

# ***Report from the Working Group on Cartographic Coordinates and Rotational Elements***

Brent Archinal\* and the IAU Working  
Group on Cartographic Coordinates  
and Rotational Elements

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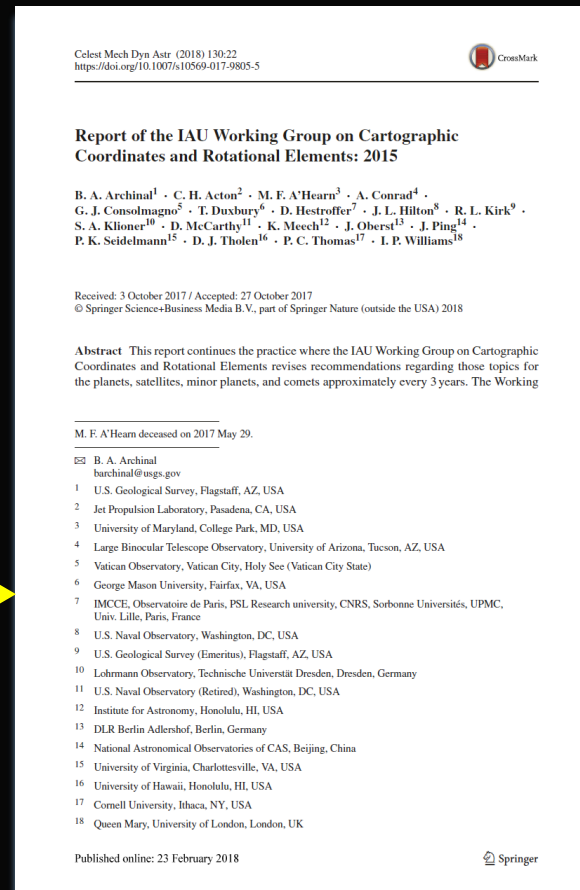
*2022 August 5  
IAU Division A Fundamental Astronomy  
Division Days*

## *Outline*

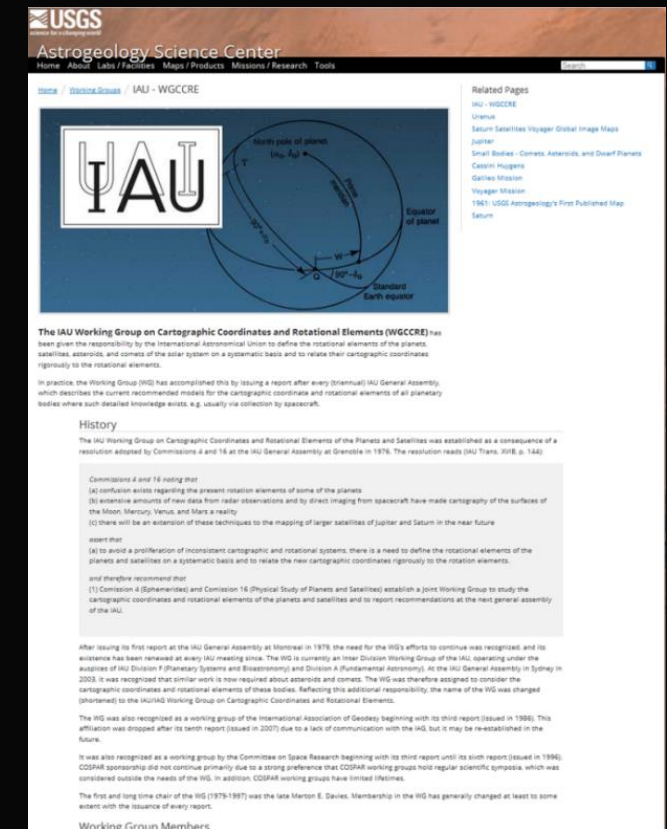
- Introduction to the WGCCRE
- Recent activities
- Seeking input on evolution of standards and the WGCCRE
- Examples, feedback needed
- Long term planning
- Summary – Discussion desired

# IAU Working Group on Cartographic Coordinates and Rotational Elements

- Promotes the use of a standardized set of mapping parameters
- Makes recommendations, open to further modification when needed, **intended to facilitate the use and comparison of multiple datasets!**
- Issues reports with recommendations about coordinate systems and related parameters for making cartographic products of the Solar System bodies
- Starting in 1979 (Davies et al., 1980), reports every ~three years
  - Associated with IAU General Assemblies
- Current 2015 report published 2018 (Archinal et al.); correction published 2019



