MARS EXPLORATION

Ginny Gulick

SST/CMEX/SETI Institute

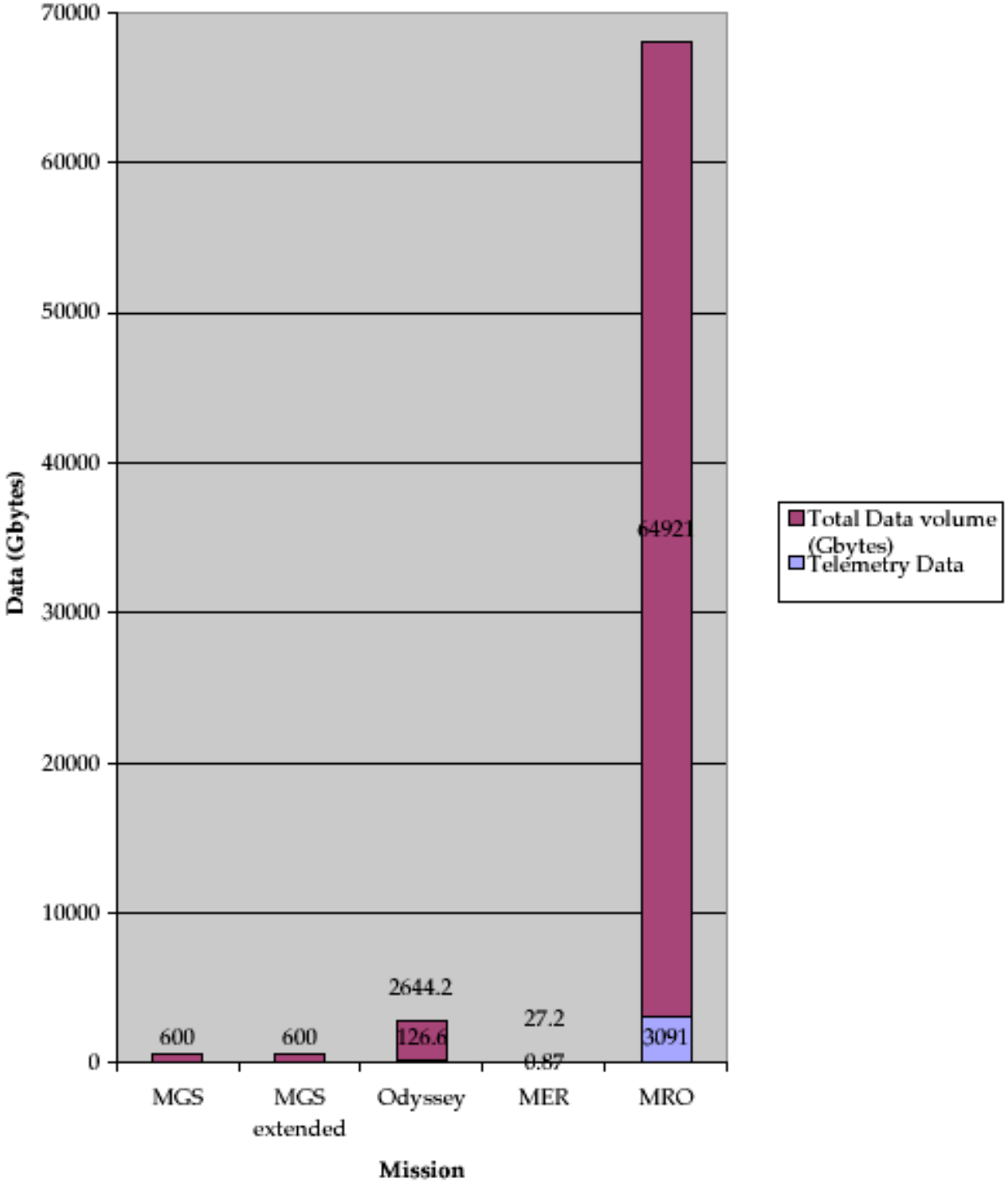
Geoff Briggs

S/CMEX

Glenn Deardorff

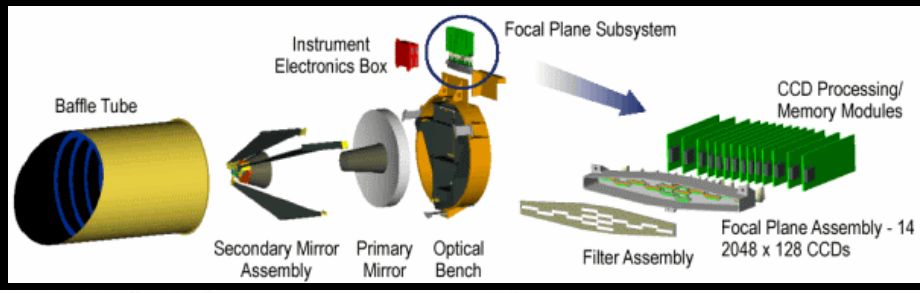
IN/AMTI

Expected Data Volumes from Mars Exploration Program missions

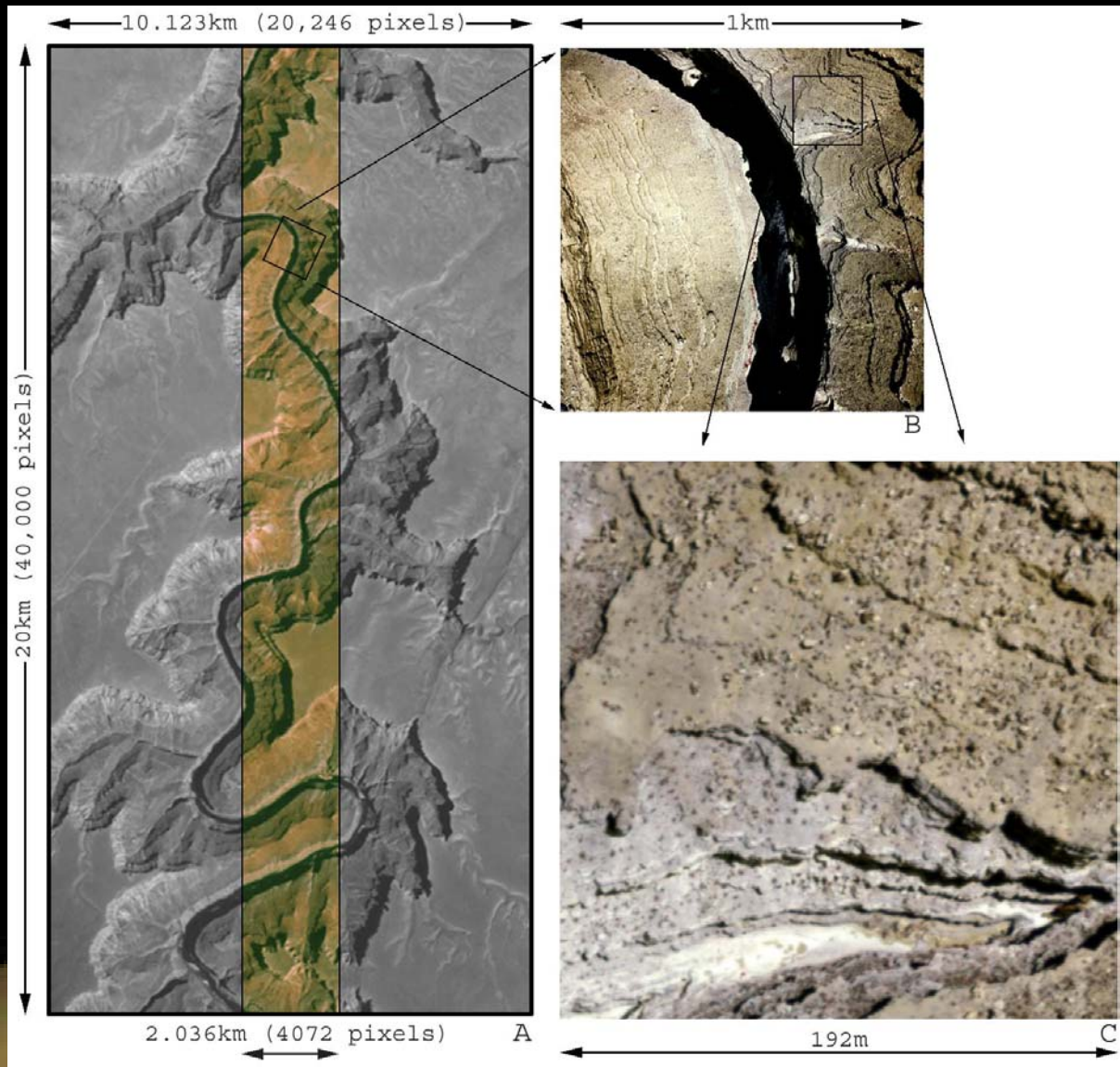


Nelson et al, 2001

MRO'05 HiRISE - The "People's Camera"



- HiRISE instrument will fly on the Mars Reconnaissance Orbiter 2005 mission
- Image sub-meter scale (beach-ball sized") features viewed in 1-2m/pixel context
- "Democratic", web-based targeting. Anyone can propose targets. Goal of 1 image/week for public.
- Images posted within days of arrival on ground
- **Marsoweb** will be modified to become **HiWeb**: the user-interface for science community & public to download & analyze data & submit image target requests.
