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Planetary Geodesy: An Essential Tool for Illuminating Planetary and Solar System Dynamics

Mars Geodesy and Cartography

by

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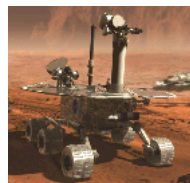
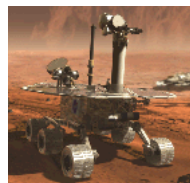
Time: 14:10
Place: MCC 2010



Mars and Cartographic

Pre-MGS

- **Mars Science Suffered from Lack of Accurate Reference Surface and Geoid**
  - **Absolute Surface Coordinates (Latitude and Longitude)**
  - **Absolute Radii and Topography Relative to Geoid**
  - **Ability for Precision Orbit Reconstruction and Long Term Predicts**



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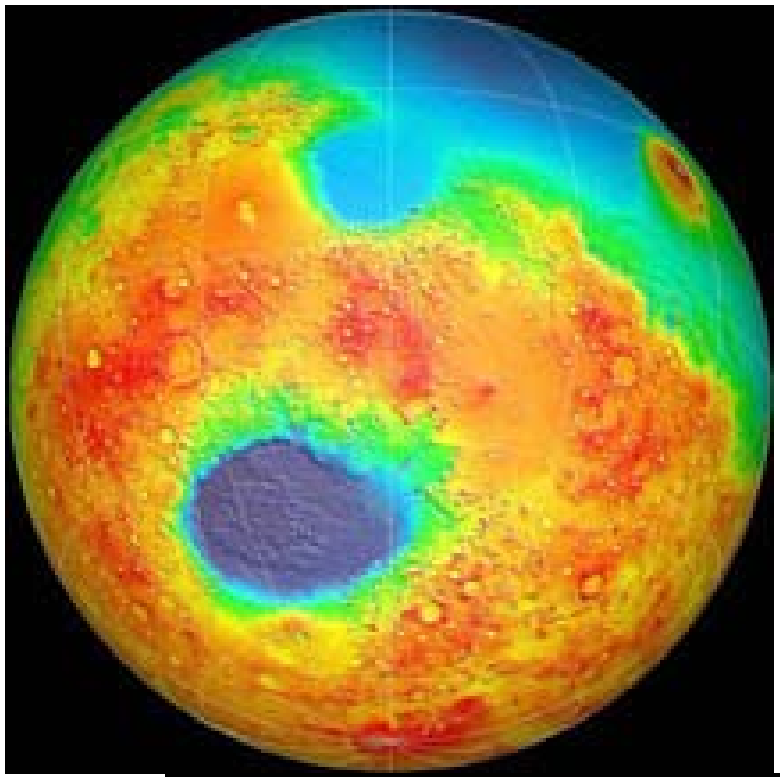
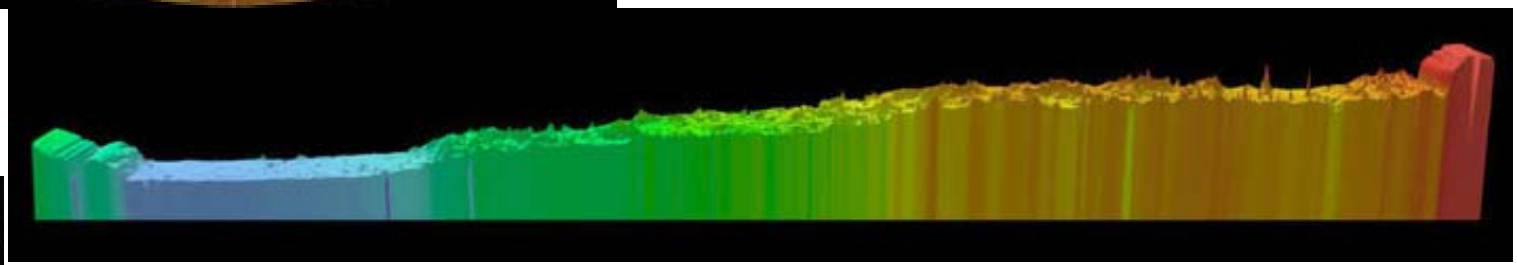
MGS MOLA: A New Era for Mars Geodesy and Cartography



- **David E. Smith - PI; Maria T. Zuber - Deputy PI**
- **Processed Jointly w/ Radio Science Tracking Data to Tie Geodesy and Cartography Together**
  - **Registered the Mars Surface and Gravity Field / Geoid**
  - **Produced Precision Orbits as By-product**
  - **Adopted Areocentric Coordinates**



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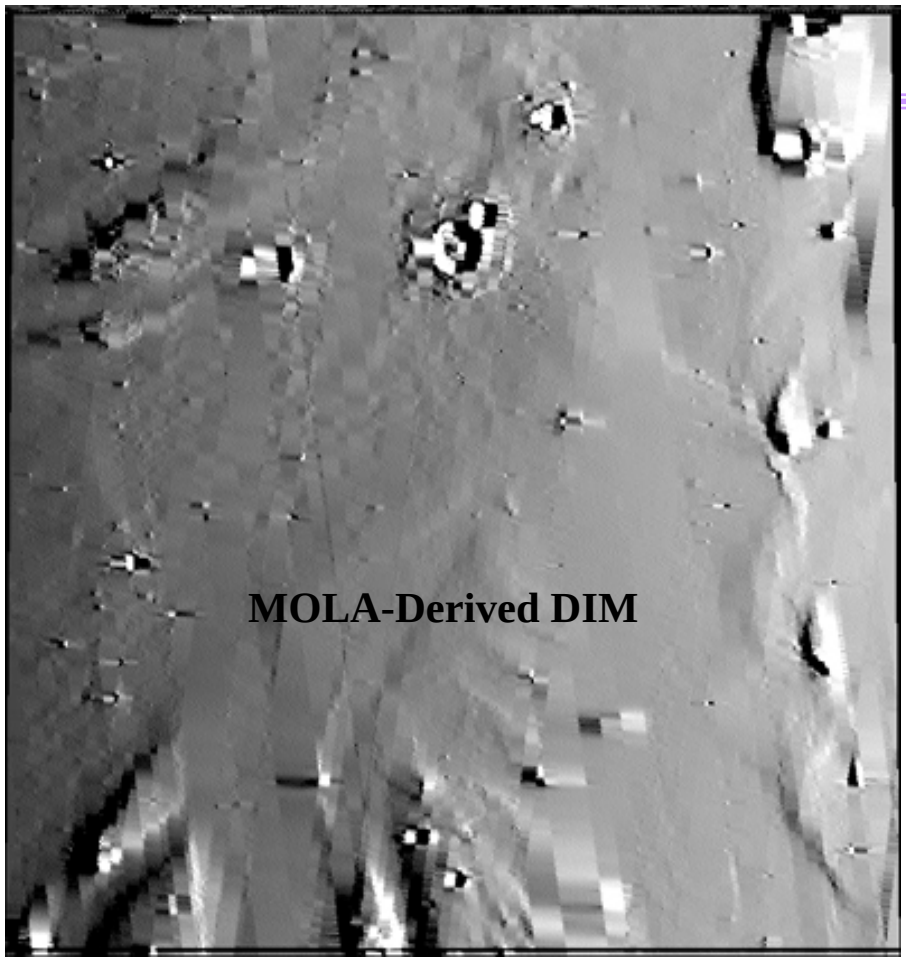
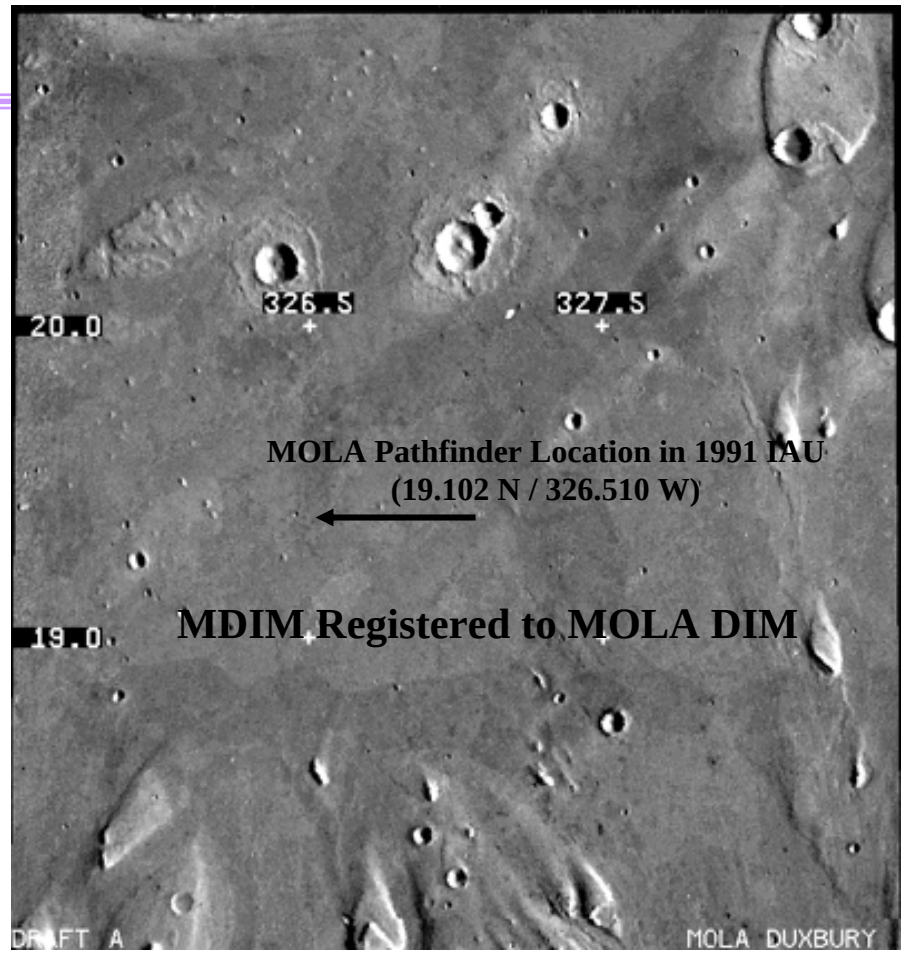
Preliminary MOLA / Pathfinder Test Case





MOLA-derived Location	**19.102 deg**	**326.477 deg W (1991 IAU translated to 1994 IAU)**
Folkner Location	**19.095 deg**	**326.476 deg W (1994 IAU)**
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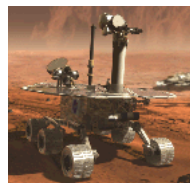
Difference	**0.007 deg**	**0.001 deg ~400m difference**



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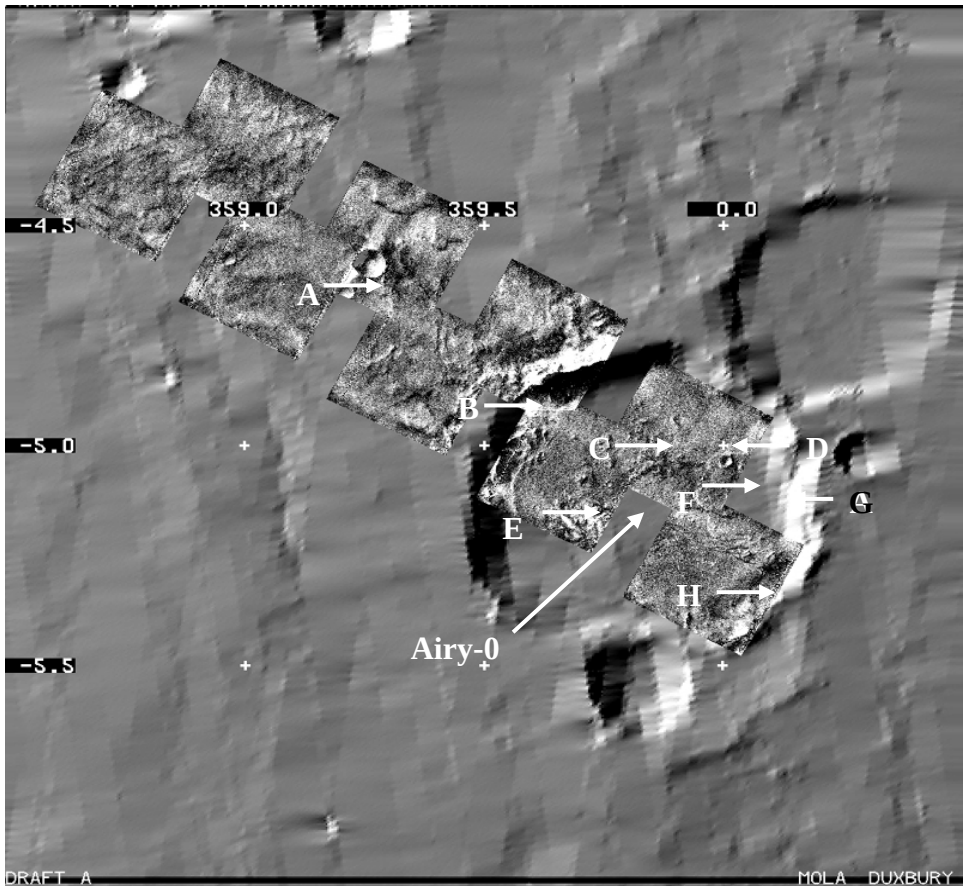
Viking Orbiter Images Registered to MOLA DIM - T. Duxbury (The Hunt for Red Airy-0 in October)



746A40-48
Airy-0:
ϕ = -5.082 deg
λ = -0.241 deg
= 359.759 deg
(areocentric)

W0 (2000 IAU) =
176.868 - 0.241 =
176.627 deg

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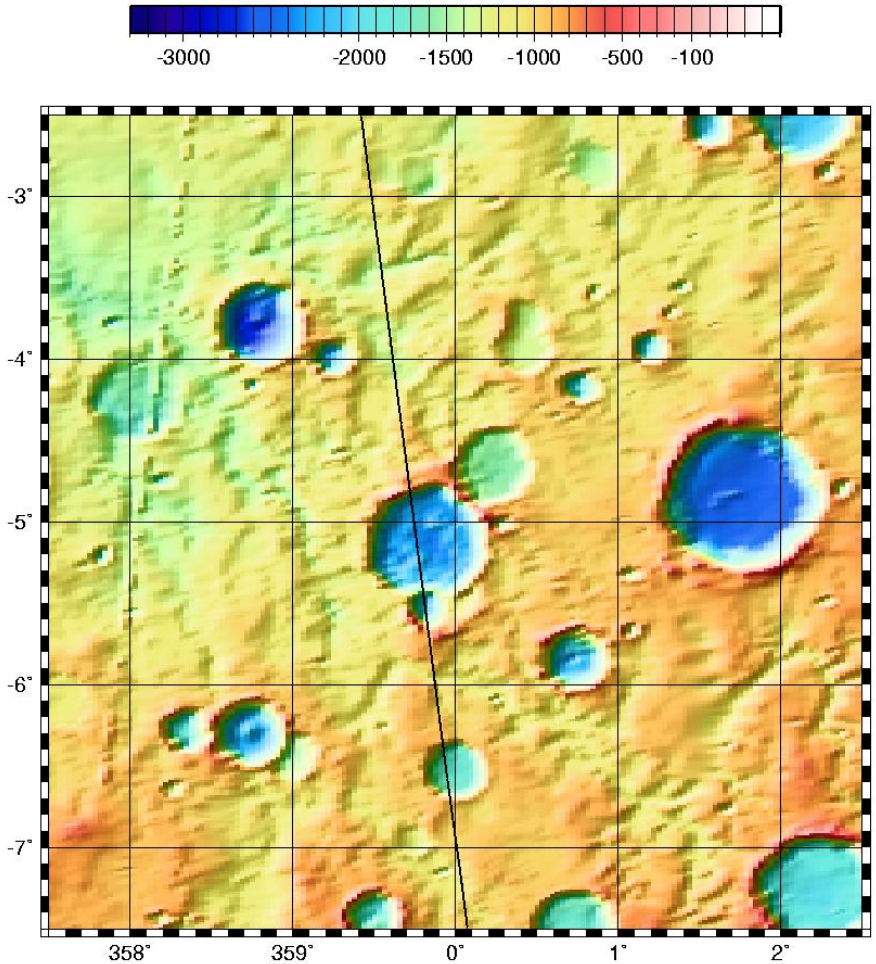
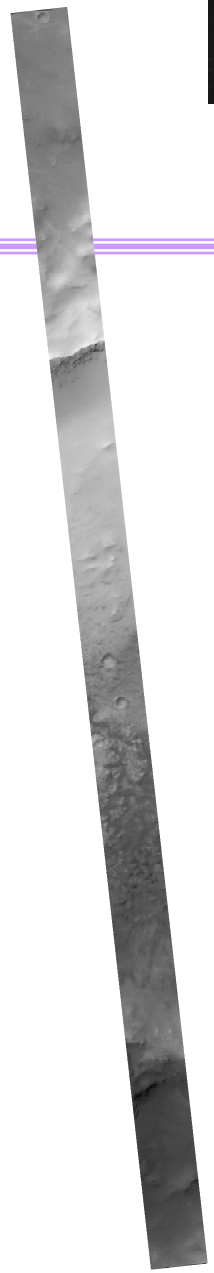
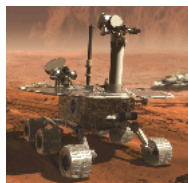
MOC Registration to a MOLA Strip

G. Newmann and M. Caplinger



W0 = 176.633

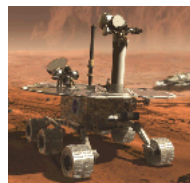




The Mars Prime Meridian – A Selected History

compiled by Michael Allison, NASA/GISS

	W_0 (J2000 eqnx)	VL1 W lon	VL2 W lon	PF W lon	Δlon (*wrt* 2001)	$V_{m(J2000)}$
Mayo *et al.* (1977)	[176°.627]	47°.94 ±0°.2	225°.71±0°.2	–	–0°.003	313°.382
Davies (1977)	[176°.507]	47°.82 ±0°.1	225°.59±0°.1	–	–0°.123	313°.262
Davies *et al.* (1983)	176°.655	–	–	–	+0°.025	[313°.410]
Davies & Katayama (1983)	176°.646	47°.962	–	–	+0°.016	[313°.401]
Davies *et al.* (1991)	176°.868	–	–	–	+0°.238	[313°.623]
Davies *et al.* (1996)	176°.901	–	–	–	+0°.271	[313°.656]
Folkner *et al.* (1997)	176°.901 (fixed)	48°.2217	225°.9900	33°.5238	+0°.271	[313°.656]
Davies *et al.* poster (1999)	176°.7440	48°.0647	225°.8330	33°.3668	+0°.114	[313°.499]
Davies email (10/11/99) (personal comm. to M.A.)	176°.7215	[48°.0422]	[225°.8105]	[33°.3443]	+0°.0915	[313°.476]
Zeitler & Oberst (1999)	176°.7195	48°.0402	[225°.8085]	33°.3423	+0°.0895	[313°.474]
Allison& McEwen (2000)	[176°.721]	–	–	–	[+0°.091]	313°.476 (adopted)
Duxbury *et al.* (2001) MCWG	176°.630	[47°.9507]	[225°.7190]	[33°.2528]	0°.000	[313°.385]



Allison - cont.

V_m represents the Mars prime meridian referred to the planet's vernal equinox, apparently the adopted convention prior to 1983 (or so). The difference $V_{m(J2000)} - W_0 \approx 136°.755$ is just the areocentric right ascension of the ascending node of the Mars equator on the terrestrial equator. Owing to precession, V_m advances at a slightely faster rate dV/dt = 350.8919852(°/d) than dW/dt = 350°.89198226, which is convolved with the motion of the Earth. (dV/dt is a more accurate measure of the Mars sidereal rotation rate.)

The [translated] V_m implied by the results of Folkner *et al.* (1997), assuming $W_0 = 176°.901$, is consistent with their rotation angle ϕ + 180° + a small 0°.0433 correction which (as communicated in an email from Folkner to Allison dated 12/16/97) should have been added for consistency between their Tables1 and 2.

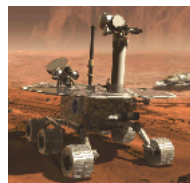
The tabulated values from Zeitler & Oberst (1999) reflect an adjustment of their given values by their noted 0°.1815 adjustment of the location of Airy-0 with respect to the Davies *et al.* (1996) value for W_0.

Note that there seems to have been a systematic forward shift of W_0 by some ~0°.3 sometime between 1983 and 1991, about the same time as the switch from the J1950 to the J2000 epochs. The new MCWG revision, with $W_0 = 176°.630$, appears to be very nearly consistent with the values given by Mayo *et al.* (1977) and Davies & Katayama (1983).

Conjecture: The difference between the J2000 and J1950 equinox and ecliptic reference for W amounts to

$$W_{2000(J2000)} - W_{1950(J2000)} = 0°.311$$

Could this difference have propagated into the ongoing determinaton of W post-1983?



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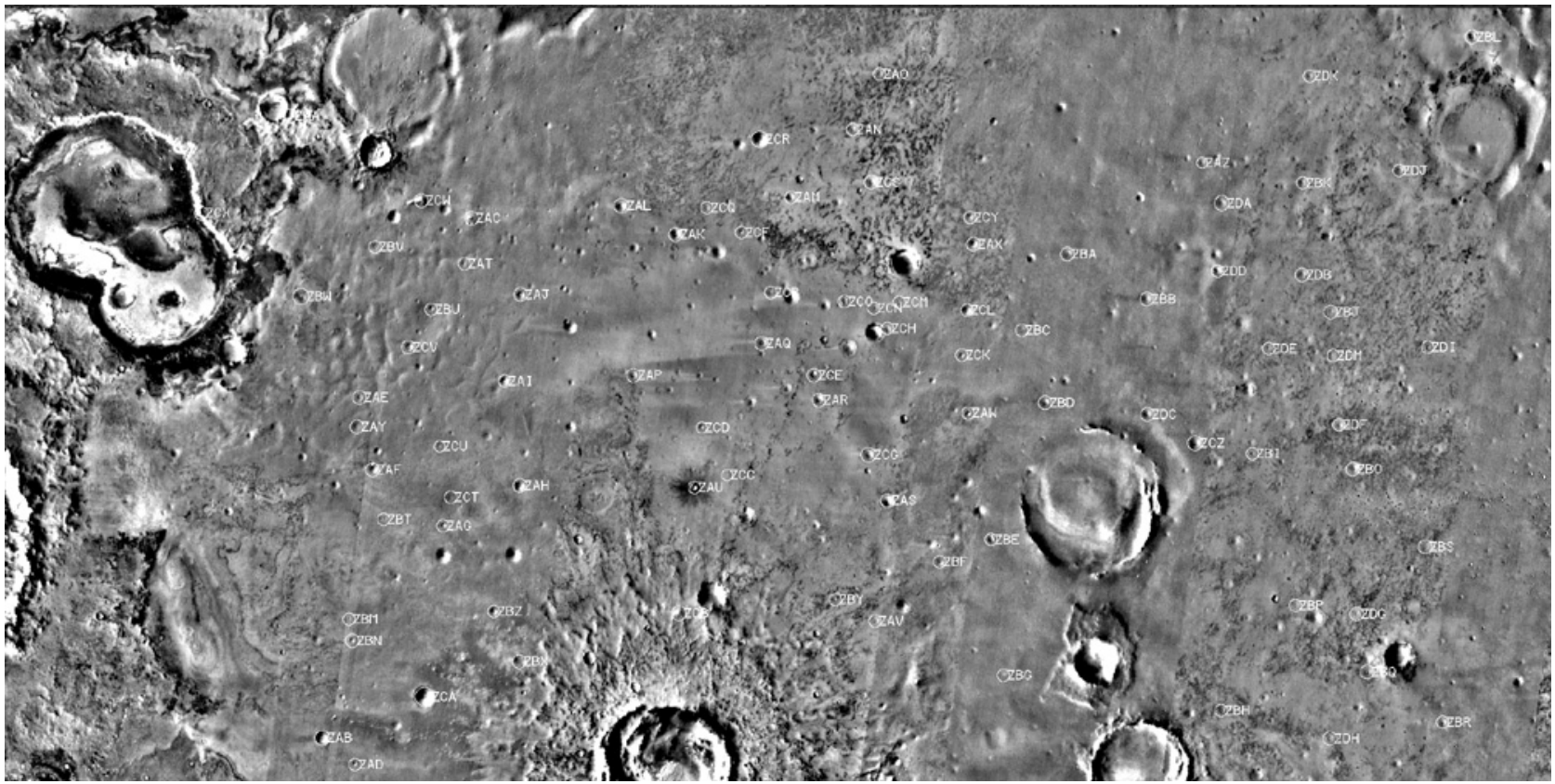
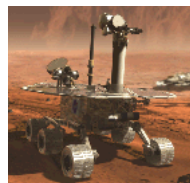
MER Meridiani: THEMIS IR Registered to MOLA Pre-Landing



Post Landing Reconstruction: Absolute Error of 130 m (~1 THEMIS IR Pixel)



Future of Mars Geodesy and Cartography

- **Local Maps (e.g., Landing Sites) will be Routinely Produced having Absolute Accuracies at the 100 m Level and Better Near the Poles**
  - **A Major Objective of the Mars Exploration Program has Been Met**
- **Targeting High Resolution Instruments to Specific Surface Features is / will be Routine**
  - **HRSC/SRC, HIRISE, CRISM**
  - **MOC has to Figure this out on Their Own**
- **Significant Improvements to Gravity Field and Rotational Properties**
  - **MGS, Odyssey, MeX, MER and MRO added to M'9 and Viking Orbiter / Lander Tracking Data**
  - **Seasonal Migration (Sublimation and .) of Mass Between Equator and Poles**
  - **Seasonal Rotational Variations**
  - **Internal properties**
  - **. . . and the list goes on . . .**
- **The Cartography Community Would Like more MOLA-type Instruments in its Future**