Current WGCCRE "2015"  
Report, published 2018  
CDMA, 130:22



WGCCRE web site  
<http://astrogeology.usgs.gov/groups/IAU-WGCCRE>

# WGCCRE Operation

- Membership by invitation or volunteering
- Currently 16 members from 5 countries, from 4 to 46 years of membership!
- Considers new published coordinate system related determinations
- Recommends standards based on consensus
- No independent resources of its own
- Does not “bless” or “enforce” recommendations – their value is validity and consistency as a reflection of general consensus and use
- Recommendations are primarily for mapping, but other uses are quite common (e.g., dynamical systems, navigation)
- Does not deal with formats, “lower level” mapping standards

## Current WGCCRE Membership

B.A. ARCHINAL (Chair)  
*U.S. Geological Survey, Flagstaff, AZ, U.S.A.*

C.H. ACTON  
*Jet Propulsion Laboratory, Pasadena, CA, U.S.A.*

A. CONRAD (Vice Chair)  
*Large Binocular Telescope Observatory, Tucson, AZ, U.S.A.*

T. DUXBURY  
*George Mason University, Fairfax, VA, U.S.A.*

D. HESTROFFER  
*IMCCE, Observatoire de Paris, CNRS, Paris, France*

J.L. HILTON  
*U.S. Naval Observatory, Washington D.C., U.S.A.*

L. JORDA  
*Laboratoire d'Astrophysique de Marseille, Marseille, France*

R. Kirk  
*U.S. Geological Survey, Flagstaff, AZ, U.S.A.*

S.A. KLIONER  
*Technische Universität Dresden, Lohrmann Observatory, Dresden, Germany*

J.-L. MARGOT  
*University of California, Los Angeles, CA, U.S.A.*

J. OBERST  
*DLR Berlin Adlershof, Berlin, Germany*

F. PAGANELLI  
*National Radio Astronomy Observatory, Charlottesville, VA, U.S.A.*

J. PING  
*National Astronomical Observatories of CAS, Beijing, China*

P.K. SEIDELMANN  
*University of Virginia, Charlottesville, VA, U.S.A.*

D.J. THOLEN  
*University of Hawaii, Honolulu, HI, U.S.A.*

I.P. WILLIAMS  
*Queen Mary, University of London, London, U.K.*

## *WGCCRE – Recent Activities*

- Substantial activity 2020-2021, meeting presentations asking for input to WG
- More below, but mainly requesting input on WG recommendations, how the WG makes recommendations, and the future of the WG
- Abstracts/presentations at:
  - ISPRS, 2020
  - IUGG/IAG, 2019
  - LPSC, 2019 & 2020
  - NASA MAPSIT, 2020
  - Planetary Data Workshop, 2019 & 2021
  - International Cartographic Conference, 2021
  - Planetary Science Informatics and Data Analytics, 2022
- 2020 White paper to NASA Decadal Survey
- Not particularly successful at getting much input, partially due to nature of virtual meetings – may try community survey route
- Continuing with Annual and Triennial reports to Divisions A and F
- Always seeking new members for WG
- Some recent volunteers
- Currently completing a “new members’ packet; then inviting new members to join
- *Further volunteers always welcome!*
- Next main WG report
  - Delayed, due to...
  - Pandemic
  - Effort to make presentations and collect input
  - Chair (Archinal) workload
  - Hope to get on track and complete version this year
  - Publication by early next year?
  - Some details on possible contents follow

# Seeking Input on the Evolution of the WGCCRE

- After 46 years of operation, the WGCCRE is considering what changes may be needed
- Considering issues and accumulated experience over years of operation
- Many other groups do related work →
  - E.g., international, national, space agencies, international organizations
  - What type of coordination is needed?
- In 2020, submitted a white paper for NASA *Planetary Science and Astrobiology Decadal Survey 2023-2032 about coordinate system recommendations and evolution of the WGCCRE*

## International Astronomical Union

Working Group on Cartographic Coordinates and Rotational Elements

Division F Planetary Systems and Astrobiology

Division A Fundamental Astronomy

IAU Commission A3 on Fundamental Standards

IAU Working Group on Planetary System Nomenclature (WGPSN)

## Other International Groups

International Association of Geodesy (IAG)

ISPRS ICWG Commission III/II Planetary Remote Sensing and Mapping WG

International Cartographic Association Commission on Planetary Cartography

International Planetary Data Alliance (IPDA)

Regional and National Space Agencies

Committee on Space Research (COSPAR)

## NASA groups

Mapping And Planetary Spatial Infrastructure Team (MAPSIT)

Other analysis and assessment groups

Planetary Data System (PDS)



