PROPOSED DOCUMENTATION STANDARDS FOR DESCRIBING SPECIFICATIONS OF IMAGING SYSTEMS FOR PLANETARY MAPPING.

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Introduction: A key step in converting planetary image data into scientifically useful information is georeferencing into a defined planetary coordinate system. However, the details of this cartographic process vary from one imaging system to the other. Each instrument requires a geometric "sensor model" or "camera model" first defined mathematically and then embodied in a related set of software tools that are compatible for downstream analyses and planetary cartographic production [1]. The lack of adequate and consistent information about space imaging systems presents a major bottleneck to the development of the needed analysis tools and consequently to subsequent cartographic production, with measureable cost consequences to NASA and the planetary research community it supports.

This abstract presents a multiphase approach that would aim at establishing standards for all future space imaging systems. These standards involve documenting technical specifications at the design stage, measuring geometric properties using clearly defined prelaunch and in-flight calibration procedures, and publishing the outcome of the camera calibration in a form that is verifiably complete enough to support processing.

Rationale: There are numerous space imaging systems that have been launched strictly for planetary scientific studies. The design of such systems reflects an engineering trade between various factors, such as the:

- Current state of the art in flight-qualified technologies for detectors, optics, structures, flight category and data processing (i.e., the level of risk the mission is willing to accept regarding the success of the specific instrument in question);
- Target planet and phenomena to be observed, which define the desired spatial, temporal, and spectral coverage and resolution;
- Hardware considerations, electronic circuitry, power supply, downlink and data transfer;
- Stability, thermal resistance, and quality of optical positioning;
- Cost and financial constraints; and
- Payload constraints, especially mass.

As a result, cameras used in the US lunar and planetary program have ranged from framing cameras with wide-angle refractive optics using photographic film, such as the Apollo Metric camera [2] to a pushbroom scanner with complex, multi-surface reflective optics and a total of 14 solid-state detector arrays (MRO HiRISE [3]). Detailed information about each space imaging system is crucial for planetary science because it is the first link in the chain from raw observations to scientifically useful high level products [e.g., 4]; thus there is a need for establishment and enforcement of standards of the description of these systems. Such standards would facilitate development of camera models required for image analysis, developments of processing tools, software compatibility, and planetary cartographic production. Lack of these standards makes it costly (and sometimes impossible) to derive meaningful information from the acquired image data.

Proposed work: The USGS has a demonstrated leadership in setting and validating calibration standards for aerial cameras and space-based earth observing imaging systems [5, 6]. Based on such technical leadership, the proposed work aims at establishing standards for describing and documenting key geometric aspects of future space imaging systems. The proposed standards would allow cartographic processing to be carried out without exposing proprietary or ITAR (International Traffic in Arms Regulations) sensitive materials. The proposed work can be realized in three phases described as follows:

Phase 1: Making the Case: In this phase, a convincing argument would be presented in the form of a study that would make the case for standards through a cost/benefit analysis. The goal is to facilitate the willingness to adopt and adhere to the standards. The study would present specific quantitative measures to demonstrate:

1. That lack of standards does impose a substantial and unnecessary cost overhead in searching and defining critical data that are essential to developing the camera models and adjunct analysis tools and software development. Conversely, the study would demonstrate that proposed standards would bring about measurable savings on developing the camera model and related software tools.
2. That lack of a standard form for camera calibration reports increases the uncertainty of both the magnitude of errors and the sources of accuracy degradation in control networks and cartographic products.

<u>Phase 2: Initial Standards Development</u>: Phase 2 is the core development of the standards, including but not limited to a:

1. Set of standards for design stage technical specifications of geometric, radiometric, and spectral properties.
2. Clearly defined description of procedures for pre-launch and in-flight calibration; and
3. Comprehensive reporting language of the outcome of the pre-launch and in-flight calibration as defined in the calibration procedures in #2.

<u>Phase 3: Implementing the Standards:</u> Following the study in Phase 1 and the standards in Phase 2, the outcome would be transmitted to NASA and other groups who fund the development of planetary missions to formally adopt the standards. The goal is that these standards would be listed as a requirement in any new Announcement of Opportunity (AO) (or equivalent). In addition, the funding organization would stipulate that the calibration report would be submitted along with documents for other technologies and instruments for review and validation prior to launch. A panel of expert cartographers and software developers (not instrument builders) should serve as the technical reviewers of the documentation. Finally, the development of new and novel sensors may require periodic standards addendums or amendments.

Conclusion: Feedback on the needs for such standards, the phased approach, and the desired cost savings outcome is solicited for this effort. We are particularly interested in working closely with the developers of past, present, and notional camera systems to maximize the simplicity and consistency of calibration reports while ensuring that the documentation standards capture the details of even the most complex instruments.

References:

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