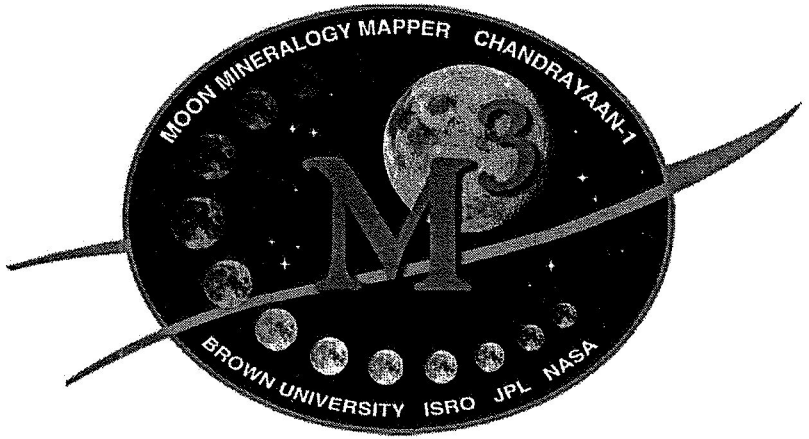
M3 Status and Science Discussion

Carle Pieters

Chandrayaan-1
Science Team Meeting, Bangalore
February 12, 13, 2007

Members of the M3 Science Team will attend the Chandrayaan-1 Science Team Meeting in Bangalore, India to present a brief summary of instrument status and the near-term milestones (e.g., final I&T, pre-ship review). The principal purpose of the meeting is to interact with other members of the Chandrayaan-1 Science Team to prepare for successful science return.



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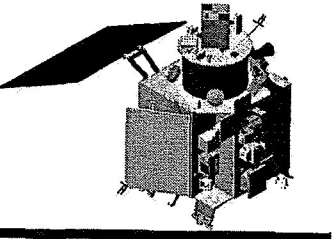
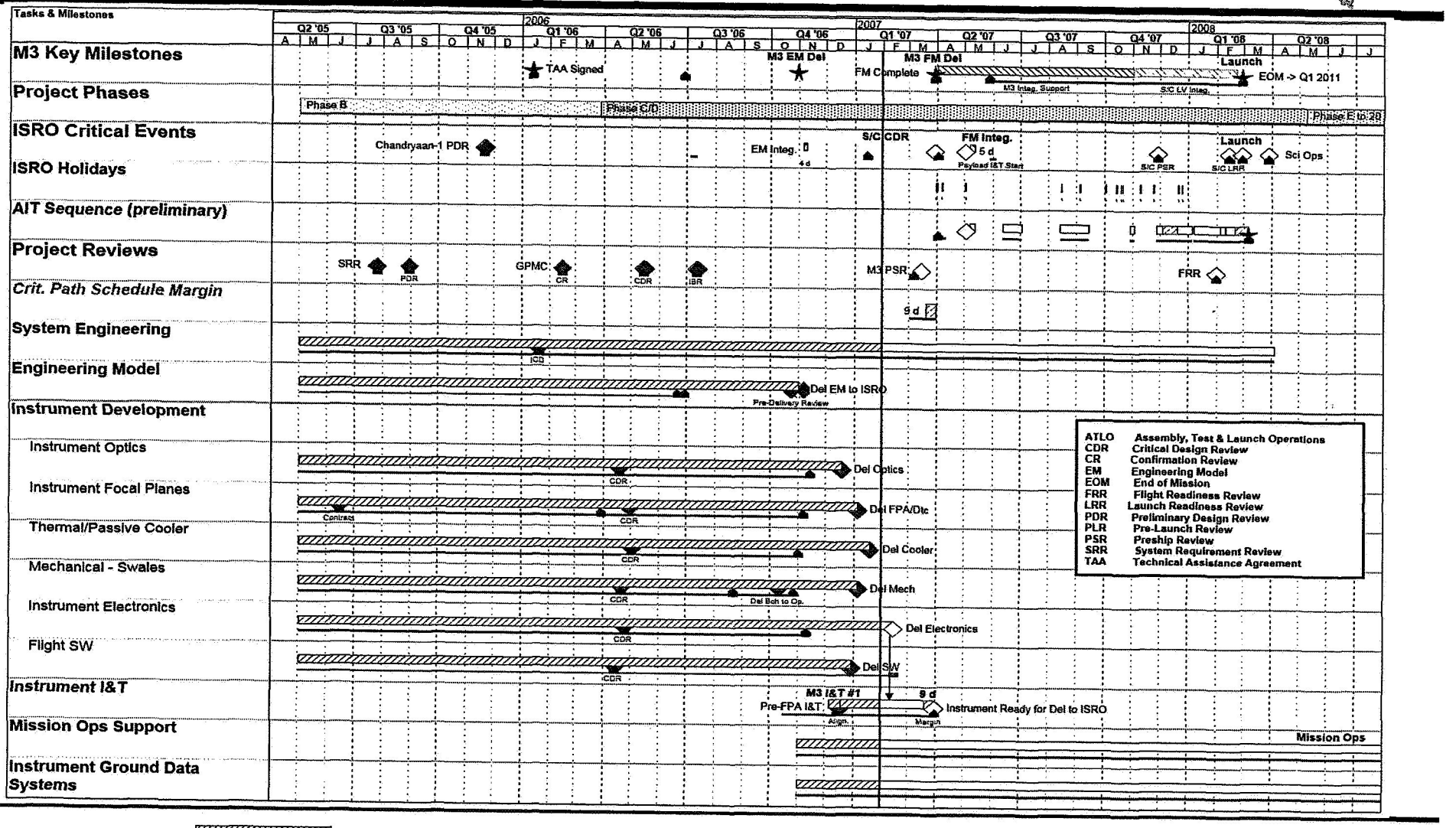
M3 Top Level Schedule

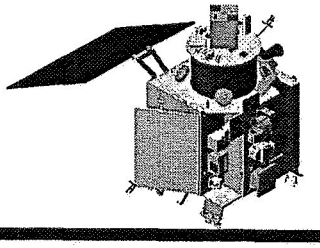




Statused Summary Task — Baseline Task — Complete Milestone — Reserve

Critical Summary Task — Milestone — Baseline Milestone — Launch

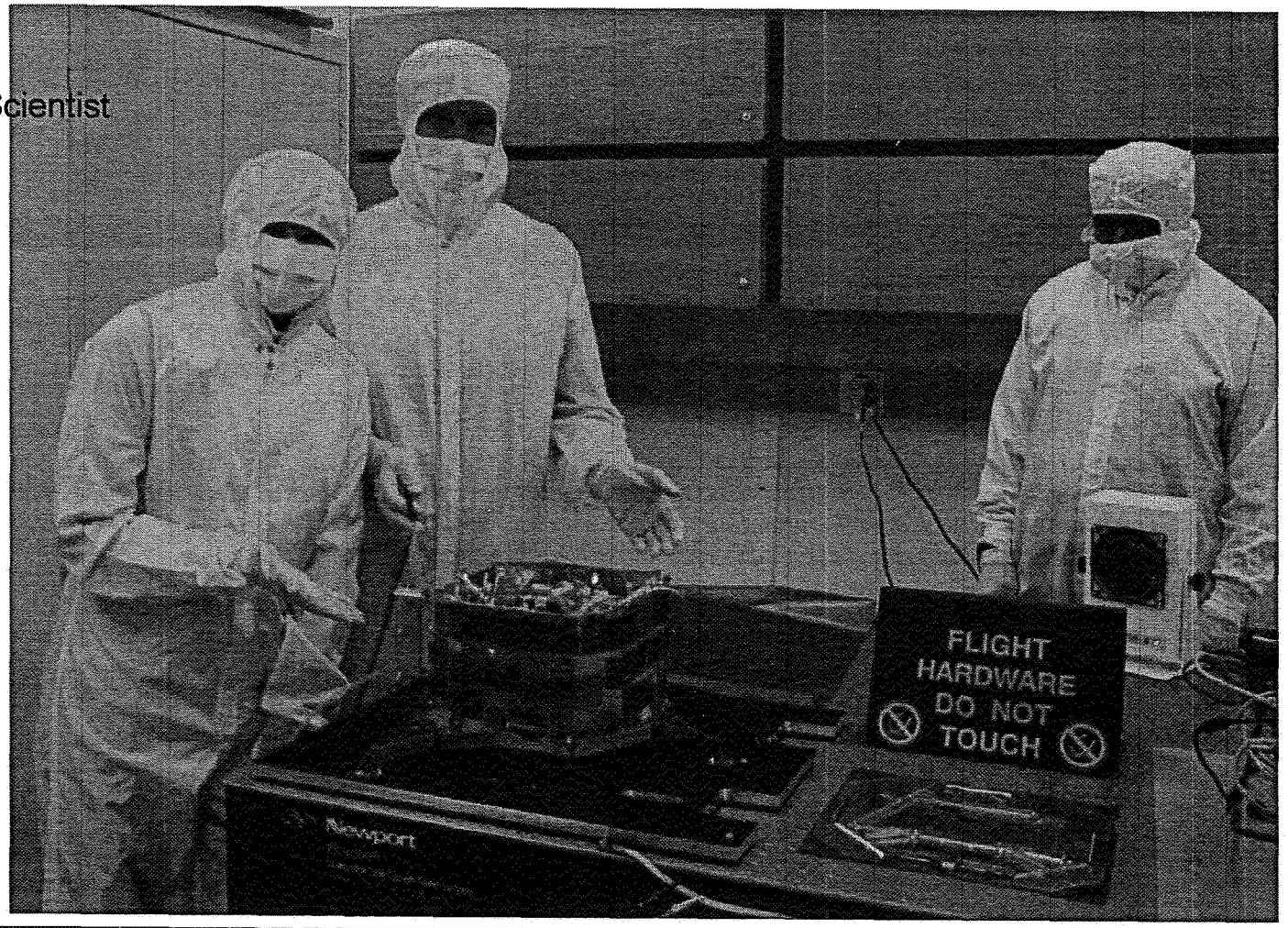
M3 31 Jan 2007
between Thermal-Vac cycles



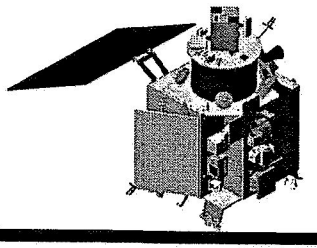
R. Green
M3 Instrument Scientist

C. Pieters
M3 PI

M3

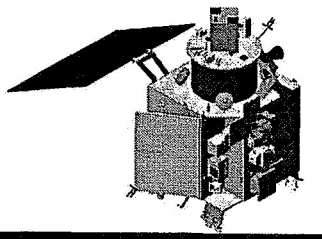


Key Calibration Requirements

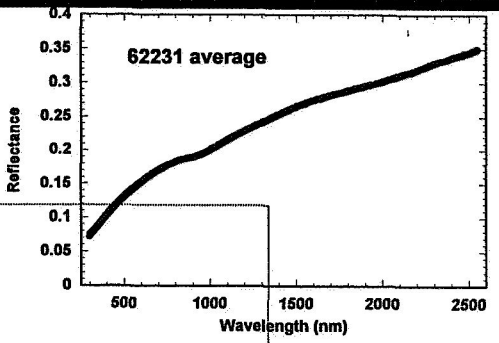


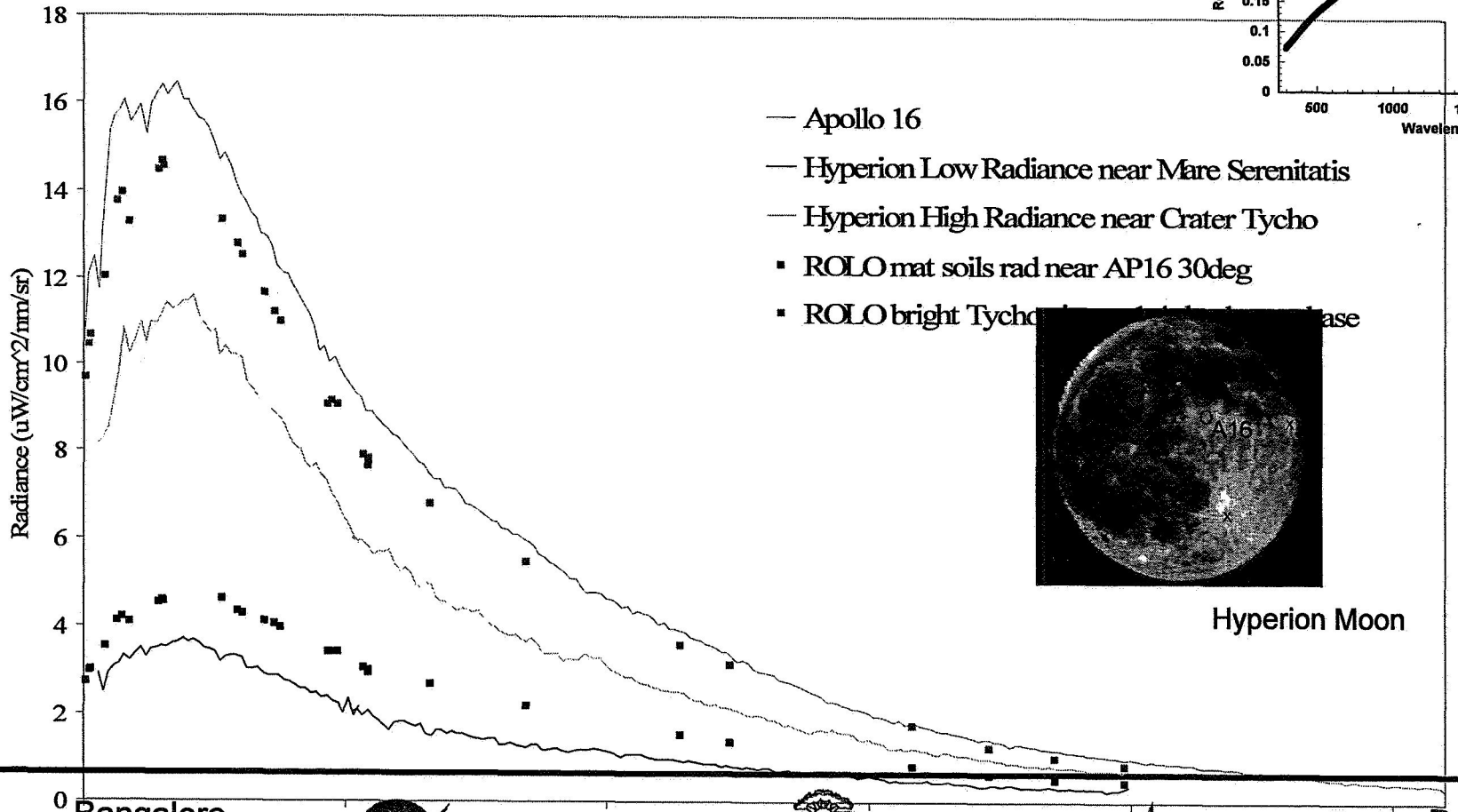
Spectral	
Range	430 to 3000 nm in the solar reflected spectrum
Position	10 nm with knowledge to 10% of FWHM
Response	10 to 15 nm with knowledge to 10% of FWHM
Radiometric	
Range	0 to specified saturation radiance
Precision	100:1 at polar and 400:1 at equatorial radiance
Accuracy	<10% absolute radiometric calibration uncertainty
Linearity	>=99% characterization
Spatial (at 100km)	
Range	24 degree field-of-view
Sampling	70 m with knowledge to 10% of sampling
Response	70 m with knowledge to 10% of sampling
Geometric	
Camera Model	3 Axes cosines to 25% of the spatial sampling
Uniformity	
Spectral Cross-Track	<10% cross-track non-uniformity
Spectral-IFOV-Variation	<10% spectral IFOV non-uniformity

M3 On-Orbit Calibration: Apollo 16 and other L-ISCT



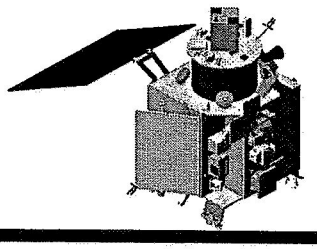
Several targets are measured regularly throughout the mission to validate and monitor instrument calibration.





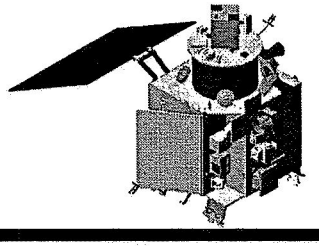
Hyperion Moon

M3 Splinter Group Topics



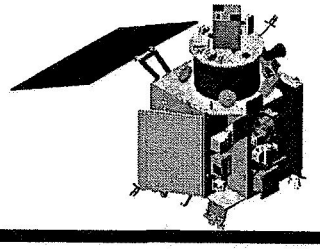
- Interaction with other Chandrayaan-1 Instrument teams
  - Establish joint science projects and data exchange procedures
  - No simultaneous coverage needed.
- Sequence planning and downlink
  - Nearside coverage (global and science targets) needs special planning due to downlink constraints
- Lunar International Science Calibration Targets
- Extended mission preferences
  - => Expand coverage of science targets at 100 km [M3 operations are degraded at 50 km altitude]

Interaction with Other Teams



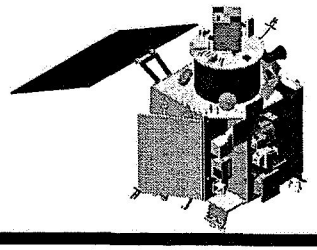
- M3 strongly supports integration of data with other experiments for
  - Initial ISRO-led science publications
  - Ongoing science activities
- M3 L1 and L2 data will be sent to ISSDC as soon as it is available.
- No simultaneous coverage is required although coordinated measurement of calibration targets is highly desired.
- M3 would like to have a data exchange agreement with other experiments:
  - SIR2: allow location of SIR2 data within M3 "Global Mode" data and continuous ties with higher resolution "Target Mode" data. This enhances the science return of both experiments.
  - TMC single band images provide dramatic geologic context at high spatial resolution. Low illumination also excellent for mare morphology.
  - TMC stereo: Extremely valuable for detailed photometric analyses.
  - CD1X: Coordinate mineralogy and chemistry science analyses.
  - HySI: Coordinate visible - near-infrared spectroscopy.
  - Other?

M3 Measurement Plan Assessment & Issues



- Nominal draft plan assumed simple geometry for optical periods
- Improved plan uses Lunar Prospector 100 km orbit data with SPICE for realistic orbit projections
  - Optical period 1 is modeled to emphasize global mode coverage
  - Optical periods 2, 3, & 4 modeled for target mode
- Current nearside downlink issues and a proposed solution are evaluated using LP data.

Lunar Prospector as a Proxy for Chandrayaan-1



- SPICE models using LP kernels and associated celestial mechanical kernels used to get detailed LP model for full optical period at 1 minute intervals
- Columns are : UTC time, J2000 time, solar zenith, lon, lat, lunar-fixed-rotating LP XYZ and visibility flag (0 = vis, 1=moon blocked, 2=earth blocked, 3= both blocked)

lp_ch1_model_geometry_and_vis_full_optical_period.txt - Notepad

File Edit Format View Help

1998 FEB 16 00:00:00.000000	-59140736.815	103.314	170.977	71.196	-587.168	93.242	1745.961	1
1998 FEB 16 00:01:00.000000	-59140676.815	101.241	170.430	74.223	-494.662	83.401	1775.518	0
1998 FEB 16 00:02:00.000000	-59140616.815	99.152	169.636	77.247	-400.771	73.296	1800.091	0
1998 FEB 16 00:03:00.000000	-59140556.815	97.051	168.365	80.265	-305.759	62.955	1819.616	0
1998 FEB 16 00:04:00.000000	-59140496.815	94.941	165.980	83.273	-209.892	52.408	1834.043	0
1998 FEB 16 00:05:00.000000	-59140436.815	92.825	159.824	86.249	-113.440	41.684	1843.334	0
1998 FEB 16 00:06:00.000000	-59140376.815	90.706	118.416	88.914	-16.672	30.814	1847.469	0
1998 FEB 16 00:07:00.000000	-59140316.815	88.588	13.895	87.440	80.142	19.826	1846.440	0
1998 FEB 16 00:08:00.000000	-59140256.815	86.472	2.835	84.508	176.730	8.752	1840.252	0
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1998 FEB 16 00:15:00.000000	-59139836.815	72.001	-4.755	63.461	824.193	-68.562	1655.982	0
1998 FEB 16 00:16:00.000000	-59139776.815	70.022	-4.977	60.451	909.504	-79.204	1610.433	0
1998 FEB 16 00:17:00.000000	-59139716.815	68.076	-5.163	57.442	992.282	-89.652	1560.405	0
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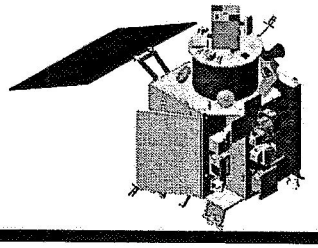
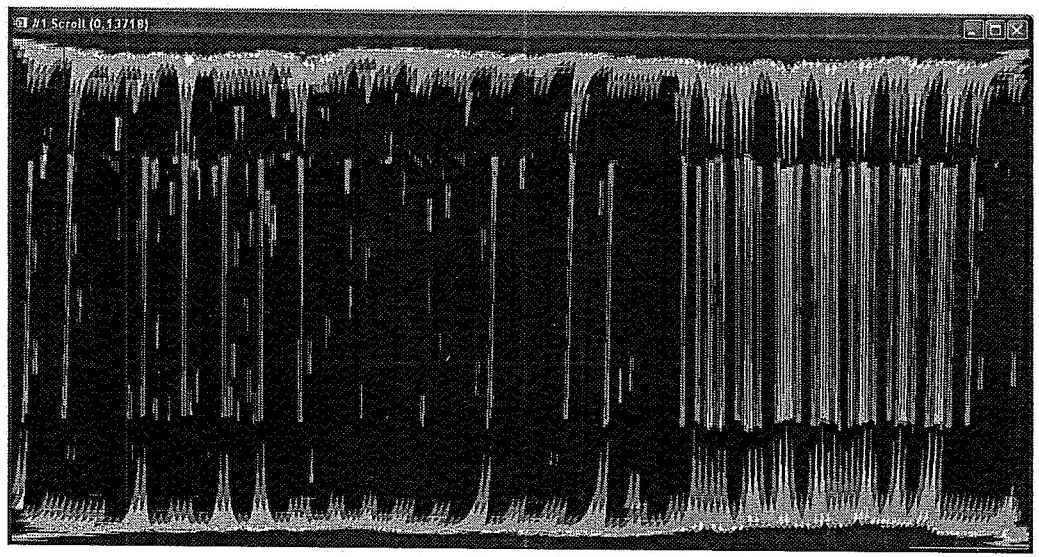
Optical Period 1 Model



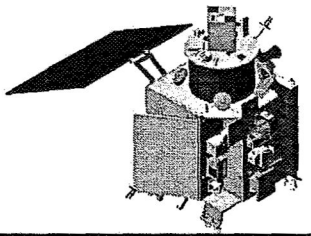
- Two weeks of target mode (~11° longitude images) during 45-30 deg solar period
- Two months of global mode (135° longidude images) during 30-0-30 deg solar period
- Two weeks of target mode (~11° longitude images) during 30-45 deg solar period



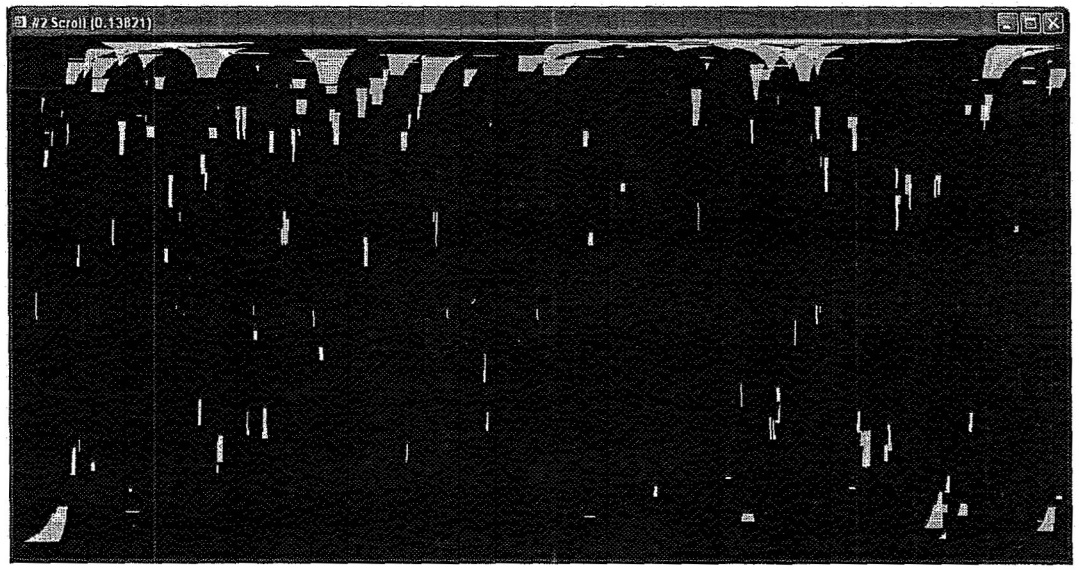
•141 targets (74 in first two weeks, 67 in second two weeks), modeled as random within illuminated half-orbit

•357 global strips during prime 2-month period, each 135 degrees alternate pole start/end scheme

Optical Period 2 (3,4) Model

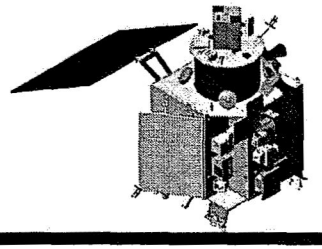


- Three months of target mode during 45-0-45 deg solar period
- Periods 3 and 4 will be essentially repeats of Period 2 model to complete science target coverage
- Most targets require multiple image strips for longitude coverage
- In reality we will fill some global data gaps in these periods as well, but it does not change op/downlink modeling



