MARS EXPLORATION PROGRAM GEODESY AND CARTOGRAPHY WORKING GROUP AND INTERNATIONAL SPACE AGENCY PHOBOS/DEIMOS WORKING GROUP

by

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presented at the

36th Meeting
Mars Exploration Program Advisory Group
Crystal City Marriott at Reagan National Airport
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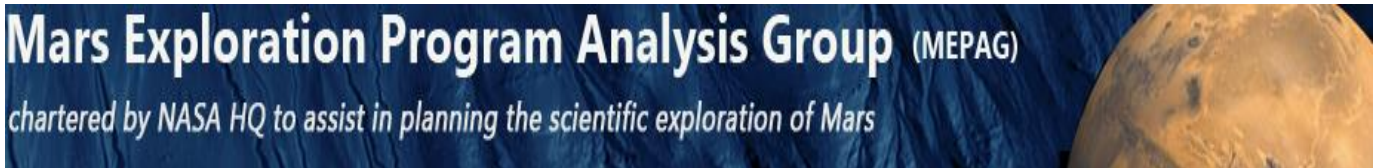
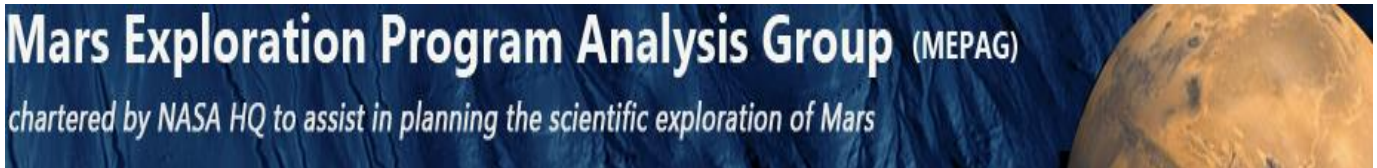


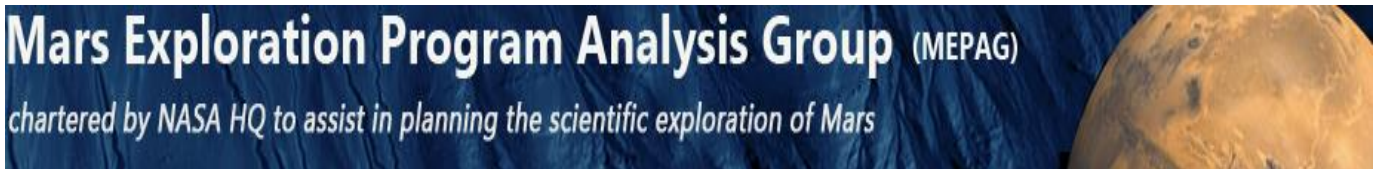
MARS EXPLORATION PROGRAM
GEODESY AND CARTOGRAPHY WORKING GROUP
(MGCWG)



MGCWG OBJECTIVES

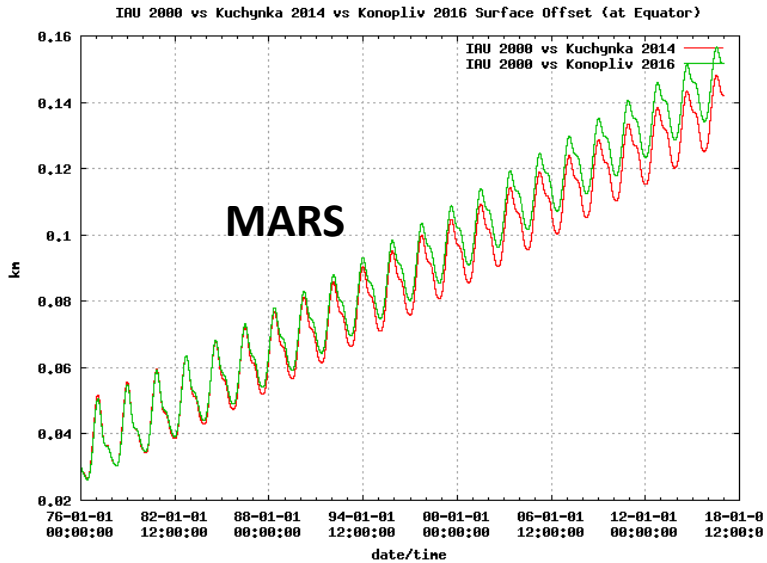
- Develop, Evaluate and Recommend Cartographic Standards for Mars and its moons to the NASA Mars Exploration Program Mission and Data Analysis Programs and to the IAU Working Group for Cartographic Conventions and Rotational Elements (WGCCRE)
  - Mars, Phobos and Deimos Inertial Orientation Models
    - Spin Axis Directions / Spin Rates
    - Rotational Librations
  - Prime Meridian Definitions
  - Cartography Coordinates (east or west longitude, ographic, ocentric, . . .)
  - Reference Surfaces (Digital Terrain Models)
  - Map Projection Standards
- Produce or Validate Cartographic Map Products used for Mission Design and Landing Flight Operations for Landers / Rovers
  - Produced: Phobos 88*, MEX Beagle 2*, Mars Polar Lander*, MER Spirit and Opportunity, Phobos Grunt
  - Validated: Viking Lander 1*, Mars Pathfinder*, PHOENIX, Mars Curiosity, TGO Schiaparelli, ~InSight

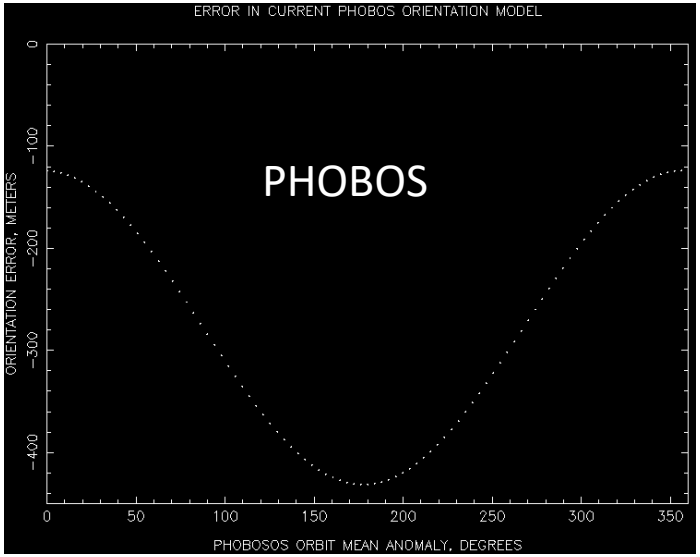
* produced by current MGCWG Chair before group formalized



New Orientation Models

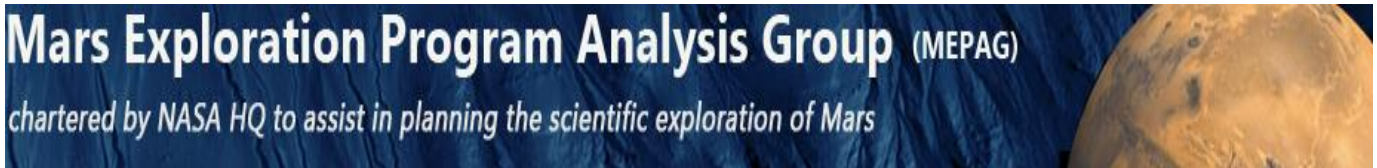
- Archinal, B., *et al.* (2018), Report of the IAU Working Group on Cartographic Coordinates and Rotational Elements: 2015, *Celestial Mechanics and Dynamical Astronomy*, 130:22, DOI: 10.1007/s10569-017-9805-5
- Jacobson, R., A., A. S. Konopliv, R. S. Park, W. M. Folkner, (2018), The Rotational Elements of Mars and Its Satellites, *Planetary and Space Sciences*, 226.





- NAIF is producing new Planetary Constants SPICE kernels (.tpc) from the IAU and Jacobson, *et al.*, models as we speak for the NASA Mars Program and International use

NOTE: the MGCWG agreed that any future changes to the Mars Prime Meridian location will be tied to changes in Lander locations (meters) and not to changes in the Airy 0 location (10's of meters)



New Orientation Models

FORM OF OLD MODELS (Ignores terms at the 10 to 100 meter level):

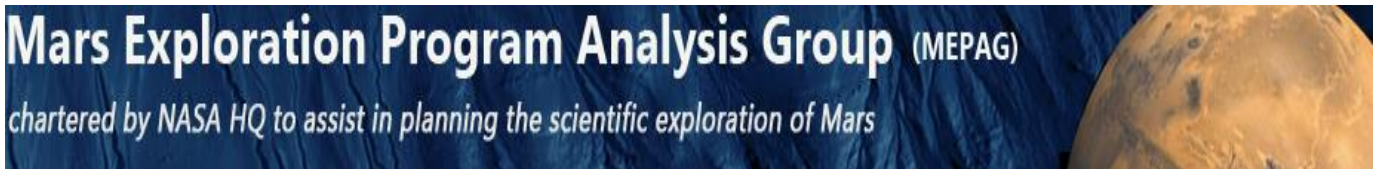
$$W = 79^\circ.398222 + 285^\circ.1618889940\, d + 0^\circ.004\, T^2$$

FORM OF NEW MODELS:

$$W = 79^\circ.398222 + 285^\circ.1618889940\, d + 0^\circ.004\, T^2$$

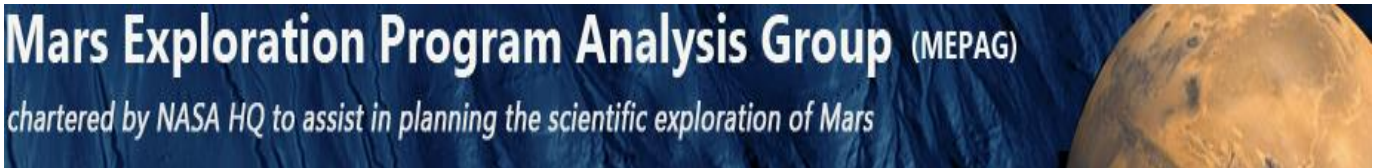
$$-0^\circ.012397 \sin M04 \quad -0^\circ.011665 \sin M05$$
$$-0^\circ.028488 \sin M07 \quad +0^\circ.008046 \sin M08$$
$$+0^\circ.005842 \sin M09 \quad -0^\circ.000781 \sin M10$$
$$-2^\circ.614257 \sin M13 \quad -0^\circ.177195 \sin M14$$
$$+0^\circ.049723 \sin M15 \quad +0^\circ.006792 \sin M16$$
$$-0^\circ.065677 \sin M17 \quad -0^\circ.002022 \sin M18$$
$$-0^\circ.001226 \sin M19 \quad -0^\circ.002846 \sin M21$$
$$+0^\circ.001081 \sin M22 \quad +0^\circ.009372 \sin M23$$

$$M01 = 190^\circ.843500 + 15917^\circ.1207778\, T$$
$$M02 = 280^\circ.843500 + 15917^\circ.1207778\, T$$
$$M03 = 106^\circ.707868 + 15881^\circ.2992241\, T$$
$$M04 = 335^\circ.484007 + 19139^\circ.8902255\, T$$
$$M05 = 65^\circ.484007 + 19139^\circ.8902255\, T$$
$$M06 = 21^\circ.687000 + 31834^\circ.2408542\, T$$
$$M07 = 224^\circ.821984 + 38280^\circ.9225007\, T$$
$$M08 = 314^\circ.821984 + 38280^\circ.9225007\, T$$
$$M09 = 51^\circ.027069 + 57419^\circ.8755329\, T$$
$$M10 = 213^\circ.044468 + 57419^\circ.8755329\, T$$
$$M11 = 144^\circ.596244 + 3222^\circ.5862146\, T$$
$$M12 = 36^\circ.489481 + 6487^\circ.2881732\, T$$
$$M13 = 124^\circ.804261 + 660^\circ.1920057\, T$$
$$M14 = 214^\circ.804261 + 660^\circ.1920057\, T$$
$$M15 = 16^\circ.807321 + 666^\circ.3597060\, T$$
$$M16 = 124^\circ.492169 + 665^\circ.8337306\, T$$
$$M17 = 251^\circ.363620 + 1320^\circ.4484200\, T$$
$$M18 = 17^\circ.054464 + 1979^\circ.9568335\, T$$
$$M19 = 91^\circ.718836 + 37620^\circ.6430128\, T$$
$$M20 = 41^\circ.416408 + 38941^\circ.1057273\, T$$
$$M21 = 193^\circ.893734 + 38941^\circ.3092472\, T$$
$$M22 = 86^\circ.305290 + 76559^\circ.4995416\, T$$
$$M23 = 346^\circ.004396 + 4801583^\circ.3938944\, T$$
$$M24 = 189^\circ.632613 + 41215158^\circ.1892936\, T + 12.^\circ71179247^2$$
$$M25 = 19^\circ.265226 + 82430316^\circ.3785872\, T + 25.^\circ4235848^2$$



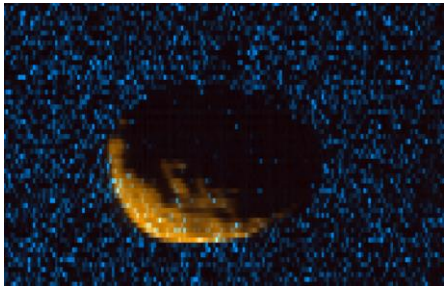
INTERNATIONAL SPACE AGENCY PHOBOS / DEIMOS SURFACE CHRACTERIZATION AND SITE SELECTION WORKING GROUP (PDWG)*

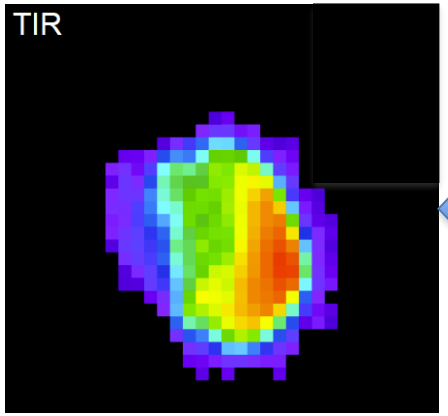
** NASA, ESA, JAXA and ROSCOSMOS*

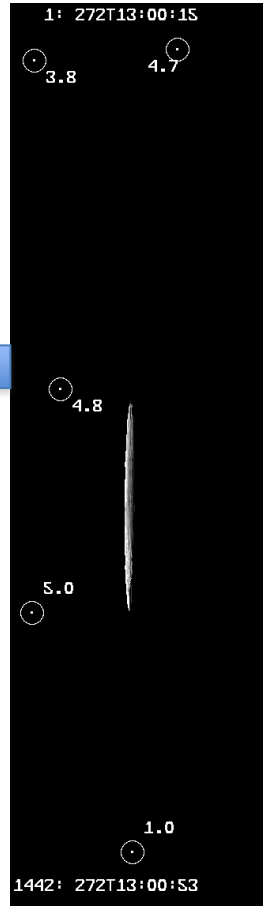


PDWG GOALS

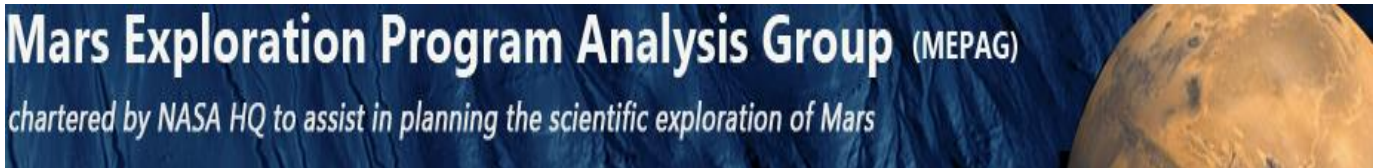
- ENCOURAGE CURRENT MISSIONS TO CONTINUE OBSERVATIONS
  - MEX, MRO, TGO
- ENCOURAGE NEW TYPES OF OBSERVATIONS FROM CURRENT MISSIONS THAT RESOLVE THE MARTIAN MOON SURFACES
  - THEMIS IR, MAVEN IUVS, . . .





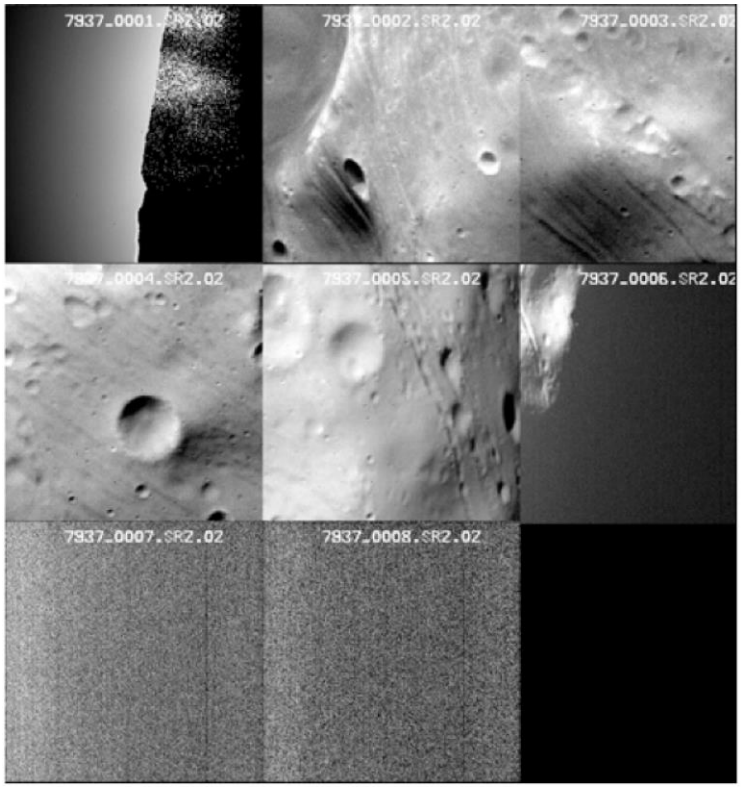


- ENCOURAGE, SUPPORT AND PRODUCE HIGHER-LEVEL, DERIVED DATASETS TO SUPPORT MISSION DESIGN, SURFACE CHARACTERIZATION, SITE SELECTION, MISSION OPERATIONS AND FLIGHT DATA / SAMPLE CONTEXT
  - LEVEL 3 MAP PROJECTION AND GIS DATA INTERCHANGE STANDARDS
  - JAXA MMX MISSION AND OTHER SPACE AGENCY MISSIONS BEING STUDIED
  - TOOLS: JPL/ARC TREK, APL SBMT, USGS PILOT, OTHER GIS TOOLS
  - INFORM SCIENCE COMMUNITY OF ACTIVITIES / STATUS AND ENCOURAGE SUPPORT
    - MEPAG, SBAG, DPS, COSPAR, EGU, LPSC, EPSC, . . .

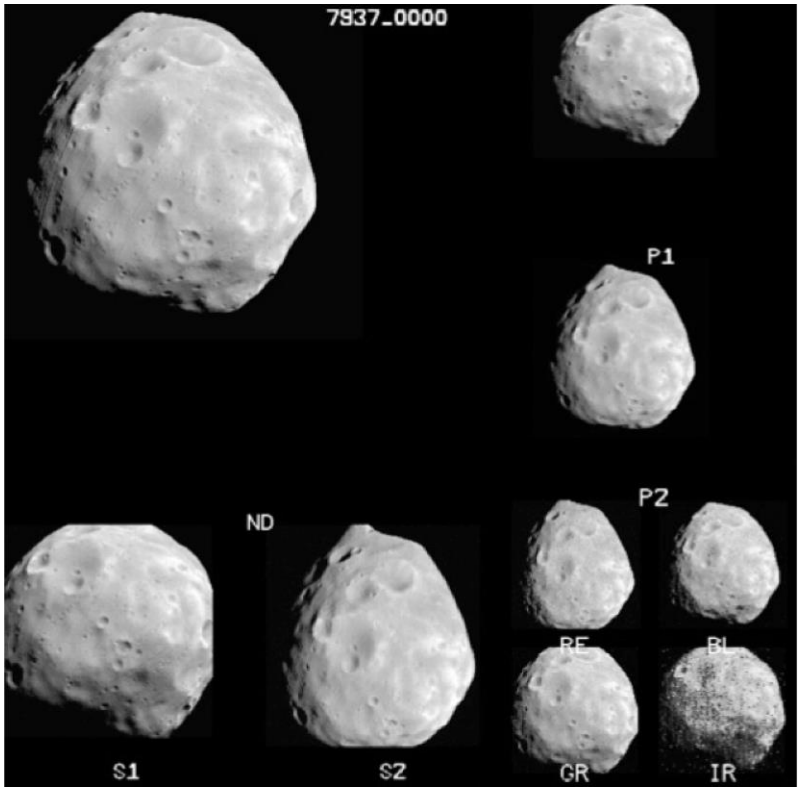


EXCELLENT PHOBOS GLOBAL SURFACE COVERAGE: VISUAL / COLOR / IR / STEREO FROM VO-1, VO-2 & MEX

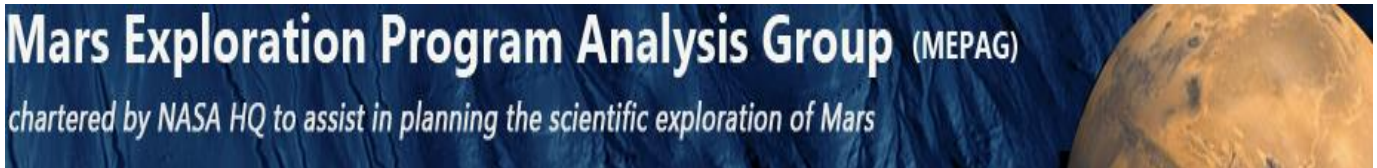
- **MEX EXAMPLE # 1**



SRC VISUAL @ 10 m/pixel



HRSC COLOR, PHOTOMETRY AND STEREO

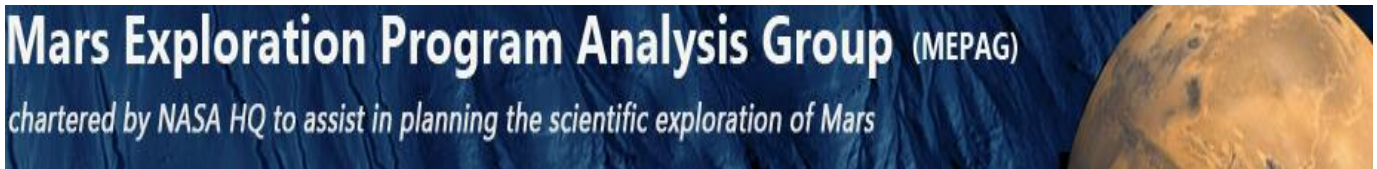


GLOBAL HRSC AND OMEGA

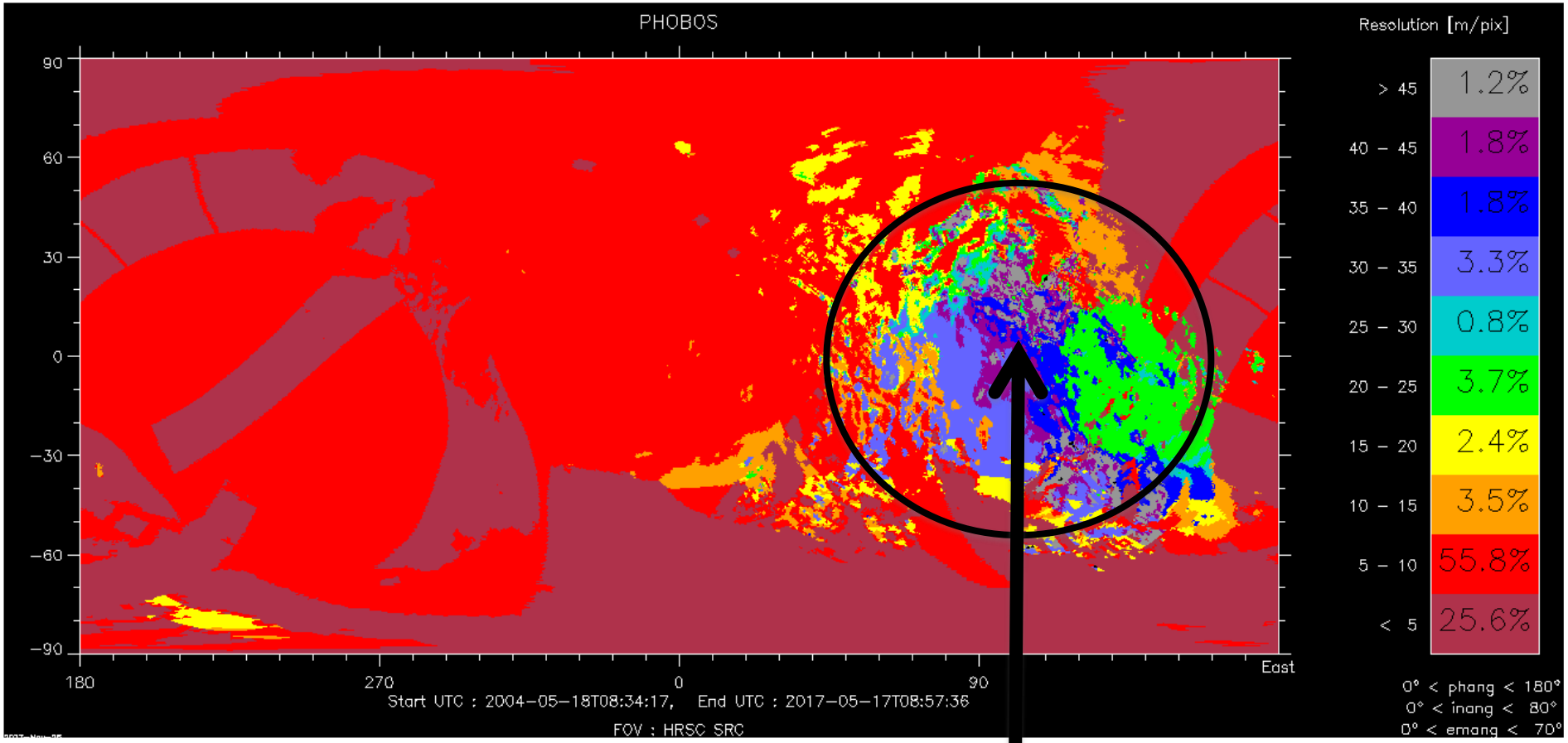
- **MEX EXAMPLE # 2**

