

**OVERVIEW OF THE IAU WORKING GROUP ON CARTOGRAPHIC COORDINATES AND ROTATIONAL ELEMENTS AND ITS CURRENT REPORT.** Brent A. Archinal, U. S. Geological Survey (2255 N. Gemini Drive, Flagstaff, AZ 86001, USA, barchinal@usgs.gov).

**Overview:** Approximately every 3 years since 1979, the Working Group on Cartographic Coordinates and Rotational Elements (hereafter the “WG”) of the International Astronomical Union (IAU) has issued a report recommending coordinate systems and related parameters (body orientation and shape) that can be used for making cartographic products (maps) of solar system bodies. These recommendations, which are open to further modification when needed, are intended to facilitate the use and comparison of multiple datasets by promoting the use of a standardized set of mapping parameters. This abstract is intended to draw attention to the WG’s efforts and the recently published WG 2009 report [1]. The WG encourages input and can assist users, instrument teams and missions on cartographic issues.

**Operation of WG:** The WG consists of volunteers, currently including 17 members from 8 different countries. Individuals are invited or can volunteer themselves for membership. The WG looks at new determinations of coordinate systems (e.g., body sizes and orientation) that have preferably been published in refereed papers and makes recommendations as to which to use based where possible on consensus decisions. As a volunteer organization the WG has no resources to verify results or conduct its own research so it relies on only published results and community input. For that reason it is sometimes not possible to recommend one set of results over another. The WG also cannot verify or “bless” any particular results, and for reasons of practicality, these recommendations are not from the full IAU. The WG has no “enforcement” powers, but tries, in reflecting the planetary community consensus, to make useful recommendations. The WG acknowledges that other (e.g., dynamical) coordinate system definitions are possible for any given body, but makes recommendations primarily for mapping purposes. The WG also does not deal with issues relative to the types of formats of mapping products. Such issues have largely been left to individual map developers, archiving organizations such as the Planetary Data System (PDS) or the IPDA (International Planetary Data Alliance), or other groups such as the NASA Mars Geodesy and Cartography and Lunar Geodesy and Cartography Working Groups (MCGWG[2], LGCWG[3]) and individual missions (e.g., the Cassini Icy Satellites Cartography Working Group). Input from such organizations has been welcomed by the WG and the frequency of interaction highlights the strong need for such organizations at mission, space agency, and/or international levels.

**Defining Longitude:** One recent issue that has resurfaced recently is the question of how the definition of longitude should be updated on solar system bodies, such as Mercury and the satellites of Jupiter and Saturn. The WG addressed this issue in its first report [4] and reiterates in the recent report that once an observable reference feature at a defined longitude is chosen, the longitude definition origin should not change except under unusual circumstances (such as perhaps a change in or loss of the feature). This implies that once such a feature has been adopted, a return to a longitude system defined by some other method (e.g., the principal axes of inertia for resonantly or synchronously rotating bodies such as Mercury [5], the Moon, or Jovian or Saturnian satellites) should be avoided. However, this does not preclude the use of smaller or more precisely determined features, multiple features, or even human artifacts to define longitude, as long as the original definition is maintained to within the accuracy of previous determinations. An example is the redefinition of the origin for longitude for Mars from the large feature then known as Sinus Meridiani to the small crater Airy-0 [6]. There are of course pros and cons of both possible methods of updating the longitude definition as new data are obtained. However for cartographic products there appears to be no obvious advantage to changing the convention to a definition based on a dynamical system. Shifts in longitude will occur whenever new data are available and processed, but at least are minimized in the area of any defining feature. Longitude is also somewhat more logically tied to (mapping) data related to the surface of the body (e.g., direct imaging or altimetry) than dynamical (e.g., gravity field, natural satellite orbit) data.

