

The 2009 Report of the IAU Working Group on Cartographic Coordinates and Rotational Elements

(and how recent advances in adaptive optics and multi-data inversion are influencing those sections and tables related to small bodies in the solar system)

Questions Answered in this Talk

- What is the WGCCRE and what is covered in their report?
- How are recent advances in AO (and multi-data inversion techniques) changing content in the report?
- What happened at the 2009 general assembly meeting?
- Since that meeting of the working group has there been any discussion related to ground-based observations of small bodies?
- Will there be changes to the report based on ground-based observations of small bodies?
- Why is this report of interest to participants of PPA2010?



(IAU Working Group for Cartographic Coordinates and Rotational Elements)

WGCCRE

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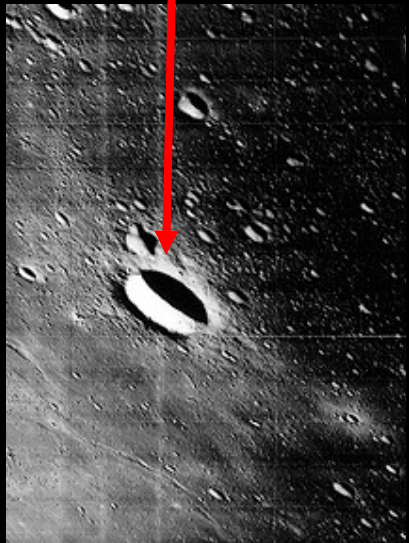
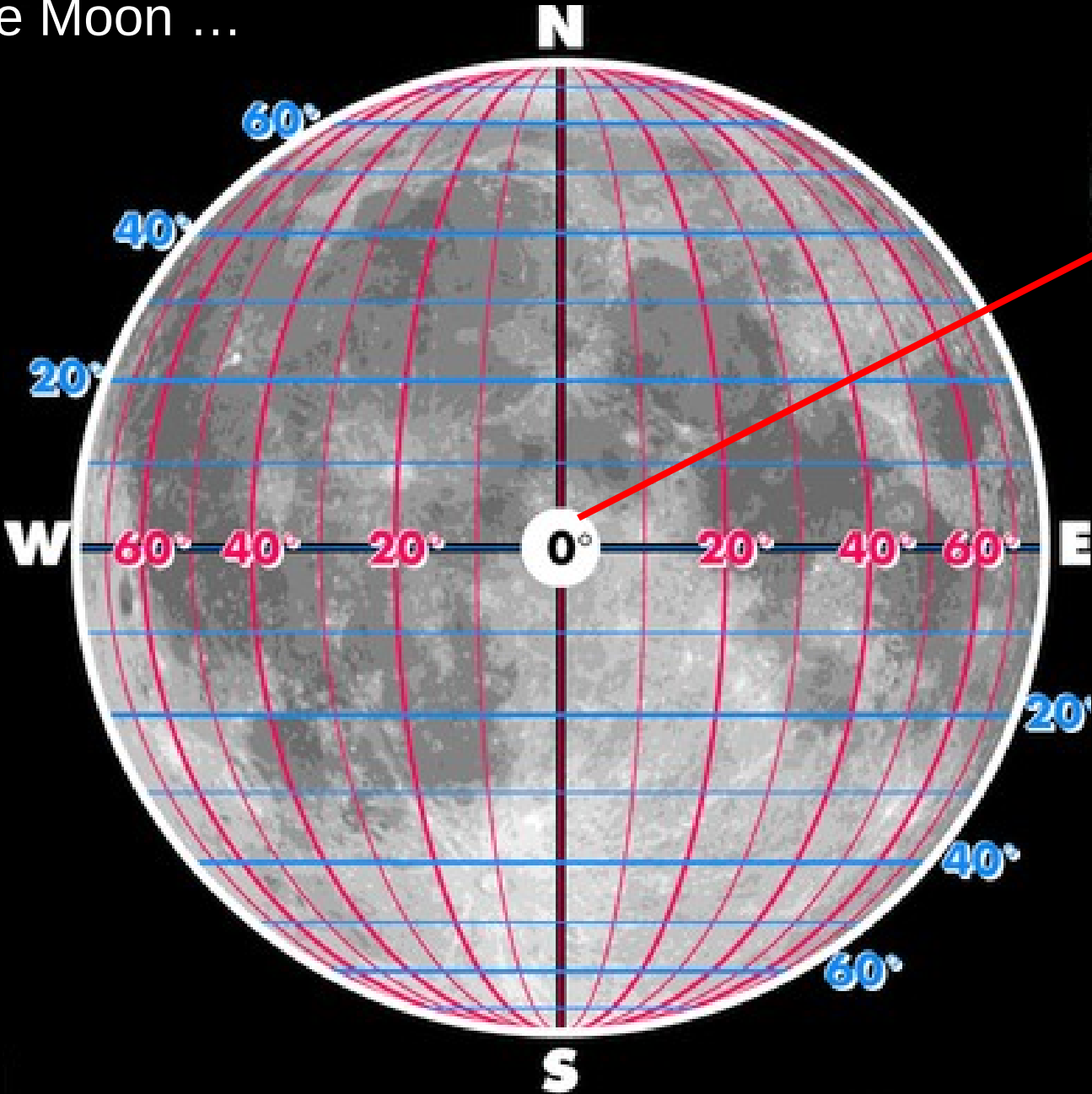
WGCCRE Report (cont.)

- The report is published every three years, in conjunction with the IAU general meeting, in the journal *Celestial Mechanics and Dynamical Astronomy*
- Including the 2009 report, there have been 10 reports since the first report was published in CM in 1979.

Report	General Assembly	<i>Celestial Mechanics and Dynamical Astronomy</i>
1	Montreal in 1979	22 , 205-230 (Davies et al. 1980).
2	Patras in 1982	29 , 309-321 (Davies et al 1983).
3	New Delhi in 1985	39 , 103-113 (Davies et al 1986).
4	Baltimore in 1988	46 , 187-204 (Davies et al 1989).
5	Buenos Aires in 1991	53 , 377-397 (Davies et al 1992).
6	Hague in 1994	63 , 127-148 (Davies et al 1996).
7	Kyoto in 1997	No report
8	Manchester in 2000	82 , 83-110 (Seidelmann et al. 2002).
9	Sydney in 2003	91 , 203-215 (Seidelmann et al 2005).
10	Prague in 2006	98 , 155-180 (Seidelmann et al 2007).
11	Rio de Janeiro in 2009	to appear (Archinal et al 2010)

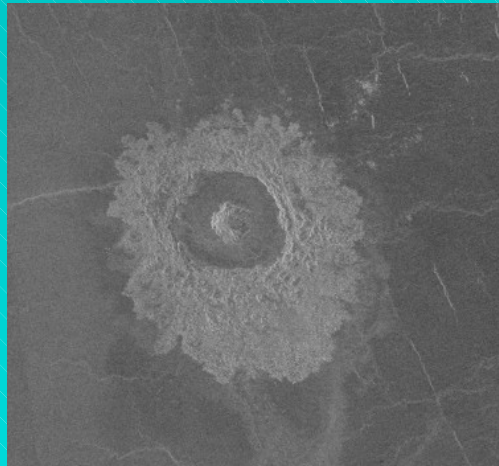
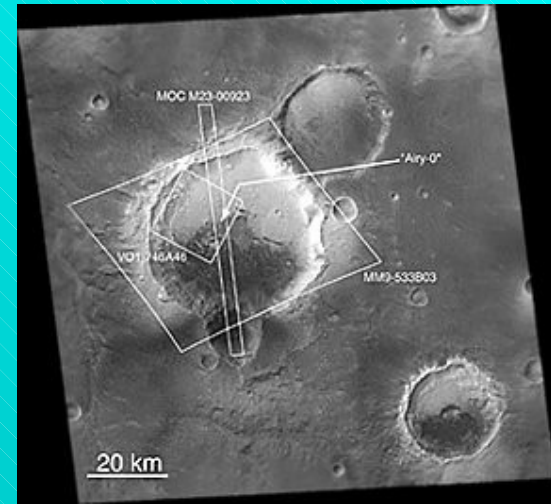
Solar system bodies are divided into three categories ...

The Moon ...



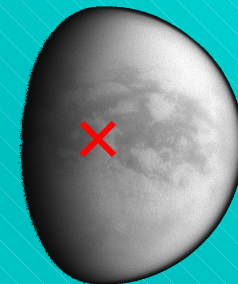
Planets and satellites ...

The prime meridian of Mars is defined by the crater Airy-0.