6 SPECTRAL BANDS FOR PHOTOMETRY, COLOR AND STEREO

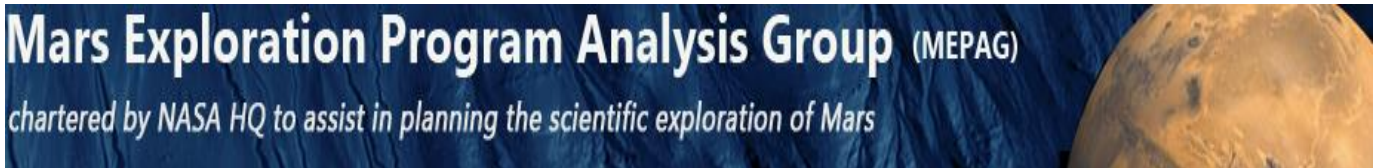
352 SPECTRAL BANDS



MEX SRC SURFACE COVERAGE



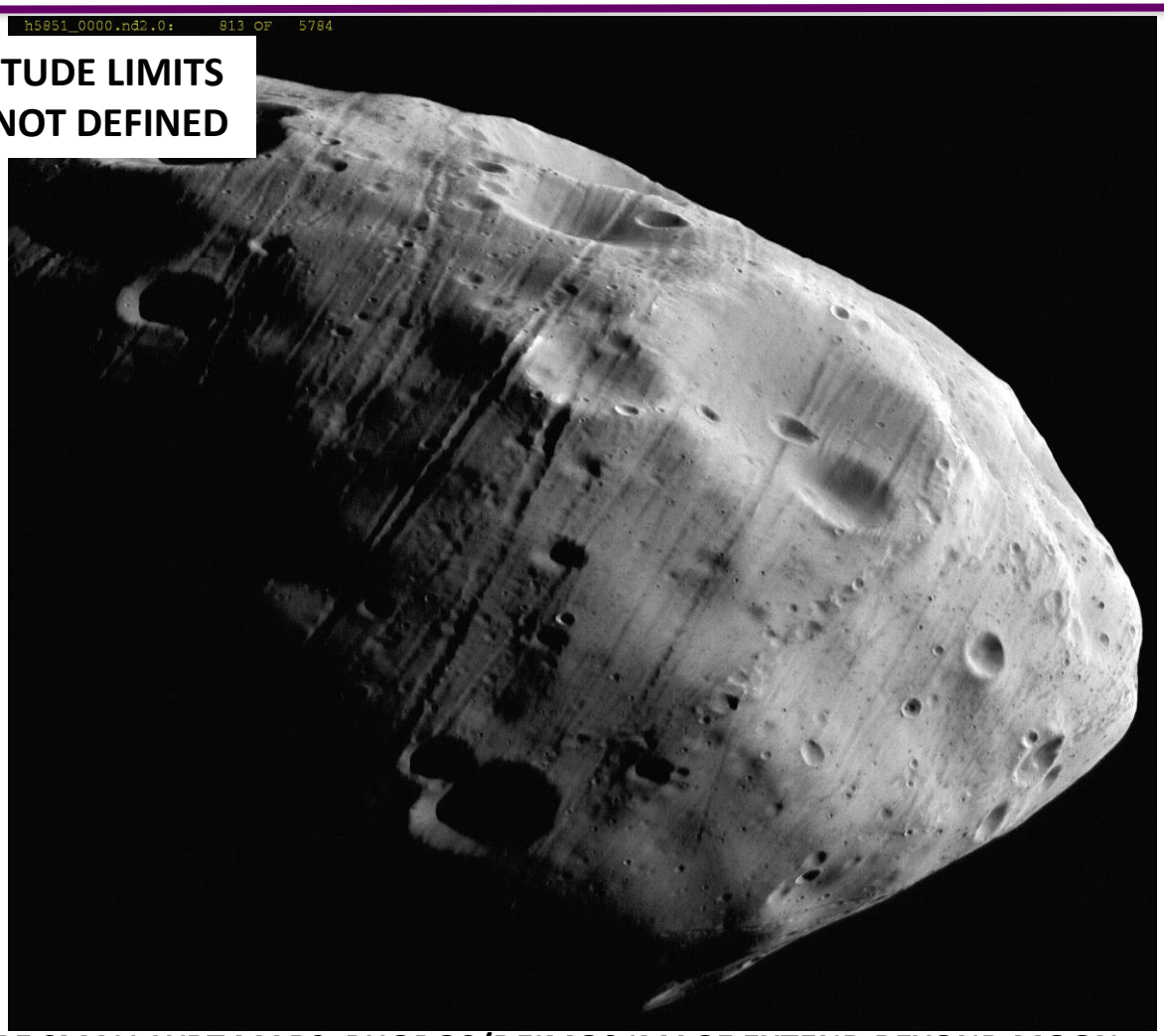
MEX CHANGED ITS ORBIT TO BETTER VIEW THE AREA CIRCLED



NO SEACHABLE CATALOG FOR VIKING / MEX / . . .
PDWG WILL PRODUCE INITIAL CATALOG WITH COMMUNITY INPUT

LATITUDE / LONGITUDE LIMITS

DEFINED NOT DEFINED

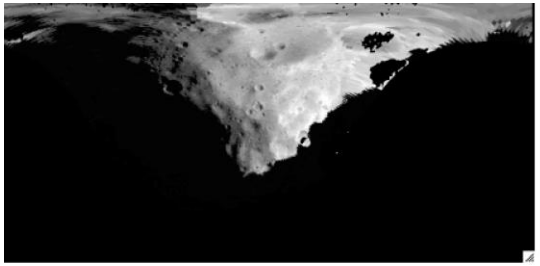
