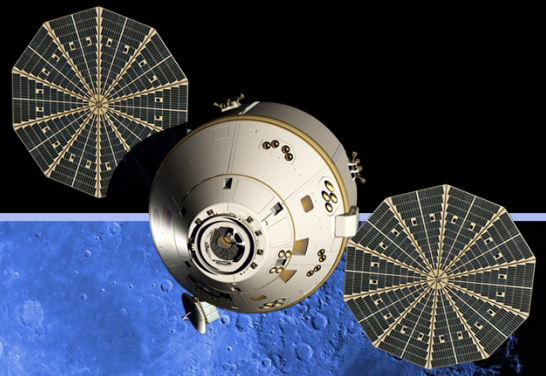
National Aeronautics
and Space Administration
Jet Propulsion Laboratory
California Institute of Technology



Constellation, ESMD and JPL

- An Update

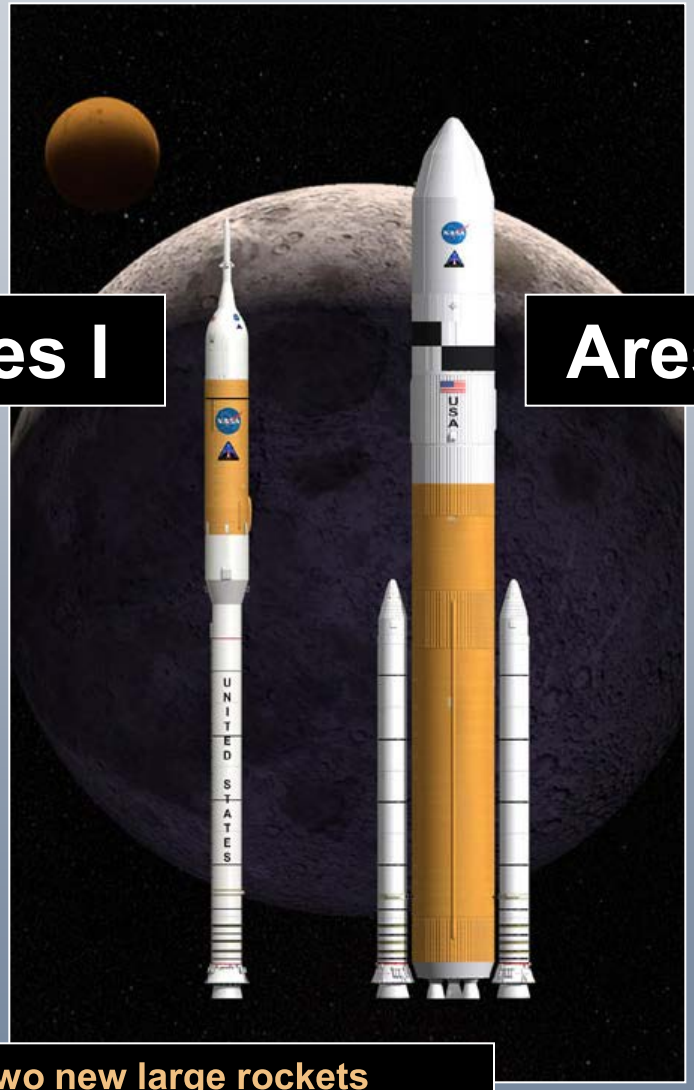
September 17, 2009

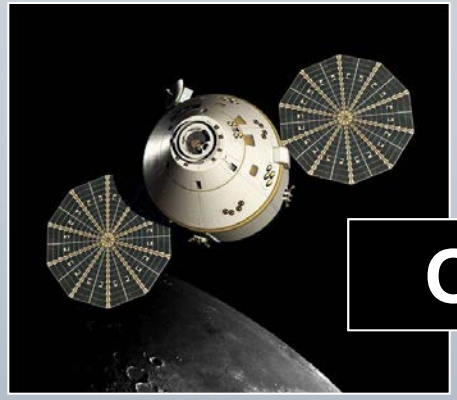
Mike Sander
Manager, Exploration Systems and Technology Office

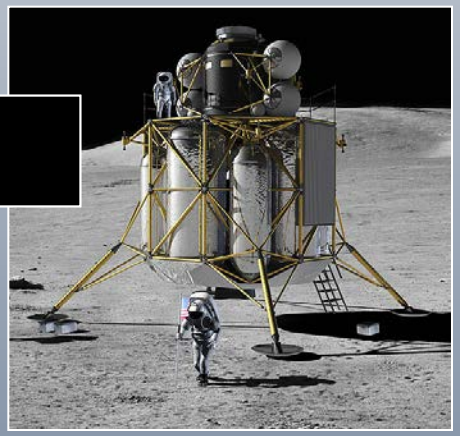
What is in ESMD?

- **Constellation Program**
- Advanced Capabilities Program
- Lunar Precursor Robotics Program

What is Constellation?







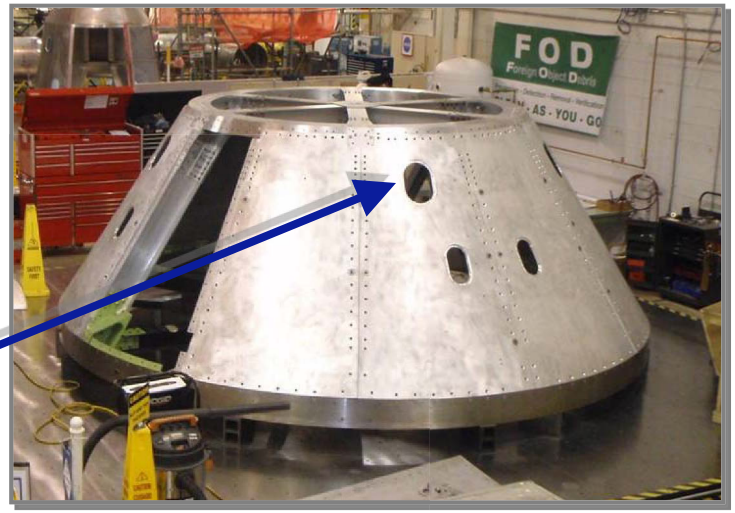
Ares-I and Ares-V Size Comparison

Exploration Systems & Technology Office

Orion Crew Module / Launch Abort System (CM/LAS) Simulator

LAS Tube Assembly

LAS Party Hat



Crew Module

DFI Access Covers

CM/LAS 70' Transport Vehicle in Hangar

LAS Nozzle Assembly

Upper Stage Simulator (USS)

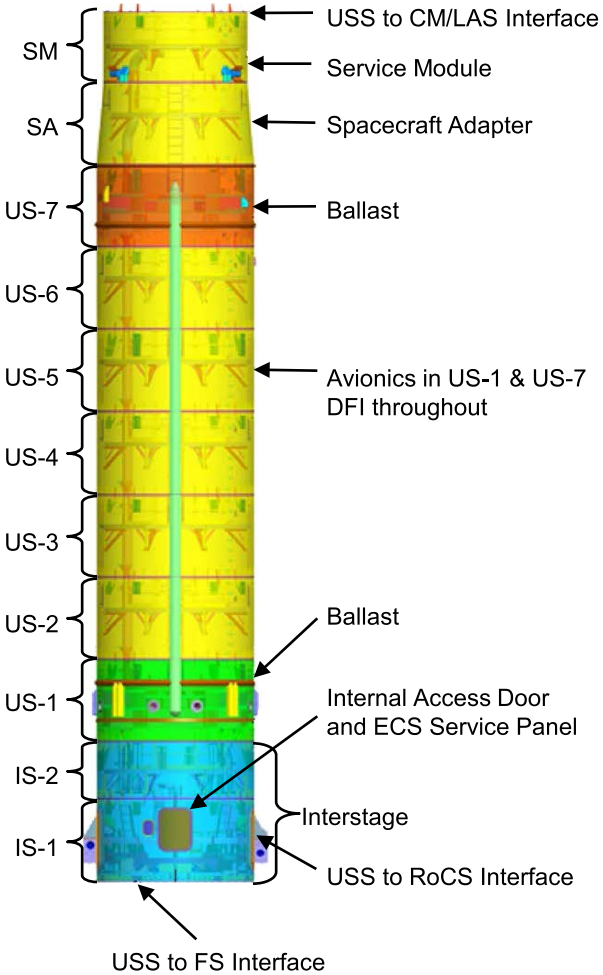
Flange Machining

Support Welding

Super Stack

Interstage 1

Dummy Ullage Motors



Upper Stage Simulator (USS) *cont.*

IS1/IS2 Mate for Drilling

Inside a USS Segment

Ballast Plates Loaded onto Truck

Segments Wrapped for Shipment

Segment loaded onto the *Delta Mariner*

Segment Transported by Truck

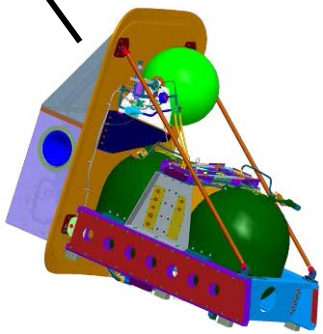
Roll Control System (RoCS)