- **Clickworkers** modules developed & incorporated into HiWeb E/PO to allow public participation in science analysis.



Project Data Volume Comparison

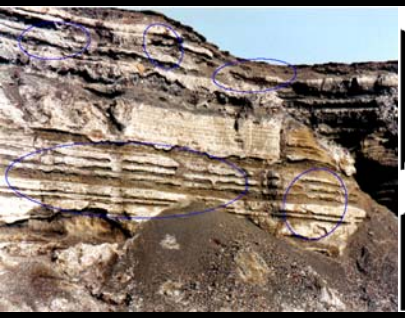
Areas of Potential SS & IT Collaborations

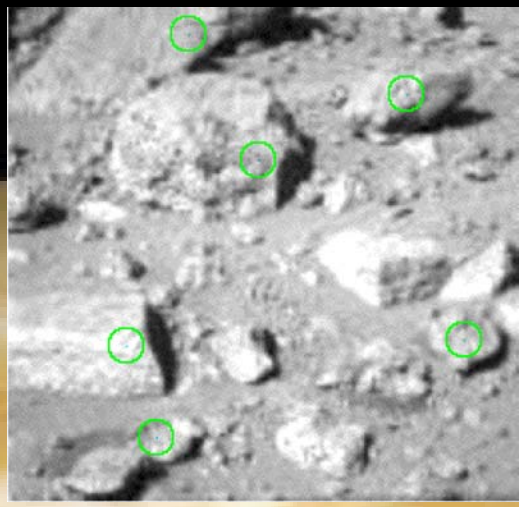
Onboard s/c:Data Acquisition, Collection and Downlink

- Onboard Data Analysis (?)
- Faster Onboard Image Compression
- Improve data downlink approach
- Improve model-data interface for decision making
  - Ability to quickly and easily input real data retrieved at particular locations and produce reliable predictions critical for mission planning (e.g., meso-scale wind models) and other applications.

