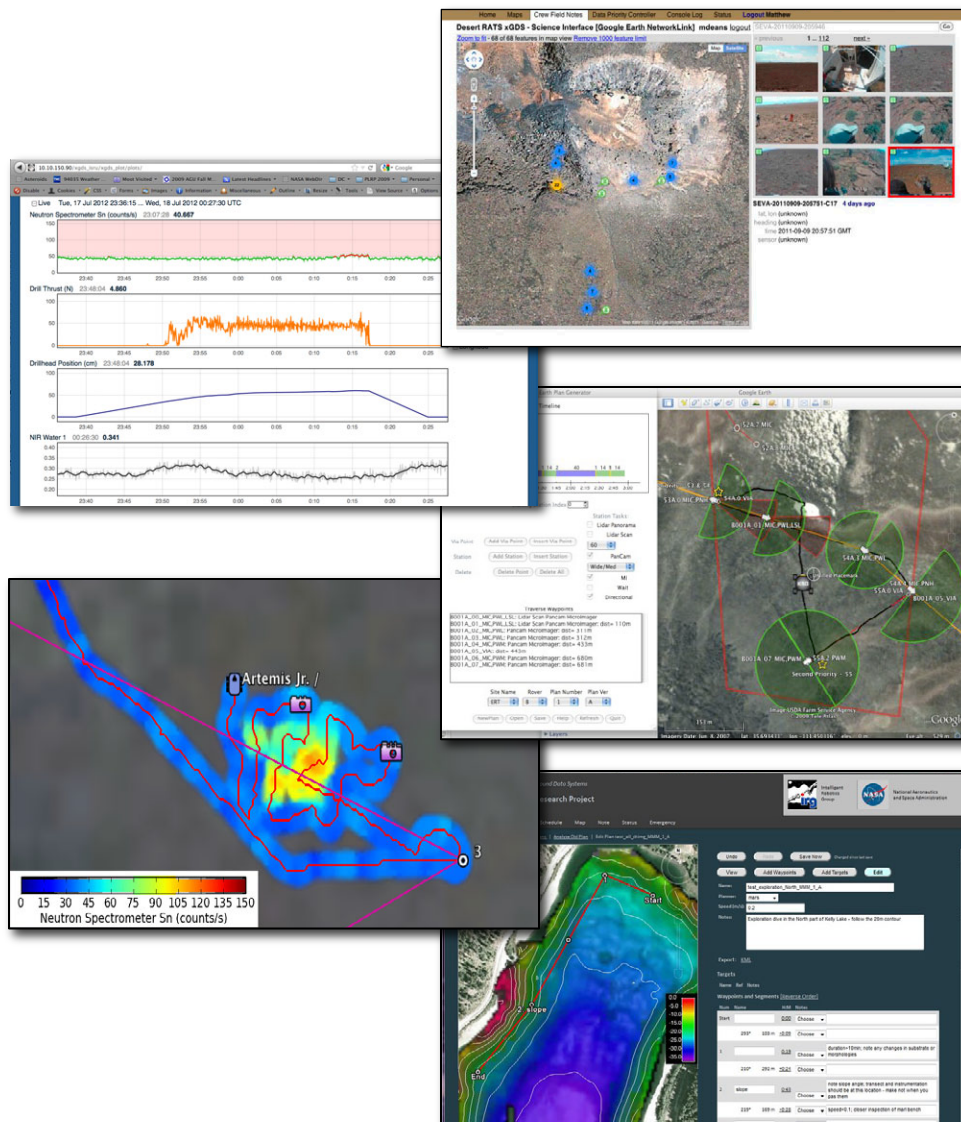
# Exploration Ground Data System (xGDS)

xGDS is ...

