

ADDRESSING STRATEGIC PLANNING NEEDS FOR PLANETARY CARTOGRAPHY.

S. J. Lawrence¹, B. A. Archinal², L. R. Gaddis² ¹School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA (sjlawren@asu.edu) ²U. S. Geological Survey, Astrogeology Science Center, Flagstaff, AZ, USA

Introduction: Cartography is the science and practice of placing information in a standards-compliant, community-recognized spatial framework. The goal of planetary cartography is to enable any conceivable science investigation with returned planetary mission data, now or in the future. Archived standards-compliant cartography products are a resource that continues to produce scientific benefits for decades after a planetary mission is complete, much like how the Apollo lunar samples continue to enable a steady stream of new discoveries as analytical instrumentation has steadily improves.

Planetary cartography enables science investigation and human exploration planning for all planetary bodies. However, cartographic products involve major efforts in time and research to properly execute. For this reason, strategic planning for planetary cartography is essential for successful planetary science research.

Here, we briefly outline the history of NASA strategic cartography planning and issues where the community-driven capabilities provided the newly-established NASA Cartography Research Assessment Group (CRAG) will facilitate future effective NASA strategic planning.

Background: Historically, planetary cartography has involved broad segments of the community. During the Apollo era, multiple organizations helped to plan and carry out the work, including the United States Geological Survey (USGS), NASA Johnson Space Center, the National Geodetic Survey, the Defense Mapping Agency, RAND, academia, and others. The table below lists the various groups that have historically been established to coordinate these efforts, disseminate information to the broader community, and advise NASA on cartographic matters [1].

The last of these, the PCGMWG, includes broad representation from the planetary science community and includes the Geologic Mapping Subcommittee (GEMS). Other groups have been active in making recommendations on mapping standards (e.g., IAU

Start Date	Name
1974	Lunar and Planetary Cartography Committee
1977	Lunar and Planetary Photography and Cartography Committee
1979	Planetary Cartography Working Group
1994	Planetary Cartography and Geologic Mapping Working Group

WGCCRE, 1976-present; MGCWG, mid-‘90’s-present; LGCWG, 2007~2009) but not general cartography planning [2-4].

From 1994 to 2012, the PCGMWG made cartography recommendations to NASA, including submitting a white paper on cartography [5] to the NRC Decadal Survey. The PCGMWG ceased making cartography recommendations in 2012. The group continues its other responsibilities, primarily an annual External Review of the NASA Planetary Cartography program. Currently, no entity is charged with NASA strategic cartography planning

CRAG: To address this issue, the NASA Planetary Science Subcommittee has endorsed the formation of CRAG to serve as a community-based resource to coordinate NASA strategic planning needs for planetary cartography. As presently envisioned, the responsibilities of CRAG are projected to include:

- (1) Provide findings concerning the scientific rationale, objectives, technology, and long-range NASA strategic priorities for geologic mapping, geospatial software development, and cartographic programs;
- (2) Assist, through the activities of Specific Action Teams, with developing cartographic, planetary nomenclature, and geologic mapping standards for present and future NASA flight missions and research activities
- (3) Providing findings regarding the accuracy and precision required for cartographic technologies and products
- (4) Help to coordinate and promote the co-registration of datasets from international missions with those from US missions.

In principle, these activities will help enable flight missions and the broader planetary science community to widely leverage planetary geospatial science data and products to make ongoing research discoveries. At the present time, CRAG is intended to potentially carry out three discrete functions to carry out its responsibilities:

Strategic Program Analysis: CRAG will be responsible for reviewing and prioritizing the cartoplanetary cartography objectives represented in past, present, and future NASA flight mission operations, research and analysis programs, cartographic research, geospatial software development, and geologic mapping programs. CRAG provides findings in response to requests from HEOMD, SMD, the Space Technology Mission

Directorate (STMD), and the NASA Advisory Council (NAC).

Community Liaison: CRAG will maintain a close liaison with the NASA Science Mission Directorate (SMD), the Human Exploration and Operations Mission Directorate (HEOMD), the NASA Space Technology Mission Directorate (STMD), other Assessment Groups, Federal mapping agencies, allied space agencies, and relevant international coordination entities (e.g., the International Astronomical Union, or IAU). CRAG will promote international collaboration, to help enable the broad spectrum of geospatial data products and programmatic capabilities required to effectively execute robotic precursor and human exploration of the Solar System, which include (but are not limited to) the science analysis of planetary surfaces, the identification of safe landing sites, the down selection of sample acquisition locations, hazard assessment, and the geospatial characterization of in-situ resources.

Standing Review Panel: It is intended that CRAG can assume the role historically held by the current PCGMWG and maintain a standing peer-review capability, should NASA require a future External Review of the cartography-related program elements in the NASA research and analysis portfolio. This function is similar to how the NASA Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) maintains standing peer-review panels to assess the allocation of extraterrestrial materials in the NASA collection.

Issues: There are numerous high priority issues that CRAG and the larger planetary science community must address in the years and decades to come. These issues include:

- How should the current, unprecedented influx of planetary mission data sets, (e.g., the Mars Reconnaissance Orbiter, the Lunar Reconnaissance Orbiter, MESSENGER) be geodetically controlled and integrated to enable science and operation of current and future missions?
- How should global, regional and local topographic models be created from multiple available data sets?
- What requirements should be developed for missions to follow during the formulation and definition stages to prevent subsequent cost-growth?
- How can research and analysis programs support development of mapping procedures for large scale and complex products?
- How can cartographic products be used to enable and facilitate future human exploration and in-situ resource utilization? [6]

- When and how should mapping tools be developed and how should they be tested for accuracy and user-friendliness?

As an example of the kind of in-depth assessment that the community-driven expertise coordinated by CRAG can help facilitate, many needs exist for new or improved tools to handle the increasingly complex instruments and vast data volumes of current and planned missions. Examples include (1) faster and more robust matching between disparate data types, enabling new types of data fusion; (2) ability to simultaneously adjust data from different platforms (e.g., orbital, descent, lander, and rover) and data types (e.g., images, radar, and altimetry); (3) new tools to combine different methods for generating topographic information, especially combining LIDAR and image-based techniques. In the current budget environment it is impossible to develop all the desired tools concurrently, and so the community must prioritize desirable capabilities that can be enabled by near-term investments in software tool development.

Conclusions: The planetary science community faces numerous issues relating to NASA strategic cartography planning for the coming decade and beyond as the United States aims to carry out ambitious planetary missions throughout the Solar System. By involving key stakeholders in the process and inclusively building an active and productive cartography community, CRAG can and will help NASA and the community effectively prioritize cartography needs and drive future discovery and innovation.

Additional Materials: An extensive historical archive of additional background materials related to the history of planetary cartography strategic planning can be found at:

<http://astrogeology.usgs.gov/groups/nasa-planetary-cartography-planning>

References: [1] PCWG, 1993, "Planetary Cartography 1993-2003". [2] Archinal, B. et al., 2011, *Cel. Mech. Dyn. Ast.*, 109, 101. [3] Duxbury, T. et al., 2002, <http://astrogeology.usgs.gov/search/details/Research/ISPRS/Duxbury/pdf>. [4] Archinal, B. et al., 2009, *LPS XL*, #2095. [5] Johnson, J. et al., 2010, http://www.lpi.usra.edu/decadal/sbag/topical_wp/JeffreyRJohnson.pdf. [6] Wargo, M. et al., 2013, *IAC 64*, IAC-13-A3.1.4