**Changes for Specific Bodies:** The new WG report introduces improved values for the pole and rotation rate of Mercury (based on, but not precisely as recommended in [5]), returns the rotation rate of Jupiter to a previous value, introduces improved values for the rotation of five satellites of Saturn, and adds the equatorial radius of the Sun for comparison purposes. It also adds or updates size and shape information for the Earth, Mars’ satellites Deimos and Phobos, the 4 Galilean satellites of Jupiter, and 22 satellites of Saturn. Pole, rotation, and size information has been added for the asteroids (21) Lutetia, (511) Davida, and (2867) Šteins. Pole and rotation information has been added for (2) Pallas. Pole and rotation and mean radius information has been added for (1) Ceres. Pole information has been updated for (4) Vesta. The high preci-

sion realization for the pole and rotation rate of the Moon is updated to use the JPL DE 421 lunar ephemeris, but rotated (by small fixed angles) to represent the mean Earth/polar axis system. Alternative orientation models for Mars, Jupiter, and Saturn are also noted. Rather than try to decipher the conflicting IAU Resolutions regarding the definition of a planet, the WG has simply adopted the IAU Working Group for Planetary System Nomenclature (WGPSN) and the IAU Committee on Small Body Nomenclature (CSBN) definition of dwarf planets.

**Updating Procedures:** Upon request and to provide information more often than every three years (e.g., for use by missions and for new cartographic products) the WG will consider providing limited updates to its recommendations on its Web site (<http://astrogeology.usgs.gov/Projects/WGCCRE>). The tentative plan is to determine every ~6 months whether time-critical updates are necessary and, if so, announce them on the WG site. We will also offer on the Web site newly published and (preferably) peer-reviewed determinations related to solar system coordinate systems. These postings do not remove the need for our triennial reports, in which we will continue to publish the majority of our recommendations. In our next report, we will consider the usefulness of these interim procedures and whether they should continue. Input for such updates (whether for WG consideration or information only) and comment on these procedures from the community is welcome.

**Recommendations to the planetary community:** For the first time, in its recent report the WG also provided some general recommendations regarding current urgent needs relative to the development of planetary cartographic products. These include the following recommendations: 1) The advantages of geodetically controlled cartographic products are many and well known, yet the current trend seems to be that such products are often not planned for or funded. It is strongly recommend that this trend be reversed and that such products be planned for and made as part of the normal mission operations and data analysis process. 2) The WG recommends that the Konopliv, et al. [7] Mars orientation model be updated or a similar model be developed that takes advantage of the substantial additional Mars data available since the time of their work, so that it can be adopted by the WG and operational Mars missions in the 2012 time frame. 3) The WG urges the planetary community to jointly address resolving the various determinations for the rotation of Jupiter and Saturn and to develop consensus determinations, such as was done in the past for Jupiter [8]. The WG would like to hear feedback from the planetary community regarding these recommendations, e.g., actions planned or taken, the appropriate-

ness of such recommendations, or even suggestions for further such general recommendations.

**Outlook for 2012 Report:** Although specific changes for the next report will depend largely on what new results are published, the WG anticipates updates or new values in several areas including a) the use of an improved lunar ephemeris to define the Moon's orientation, either from JPL or others; b) updates for the orientation of Mars, Jupiter, and Saturn (noted in the previous section); and c) updates due to new results from on-going missions (Mercury, Saturnian satellites, (4) Vesta, (21) Lutetia) and Earth-based observations (various asteroids). Under proposed structural changes in the IAU, the WG itself may morph into an "IAU Standing Committee," but in the near term would likely operate much as it does now. The WG also will look into establishing or re-establishing links to other organizations, such as the International Association of Geodesy and the International Society for Photogrammetry and Remote Sensing. On a "reasonable effort" basis, it will continue to provide assistance on coordinate system and mapping issues the planetary community (missions, product developers, etc.)

**Request for Participation and Input:** Additional volunteer members for the WG are needed, as the number of new missions, bodies studied, and new results increases. The WG particularly has need of expertise on the orientation of the gas giant planets.

The WG would also greatly appreciate receiving input from the planetary community, e.g., regarding the systems for specific bodies, the operation of the WG, and even the need for and/or usefulness of the WG's efforts. As already noted above, input is also welcome on the need for updates more often than every 3 years and on the issuing of general recommendations. Please contact the author at the address above for information or to provide input.

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