Onboard Data Analysis

- Great in theory
- Large obstacles to adoption and inclusion on to a mission
  - Science community and Science PI
    - Want all the data returned
    - Skeptical that analysis algorithms will really work
    - Concern that interesting data will be thrown away
  - Project Engineers
    - Risk adverse attitude to incorporating algorithms with no heritage
    - CLARAty for '09-- remains to be seen how much science community will actually trust results from onboard science analysis techniques enough to use them instead of downloading raw data.





Geologist's Field Assistant

Project lead: V. Gulick

Project CoI's: J.Bishop (SSX), R.L. Morris & P. Gazis (SST), R. Alena & M. Sierhuis (IC)

Vision:

silicate, carbonate, or salt??

Obtain Image & spectral instrument data

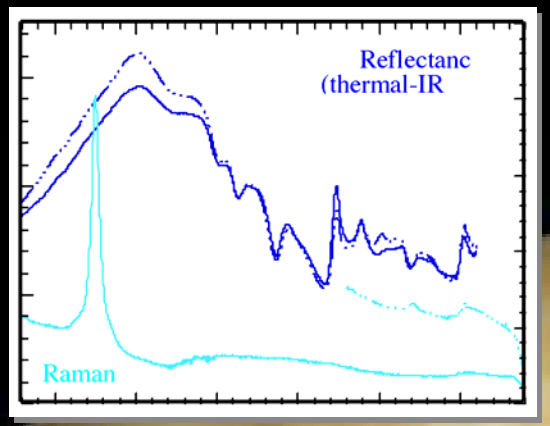


Image & spectral recognizers

Final Analysis = Hydrothermally-deposited rock containing silica

Reality: **Working Raman, VIS/NIR and IR spectral identifiers, image/spectral database, image texture/color identifiers, top level system in development.**

Faster Onboard Image Compression

Example: MRO HiRISE - the People's camera can acquire much more data than can be returned.

- Was planning to use ICER (in our proposal) ~5:1
  - Pro: a wavelet compression code similar to "a bare bones" JPEG2000
    - **Best for compressing images; good progressive error containment**
    - **Heritage --being used for MER (MER's expected data volume returned miniscule compared to MRO)**
  - Problem: ICER -too slow to compress HiRISE's images (~16.4Gbit full uncompressed image) using the onboard s/c processors (antiquated in comparison to the mass produced processors).
    - **Takes many hours to days to compress a single data downlink volume**
    - **Results in severe bottleneck in data volume downlink and unacceptable delays in acquiring new data.**
    - **Not able to meet Level 1 requirements**
- Now planning to use FELICS
  - Pro: Lossless compression ~2:1
  - Cons: Allows us to return much less data than desired
    - » Possibly still meet Level1 requirements
    - » Less vigorous public and science community image requests
    - » Less Science images requested by team returned
    - » MGS experience shows that project requests were 10x higher than expected
    - Packet loss issues

Areas of Potential SS & IT Collaboration cont'd

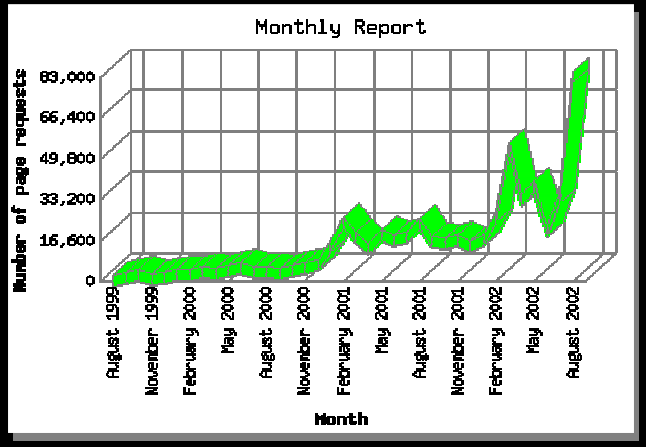
Returned data sets

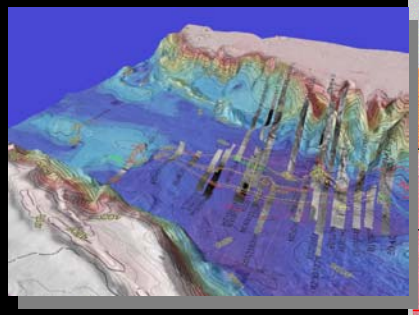
- Improve ability to quickly and easily inter-compare disparate data sets from various missions and from various sensor instruments.
  - e.g., Marsoweb (http://marsoweb.nas.nasa.gov)
  - Pigwad (http://webgis.wr.usgs.gov)

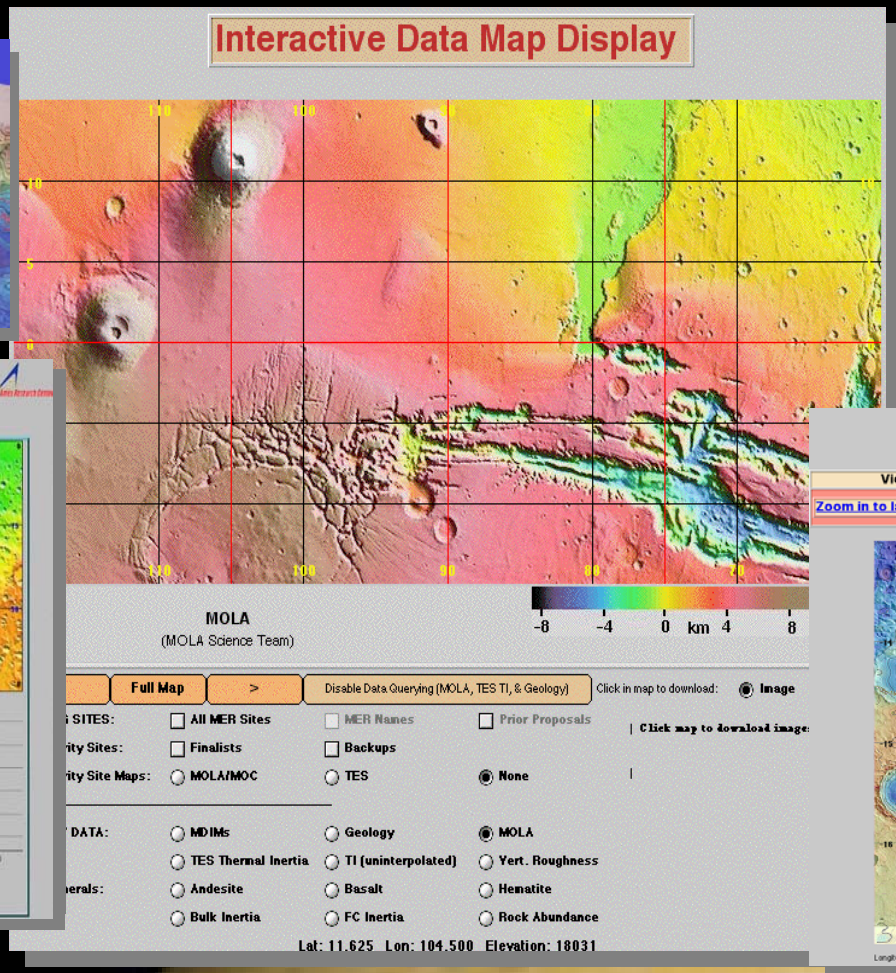
Marsoweb: A User-friendly Analysis and Visualization Web Environment for Mars Science Studies.

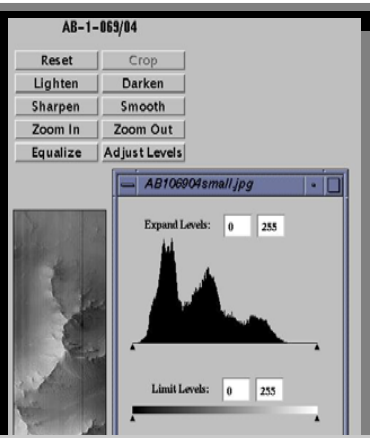
Project science lead: V. Gulick

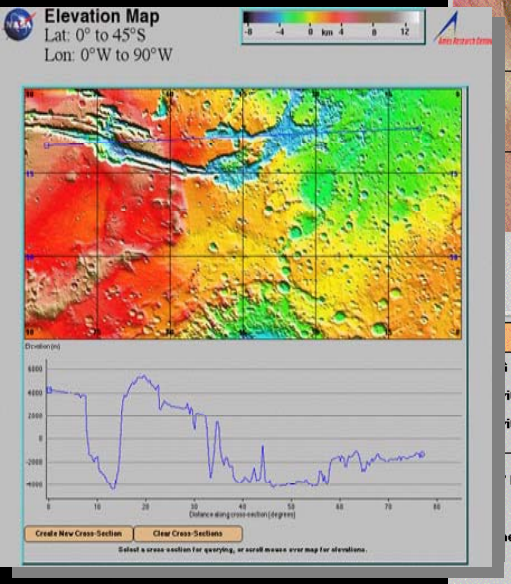
Technical lead: G. Deardorff

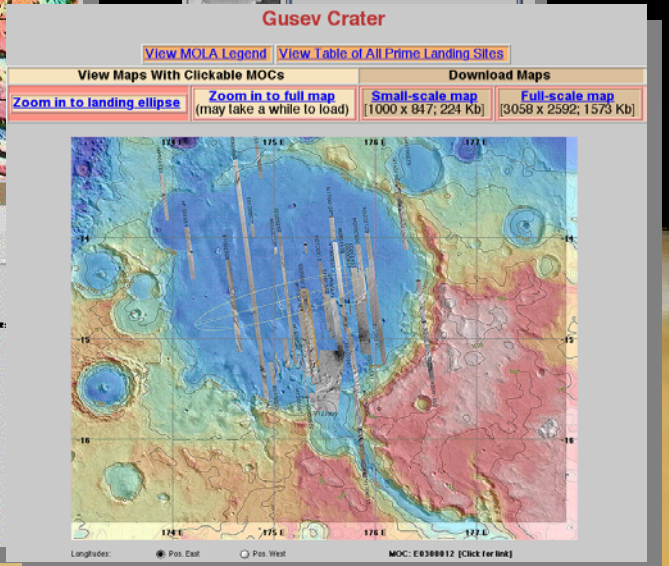












Interactive Data Map Display

DISPLAY DATA

Queriable Data

Disable Data Querying

- MDIM (Visible)
- Vert. Roughness
- TES Thermal Inertia
- Geology
- MOLA (Lo-Res)

TES Mineralogy

- Andesite
- Basalt
- Hematite

IRTM Data

(15N to 15S)

- Bulk Inertia
- Fine Comp. Inertia
- Rock Abundance

HYPERLINK OPTIONS

Enable MOC Images

Link to: Image Webpage

Render in: Black White

Enable MOLA Tracks

Enable Hi-Res MOLA

Enable Hi-Res MDIMs

(15N to 15S)

MER 2003 OPTIONS

(15N to 15S)

Landing Sites

Show All Candidate Sites

Show Top Priority Sites

Show Prior Proposals

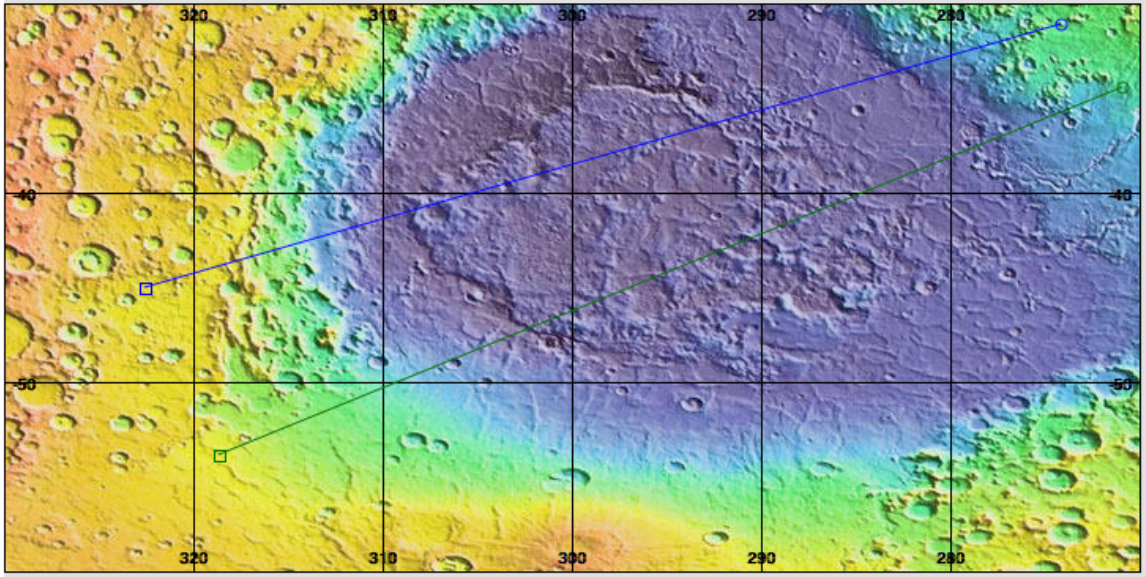
Show Site Names

Priority Site Maps

- Latest MOCs
- MOLA/MOC
- TES TI
- None

Scroll mouse over map for data values.

Lat: -57.583 Lon: 316.000 Elev: 399



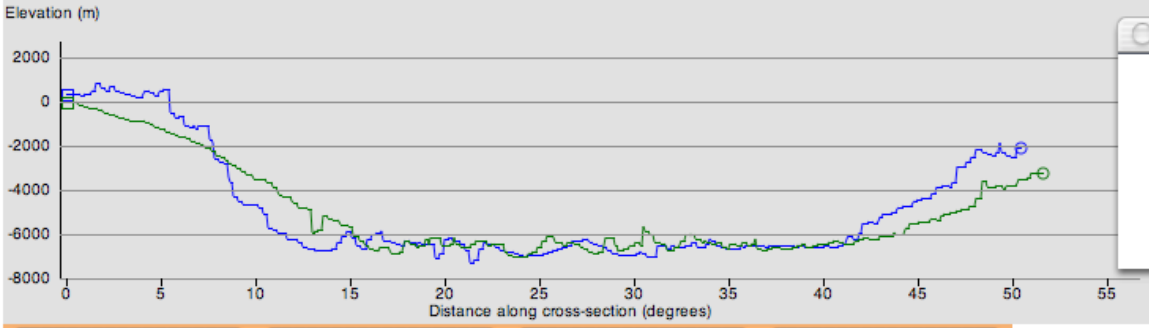
NAVIGATION

NW N NE

W E

SW S SE

Global Map



MOLA Elevations – Netscape

MOLA Elevations

-8 -4 0 km 4 8 12

MOLA Science Team

Create Cross-Section | **Clear Cross-Sections** | **Display Point List (short)** | **Display Point List (long)**

Plans for Marsoweb

- Continue to support Mars landing site selection process through MER'03, MSL'09 and beyond.
- Continue expanding Marsoweb to include data covering all of Mars.
- Add new data from all Mars missions as it becomes available.
- Modify existing analysis & visualization tools to incorporate new data.
- Develop new tools to analyse new data sets*
- Develop seamless, user-friendly interface to analyse and inter-compare terrestrial analog sites with Mars sites using a variety of sensor data and at a variety of resolutions.*

*Denotes areas of particular need for potential collaboration

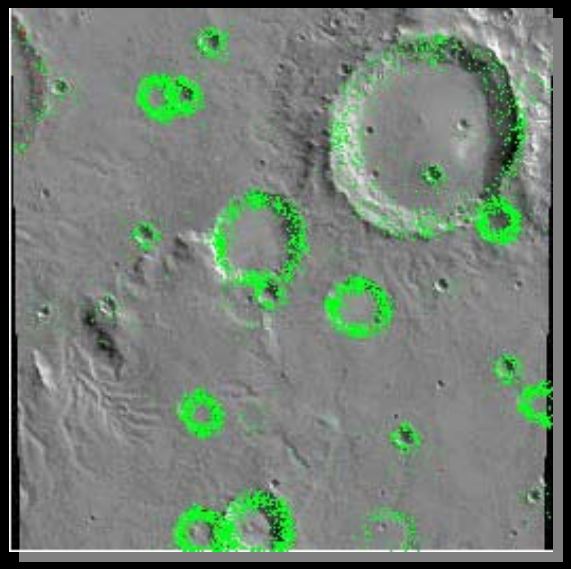
Areas of Potential SS & IT Collaborations (cont'd)

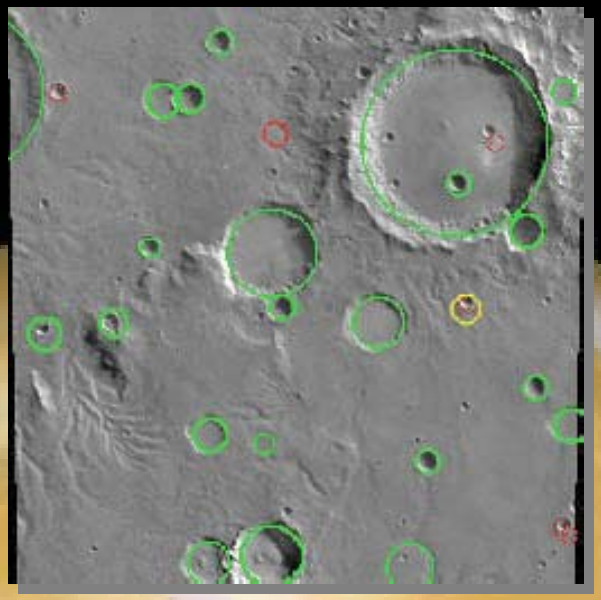
- Improve MEP mission & instrument E/PO efforts
  - Why?
    - Important to involve the public in the science they pay for
    - Educate the next generation - They are the future taxpayers & source of funds for future missions.
  - What can we do?
    - Develop the technology to allow participation from a wider audience
    - Form SS & IT collaborations with educators to develop innovative ways to capture & harness students and the public interest & participation.
  - Examples of successful SS/IT collaborations applied to E/PO
    - Marsoweb (marsoweb.nas.nasa.gov) -HiRISE E/PO
    - Clickworkers (clickworkers.arc.nasa.gov) -HiRISE E/PO
    - Mars Student Imaging Project (MSIP) -THEMIS E/PO effort, etc…
  - MRO - HiRISE

Clickworkers

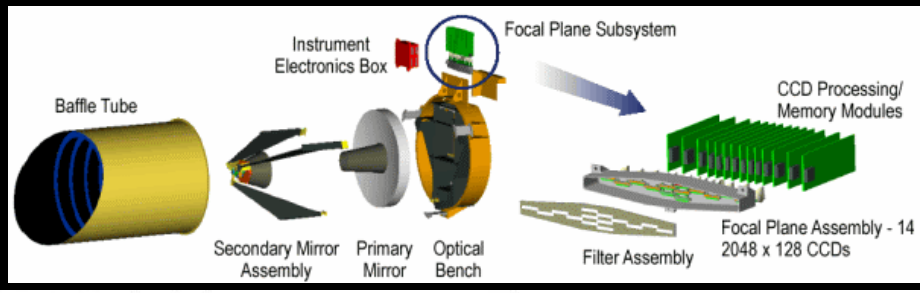
HiRISE E/PO Collaborator: B. Kanefsky, Ames/Code IC

- Goal:
  - Harness volunteer interest in space science **(clickworkers.arc.nasa.gov)**
  - Produce scientifically useful data
- Tested crater marking and identification
  - 80,000+ people participated
    - 1.8 million Viking craters marked
    - 52,000 MOC images marked average 2.1 times
  - Cross checking results yields excellent quality
- Widespread public interest
  - New York Times
  - Discovery Channel, etc.
- Will deploy for HiRISE E/PO
  - Allows public to actively participate in mission science they pay for
  - Feature marking (e.g. crater or boulder database) or data validation

