

UPDATING SOLAR SYSTEM REFERENCE FRAMES FOR CARTOGRAPHY IN 2019.

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Overview: Approximately every 3 years since 1979, the Working Group on Cartographic Coordinates and Rotational Elements of the International Astronomical Union (IAU) has, after most IAU General Assembly (GA) meetings, issued a report [1] 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 indicated by community consensus, are intended to facilitate the use and comparison of multiple datasets by promoting the use of a standardized set of mapping parameters. This abstract summarizes the WGCCRE's ongoing efforts to create a new report. The WGCCRE encourages input and is available to assist users, instrument teams, and missions. *For information* on the creation, history, operation, general philosophy of the WGCCRE, and for links to related organizations, *see our website* at <http://astrogeology.usgs.gov/groups/IAU-WGCCRE>.

WGCCRE membership: The Working Group currently consists of 17 volunteers, including C. Acton, B. Archinal (Chair), A. Conrad (Vice Chair), T. Duxbury, D. Hestroffer, J. Hilton, L. Jorda, R. Kirk, S. Klioner, J.-L. Margot, K. Meech, J. Oberst, F. Paganelli, J. Ping, K. Seidelmann, D. Tholen, and I. Williams. We are always looking for volunteers to join the WGCCRE to help with each new report following the IAU GA.

Outlook for the Next WGCCRE Report: We are currently compiling our next overall report, associated with the 2018 IAU GA. We expect there will be routine updates to recommended orientation and size models resulting from reprocessing of various existing, or

processing of new, planetary datasets. We expect there may be improvements for various bodies for which there has been recent or is active exploration, such as Mercury, Jupiter, Saturn, Saturnian satellites, (1) Ceres, 67P/Churyumov-Gerasimenko, (486958) 2014 MU69, (4179) Toutatis, (101955) Bennu, and (162173) Ryugu.

We will also consider updating the recommendations for lunar coordinates. At the 2018 IAU GA, the X2 Cross-Division A-F Commission Solar System Ephemerides recommended, and the WGCCRE informally concurred, that a new working group should be set up to consider issues related to such updates [2]. Although lunar ephemerides currently seem to provide the orientation of the Moon with an accuracy of several meters, updates from various groups based on new lunar laser ranging (LLR) solutions continue to be made and improvements should be considered. Another issue is whether to finally base the mean Earth/polar axis (ME) lunar system directly on no-net rotation based LLR solutions for retroreflector coordinates rather than on a specific lunar ephemeris as is done currently. The WGCCRE is willing to collaborate with such a new working group and consider any recommendations made on a timeframe consistent with our report.

For Mars, the recommended orientation model could be updated to that of Konopliv et al. [3] as formulated by Jacobson et al. [4], since this model is based on additional data and improved over the previously recommended system [5]. A separate issue has also been raised about the new systems [3-5] for Mars which seem to have a ~100 m offset in longitude at the fundamental epoch of J2000.0 relative to the previous recommended

system. Clarification is needed as to the cause of this offset, given the intent that “the definition adopted in this paper does not change the position of the prime meridian” [5]. Based on community input, a decision may then need to be made by e.g. the Mars Geodesy and Cartography Working Group and WGCCRE, as to whether a correction in longitude needs to be made to these newer models, and perhaps whether such a change should be made in advance of the next report.

Future Projects: The WGCCRE has over time received multiple requests for some type of (e.g., an online database) summary of model recommendations made since the formulation of the WGCCRE in 1976. We have also received suggestions that we provide more detailed recommendations in our reports about establishing and updating coordinate systems. These and perhaps other projects may be undertaken given enough volunteer effort.

Other recommendations: In our most recent report, we have repeated earlier recommendations that planning and efforts be made to make controlled cartographic products, which are important *foundational products* in the terminology of planetary spatial data infrastructure [6]. New recommendations are that common formulations should be used for orientation and size and that historical summaries of the coordinate systems for given bodies should be developed. We have noted 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. However, we would like to receive more input regarding these recommendations, and any suggestions for new recommendations.

Request for Input: In addition to such suggestions, the WGCCRE desires continued

input from the planetary community, especially regarding the systems for specific bodies, the operation of the WGCCRE, our question submitting process, and posting of updates via the WGCCRE website. We regularly provide summaries (such as this one) and make meeting presentations to make the community aware of our work [7-9]. We encourage volunteers to become WGCCRE members and help with our efforts. Our membership is open to all. Contact the first author or any member of the WGCCRE for additional information.

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References: [1] Archinal et al. (2018) *CMDA*, 130:22, doi 10.1007/s10569-017-9805-5. [2] IAU Commission X2 Triennial Report 2015-2018, https://www.iau.org/static/science/scientific_bodies/commissions/x2/commission-x2-triennial-report-2015-2018.pdf. [3] Konopliv et al. (2016) *Icarus*, 274, 253. [4] Jacobson et al. (2018) *PSS* 152, 107. [5] Kuchynka et al. (2014) *Icarus*, 229, 340. [6] Laura et al. (2017) *ISPRS Int. J. Geo-Inf.*, 6, 181 [7] Archinal et al. (2018) *PSIDA Conf.* Abstract #6047. [8] Archinal et al. (2018) *42nd COSPAR Abstract #PEX.1-0021-18*. [9] Conrad et al. (2019) *LPS L*, Abstract #2110.