

DIVISION A AND F / WORKING GROUP CARTOGRAPHIC COORDINATES AND ROTATIONAL ELEMENTS

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TRIENNIAL REPORT 2015-2018

1. Introduction

The main activity of the IAU Working Group on Cartographic Coordinates and Rotational Elements (hereafter, WG) is to make recommendations regarding the creation and maintenance of cartographic planetary coordinate systems. The agreed-upon recommendations are produced roughly in conjunction with each IAU General Assembly and are published in a refereed journal, *Celestial Mechanics and Dynamical Astronomy*. Our 2015 report was delayed further than we would have liked, but was published online in February 2018 (Archinal et al. 2018).

Significant changes and additions since our last report include the following items.

- A procedure is described for submitting questions about the recommendations made or the application of the recommendations for creating a new or updated coordinate system for a given body.
- Body orientation: The Mercury orientation model has been updated based on MESSENGER results; approximate expressions for the Earth have been removed to avoid confusion; the Mars, Phobos, and Deimos orientation models have been improved using new modeling and the definition of the Mars prime meridian refined; the expression for the rotation of Neptune has been updated; the previously on-line only recommended orientation model for (4) Vesta is repeated and an explanation of how it was updated given; orientation models have been improved for (1) Ceres, (52) Europa, (2867) Šteins; corrections have been made for the rotation model for Pluto and its satellite Charon; and the orientation model has been corrected for (243) Ida. Information has been added on the rotational states of Comets 9P/Tempel 1, 19P/Borrelly, 67P/Churyumov-Gerasimenko,

and 103P/Hartley 2, noting that such information is valid only between specific epochs. The difficulty of mapping Comet Churyumov-Gerasimenko is discussed.

- Body shape and/or size: Text has been included to explain the expected uses of such information, and the relevance of the cited uncertainty information. The radius of the Sun has been updated, noting that the size and the ellipsoidal axes for the Earth and Jupiter have been recommended by an IAU Resolution. Concerning the reference radius for the Moon and Titan, a distinction is made between a reference radius for cartographic uses, and for orthoprojection and geophysical uses. The recommended radius for Mercury has been updated based on MESSENGER results. The recommended radius for Titan is returned to its previous value. Size information has been given for (16) Psyche and (52) Europa. The size of (25143) Itokawa has been corrected.

- The discussion of terminology for the poles (hemispheres) of small bodies has been modified and a discussion on cardinal directions added.

- We repeat our previous recommendations that construction of controlled cartographic products should be emphasized; newly recommend that common formulations should be used for orientation and size; continue to recommend that a community consensus be developed for the orientation models of Jupiter and Saturn; newly recommend that historical summaries of the coordinate systems for given bodies should be developed, and point out that for planets and satellites planetographic systems have generally been historically preferred over planetocentric systems, and that in cases when planetographic coordinates have been widely used in the past, there is no obvious advantage to switching to the use of planetocentric coordinates. In fact, continuing to use historic planetographic coordinates is preferred to avoid confusion in new data when compared to the (often) large collection of historic data. The Working Group also requests community input on the process for submitting questions, the posting of updates to the Working Group website, and on whether recommendations should be made regarding exoplanet coordinate systems.

2. Membership

The WG currently consists of 17 members from 6 countries, with membership lengths from 0 to 42 years. Brent Archinal (U. S. Geological Survey) serves as the current chairman, and Al Conrad (Large Binocular Telescope Observatory) serves as the acting vice-chairman. In 2017 we saw the passing of member Michael F. A'Hearn, who contributed significantly to our work in the area of comets and other small bodies. The WG began operation in 1976. In recognition of the continued need for the WG, in 2016 it became a "Functional Working Group" of the IAU, with an institutional scope and purpose that naturally extends beyond the IAU three-year cycle (IAU Executive Committee, 2016).

The WG, in response to queries from the Division A and F Presidents, in 2016 developed a policy for soliciting new members and having an open membership. The WG agreed to clarify that it was open to anyone applying for membership who indicated how they wished to help with our work. Recruiting would be done by directly contacting experts in the field and any others who would likely be interested and could help. Depending on the response, we would regularly make a significant effort to make announcements that new members would be welcome to apply. We also plan to ask applicants and periodically current members what expertise they feel they are bringing to the WG and how they plan to contribute to our main report. Only in highly unusual cases and with the concurrence of the Division A and F Presidents would an applicant be turned down. Announcements to solicit new members are planned for spring 2018 in advance of the IAU General Assembly in August.

3. Community Inquiries

The WG chair and some of the WG members spend significant time answering questions from NASA, missions, mission instrument teams, journal editors, individual researchers, and the public, on various issues related to planetary coordinate systems. There are ongoing regular questions about the coordinate systems for the Moon and Mars, and regular questions from the various components of the NASA Planetary Data System. Some of our members have also provided information to the various archiving organizations such as ESA's Planetary Science Archive, to JAXA's and IKI's archiving arms, as well as to the International Planetary Data Alliance.

4. Publications

The WG has continued its various efforts to make its efforts known via its website (<http://astrogeology.usgs.gov/groups/IAU-WGCCRE>) and by various publications and community presentations. Specifically:

- We will continue to publish our main report to the planetary community, to be published approximately triennially, following each IAU General Assembly. Since our previous report was delayed, we tentatively plan to issue our next report in 2019.
- The WG will also make brief annual reports to Divisions A and F on the WG's activities. We are also willing to continue to make oral reports at the General Assembly Division meetings.
- We will provide occasional reports on items of interest for submittal as an IAU News Announcement, such as that shown in (IAU, 2018).
- To make our work better known and encourage the following of the recommendations in our main report, we will continue to submit abstracts to and make presentations at various planetary science meetings, describing the activities of the WG and our reports. These would include occasional presentations at the Lunar and Planetary Science Conference and the Planetary Data Workshop (Archinal and WGCCRE, 2016; 2017; 2018b), and possibly other meetings such as NASA Analysis Group meetings (<http://www.lpi.usra.edu/analysis/>), the Journées meeting (Hohenkerk et al. 2017), the Planetary Science Informatics and Data Analytics Conference (Archinal and WGCCRE, 2018c) and COSPAR (2018 July) (Archinal and WGCCRE, 2018d), etc.

5. Closing remarks

The WG will be seeking new members during 2018. We will hold a public meeting at the IAU General Assembly in Vienna in August, and tentatively plan to issue the next version of our main report in 2019. We anticipate the next report being much less complicated in regard to general changes and recommendations than our most recent report, and hope to resume more closely issuing our reports in conjunction with the triennial General Assemblies. We will also continue to address questions from the planetary community regarding planetary coordinate system issues, and continue to further increase community awareness of our work with abstracts and presentations at appropriate scientific meetings. Inquiries from the community have increased greatly in recent years from individuals, editors, instrument teams, missions, and space agencies. So we need to move forward with an increased membership to help with that work and otherwise plan our operations or changes in operations to address that increased work load.

Brent A. Archinal
chair of Working Group

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