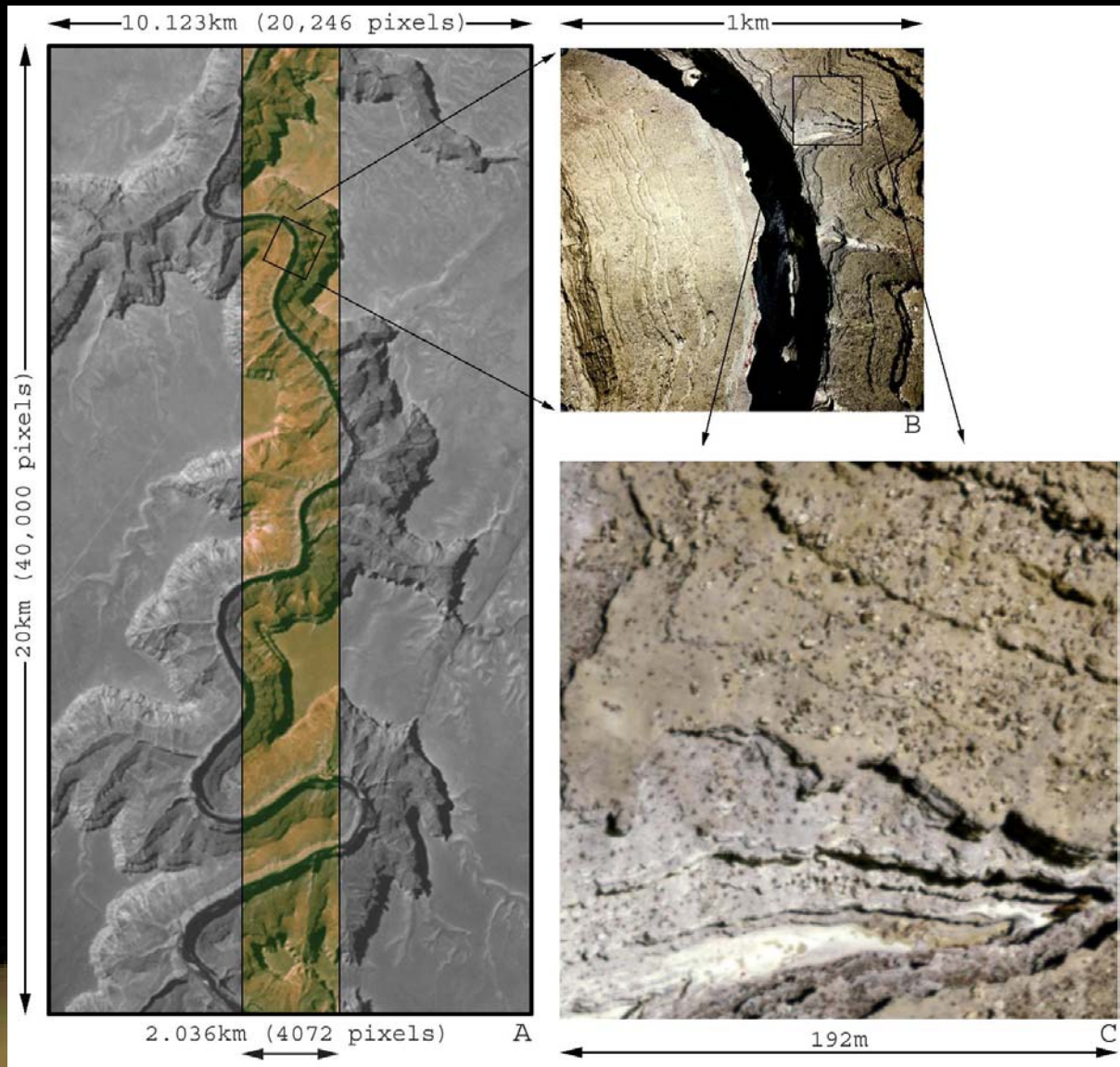




MRO'05 HiRISE - The "People's Camera"



- HiRISE instrument will fly on the Mars Reconnaissance Orbiter 2005 mission
- Image sub-meter scale (beach-ball sized") features viewed in 1-2m/pixel context
- "Democratic", web-based targeting. Anyone can propose targets. Goal of 1 image/week for public.
- Images posted within days of arrival on ground
- **Marsoweb** will be modified to become **HiWeb**: the user-interface for science community & public to download & analyze data & submit image target requests.
- **Clickworkers** modules developed & incorporated into HiWeb E/PO to allow public participation in science analysis.