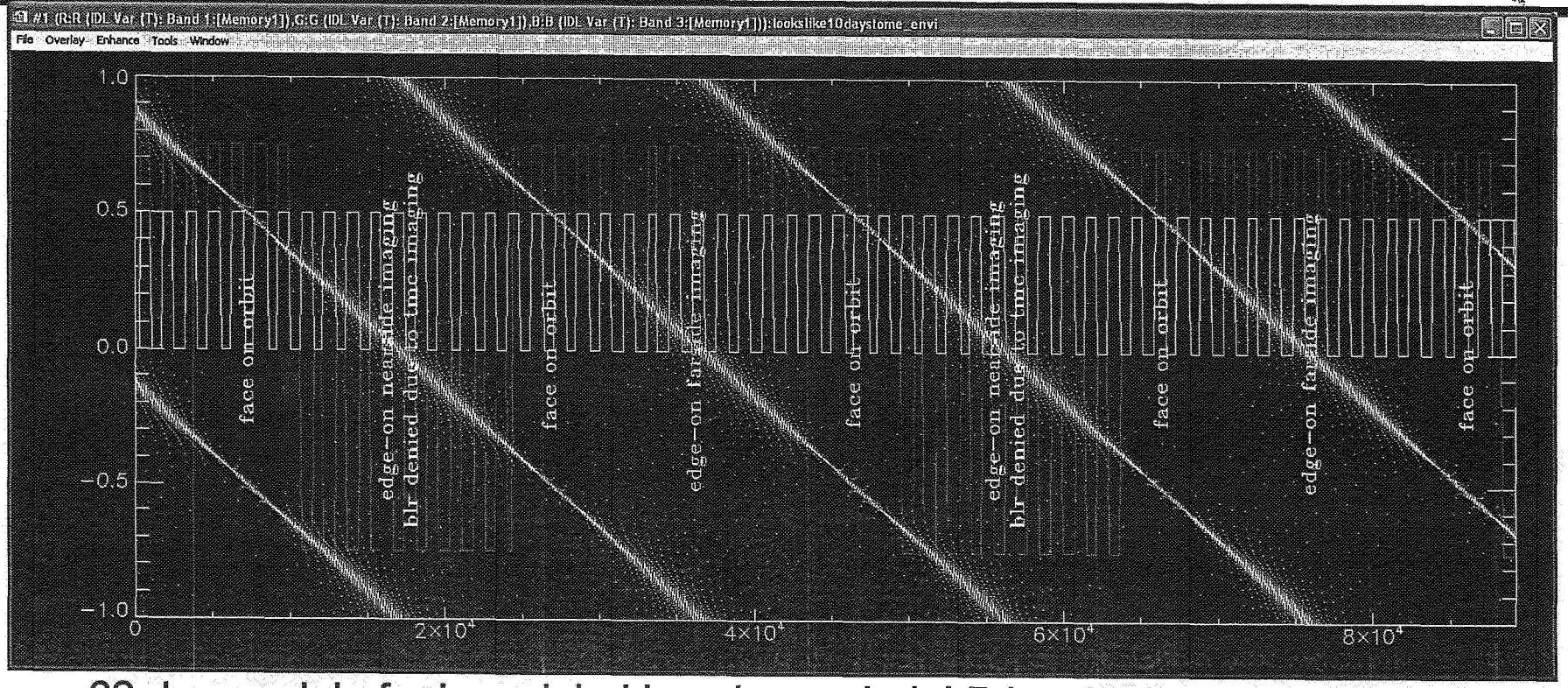
Targets modeled as random within illuminated half-orbit

Known Projection and Model Simplifications



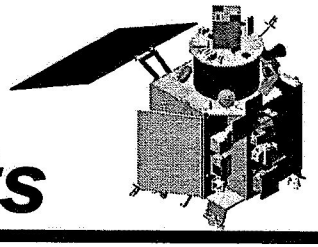
- Bangalore visibility may be overestimated, zero degree horizon, no antennae considerations
- Assumed a full downlink possible every time there was 60+ minutes of visibility
- Periods 2, 3, 4 will not solely be target mode as modeled here (some global in filling)
- Simplified downlink model with no consideration to signal strength and timing within a downlink
- Target mode data can be up to four small image segments instead of a single small image strip (11-12°) as shown here
- Modeling only performed to one-minute precision

Lunar Prospector Proxy Model of BLR and APL Downlink



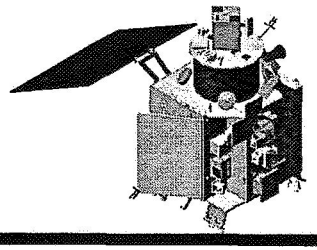
- 62 day model of prime global imaging period, LP longitude in white, x-axis time (seconds), problem areas are edge-on-near-side imaging
- Green sawtooth, nominal Bangalore desired downlinks (6-on-6-off)
- Red shows 10-days/sidereal month for supplemental APL coverage

Lunar International Science Calibration/Coordination Targets



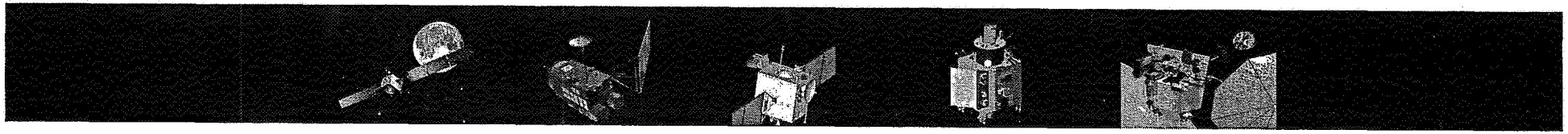
- Purpose: Eight specific lunar targets are recommended
  1. for cross-calibration of diverse multi-national instruments.
     - Repeat targets
     - Ground truth validation
  2. as the seed for real-time training young scientists with lunar science issues.
- Recommended Coordination: Within the science plan of individual missions, these small targets
  - merit special study
  - by a wide range of sensors
  - Coordinate with other sensors of the international community
- Target Characteristics:
  - Size ~200x200 km (or near central strip)
  - Diverse properties
  - Representative terrain types
  - Scientifically interesting, but not unique (does NOT harm science goals)
- For mutual benefit, LISCT data should pass initial calibration then be scheduled for early release and coordinated calibration by the international community.

