The Need for Planning the Future of Planetary Cartography

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Introduction
Cartography is the science and art of placing information in a community-recognized spatial framework. It is essential for comparing or combining data taken at different times or by different instruments. As such, it is foundational to planetary science, especially as more involved data analysis is required to solve more mature questions. A lack of planning in constructing this foundation can have and has had serious and expensive consequences to the scientific return from planetary missions. Here we highlight the unprecedented lack of formal cartographic planning for the U.S. space program and suggest a straightforward community-driven solution.

Background
- Always a community effort, although including USGS involvement for > 50 years
- From the late 1960’s, multiple organizations have helped plan and carry out this work, under NASA direction
- The table at right lists the various groups chartered to coordinate these efforts, effectively disseminate information to the broader community, and/or advise NASA on cartographic matters [1]
  - These groups have produced various long range plans (Figure 1 & 2) and recommendations
  - Other groups have been active in making recommendations on mapping standards
    - IAU WGCRE (Figure 3), 1976-present [2]
    - MGGWG, mid-90’s-present [3]
  - From 1994 to 2012, the PCGMWG ceased making cartography recommendations to NASA, including a draft 10 year plan (Figure 4) and a Decadal Survey white paper on cartography (Figure 5)
- HOWEVER, the PCGMWG ceased making cartography recommendations in 2012

Unaddressed Issues
Need for geodetic control
- Controlling data sets is the only way to register data in a common frame at known levels of accuracy
- Critical for science
  - Body orientation variations, photometry for spectral/mineral studies, geologic mapping, change detection, multi-instrument comparisons
- Critical for mission operations
  - Landing site selection, targeting images from orbit, landed surface operations
- Can sometimes do without controlled data, but confidence in the results is a serious issue.
- Uncontrolled data not only have poorer spatial accuracy, but also the level of uncertainty is usually unquantified (Figure 6 & 7)
- Current special concern is related to the volume (order PBs) of uncontrolled data that has been collected, especially from Mars and the Moon (Figure 8)
  - An urgent and growing need to devise a real plan to refine this vast treasure trove
- Very economical to systematically control the most widely used data sets, but a rough prioritized implementation plan needed

Need for accepted cartographic standards
- Controlling each data set to a different standards provides minimal scientific value (Figure 9)
- Operationally, confusion over coordinate systems could have catastrophic consequences
- The effect of ignoring standards is comparable to that of not standardizing measurement units
- Key is to have universal acceptance of a standard – even if no one best choice is obvious
- A special concern is how to obtain the widest acceptance of standards by missions
- A recent example of concern is the Dawn mission’s confusing use of multiple coordinate systems for Vesta (6), only one of which has been recognized as following existing international conventions and standards (7) (Figure 10)
- An international problem but NASA could lead, if plan developed by stakeholders

Recommendations
Charter a new group to resume planetary cartography planning
Contributing actions:
1) The community needs to advocate such a group to the NASA analysis groups and NASA HQ
2) A clear charter and metrics for such a group is needed
3) All planetary scientists need to be involved and heard, not just professional cartographers

Multi-mission data analysis
- Individual missions and instruments usually understand their own cartographic needs, but multi-mission needs are neglected
- Concerns span the entire solar system
- Mercury, how will Mariner 10, MESSENGER, and Bepi-Colombo data be combined?
- Venus, complete processing of the Magellan stereo data has not been attempted
- Moons, hundreds of TB of data from multiple nations, missions, and instruments need to be controlled and co-analyzed (10)
- Mars & satellites, similar problems exist with many complex data sets that have not been well processed or registered to each other, or are not of sufficient resolution (e.g. Figure 12)
- Iovian satellites, joint processing of Voyager, Galileo, and New Horizons data still needed, possibly could help determine internal structure/oceans of the Galilean moons
- Saturnian satellites, serious problems
- Uranian and Neptunian satellites, reprovisioning of Voyager data would yield improved results
- Pluto and Charon, New Horizons has no requirement for producing global controlled maps
- Small and irregular bodies, the “state of the art” for mapping such bodies is poor (12) – and should be a huge concern for current and future missions and any asteroid hazard mitigation or return mission (e.g. Figure 11 & 19)

References: