Mars, the Meridian, and Mert: The Quest for Martian Longitude

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Outline

- Historical overview
- Initial Mars network and Airy-0
- Mars orientation and W_0
- Network improvements
- W_0 from new data (2001)
- Current uses and network
- Summary

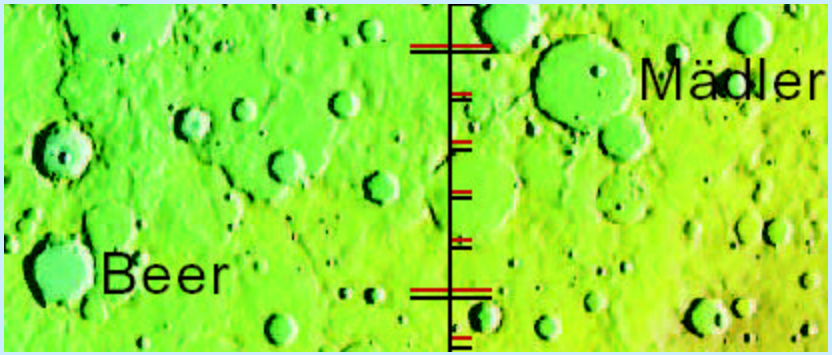
Acknowledgements
Contributors to this work…

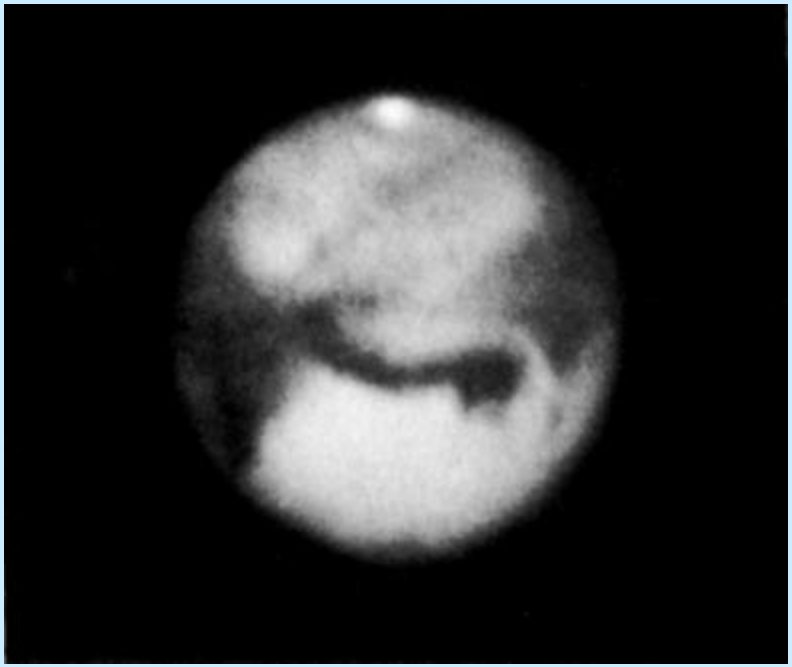
- Numerous individuals and organizations since the 1960's. More recently…
- Members of the NASA Mars Geodesy and Cartography Working Group (MGCWG)
- Includes or has included individuals from ==>

- RAND (Mert and T. Colvin)
- Jet Propulsion Laboratory
- NASA Ames
- NASA Goddard
- Purdue University
- Ohio State University
- Malin Space Science Systems
- German Center for Aerospace Research DLR
- U. S. Geological Survey
- Representatives of current and future Mars mission teams

Orientation of Mars – Historical

- Mars maps have always been derived by assuming a 0º longitude for some surface feature.
- Wilhelm Beer and Johann Mädler (1830) adopted a dark feature (called “a”).



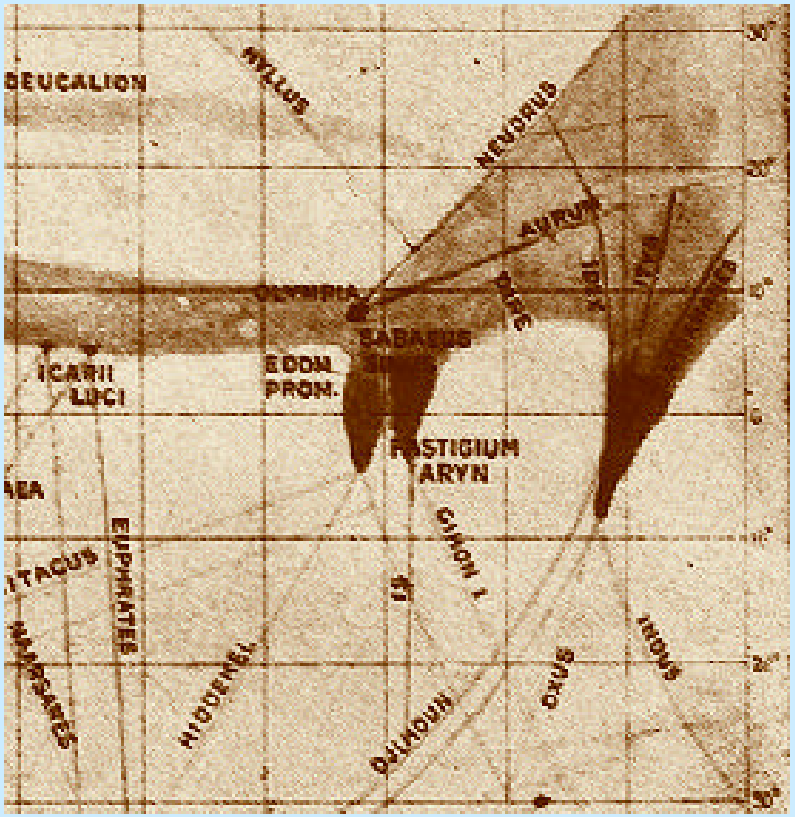


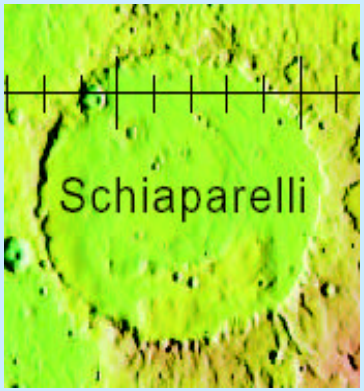
1941 photo from Lowell Obs.
(south up)

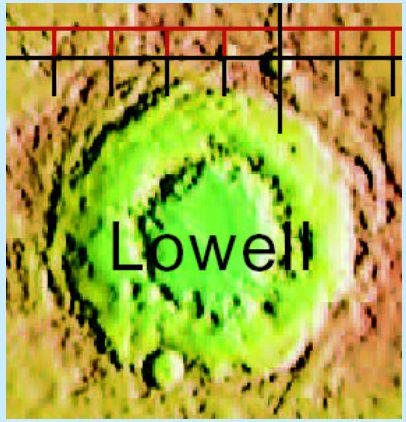
Named crater images from forthcoming USGS MOLA I-map (funded by NASA PG&G)

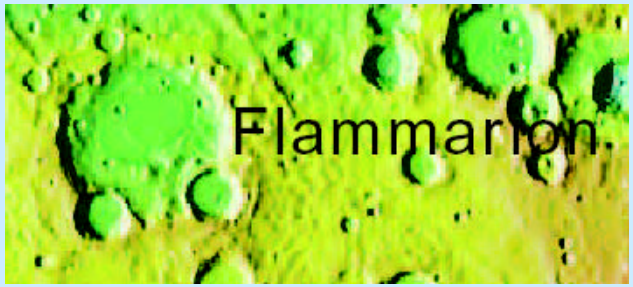
Orientation of Mars – Historical, cont.

- Same feature adopted by others later in the 19th century
- Schiaparelli and Lowell's "Fastigium Aryn"
- Flammarion's (1889) "Baie duMéridien"
- Later "Sinus Meridiani".





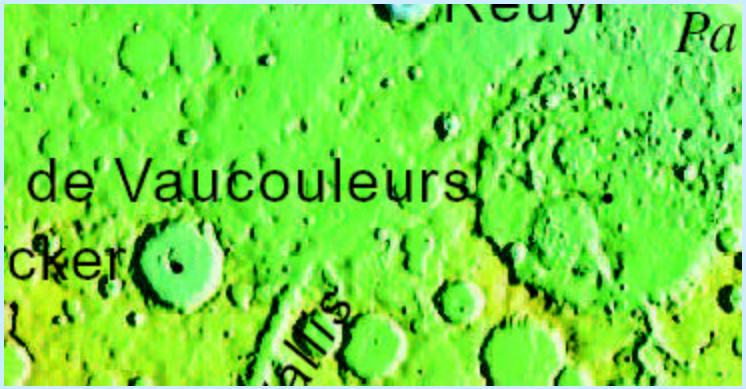


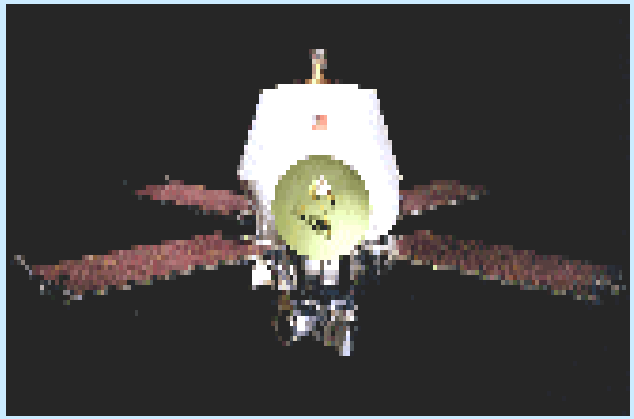


Above: detail -1905 Lowell map (south up)

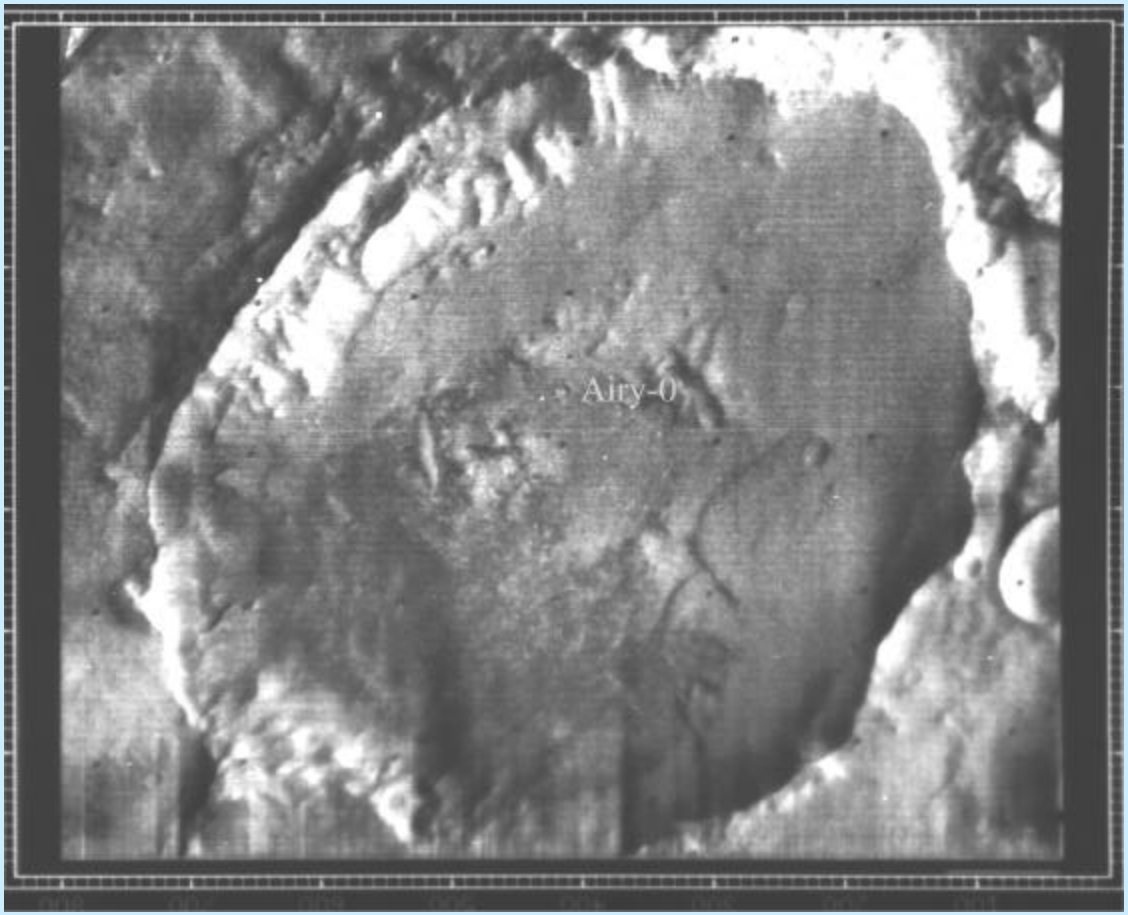
Orientation of Mars - Modern

- Also adopted again by G. de Vaucouleurs in the late 1960's during creation of last and best Earth observation based map of Mars.
- In 1972 de Vaucouleurs, Mert, and H. Masursky arranged to have some of the last Mariner 9 images taken of the 0º longitude area on Mars.

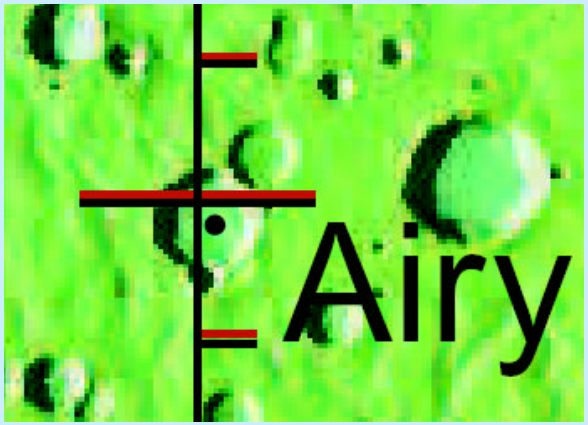




Airy-0 Defined as on Prime Meridian



Result was adoption of large crater, named by them “Airy”, and more specifically a small 500-m crater in it “Airy-0” as marking 0º longitude, the Prime Meridian of Mars



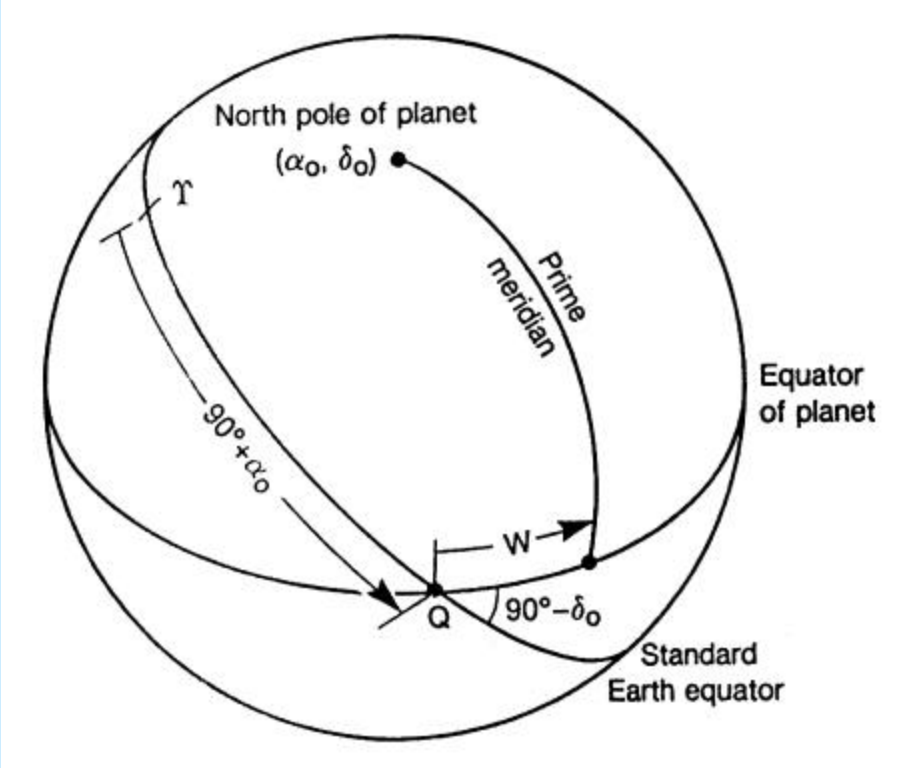
Orientation Definition

•In order to determine the orientation of Mars at any given point in time (W), the offset to Airy-0 – relative to inertial space – must be specified at a given instant in time.

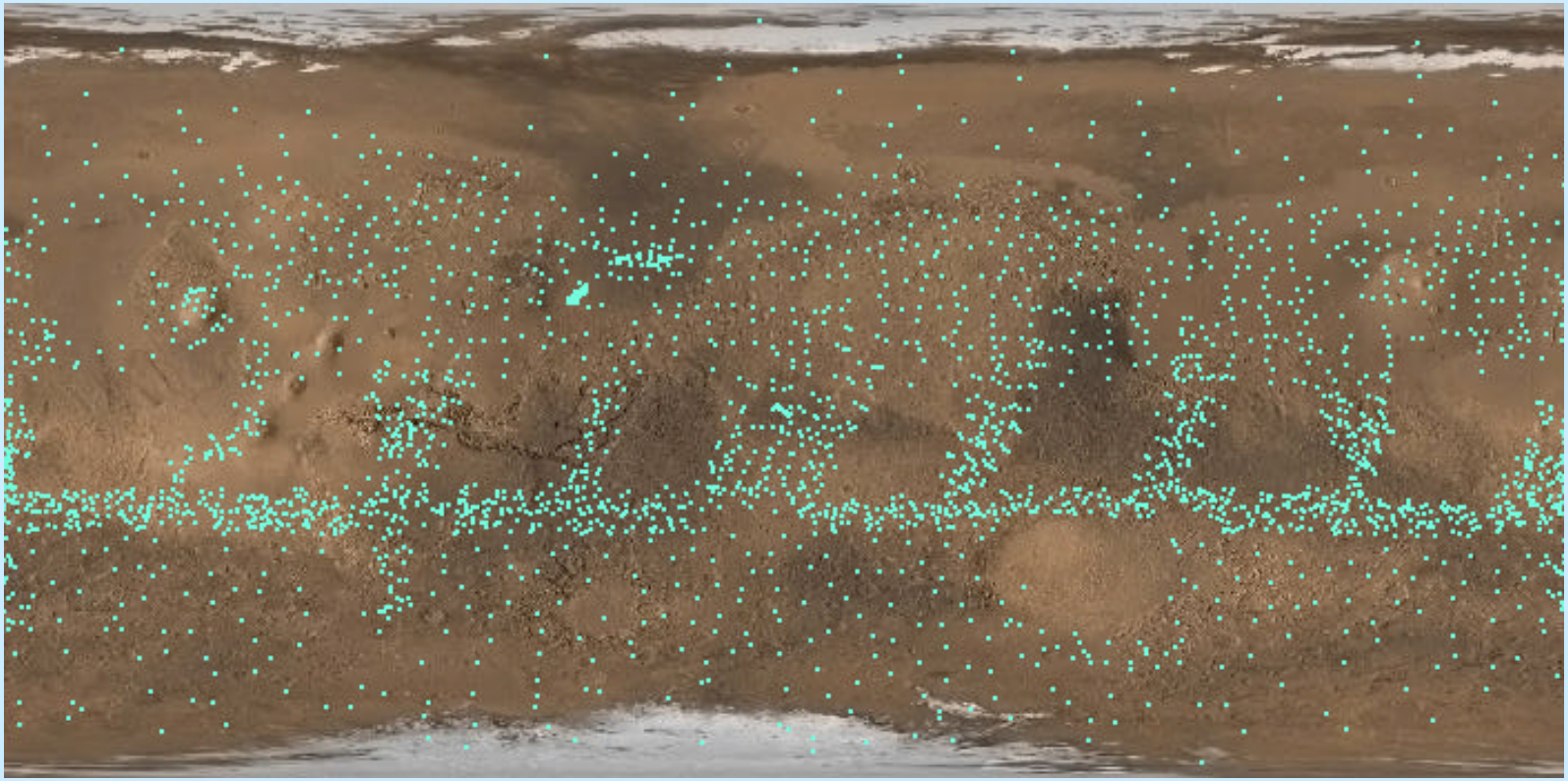
•This offset is called W_0, and is defined for Mars as the angle along the equator to the east, between the meridian passing through Airy-0 and the Martian equator's intersection with the celestial equator at the standard epoch of J2000.0.

$$W = W_0 + W_dot * d$$

where W_dot is the rotation rate and *d* is the number of days from the standard epoch.



Initial Mariner 9 Control Network and W_0 Determination

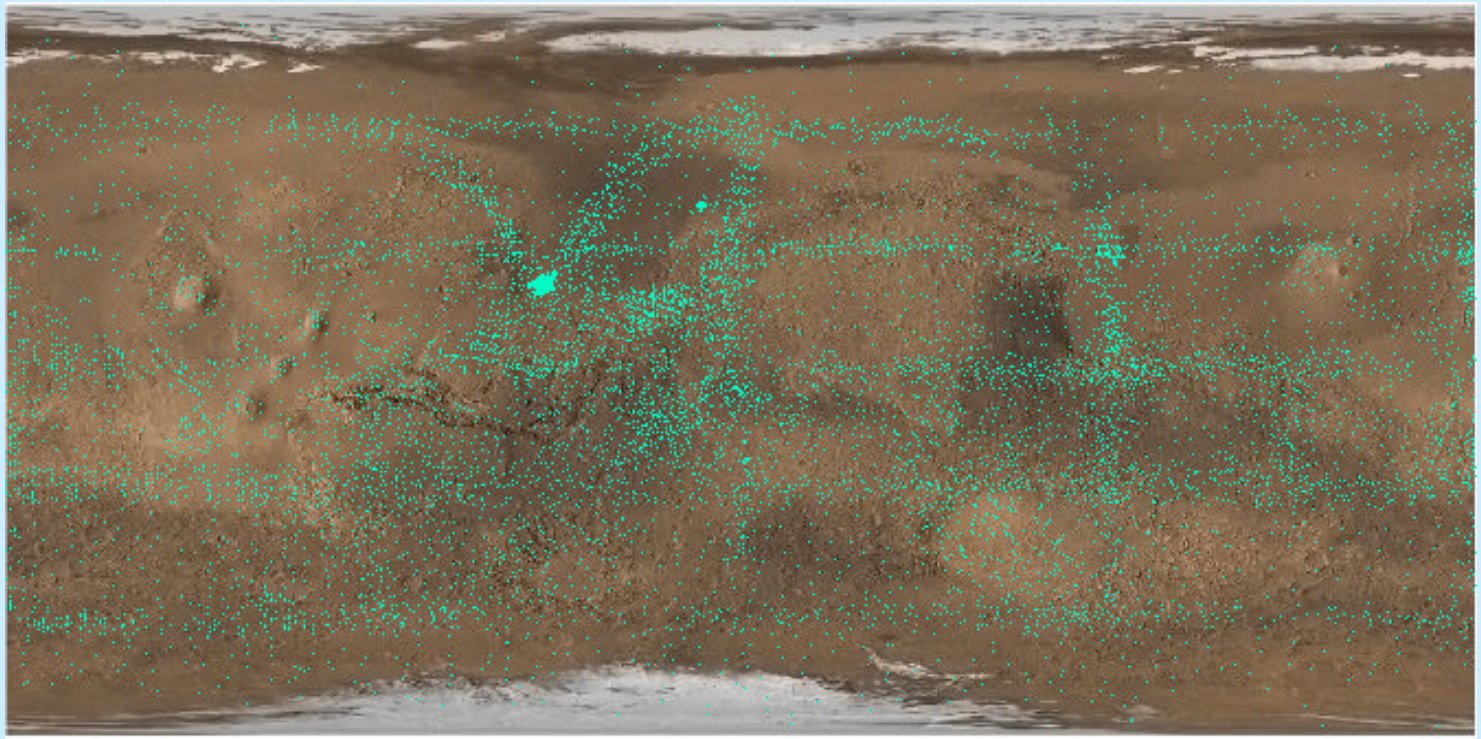


RAND (Davies et al.) network as of 1974: 762 images, 2061 points, 11678 measures

Improvements in Control Network and W_0

- From then until early 2000 W_0 continued to be determined in the same way, mostly from solutions by Davies, et al., and also Zeitler and Oberst (1999). Results were successively improved by e.g.:
  - Starting with only Mariner 9 images
  - Using Viking images
  - Holding the supposed positions of the Viking 1 and 2 landers fixed (to their positions determined by spacecraft tracking).
  - Holding the supposed position of the Pathfinder lander fixed.

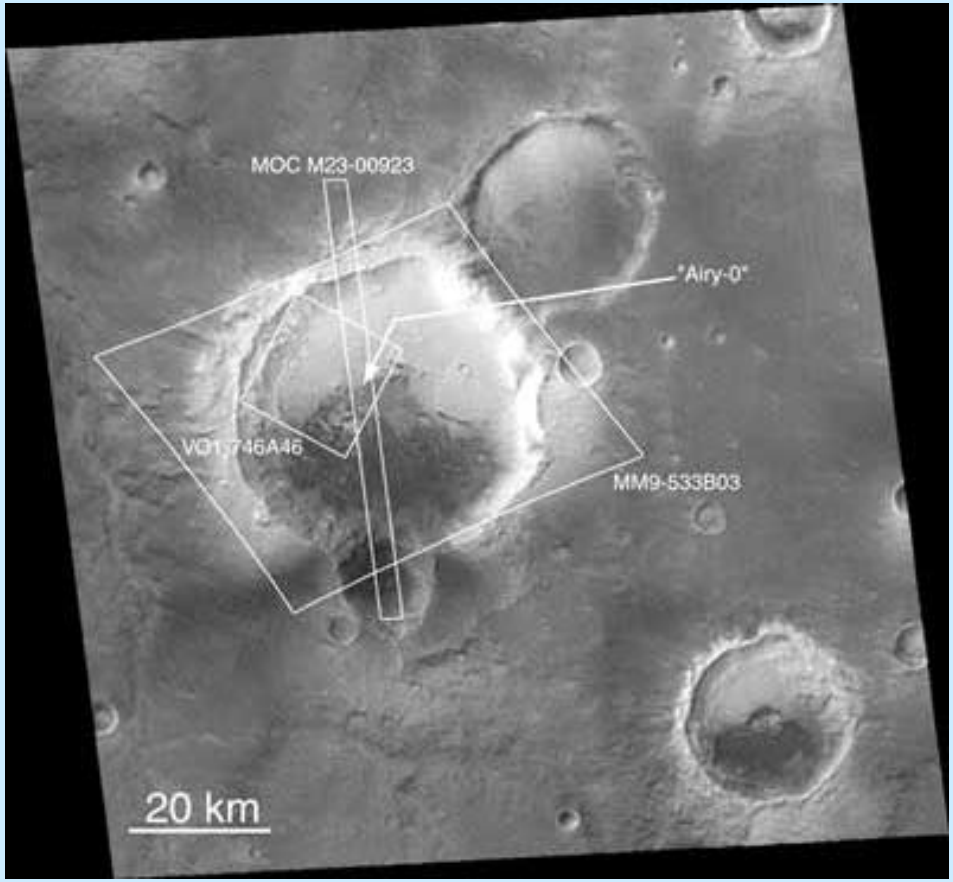
Example: ~1990 RAND Network (before merging with USGS Network)



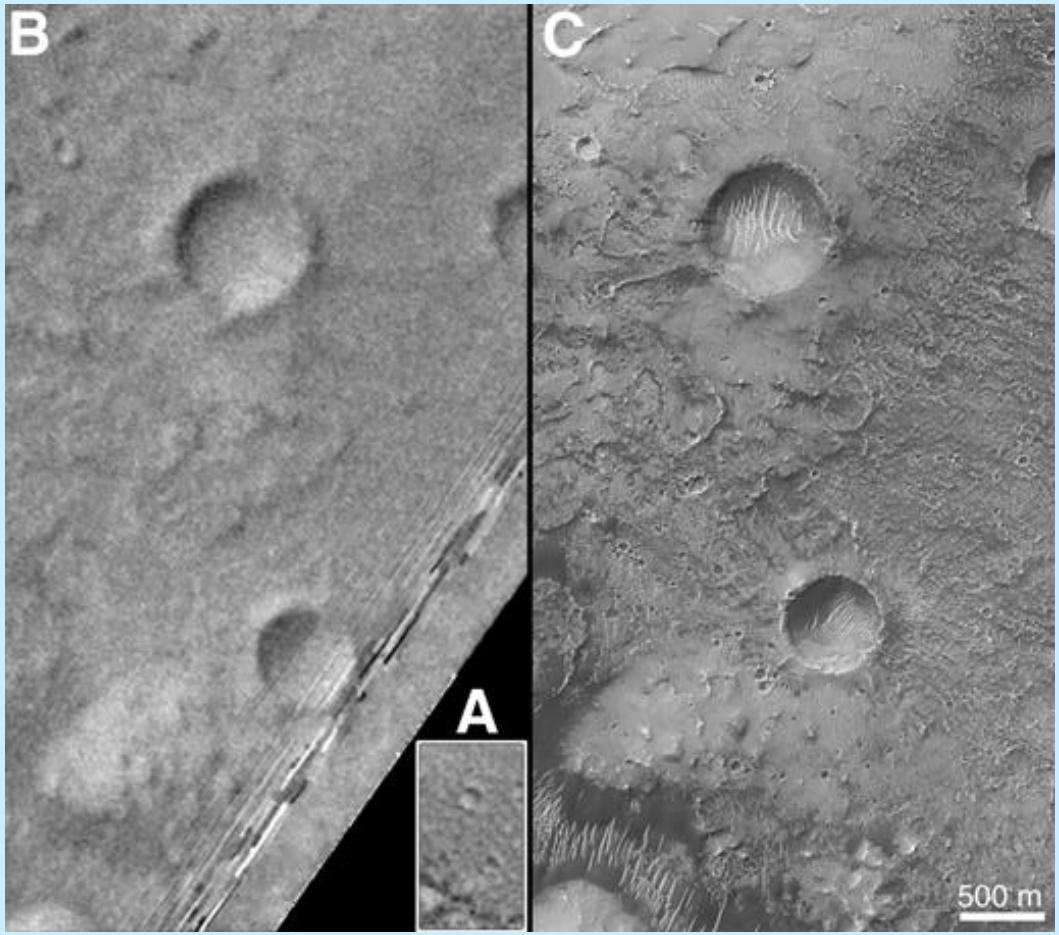
Mariner 9 and Viking images, Viking 1 lander location fixed, 9333 control points

New Data at Airy-0

- On January 13, 2000, MSSS (Caplinger et al.) obtained MOC WA image (at right) and NA image (narrow outline) of Airy and Airy-0
- Original Mariner 9 image and a Viking image outline shown for comparison.
- MOC NA image included MOLA ground track



MGS Data at Airy-0

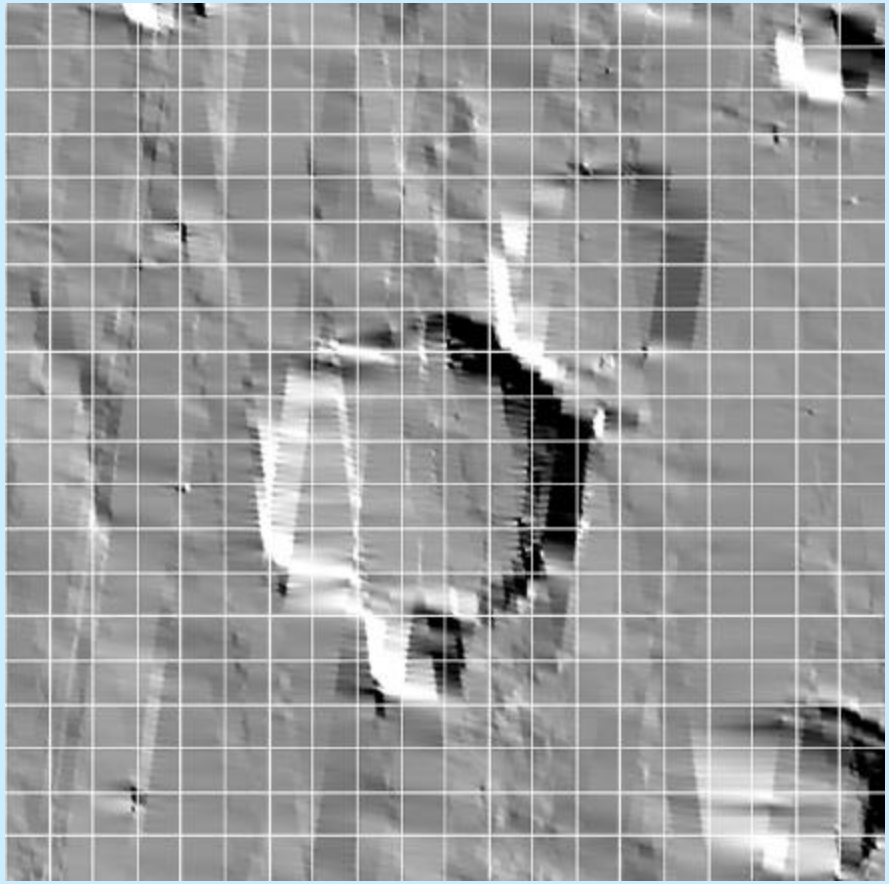


Portions of Viking image – on left - and MOC narrow angle image – on right. Now available were:

- Position in MOC image (Caplinger)
- MOLA track inertial coordinates (G. Neumann and Archinal)
- Connection between these (S. Anderson)

Result: New estimate of W_0

MGS Data at Airy-0, cont.



- MOLA tracks also allowed for construction of topographic model of Airy region
- This compared to Viking images of area showing Airy-0 (T. Duxbury)

Result: New estimate of W_0

New Determination of W_0

- MCGWG agreed to use an average of these two determinations.
- This estimate also verified by comparison with other estimates of W_0 via photogrammetric solutions (Davies and Colvin; Zeitler and Oberst) and other techniques (e.g. ties to landing sites).

And the answer is: $W_0 = 176.630^o$

The uncertainty of this value is estimated at ± 0.003º to 0.004º, or about *250 m* on the Martian surface.

An improvement in this value is unlikely until a radio transmitter (lander) can be placed in the vicinity of Airy-0. Even then it is possible that the value will not be changed and it will be accepted – as it is for the Earth – that the most accurate location for the Prime Meridian does not fall precisely through the "point" originally defining it. E.g. the Airy Transit Circle for the Earth, and Airy-0 for Mars.

Adoption of New Value

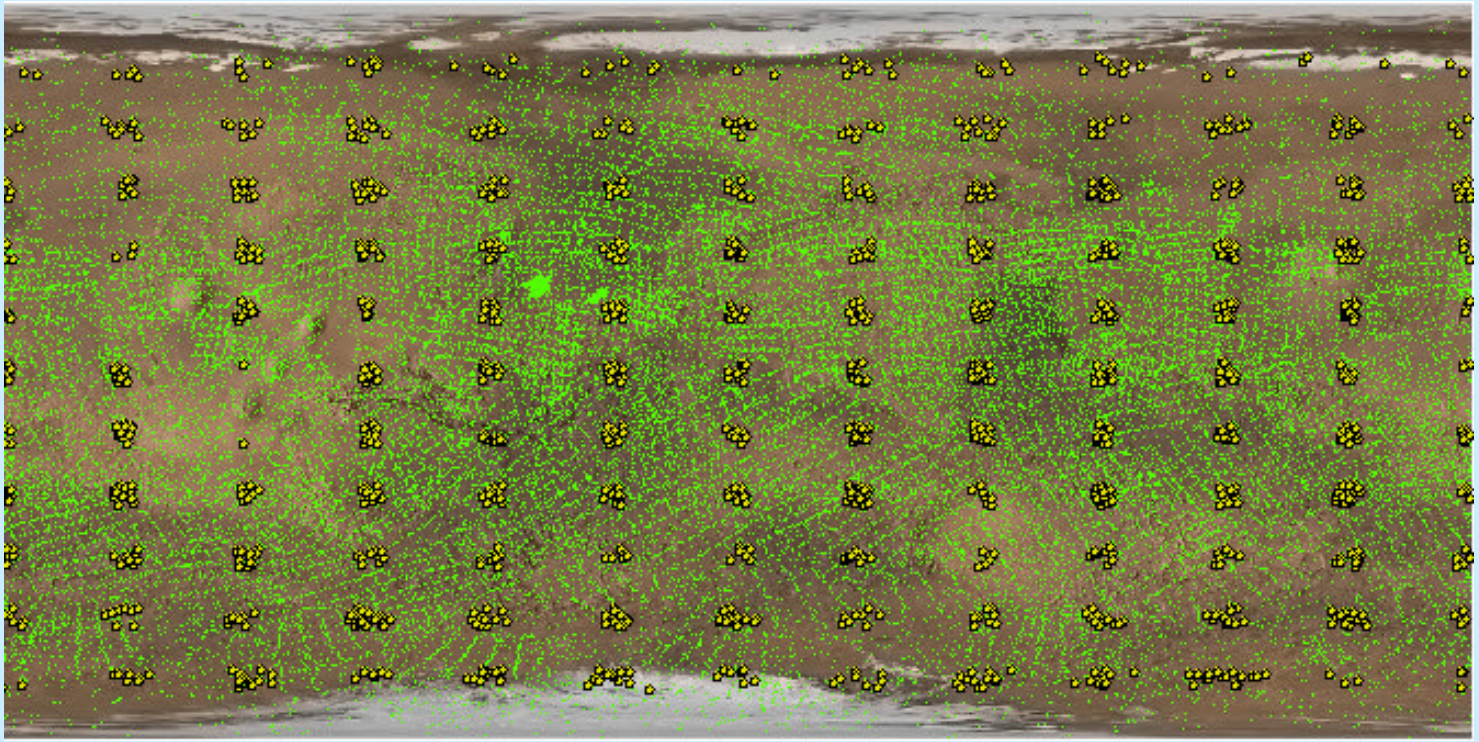
- IAU/IAG adoption (recall earlier talk by Seidelmann):

P. K. Seidelmann, et al. (2002). "Report of the IAU/IAG Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites: 2000," *Celestial Mechanics and Dynamical Astronomy*, 82, pp. 83-110, 2002.

- Partial adoption by MGS instrument teams.
- Full adoption by other current and future missions: Mars Odyssey, MER, Mars Express, Mars Reconnaissance Orbiter

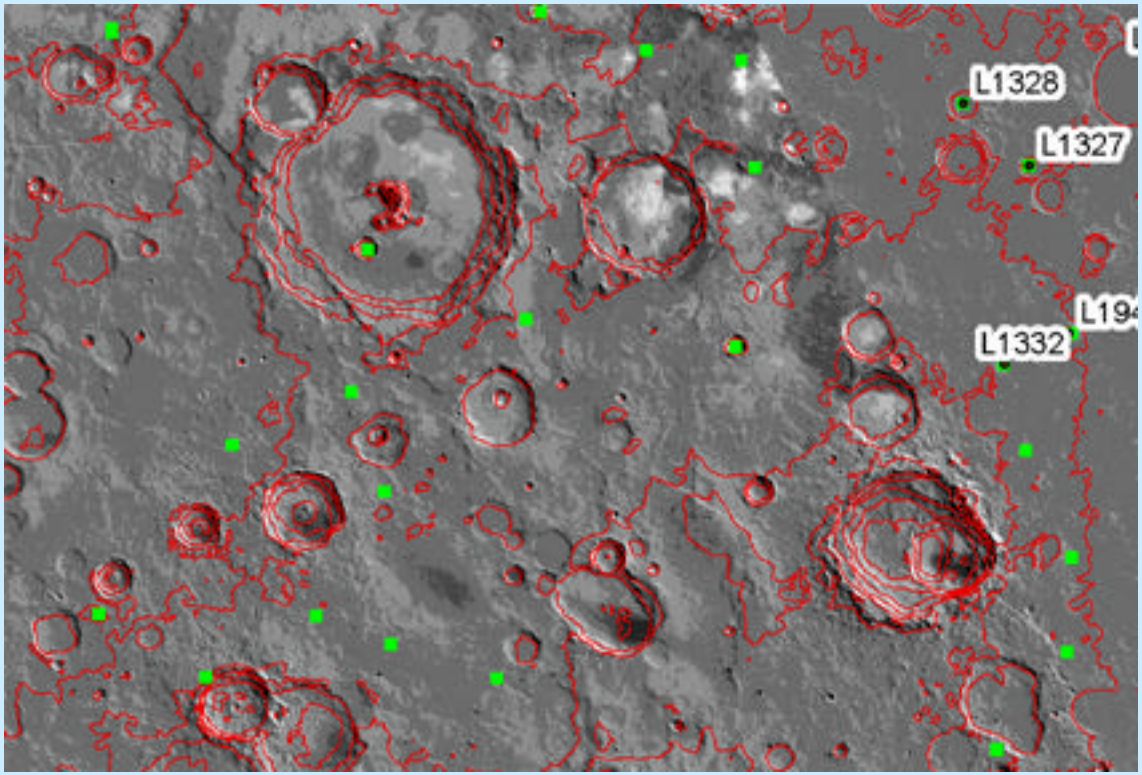
➔ All measurements and images can be intercompared in a common Mars longitude system, at the ~250 meter or better level of accuracy.

Current Viking and Mariner 9 Control Network



Current RAND-USGS network – Using new W_0: 6371 images (5317 Viking, 1054 Mariner 9), 37657 points (green), 1216 MOLA tie points (yellow), 90518 measures

Global Viking Image Mosaic, Using New System - MDIM 2.1 (in preparation)



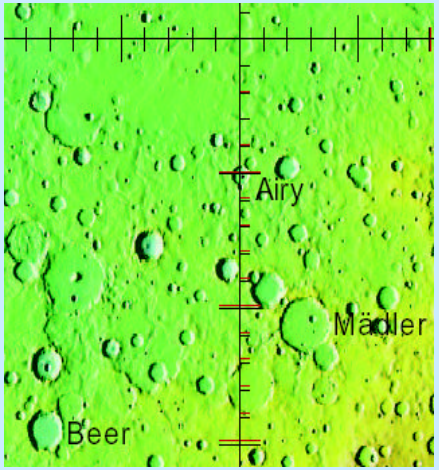
Test MDIM 2.1 mosaic with MOLA 500 m contours superposed. ~400 km wide region in Daedalia Planum (control in green, MOLA tie points labeled; no photometric corrections to mosaic)

Summary

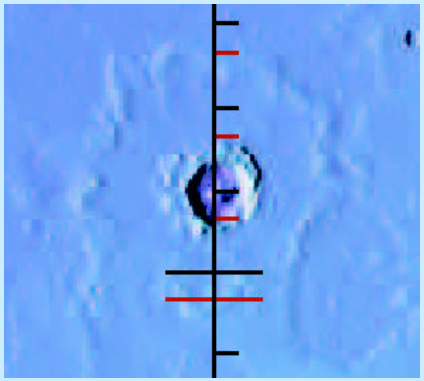
- Historical Mars longitude origin is Sinus Meridiani albedo feature
- Airy-0 chosen as new origin by Mert, et al., with first – and most following – control networks by Mert, et al.
- Current (final?) determination of origin in inertial space by MCGWG – including input from Mert…

All made possible by Mert Davies

- The pioneer in mapping the solar system
- Certainly we can know what one of those unnamed craters near 0º longitude will soon be named…



<= unnamed craters near Airy



<= unnamed crater at 0º, 46ºN