Extra viewgraph

Fact Sheet

HiRISE — The High Resolution Imaging Science Experiment

HIGHLIGHTS

- Unprecedented image quality, resolution, coverage
- Emphasis on future landing sites
- Panchromatic and color images
- Heritage from Quickbird, Deep Impact, and HST
- Clearly defined descope options in all phases
- Ample margins in mass, power, cost, and schedule

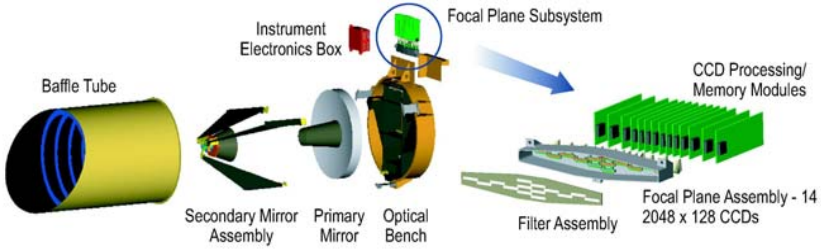
HiRISE PHILOSOPHY: *"The People's Camera"*

- Close interaction with MRO project and investigations
- Entire science community invited to participate in targeting and science analysis
- Science team with diverse expertise and distributed locations
- Automated processing and web release of all images within a few days or weeks
- Web-based targeting and analysis tools

SCIENCE

Understand the geologic and climatic processes and history of Mars, including origins, relative ages, and distributions of:

- Channels and valleys
- Former lakes or oceans
- Recent gullies
- Sedimentary and other layers
- Volcanic landforms
- Glacial and periglacial landforms
- Hydrothermal alteration
- Eolian and polar deposits
- Near-surface crusts and horizons



IMAGING

Altitude	Pixel Scale	Red FOV	Blue-Green & NIR FOVs
200 km	25 cm/pix	5 km	1 km
400 km	50 cm/pix	10 km	2 km

DATA COLLECTION

Image Size	20 K x 40 K (red), 4 K x 40 K (blue-green and NIR)
Exposure	Up to 128 lines Time Delay and Integration (TDI)
Memory	28 Gbit available (16.4 Gbit holds full uncompressed image)
Compression	14 to 8 bit; commandable N x N summation, ICER wavelet
Data Rate to S/C	20 Mbits/sec

DETECTORS

#	Color	Bandpass	Full Width	Typ SNR
2	Blue-Green	400-600 nm	4,072 pix	100:1
10	Red	550-850 nm	20,264 pix	200:1
2	Near-IR	800-1000 nm	4,072 pix	100:1

DESIGN PARAMETERS

Telescope	
Aperture	0.5 m
Field of View	1.43° x 0.1°
Effective Focal Length	9.6 m
Mass	
Telescope Optics	10.0 kg
Telescope Structures	13.6 kg
Focal Plane System	2.3 kg
Instrument Electronics Box	3.6 kg
Cabling	1.2 kg
40% Contingency and Margin	9.3 kg
TOTAL	40.0 kg
Dimensions	
Telescope	113 cm x 59 cm dia.
Instrument Electronics Box	16 x 15 x 7 cm
Power	
Imaging	<125 W Peak
Processing	<40 W
Max Orbit Average	50 W

HiRISE — The High Resolution Imaging Science Experiment

Gullies

Boulders

Layers

Dunes

Polar Layers

OBSERVING STRATEGIES

- Target planning with other MRO experiments
- Hundreds of full-resolution 20 K x 40 K pixel images
- Color images up to 4,072 pixels wide, sub-meter scales
- Thousands of high-resolution sub-scenes with 1-2 m/pixel context
- Hundreds of stereo pairs; production of Digital Elevation Models (DEMs)
- Repeat coverage for active processes

MAJOR EMPHASIS ON E/PO

- Public and student participation in targeting and image analysis
- Near real-time large-screen image displays at Smithsonian and LPL
- Special programs at minority institutions
- All Co-Investigators active in local efforts

TECHNOLOGY TRANSFERS

In from commercial high-resolution telescope development and testing.

Out for commercial sensing applications

- Custom TDI CCD
- CCD processing/memory module
- Web-based tools for interactive user interface

SCHEDULE

- Mirror blanks will be available at start of project to minimize schedule risk for this critical path item
- Functional Requirements Document written and ICD drafted
- Mirror fabrication and CCD procurement to start 11/1/01, as soon as project funded, to minimize schedule risks
- Electronics breadboard during Phase A/B
- Project reviews scheduled in accordance with the PIP
- Instrument completion 1/29/04, gives 3-month slack (required by 4/04)
- Ready for August 2005 launch

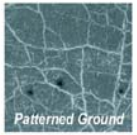
TEAM ROLES AND RESPONSIBILITIES

Principal Investigator	Alfred McEwen	LPL, University of Arizona
Project Manager	Alan Delamere	Ball Aerospace
Deputy PI and Flight Operations	Candice Hansen	JPL
Manager of LPL Ground Operations	Eric Eliason	USGS
E/PO and Web Technology Lead	Virginia Gulick	NASA Ames/SETI Institute
Calibration Lead	Ken Herkenhoff	USGS
European Operations	Nick Thomas	Max Planck Institute Für Aeronomie
Geodesy and DEM Production	Randy Kirk	USGS

COORDINATION AND PRIORITIZATION OF OBSERVATIONS

Landscape Evolution	John Grant	Smithsonian Institution
Fluvial Processes	Virginia Gulick	NASA Ames/SETI Institute
Seasonal Processes	Candice Hansen	JPL
Polar Geology	Ken Herkenhoff	USGS
Volcanism	Laszlo Keszthelyi	LPL/U. Hawaii
Periglacial, Glacial, and Regolith Processes	Mike Mellon	University of Colorado
Future Exploration	Steve Squyres	Cornell University
Layering Processes and Stratigraphy	Cathy Weitz	PSI

Channels


Patterned Ground

Craters

Lava Flows

Polar Terrain

A8950