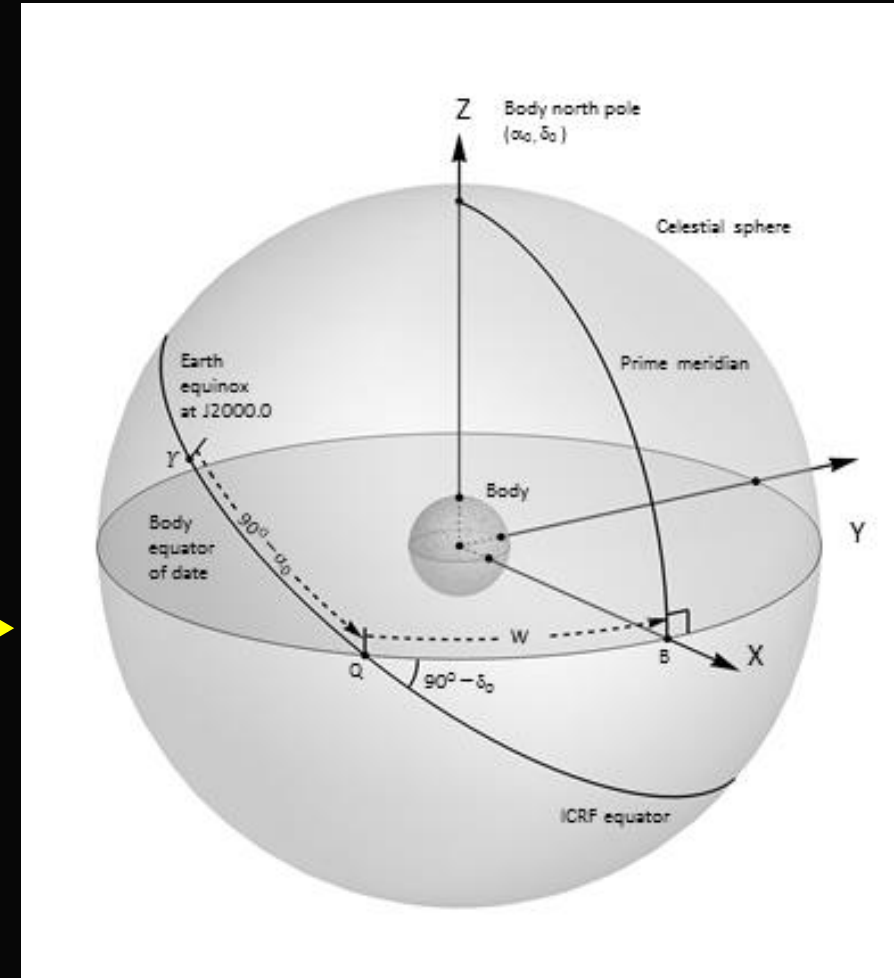
## *Examples: Possible changes for next main report*

### Next report:

- Improve lunar coordinate frame?
- Mars: Possibly remove artificial  $\sim 100$  m offset between previous and current longitude systems
- Updates from missions: Mercury, Saturnian satellites, Pluto and satellites, Vesta, Ceres, Ryugu, Bennu, Comet Churyumov–Gerasimenko
- Updates from terrestrial observations of asteroids
- Continue to assist on coordinate system and mapping issues
- Aiming for late 2022 - early 2023 publication

## *Past problems and issues – What changes could be made?*

- For many bodies, particularly the Moon and Mars, most datasets have never been well registered to each other, making data comparison and fusion difficult and lowering the value of such datasets.
- The NASA/DLR/ASI Dawn mission initially did not update and register its data to the existing coordinate system for Vesta, resulting in great (and continued) confusion as to which system the data are in.
- Planetographic coordinates have been used for mapping most planetary bodies in the past. What are the advantages and disadvantages, if any, in switching to planetocentric coordinates as some missions have proposed?
- Some open coordinate systems issues for specific bodies remain unresolved, e.g., Moon, Mars, Jupiter, Saturn



Coordinates for planets and their satellites; planetographic or planetocentric; should existing system usage be preferred?

These issues have caused problems for space agencies, missions, instrument teams, and the planetary community in general – including you!