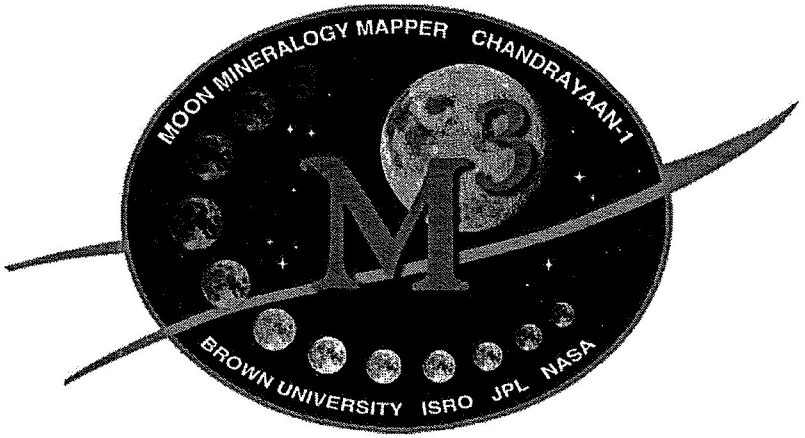
Suggested Categories for L-ISCT



	1.Apollo 16	2.Lictenberg	3. Apollo 15	4. SPA-Th Anomaly	5. Tycho	6. Polar Shadows	7. North Schrodinger	8.Mare Serenitatis
Orbital Imaging (²100 m/pixel)	A	B	A	B	B	A	A	C
UV-VIS-NIR Spectroscopy	A	B	B	B	A	A	A	B
Altimetry & stereo	B	A	A	B	A	A	A	B
Thermal & Radar imaging	A	B	B	B	A	A	A	C
Gamma-ray & neutron spectroscopy	A	B	C	A	B	A	B	A
X-ray spectroscopy	A	A	B	B	B	C	C	A
Particles, plasma, magnetometer	A	B	C	B	B	B	C	A
Microwave, sounder	B	A	B	A	B	B	A	A
Outreach	B	A	A	B	A	A	B	B

A: Best, most valuable; B: Good, quite useful; C: Supplemental





M3 Science Context

Background Material

M^3 Science Examples: Mare Basalts

Objectives

1. **Characterize the diversity & extent of different types of basaltic volcanism**

   - Relation to lunar samples
   - Heterogeneity of volcanism and mantle sources

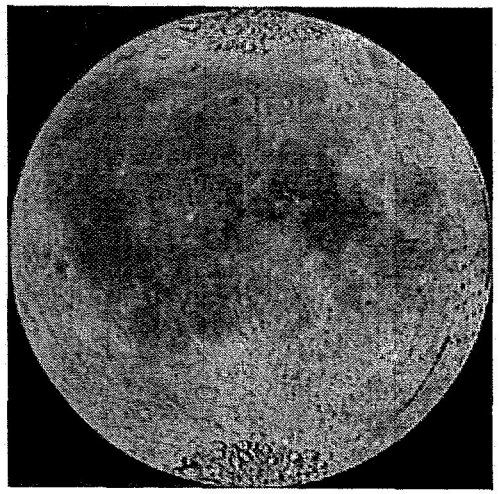
2. **Constrain evolution over time**

   - Age / stratigraphic associations
   - Evolution of sources & emplacement conditions

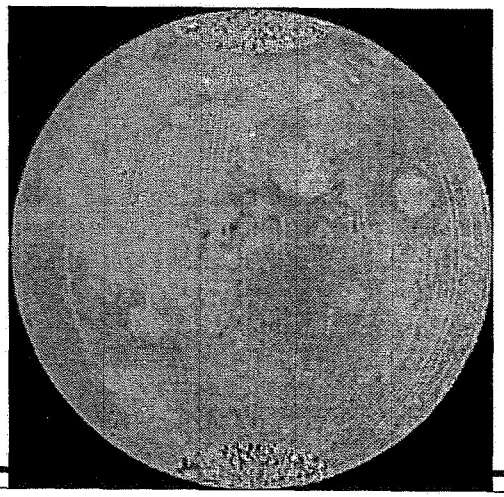
   e.g. Comparisons of sampled basalts to maria outside major basins, ancient cryptomaria and late-stage basalts

3. **Examine high priority regional sites:**

   Apollo & Luna landing sites
   Source features: rilles, flows, domes & pyroclastic deposits
   Unique settings: e.g. SPA Basin, Western Procellarum