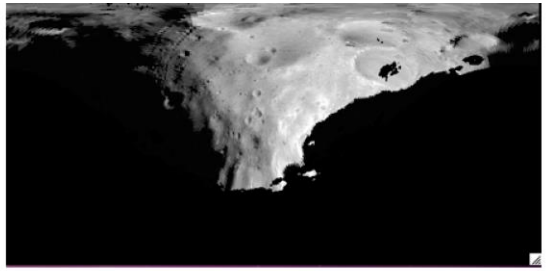
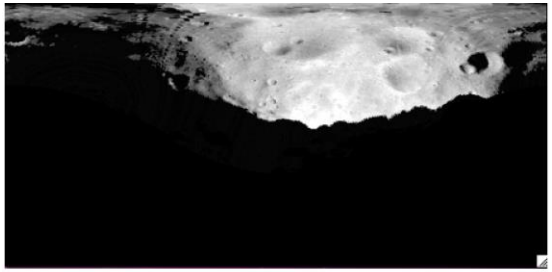


CATALOG PROBLEM: MARS IMAGES ARE SMALL WRT MARS; PHOBOS/DEIMOS IMAGE EXTEND BEYOND MOON

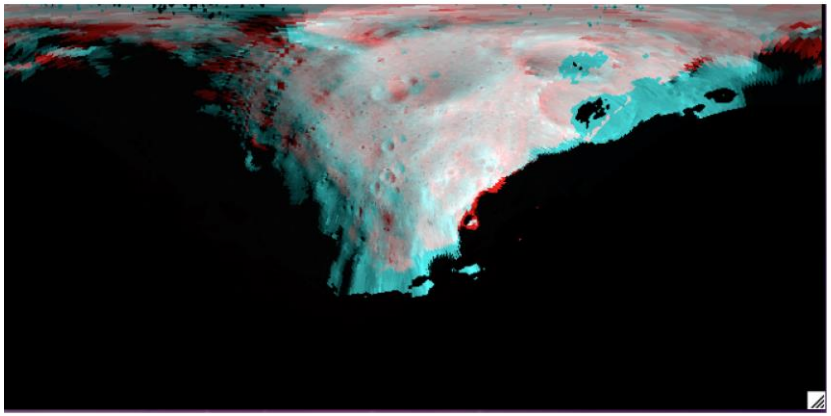
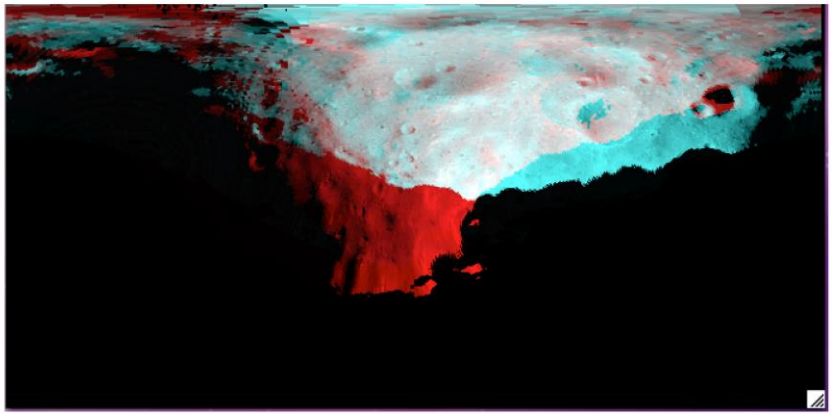
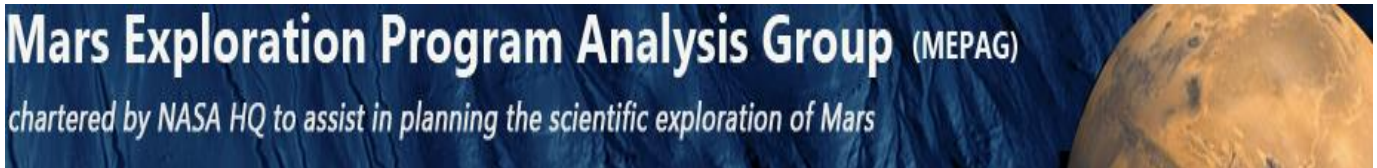
Mars Exploration Program Analysis Group (MEPAG)

chartered by NASA HQ to assist in planning the scientific exploration of Mars

Goal of Catalog: Allow International Community to Select and then Produce Level 3 / 4 Datasets to Support MMX and other Space Agency Missions

- **PRODUCE LEVEL-3 DATASETS – NEED MAP PROJECTION STANDARDS PHOBOS/DEIMOS ORIENTATION MODELS HAVE ERRORS (MGCWG/WGCCWG)**




- **PROCESS LEVEL-3 DATASETS FOR SURFACE CHARACTERIZATION, . . .**
- **NEED LEVEL 3 ARCHIVAL DATA PRODUCTS AND STANDARDS FOR GIS INPUT**