Three RoCS Assemblies

Test Rig for RoCS Helium Relief Valve & Regular Function Tests

RoCS IS-1 Lap Joint Stress Test at LaRC

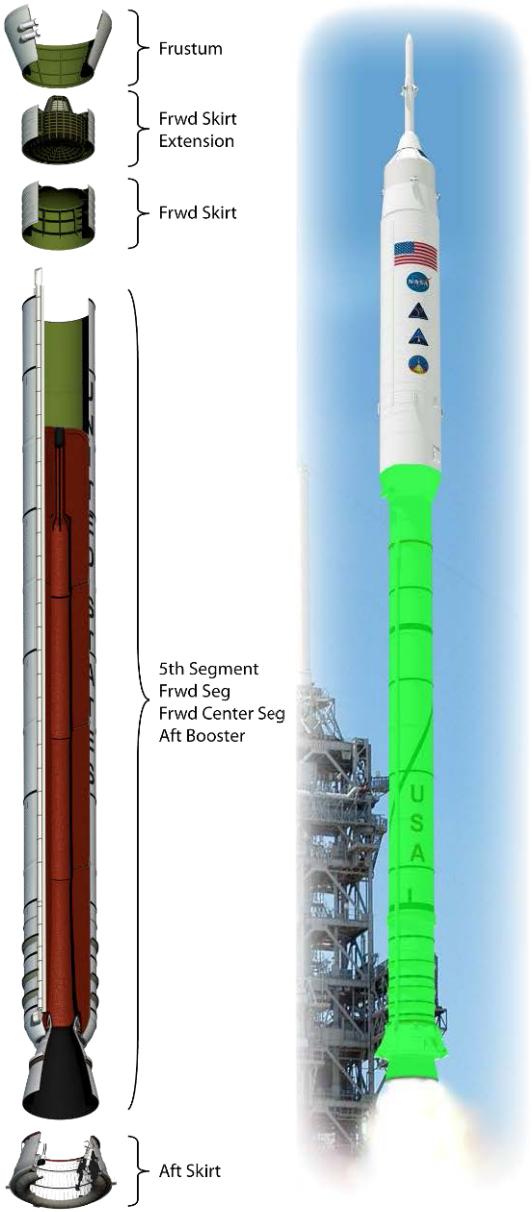
Welded Safety Caps on Tank Vent Valves



First Stage

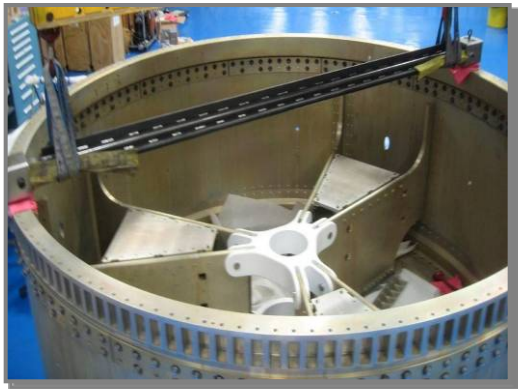
Main Chute Packing

Forward Skirt



Constellation, ESMD and JPL

Aft Skirt at the ARF



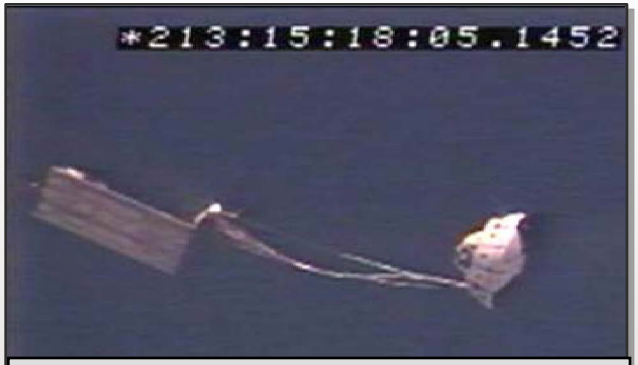
FSE Reassembly

Forward Skirt Extension Reassembly

Exploration Systems & Technology Office

Cluster Development Test 2

Actual Test Sequence

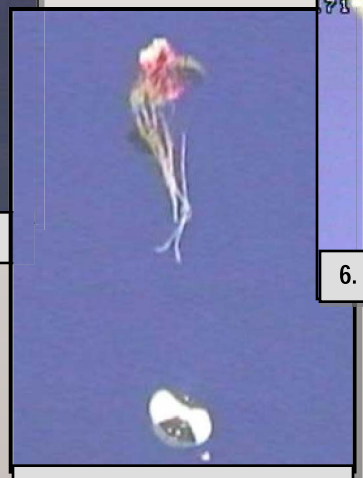


1. Good Extraction and Separation

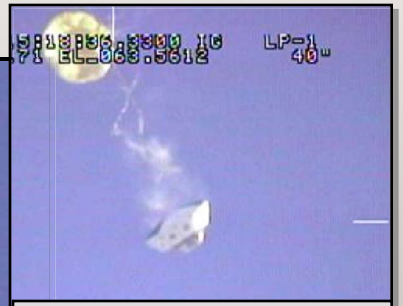
2. Programmer Inflation

3. Large Limit Cycle

4. Programmer Collapse



5. Programmer Release
Drogue Deploy



6. Drogue Risers Severed

7. Free Fall

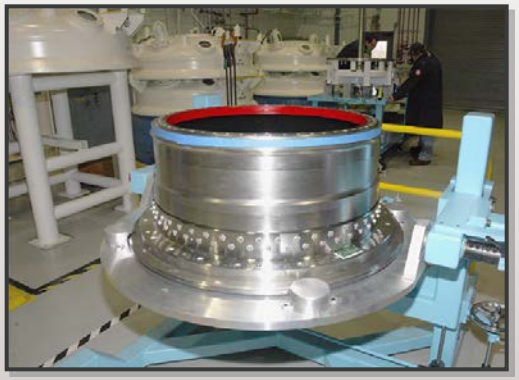
8. Flagging Main

9. Impact

Launch Abort System Propulsion

Jettison Motor (JM) – Aerojet

- DM-2 Static Test (July 17, 2008)
- SDU Inert Cast/Cure



SDU Case

SDU Core

DM-2 Static Test

Pad Abort-1 **Crew Module Integration**

Dryden Flight Research Center

Crew Module **Move to DFRC Mass Properties Lab**

Weight and Balance Set-up & Testing

Operations & Checkout Facility

What is in ESMD?

- Constellation Program
- **Advanced Capabilities Program**
- Lunar Precursor Robotics Program

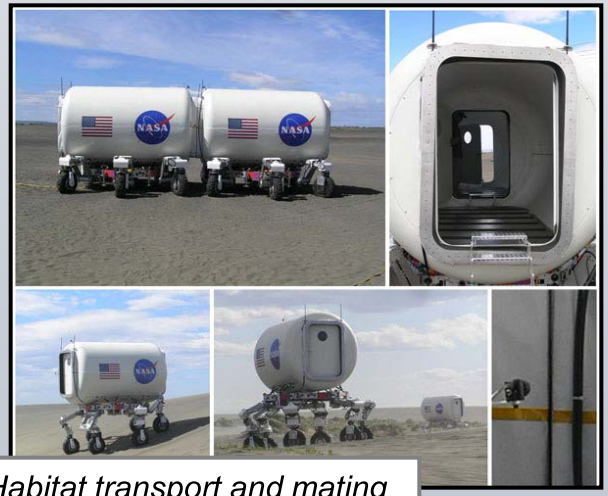
Exploration Technology Development Program (ETDP) Project Highlights

- **ATHLETE Project**
- **Autonomous Landing and Hazard Avoidance Technology (ALHAT) Project**
- **Advanced Environmental Monitoring & Control (AEMC) Project**

ATHLETE

Moses Lake, WA, June 2-11, 2008:
A Human-Robotics System project-wide field demonstrated new ATHLETE-based capabilities and integrated operations of all project vehicles in both the field and from a JSC remote command site.

