THE MAPPING AND PLANETARY SPATIAL INFRASTRUCTURE TEAM (MAPSIT): ADDRESSING STRATEGIC PLANNING NEEDS FOR PLANETARY CARTOGRAPHY. S. J. Lawrence[1,2], J. Hagerty[3], L. R. Gaddis[3], B. A. Archinal[3], J. Radebaugh[4], S. Byrne[5], S. Sutton[5], D. DellaGiustina[5], B. Thomson[6], E. Mazarico[7], D. Williams[1], J. Skinner[3], T. Hare[3], R. Fergason[3], J. Laura[3] [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA[1] sjlawren@asu.edu[2] [3]Astrogeology Science Center, United States Geological Survey, Flagstaff, AZ, USA [4]Brigham Young University, Provo, UT, USA [5]University of Arizona, Tucson, AZ, USA [6]Boston University, Boston, MA, USA [7]NASA Goddard Space Flight Center, Greenbelt, MD, USA

Introduction: Cartography is the science and practice of placing data in a standards-compliant, community-recognized geospatial framework. Archived standards-compliant cartography products are resources that are used by the worldwide scientific community for research many decades after a planetary mission is complete, much as the Apollo lunar samples continue to enable a steady stream of exciting new discoveries as analytical instrumentation improves [e.g., 1].

Geospatial information is the critical enabler for science investigation and human exploration planning across the Solar System. However, cartographic products can involve major efforts in time and research to properly execute. Furthermore, the software tools and content distribution platforms required for scientists to obtain, process, and analyze planetary mission data need continuing development and maintenance. For these reasons, community coordination and strategic planning is essential for the success of the planetary exploration enterprise.

Here, we briefly summarize the long history of NASA cartography planning and highlight community issues where the capabilities provided by the newly-established Mapping and Planetary Spatial Infrastructure Team (MAPSIT) will facilitate a cohesive response.

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 [2].

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

Other groups have been active in making recommendations on mapping standards but not general cartographic planning [3-5].

The former Planetary Cartography and Geologic Mapping Working Group (PCGMWG) had broad representation from the planetary science community and included the Geologic Mapping Subcommittee (GEMS). From 1994-2012, the PCGMWG made cartography-based recommendations to NASA, including submitting a white paper on cartography [6] to the most recent NRC Decadal Survey. The PCGMWG ceased making generalized community cartography findings in 2012, and was disbanded in 2015.

MAPSIT: To address the critical lack of a community-based organization driving strategic cartographic planning for planetary science and Exploration, the Planetary Science Subcommittee endorsed the formation of a group to coordinate NASA strategic planning needs for planetary cartography.

To this end, NASA and the USGS have worked together to establish MAPSIT, which assumes some of the roles of the former PCGMWG and includes some of its members for continuity. The MAPSIT Steering Committee includes membership from the planetary science, geologic mapping, software development, and human exploration communities.

MAPSIT's mission is nothing less than to *ensure that planetary geospatial information is readily available for any conceivable investigation, now or in the future*. MAPSIT has several functions:

1) Provide community findings concerning the scientific rationale, objectives, technology, and long-range strategic priorities for geologic mapping, geospatial software development, and cartographic programs to NASA and the USGS;
2) Assist with developing cartographic, planetary nomenclature, and geologic mapping standards for present and future flight missions and research activities;
3) Help define community needs for critical research and planetary mission infrastructure, particularly software tools and content delivery systems;

4) Provide findings on the accuracy and precision required for cartographic technologies and products; and
5) Coordinate and promote the registration of datasets from international missions with those from US missions to optimize their utility.

MAPSIT will maintain a close liaison with the NASA Science Mission Directorate (SMD), the USGS Astrogeology Science Center, the Human Exploration and Operations Mission Directorate (HEOMD), the NASA Space Technology Mission Directorate (STMD), other community Assessment Groups, the Planetary Data System [7], Federal mapping agencies, allied space organizations, and relevant international coordination entities. MAPSIT will 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. These 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 [8,9].

Issues: To maximize efficiency and control costs, there are numerous high priority issues that MAPSIT and the larger planetary science community must address in the years to come, including:

•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 mitigate subsequent cost-growth?

•How can research and analysis programs support development of mapping procedures for new and complex products?

•How can cartographic products be used to enable and facilitate future human exploration and in-situ resource utilization? [10]

•When and how should mapping tools be developed and how should they be tested for accuracy and usability?

An example of the kind of in-depth assessment that the community-driven expertise coordinated by MAPSIT can help facilitate is addressing the needs 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); and (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.

A New Strategic Plan: To that end, MAPSITs first task is to synthesize a new cohesive Planetary Geospatial Strategic Plan (PGSP). To build the PGSP, MAPSIT will solicit broad stakeholder input through community surveys and town hall meetings in order to prioritize the needed data products and infrastructural developments, following a process much like the Lunar Exploration Roadmap [11] and the 2015 SBAG Goals Document [12]. It is envisioned that the MAPSIT Strategic Plan will be a "Living Document" that evolves over time as milestones are met and the state of the art advances.

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

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

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

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