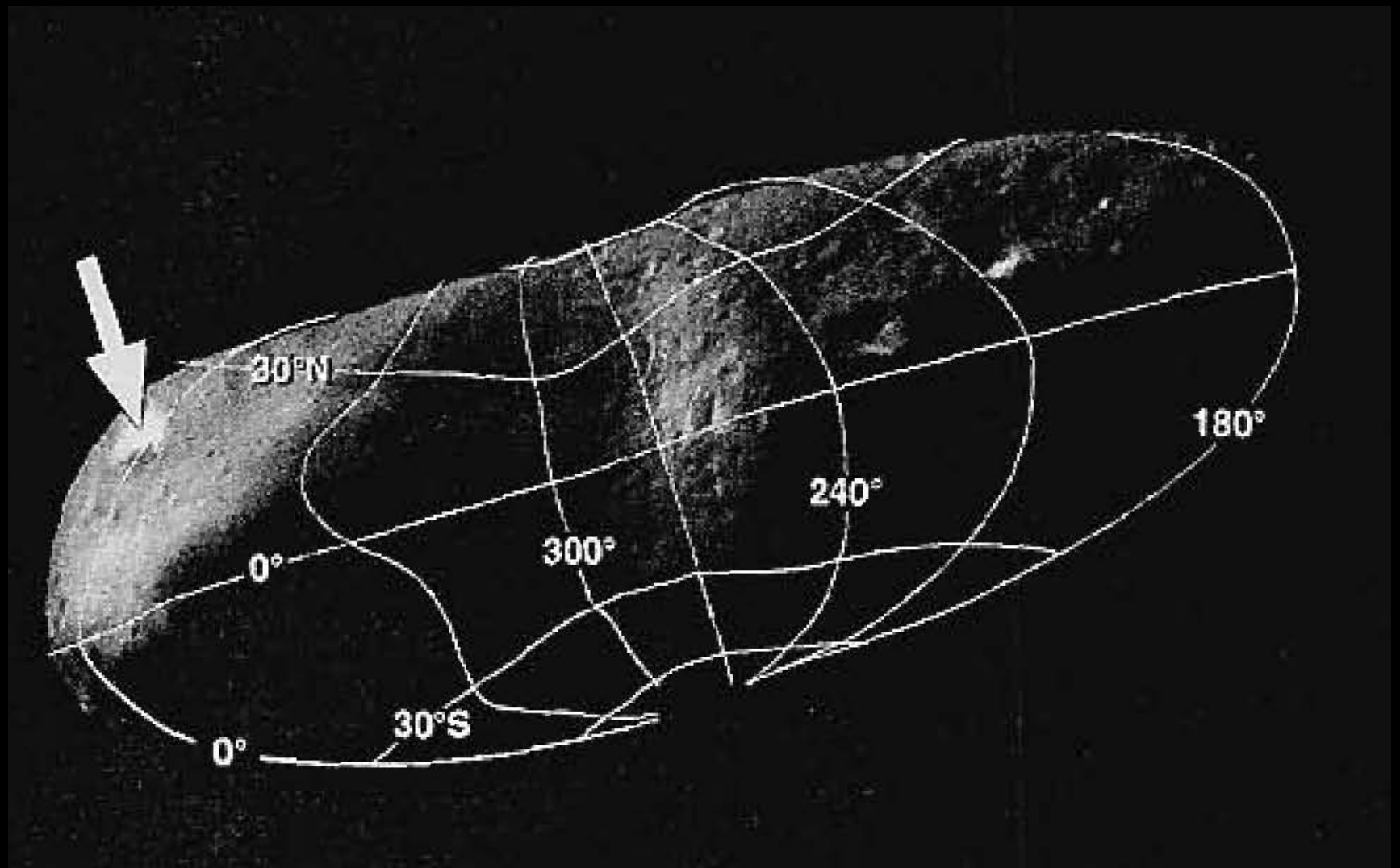


The prime meridian of Venus passes through the central peak in the crater Ariadne.

Titan, like the earth's moon, always has the same face towards Saturn, and so that face is 0 longitude.



... other small bodies.



WGCCRE Report (cont.)