JSC Chariot, ARC K10 (onboard Chariot) and the two ATHLETE robots at the Moses Lake, WA, field trial site



Habitat transport and mating

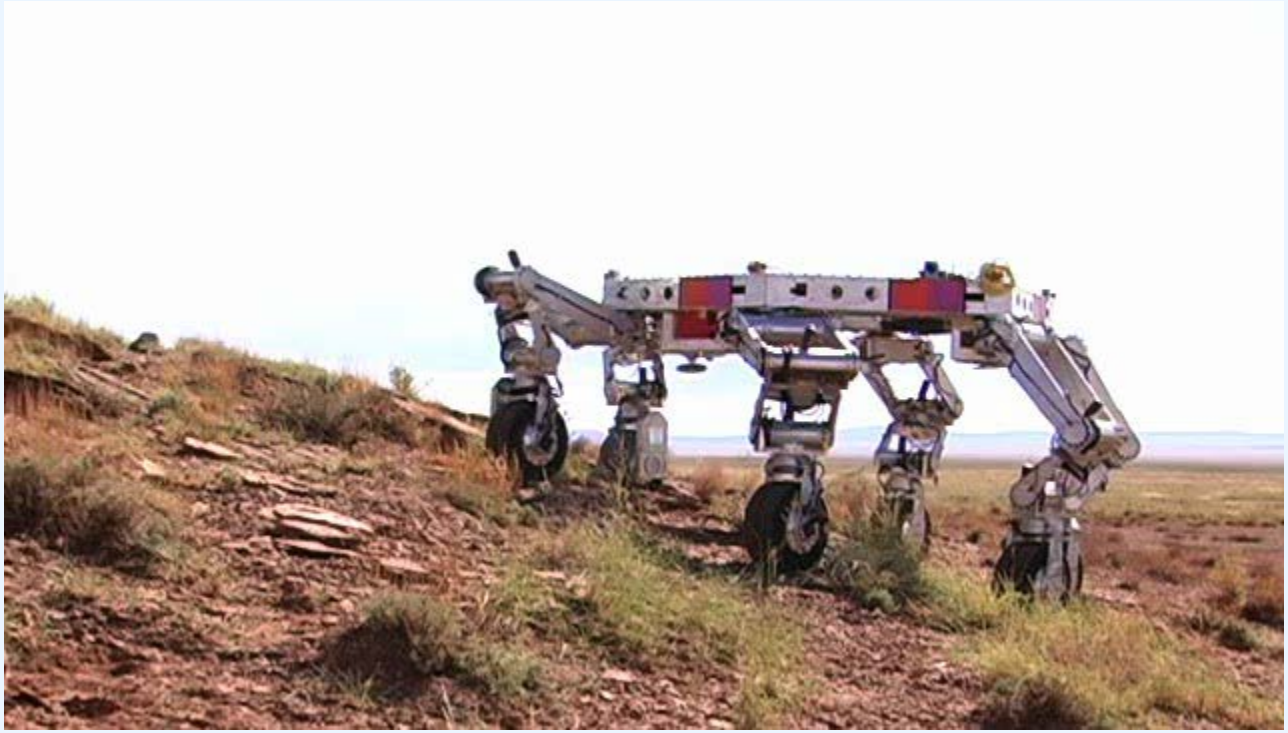
Accomplishments

- Traversed over "lunar like" terrain as much as a mile in a single traverse
- Docking of the two ATHLETE-transported habitat mockups

ATHLETE at Moses Lake

Moses Lake, WA, June 2-11, 2008:

ATHLETE at Moses Lake



Tri-ATHLETE

Exploration Systems & Technology Office

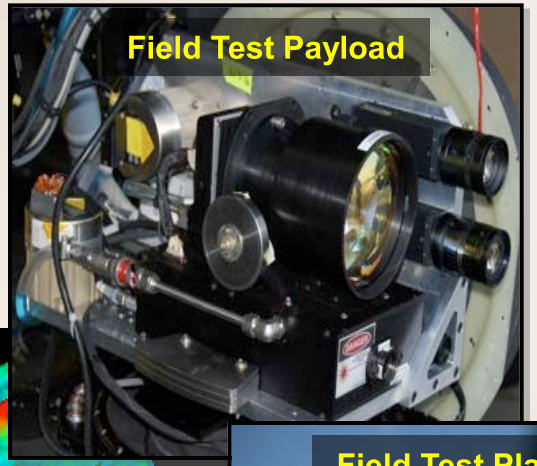
Autonomous Landing and Hazard Avoidance Technology (ALHAT) Project

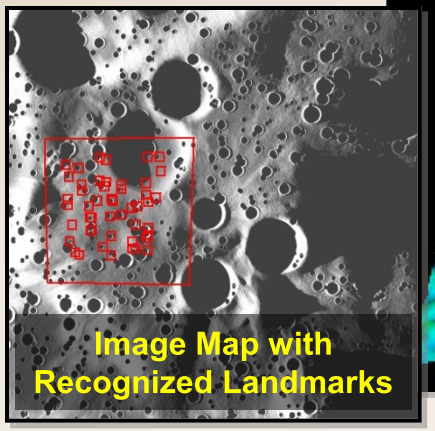
ALHAT FUNCTIONS

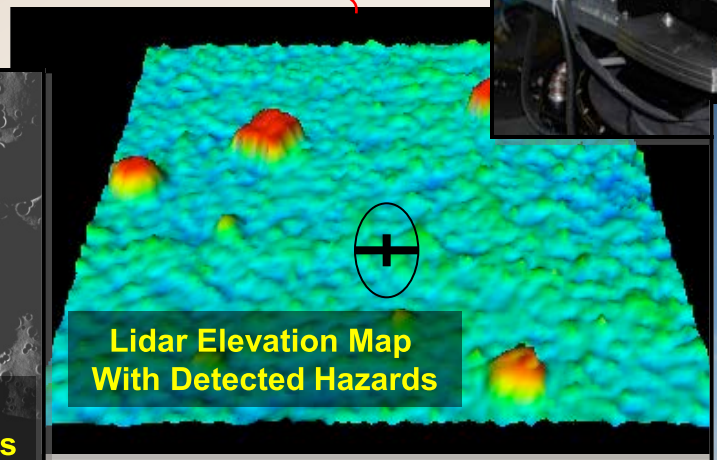
Terrain Relative Navigation

Hazard Detection and Avoidance

Hazard Relative Navigation





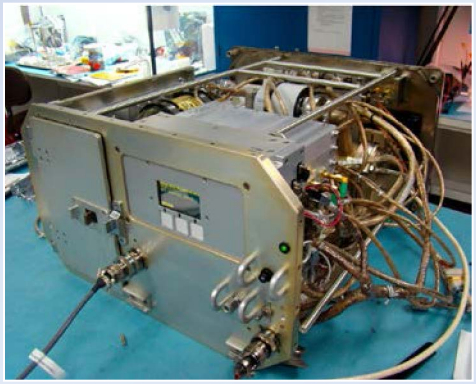


- **ALHAT Objective**
  - Precise and safe landing anywhere on the moon under any lighting condition (30-meter, 1-σ)
- **JPL Lead Responsibility**
  - Algorithms for Terrain-Relative Navigation and Hazard Avoidance
  - Field test system for ALHAT sensors and algorithms

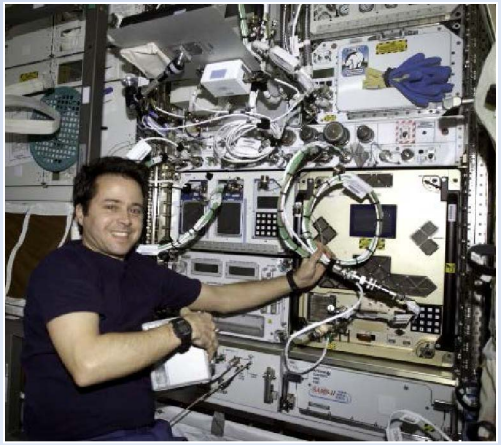
Exploration Systems & Technology Office

Advanced Environmental Monitoring & Control (AEMC) Project

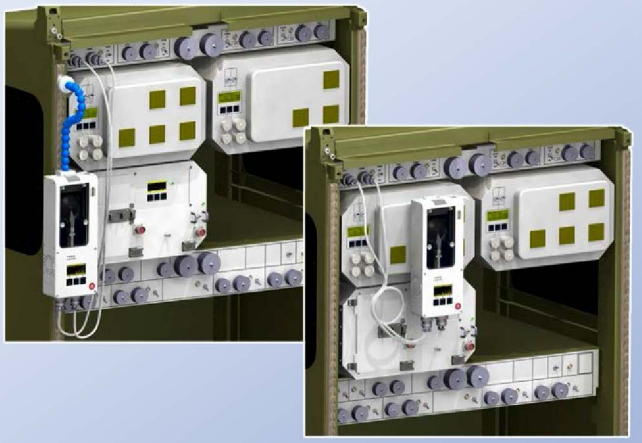
Electronic Nose (ENose)
To ISS Nov 2008,
Returned Sept 2009



Vehicle Cabin Atmosphere Monitor (VCAM)
Launch March 2010



Express Rack in ISS Destiny Lab



Depictions of ENose and VCAM mounted in Express Rack

What is in ESMD?

- Constellation Program
- Advanced Capabilities Program
- **Lunar Precursor Robotics Program**

LPRP

Lunar Precursor Robotic Program (LPRP) led by MSFC

- Lunar Reconnaissance Orbiter (LRO) now in orbit around the Moon. Providing unprecedented imaging, lidar and resource mapping
- Lunar Crater Observation and Sensing Satellite (LCROSS) – secondary payload to impact lunar dark crater to expose theorized volatiles in cold traps
- Lunar Mapping & Modeling Project (LMMP) – will provide maps, models and web-based access to georegistered images, topo maps, hazard maps, etc. for Constellation Project
- Lunar Advanced Science and Engineering Research (LASER) – a set of competed science and engineering tasks
- Other mapping projects such as lunar radar topography and Kaguya gravity model

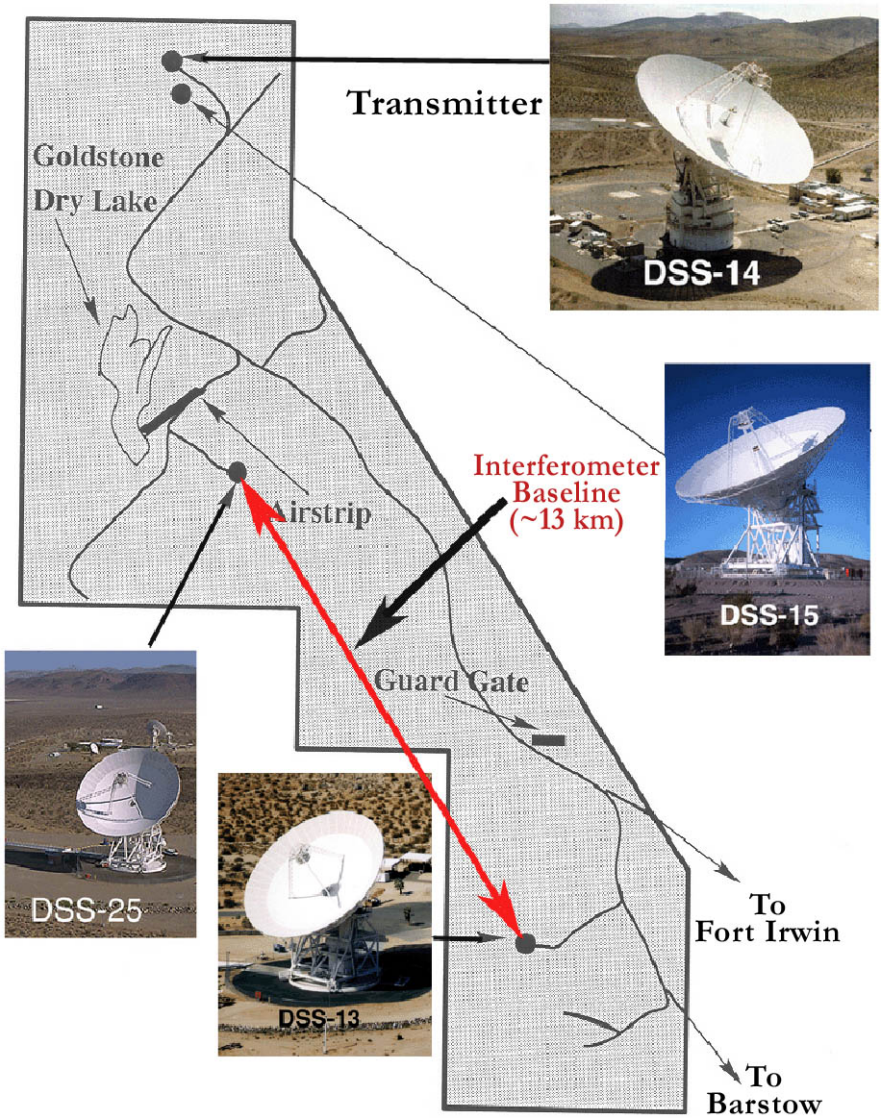
LPRP – JPL Engagement

- **LRO**
  - Diviner instrument for characterizing delivered and integrated. Will map global thermal environment and silicate mineralogy, identify polar cold traps, and assess rock abundances at landing sites
- **LCROSS**
  - JPL supporting navigation for impact into lunar dark crater
- **Lunar Mapping & Modeling Project**
  - Supported project formulation
  - Roles in system engineering, infrastructure and maps
- **LASER**
  - Co-I role in task to assess rocket plume cratering

LPRP – JPL Engagement

- **Lunar Radar**
  - Radar interferometry using Goldstone DSN antennas generated the best topography map of the lunar South Pole region
    - 3-m height accuracy, 40-m posting
  - Preliminary data distributed to ~ 50 ESMD planners with time-critical needs, >100 already requested final product - expected in January
  - System upgrade funded and underway to achieve 6-m imaging and topo map with 20-m posting
- **Support to planning activities**
  - Lander and instrument planning

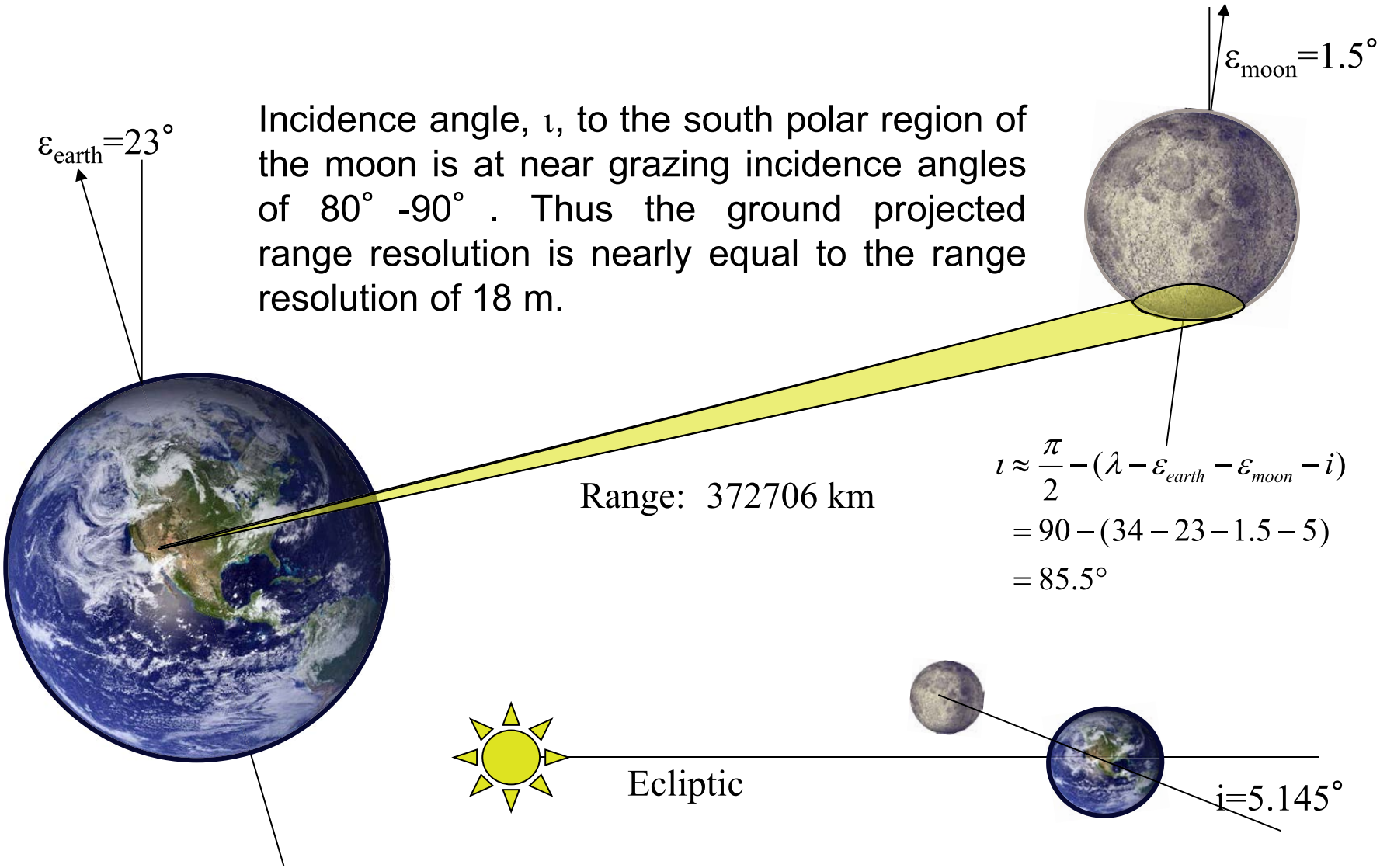
The Goldstone Solar System Radar (GSSR)