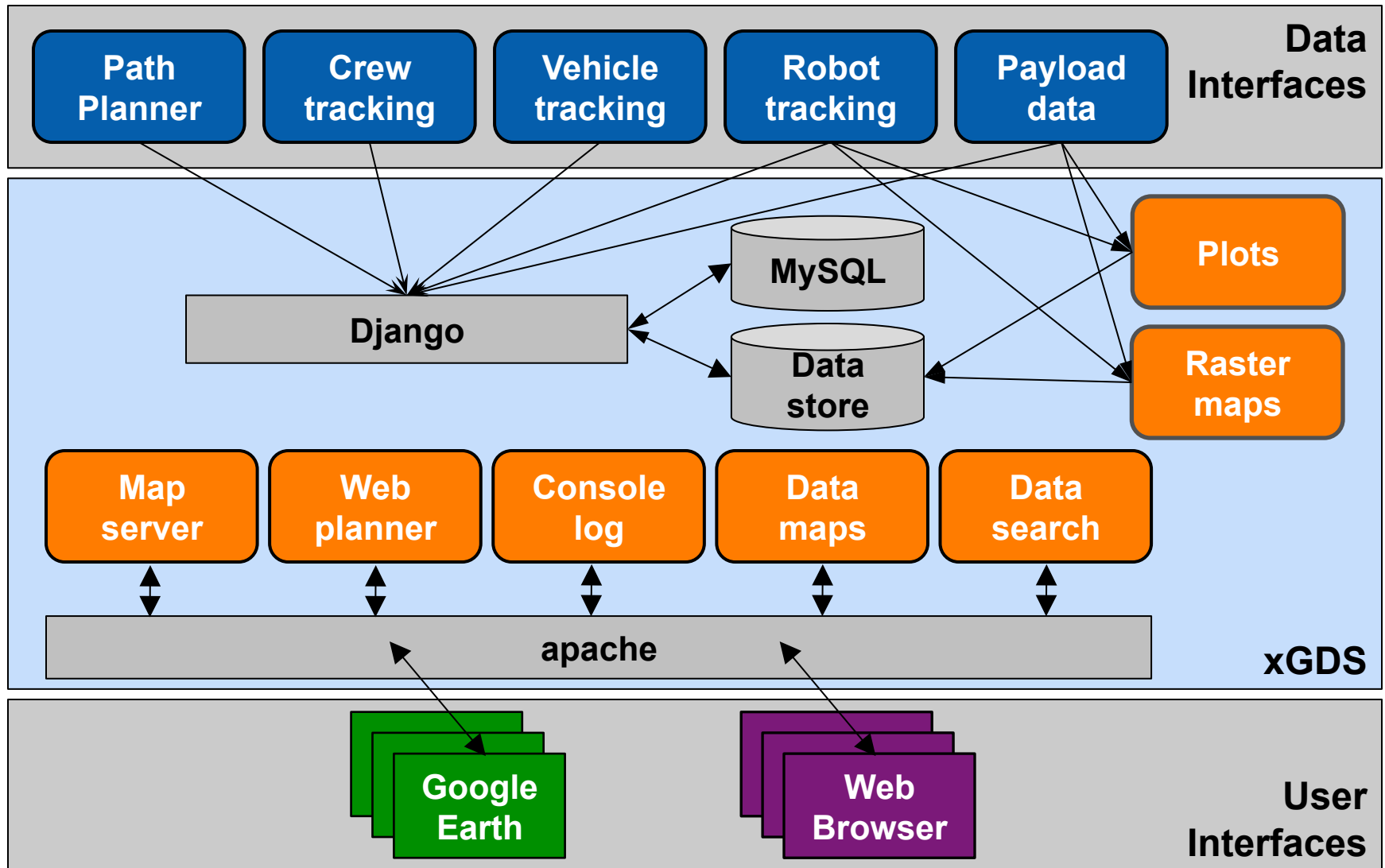
- Map content management
- Planning tool
- Real-time plots, maps, notes
- Post-processing data archive
- Browse and search tools

## Users

- Field scientists
- Planetary scientists
- Mission planners
- Flight controllers
- Local & distributed teams