- The report contains:
 1. Standards and conventions for mapping the surfaces of solar system bodies.
 2. For selected bodies (i.e., those bodies being mapped): a coordinate system specification
 - Rotational elements (for prime meridian and equator definition)
 - Shape and size

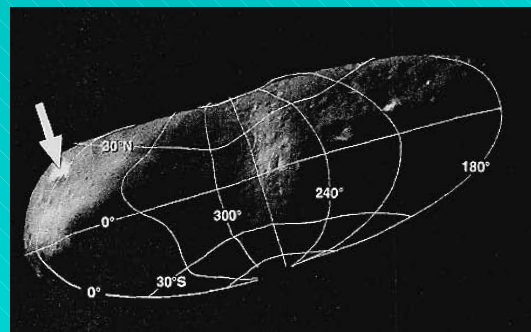
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Which small bodies appear in the WGCCRE report? (and why?)

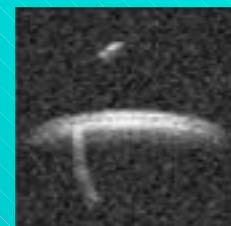
Why? If a study of the body requires a map.

Which small bodies were in the 2006 report?

Most of those visited by spacecraft



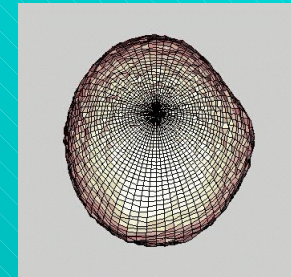
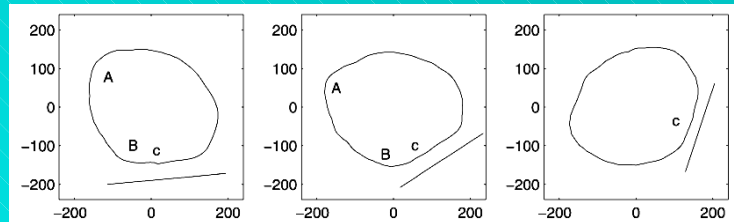
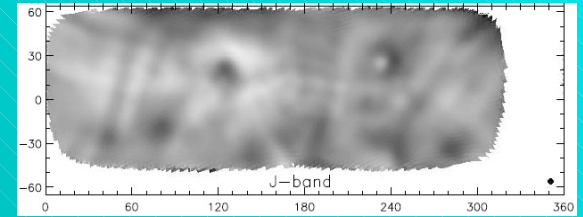
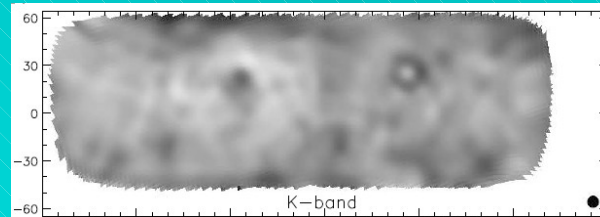
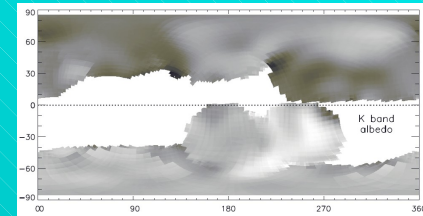
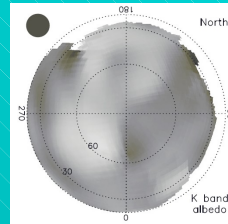
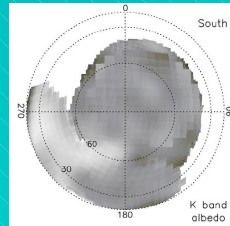
A handful from radar



plus one or two large enough to reveal features to HST and large-aperture (8m+) AO systems



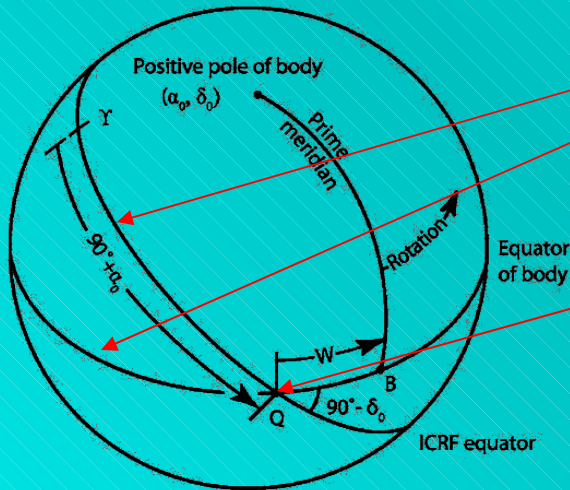
But with improvements in AO and inversion techniques this number will grow ...