- **A unique NASA facility for high-resolution ranging and imaging of planetary and small-body targets**
  - 500 kW X-band (3.5 cm) transmitter
  - Very sensitive maser receiver
  - Two receiving antennas for interferometry
- **Leverages DSN assets**
  - Deep Space Network (DSN) primary function is communication and navigation for space missions beyond low Earth orbit
- **Provides a wide variety of information**
  - Simultaneous, co-registered radar image and topography without need of sunlight
  - Surface characteristics, structure and composition
  - Orbits, rotations, spin axis
  - Cover of Science twice in last 2 years

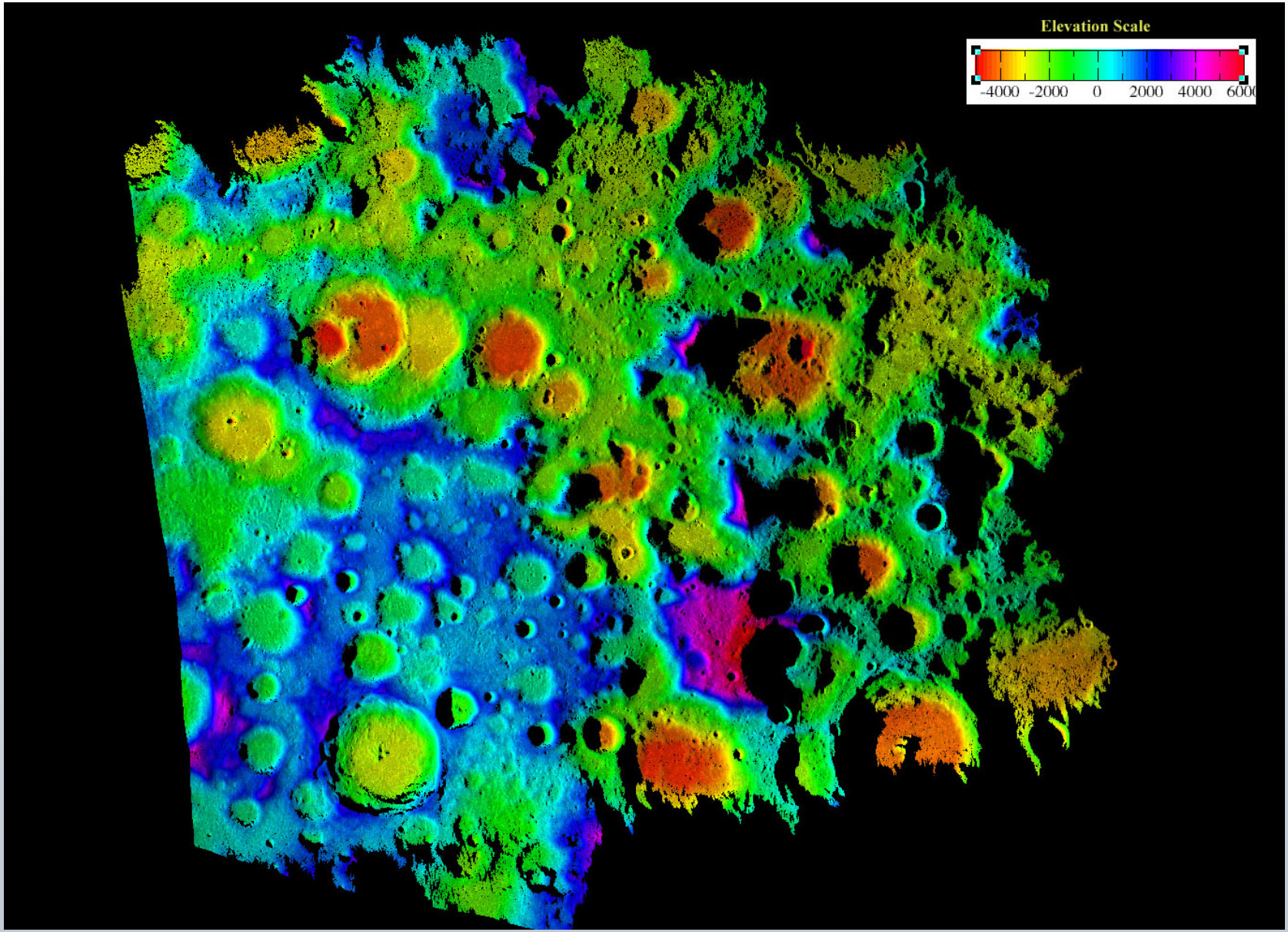
GSSR Lunar Imaging Geometry

Incidence angle, ι, to the south polar region of the moon is at near grazing incidence angles of 80° -90° . Thus the ground projected range resolution is nearly equal to the range resolution of 18 m.

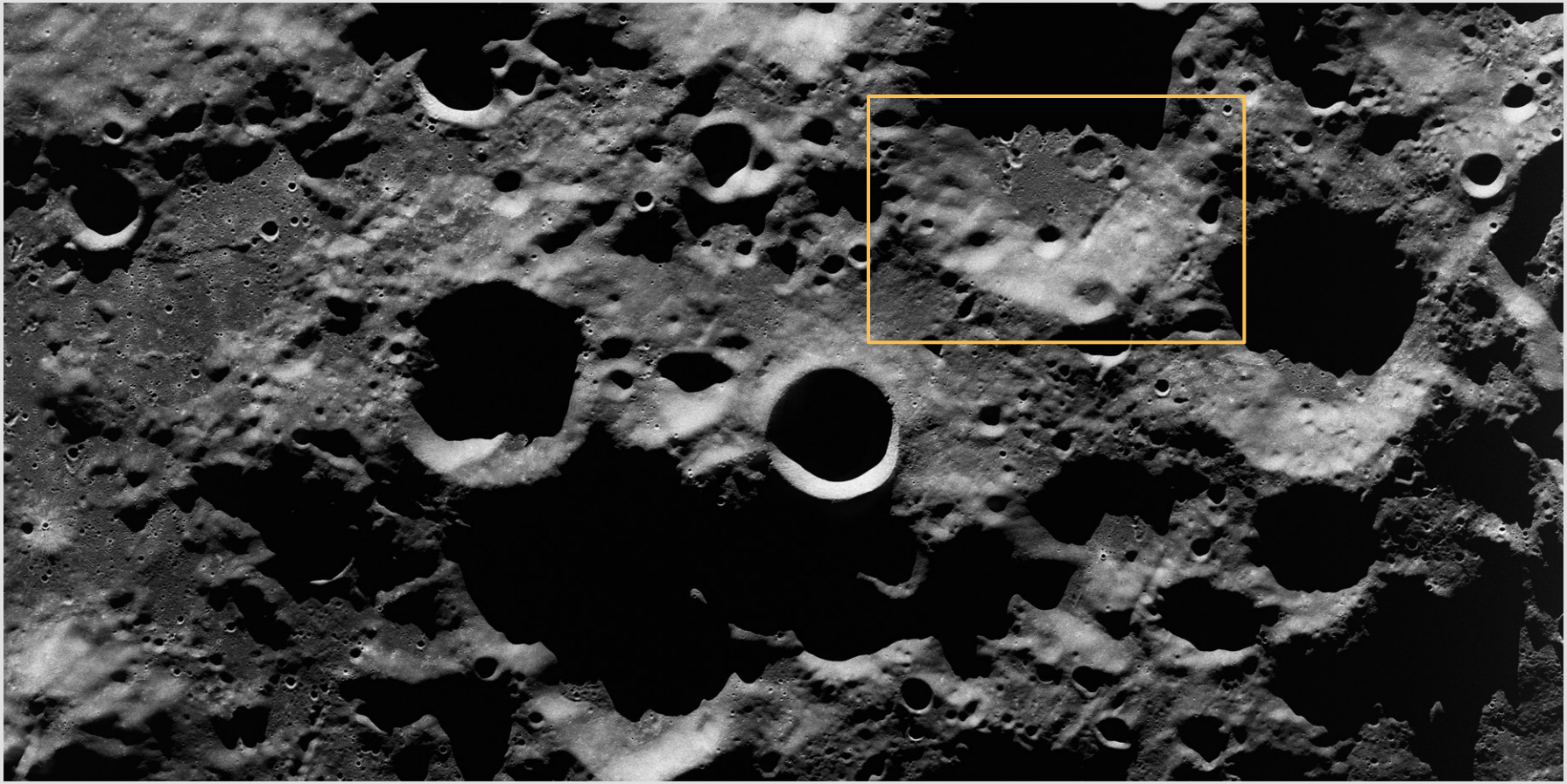


$$\iota \approx \frac{\pi}{2} - (\lambda - \varepsilon_{earth} - \varepsilon_{moon} - i)$$
$$= 90 - (34 - 23 - 1.5 - 5)$$
$$= 85.5°$$