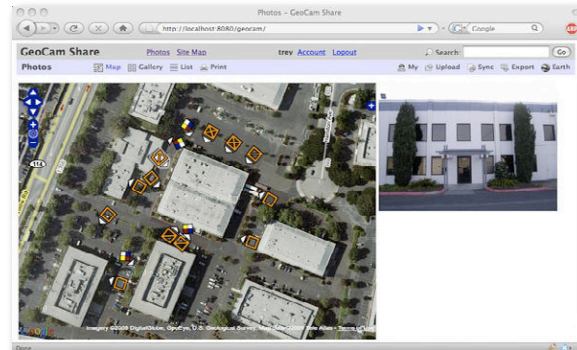
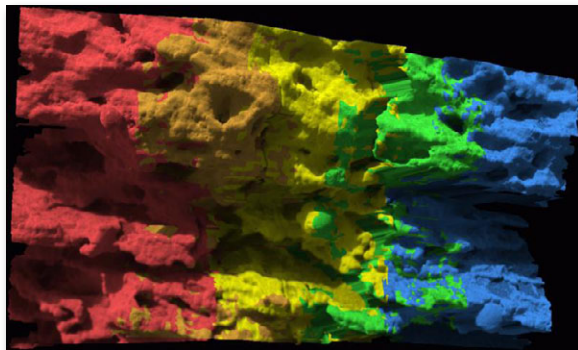
# xGDS Architecture





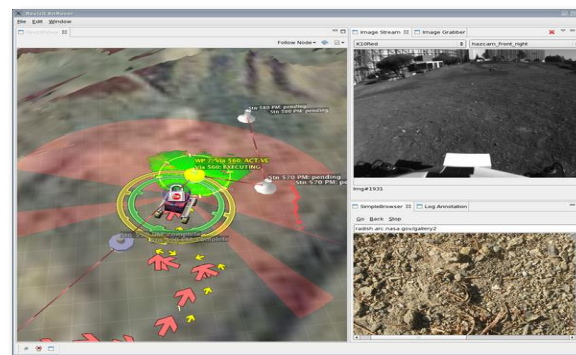
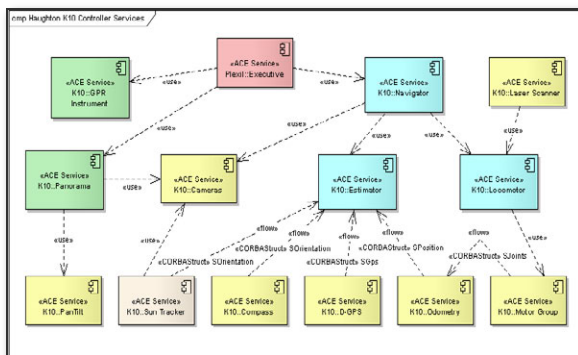
# IRG Open Source Software

**Vision Workbench**



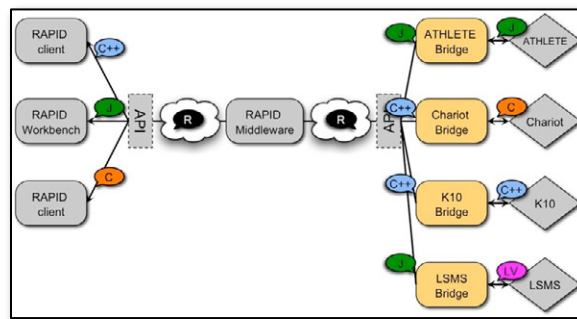
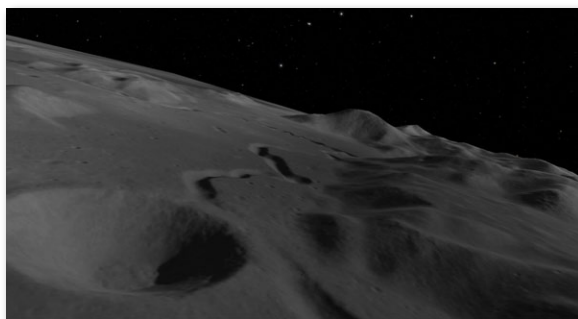
Exploration Ground Data Systems (xGDS)

**RoverSW**



Visual Environment for Remote Virtual Exploration (VERVE)

**Neo Geography Toolkit**  
(with Ames Stereo Pipeline)



**RAPID**  
(NASA robot middleware)



# Questions?



**Intelligent Robotics Group**  
Intelligent Systems Division  
NASA Ames Research Center

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