How is a prime meridian selected?

- Requires a long explanation but ...
- ... some common cases are
 - a) where the longitude of a small feature (e.g. a crater) near the equator is defined, and
 - b) where the object is in synchronous (or perhaps harmonic) rotation, and a direction toward a parent body can be used for the initial (or continuing) definition of longitude.
- For small bodies, the choice of feature is usually fairly arbitrary, although picking a small feature near the equator is useful.

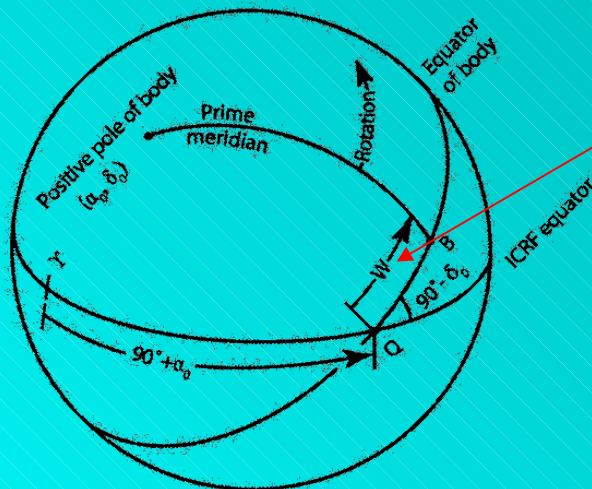
What instructions are provided in the report for specifying a prime meridian?



Start with two planes: the body's equator, and the ICRF equator

Choose the +90 intersection point

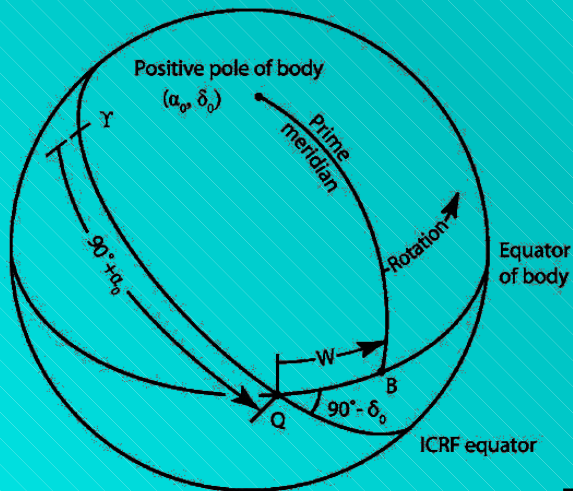
At the standard epoch (1200UT 01jan2000) measure the distance east to the PM. Call that angle W_0



For an arbitrary number of days d since the epoch, the angle W will be:

$$W = W_0 + d\dot{W}$$

WGCCRE standard for prime meridian (cont.)

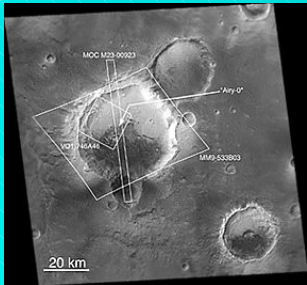


For a given body, pole RA/Dec and two constants in the expression

$$W = W_0 + d\dot{W}$$

are provided in the report.

For example for Mars, the right ascension of the pole is approx. 318, W_0 is approx. 177, and W is 350.89198226.



Airy-0 will be 177° east of the meridian facing right ascension $\alpha = 48$ (i.e., 'Q') at 1200UT 01jan2000.

And $177+350.89198226d$ east of Q d days after that epoch.

WGCCRE standard for prime meridian (cont.)

1. Please include W_0 in asteroid publications when appropriate. Note that:
 1. Once a feature and its defining longitude have been selected, W_0 fall out of the process (not the other way around).
 2. W_0 may change when a new mapping improves the location of the defining feature.
2. Also, for completeness, please include the period expressed as degrees per day (W) to form the expression $W = W_0 + dW$.
3. Precision for W & W_0 ; as well as the range of time over which the data were collected to determine W and W_0 (so that users can understand the stated precision).
4. If an observable feature was used to define W_0 , please include its name (that name should also be submitted for approval to WGPN).

What else is provided in the report related to asteroids, (besides rotation axis and prime meridian definition)?