# Specific Recommendations – Feedback Welcome

- Additional personnel and funding may be needed for the WGCCRE or some new group(s) as increasing workload (e.g., Mars, lunar systems update; studying proposed changes from planetographic coordinates) is not being addressed.
- Missions and instrument teams should follow best practices for cartographic and rotational standards or work to update them if needed.
- The previous Mars and Lunar Geodesy and Cartography and other “body focused” WGs or something like them need to be reactivated with appropriate resources.
- Appropriate planetary spatial data infrastructure (PSDI) with international scope needs to be developed body-by-body or as a single infrastructure for the whole Solar System. →

## Article

### Towards a Planetary Spatial Data Infrastructure

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**Abstract:** Planetary science is the study of planets, moons, irregular bodies such as asteroids and the processes that create and modify them. Like terrestrial sciences, planetary science research is heavily dependent on collecting, processing and archiving large quantities of spatial data to support a range of activities. To address the complexity of storing, discovering, accessing, and utilizing spatial data, the terrestrial research community has developed conceptual Spatial Data Infrastructure (SDI) models and cyberinfrastructures. The needs that these systems seek to address for terrestrial spatial data users are similar to the needs of the planetary science community: spatial data should just work for the non-spatial expert. Here we discuss a path towards a Planetary Spatial Data Infrastructure (PSDI) solution that fulfills this primary need. We first explore the linkage between SDI models and cyberinfrastructures, then describe the gaps in current PSDI concepts, and discuss the overlap between terrestrial SDIs and a new, conceptual PSDI that best serves the needs of the planetary science community.

**Keywords:** spatial data infrastructure; cyberinfrastructure; planetary science

## 1. Introduction


Rapid increases in spatial data volumes, the growing complexity of data analysis and modeling methods, the popularity of multi-disciplinary science collaborations, and the requirement for effective remote access to data have resulted in the development and promotion of cyberinfrastructures. Cyberinfrastructures are “[a] set of organizational practices, technical infrastructure and social norms that collectively provide for the smooth operation of scientific work at a distance” [1]. Increasingly, data include spatial or spatio-temporal attributes that provide a rich trove of analytical information at the cost of increased complexity in data management and analysis [2]. These data are stored, analyzed, and used in geospatial cyberinfrastructures, or cyberGIS [3–5]. These spatially enabled, distributed information systems are designed to enhance data discoverability, access, and usability across distributed science teams. As defined by this triumvirate of goals, geospatial cyberinfrastructures are concrete, albeit technologically focused implementations of Spatial Data Infrastructures (SDIs) [6–8]. The broad goal of cyberinfrastructures, geospatial cyberinfrastructures, and SDIs is to codify and standardize some collection of data using ad hoc or formalized policies to improve the data access and discoverability in support of some endeavor (e.g., data use for modeling economic growth, ecological protection, or scientific research). Adopting the view that cyberinfrastructures are technology-focused SDIs (or stage II SDIs [9]), throughout this work we use the term SDIs to describe spatial data infrastructures.

SDIs exist at the local, regional, national, and global levels [10,11]. It is also possible to identify topical, community SDIs. For example, Li [12] described PolarHub, an Open Geospatial Consortium (OGC) standards-compliant web crawler, semantic search engine, and search result visualization

# Long Term Efforts

What options are there for the long(er) term future of the mapping recommendations process?

- Continue the WGCCRE in expanded form, with additional resources
- Supplement the WGCCRE with support of other GCWGs and other groups noted previously
- Consider new organizational structures, such as used by the International Earth Rotation and Reference Systems (IERS)

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- Operational components for cartography & standards
  - Oversight handled by replacing the WGCCRE with an oversight board
  - Could employ dedicated staff at various institutions, possibly supported by various space agencies
  - Amount of work by IERS may be greater, but work of the WGCCRE may be at least as complex =>

*Handling 1 vs. 97 bodies!*

## An example: the IERS

- Serves the terrestrial and astronomical communities
- Includes a Directing Board that oversees policy and operation and the development of standards, and operational components that perform the routine work of the organization
- Maintains coordinate systems for the Earth and inertial space and the connection between the two (Earth rotation)



## For additional details, see:

- Abstract for this presentation
- Annual and Triennial Activities report to IAU
  - 2022: [https://www.iau.org/static/science/scientific\\_bodies/working\\_groups/100/wg-ccre-annual-report-2021.pdf](https://www.iau.org/static/science/scientific_bodies/working_groups/100/wg-ccre-annual-report-2021.pdf)
  - 2021: [https://www.iau.org/static/science/scientific\\_bodies/working\\_groups/100/wg-ccre-triennial-report-2018-2021.pdf](https://www.iau.org/static/science/scientific_bodies/working_groups/100/wg-ccre-triennial-report-2018-2021.pdf)
- The most recent WGCCRE report, Section 9
  - Available from <http://astrogeology.usgs.gov/groups/IAU-WGCCRE>
- White paper submitted to NASA *Planetary Science and Astrobiology Decadal Survey 2023-2032*, <https://is.gd/WGCCRE2020wp>

Questions and discussion welcome

Input on recommendations?

Input on future of WGCCRE?

Comments? Interest in membership?

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<http://astrogeology.usgs.gov/groups/IAU-WGCCRE>