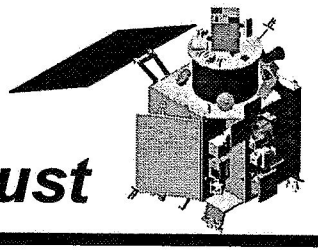


USGS Clementine mosaic

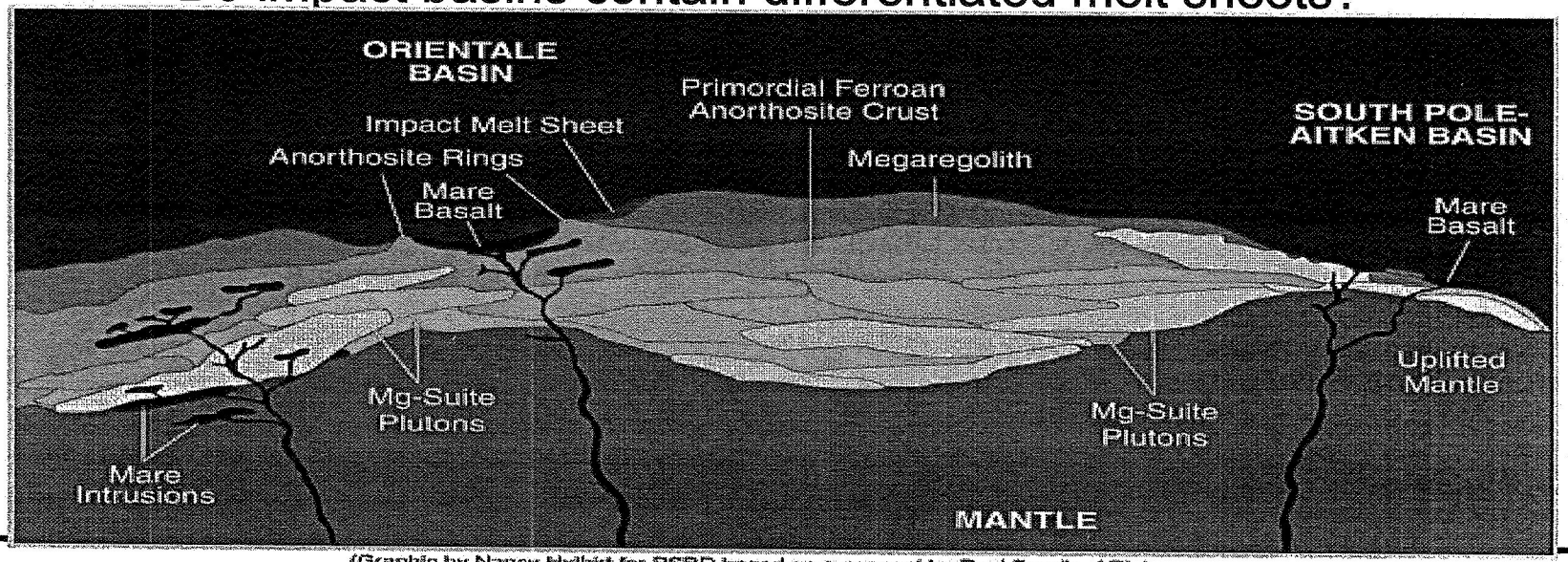


UVVIS Color Ratio Composite

M^3 Science Examples:
Composition and Evolution of the Lunar Crust

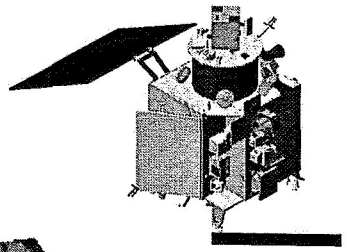


- Scale and type of mineralogical variation in the crust can address a wide range of questions about the lunar crust, such as:
  - How uniform was the magma ocean across the Moon?
  - Do Mg-Suite plutons exist & what is their composition and frequency?
  - Do impact basins contain differentiated melt sheets?

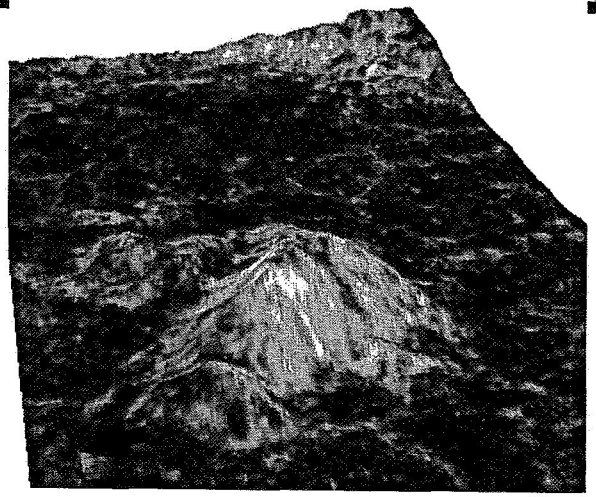


(Graphic by Nancy Hulbirt for PSRD based on a concept by Paul Spudis, APL.)

Example: Tycho Crater



- Gabbroic rocks rare among lunar craters and lunar samples
- Small % of craters from a recent global survey MAY contain gabbro
  - Some crustal evolution models predict abundant gabbro -- where is it?
  - Tycho is the only known crater with strong indications of gabbro in walls and central peaks (Hawke et al., 1986)
- Did Tycho exhume a pluton?
  - Need M3 spectral data to determine variability and significance of composition within the crater



Clementine ratio images of Tycho central peaks, draped over topographic projection. North faces out of slide in lower image, and in the direction of the arrow in upper one. Colors highlight subtle differences in mafic mineralogy. Blue-green areas have longer wavelength 1-μm absorptions than purple areas, indicating abundant high-Ca pyroxene.