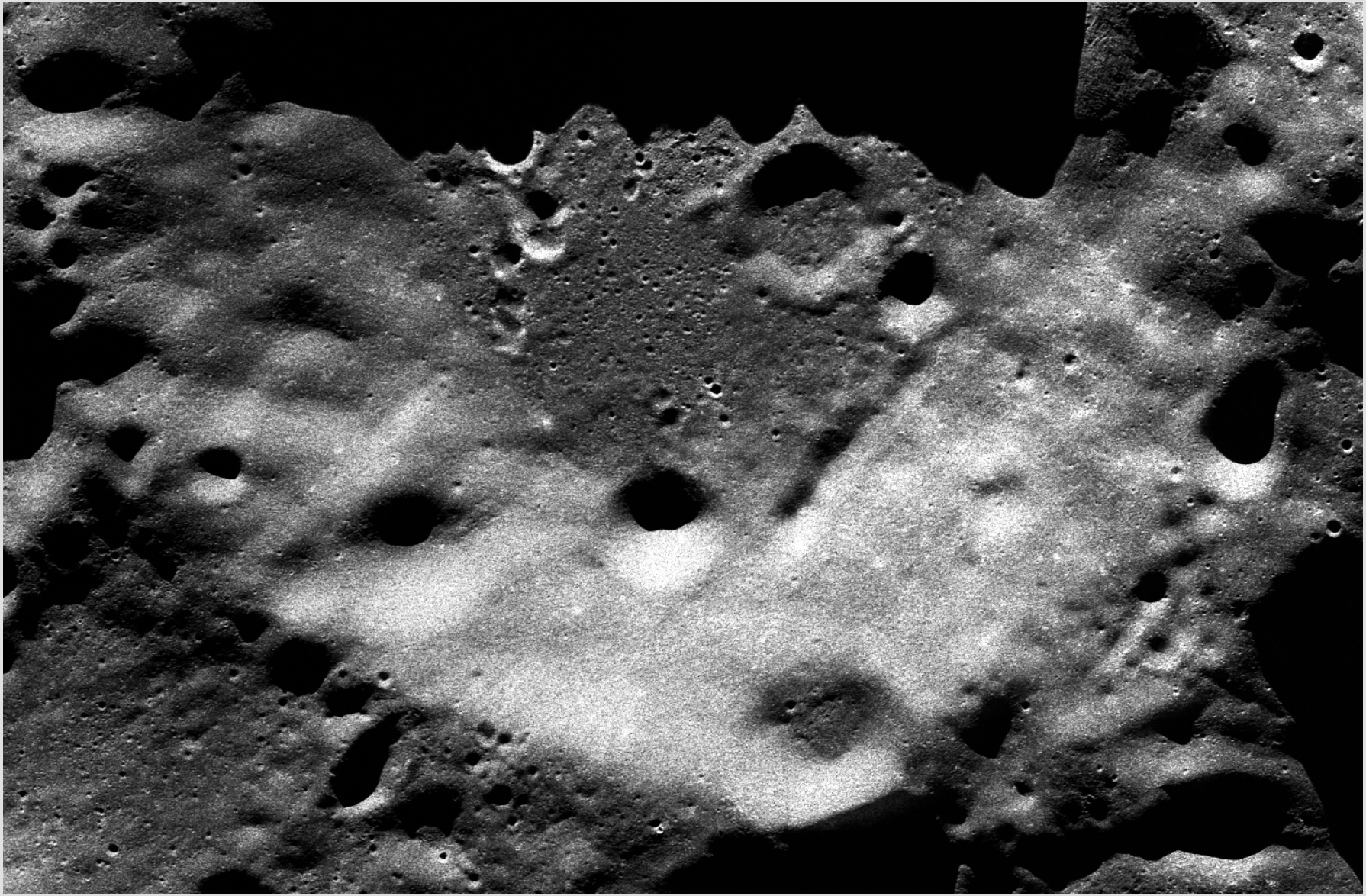
GSSR Lunar Radar Map



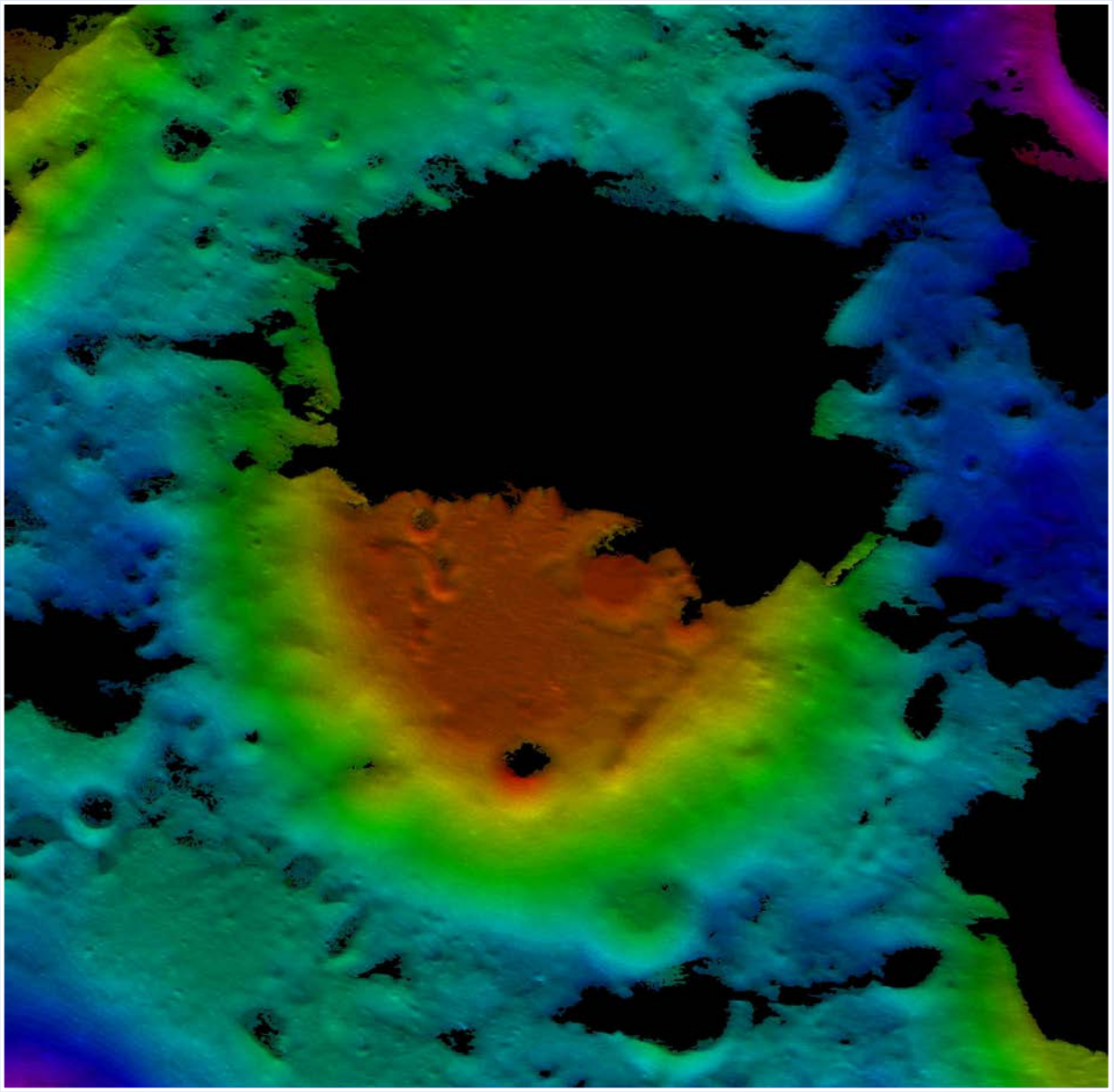
Detail: South Pole Region

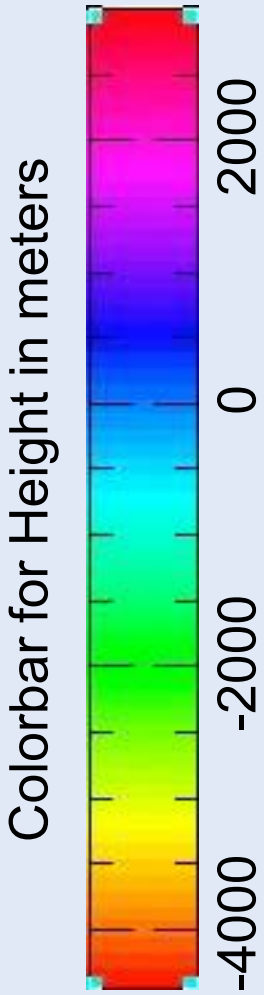


Detail: Shoemaker Crater

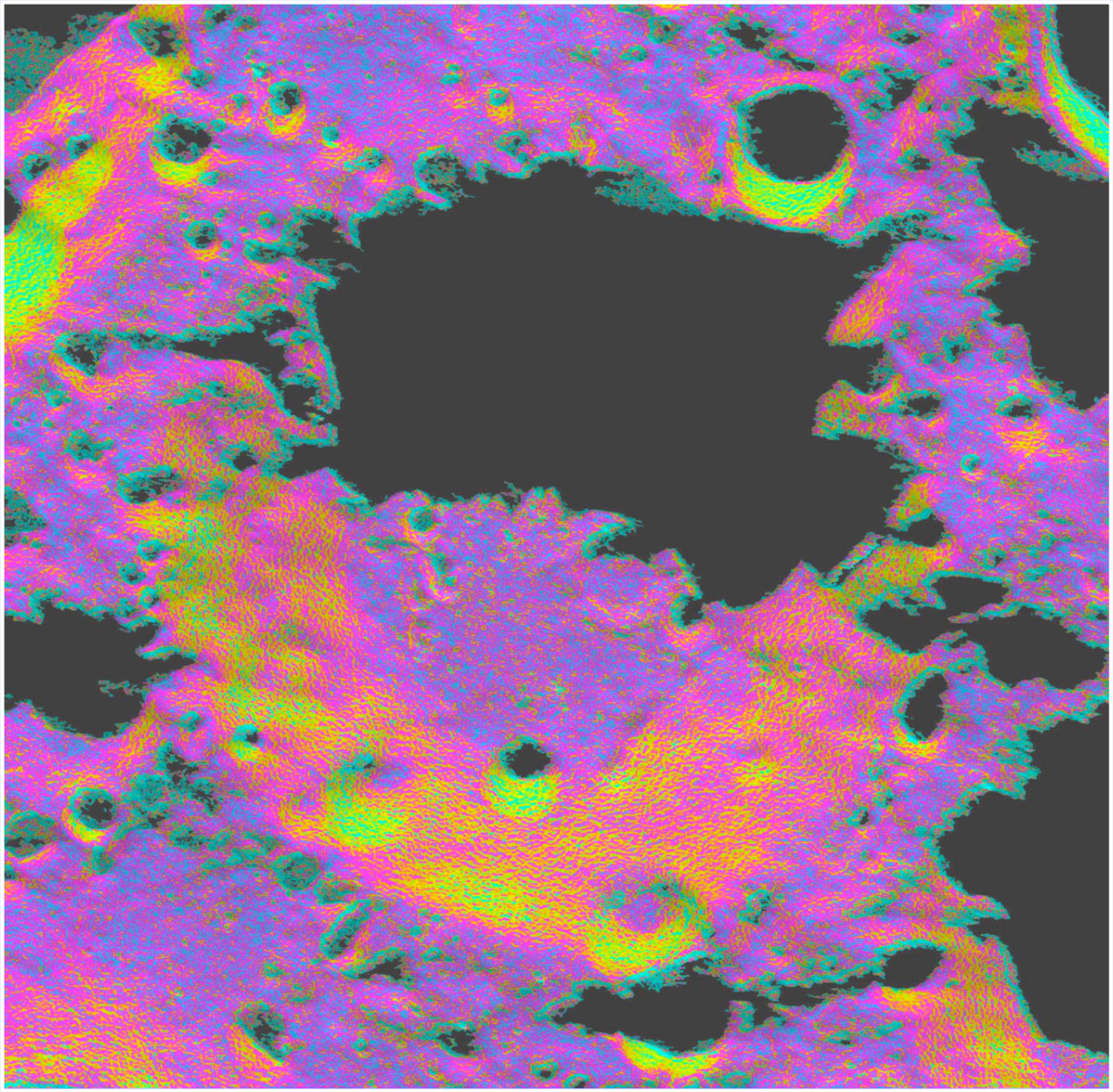


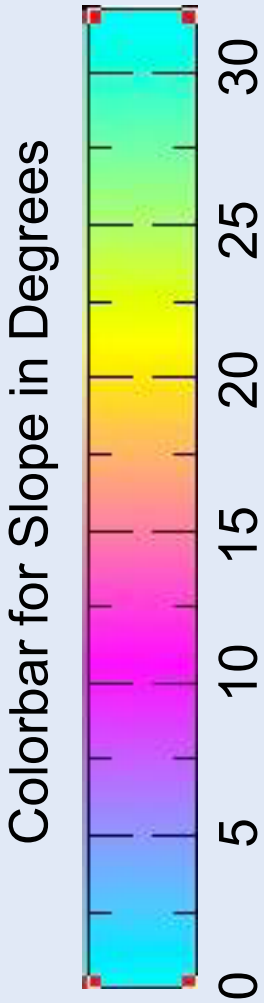
Shoemaker Crater Height Map



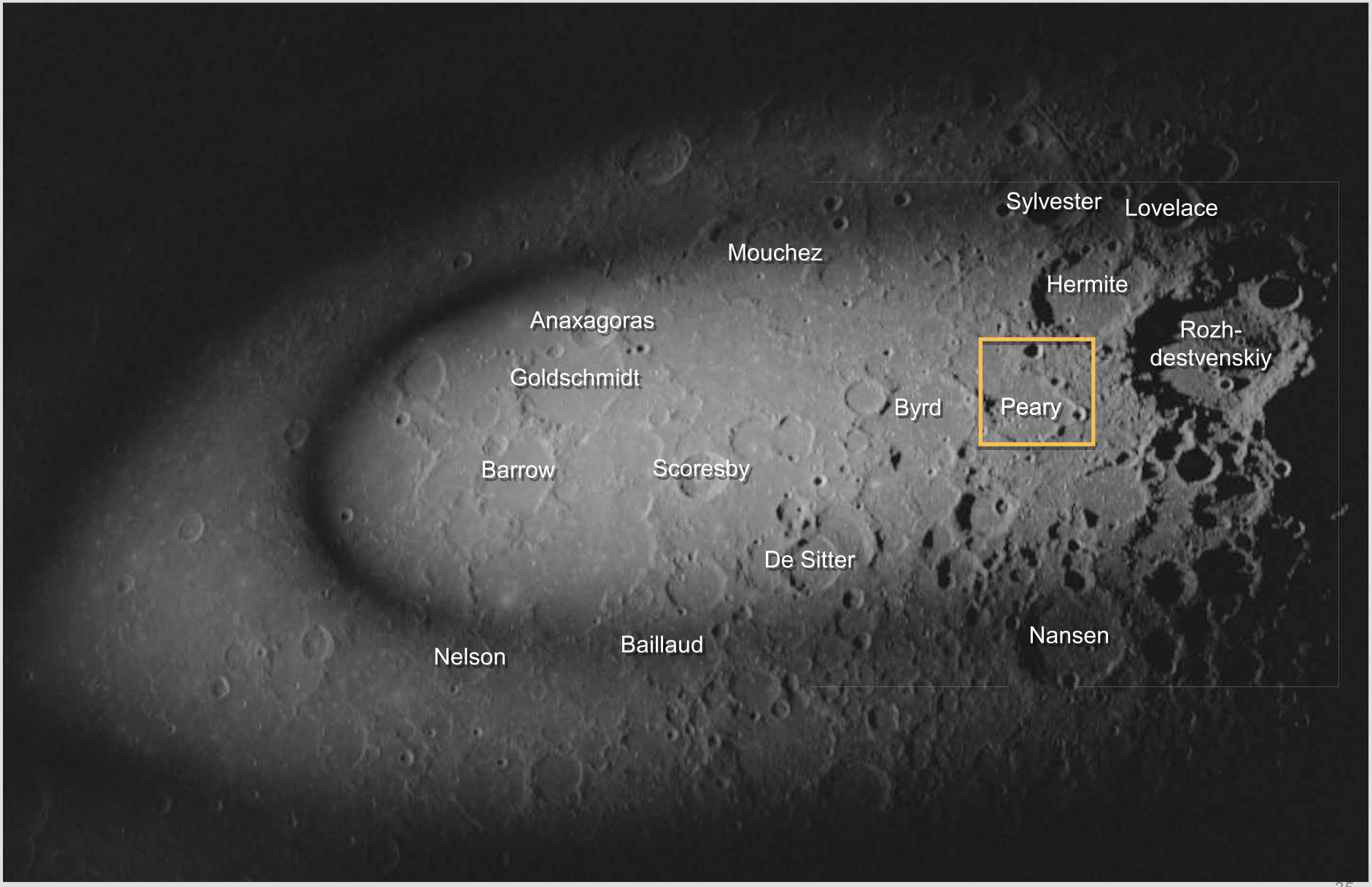


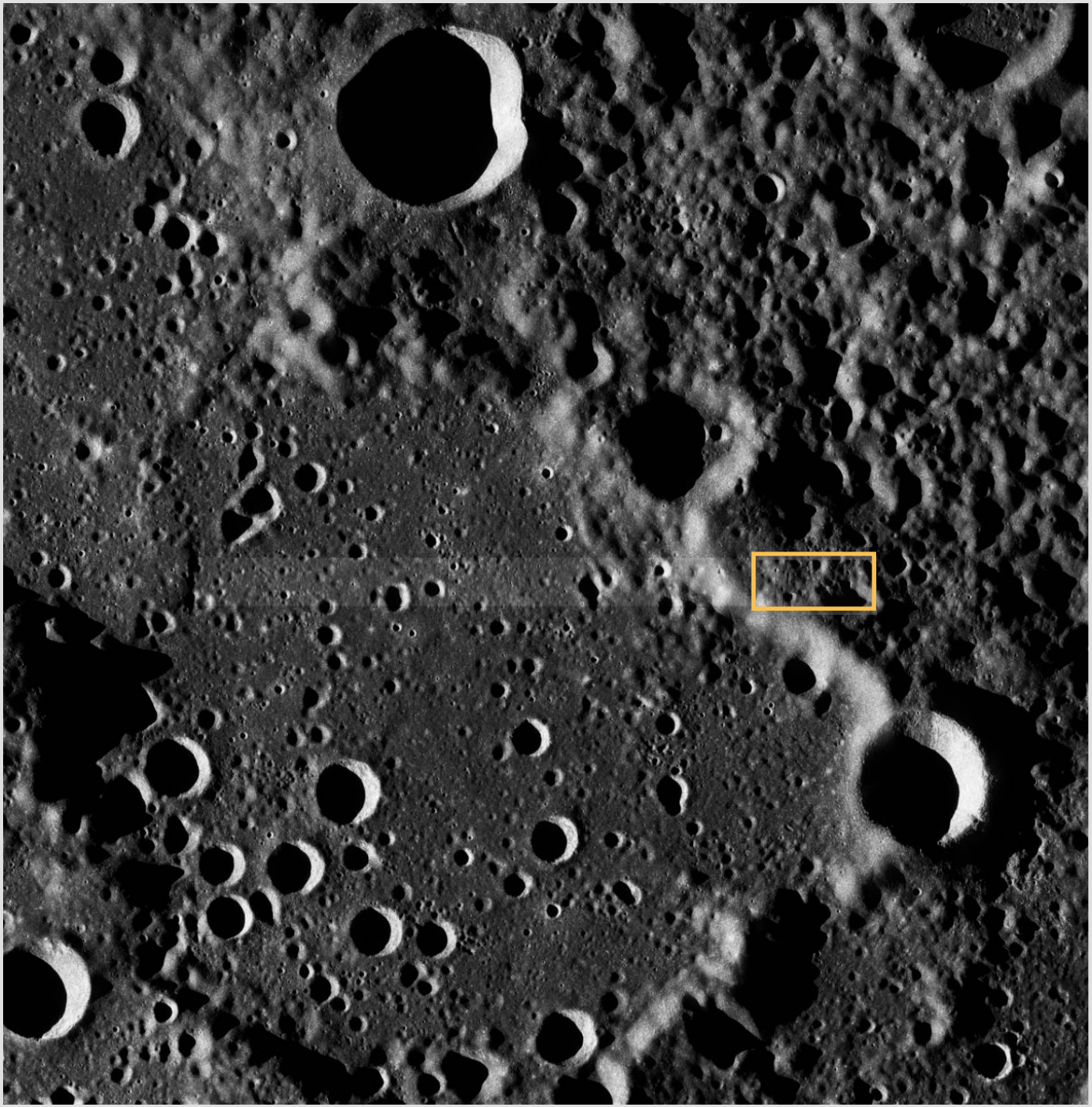
Shoemaker Crater Slope Map





First 40 MHz Image (North Pole)





High-Resolution Image of North Pole Area

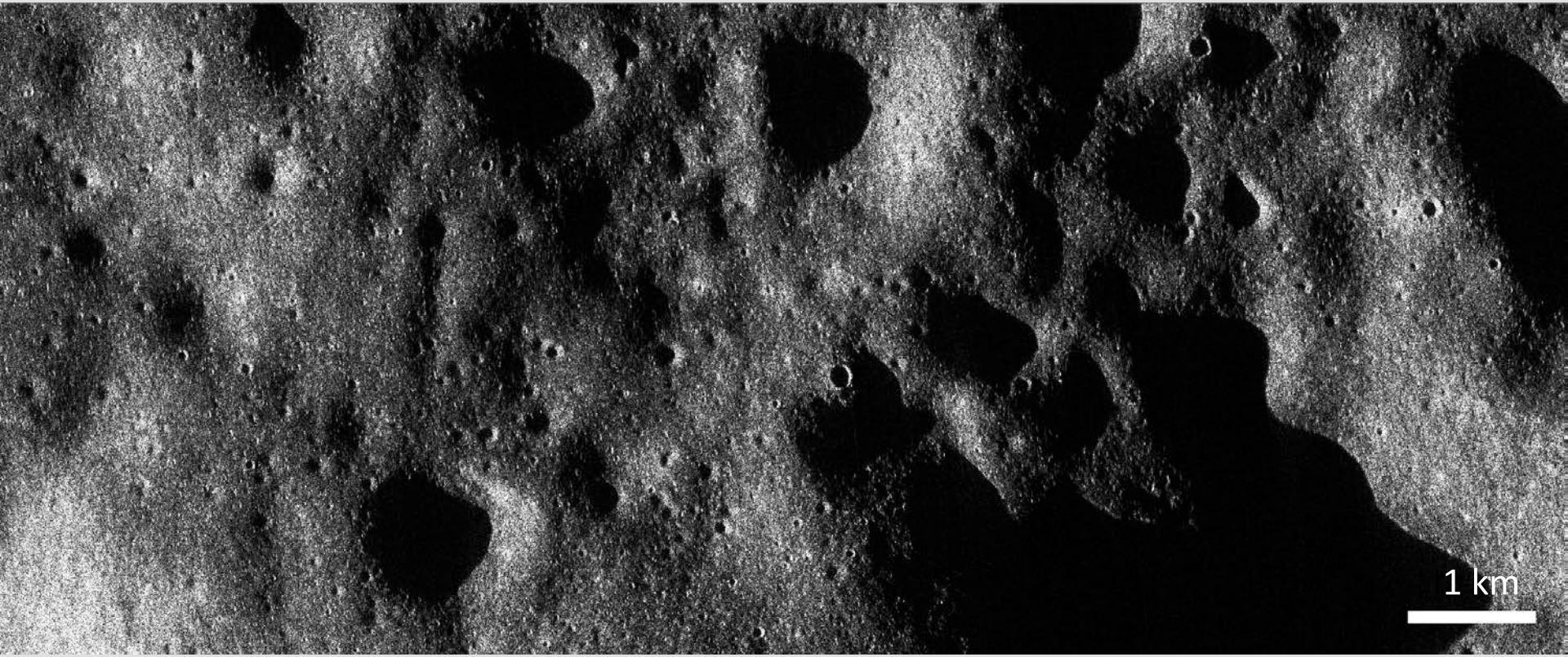


Image processed to 5-m pixels

Provided to Mini-SAR/Mini-RF team as context image for measurement strips

Augustine Committee

- **Convened by NASA at the request of the Offices of Science and Technology Policy (OSTP)**
- **Rapid turnaround examination of options for Human Space Flight (HSF)**
  - Summary published Tuesday 9-8-2009
- **Options and observations are inputs to develop recommendations for the President**

Augustine Committee Results

- FY10 budget and the Constellation program are not a match and no meaningful options exist within that budget to take humankind out of Low Earth Orbit (LEO).
- International partnerships appropriate and could be “critical path”
- Shuttle will take until mid 2011 to fly its current mission set
- There will be a gap of 6 or more years until US has a national means of transporting cargo and people to the Space Station.
- The International Space Stations should be operated until 2020 and the US should use it more aggressively
- The US should work on a heavy lift launch capability
- The US should use commercial systems to support crew and cargo to/from the Space Station
- NASA needs to restart its technology work targeted at making a human Mars mission credible
- NASA should focus on means and missions to get humankind out of low Earth orbit. A variety of missions present themselves

Now What?

- **The political process swings into action**
  - State interests worried about local economies
  - Industry will align along directions that serve their interests
  - Public interest groups will provide their suggestions
  - Other voices
- **NASA will interact with OSTP**
- **Time frame – next 2 to 4 months probably**
  - Speculative
- **Outcome TBD – stay tuned**