1. Conventions for defining latitude and longitude.
2. For shape, discussion of ...
 1. The use of a spherical or an ellipsoidal model, versus a grid of radii to the surface (i.e., a shape model)
 2. The uniqueness difficulty for very irregular shapes.
3. The asteroid's size expressed as triaxial dimensions $a \times b \times c$.
4. A short list of criteria to be used in determining whether or not a specific asteroid should be included in the report

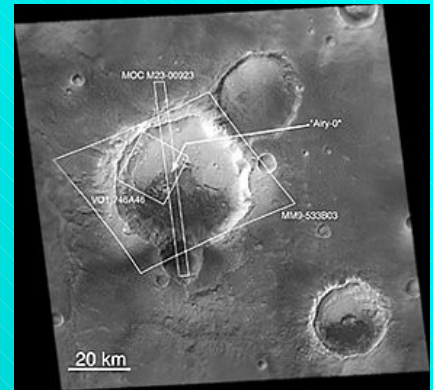
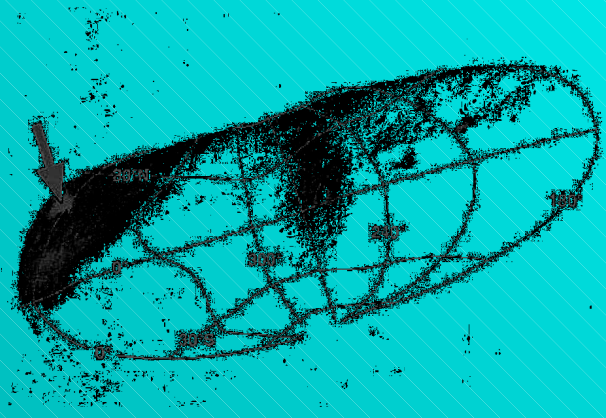


The CCRE Working Group meeting held at the 2009 IAU general meeting

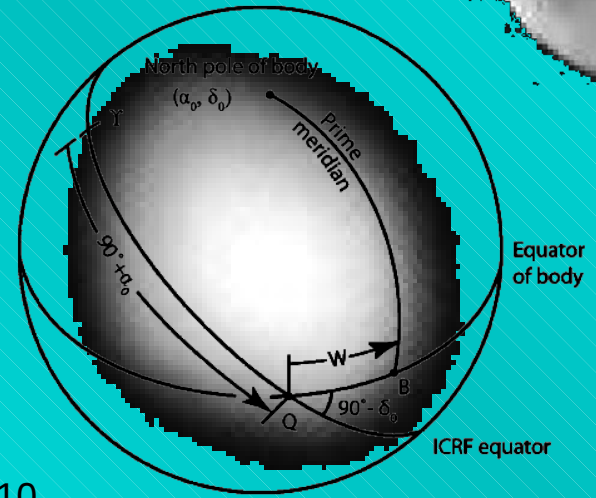
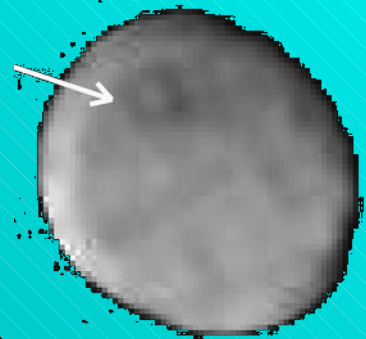
- The meeting included discussion of the two sections of the report related to asteroids.
- A subgroup was formed to look at the question of cartography on asteroids (Conrad (lead), Consolmagno, Hestroffer, A'Hearn, Stooke, Thomas)
- The subgroup defined several criteria for whether or not a particular small body should be included in the report:
 - Publication criteria: values for rotational axis, W_0 , etc, should appear in a publication accepted by a refereed journal.
 - Data quality criteria: sufficient fidelity and quality to assure an accurate estimate, and, some portion of that data will have been acquired via direct methods
 - Applicability criteria: a cartographic need that justifies the definition of a prime meridian, pole, etc, for this body

Future

- The 2009 report will be submitted for publication in in 1-2 months.
- However, discussion for the 2012 report is just beginning.
- If we see a substantial increase in the number of asteroids and comets to be added, a separate WG may need to be established.
- What else should be addressed in the report related to asteroids and the rapid changes resulting from technical improvements in AO and multi-data inversion?
- Are there issues of interoperability that, if they were addressed in the report, collaboration would be more efficient?
- Feedback from PPA2010 participants (and all members of the community) for the 2012 report is welcome!



The End



March 23, 2010

PPA2010