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. The details of this cartographic process, however, 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. The lack of consistent information about 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 poster presents a concept for a multiphase approach that would aim at establishing standards for all future space imaging systems, including documenting technical specifications at the design stage, measuring geometric properties using clearly defined pre-launch and in-flight calibration procedures, and publishing the outcome of the camera calibration in a form that is verifiably complete enough to support modeling and processing.

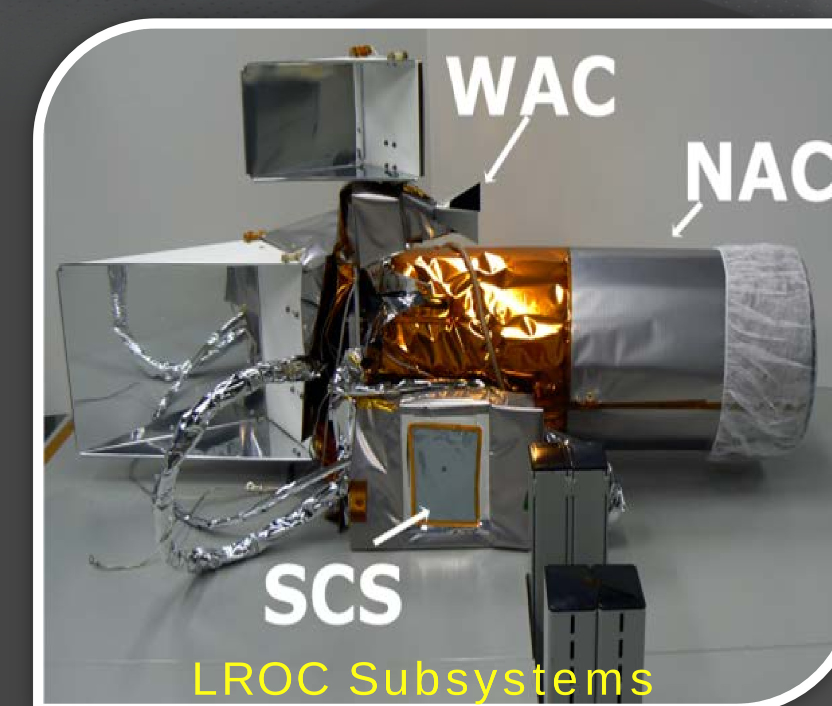
Rationale:

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:

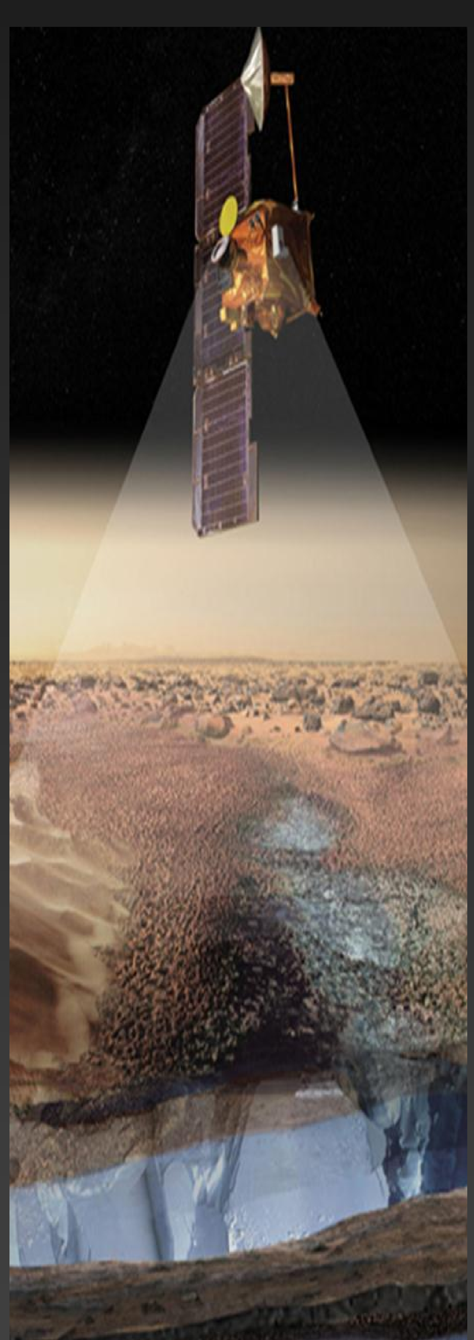
- *Current state of the art in flight-qualified technologies for detectors, optics, structures, flight category and data processing (i.e., the level of risk the mission is willing to accept regarding the success of the specific instrument in question);*
- *Target planet and phenomena to be observed, 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, e.g., Apollo Metric camera, to a pushbroom scanner with complex, multi-surface reflective optics and a total of 14 solid-state detector arrays, e.g., MRO HiRISE. Detailed information about each 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; 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.

The Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC)



LROC Subsystems



Proposed work:

The USGS has a demonstrated leadership in setting calibration standards for aerial cameras and satellite imaging systems. Based on such leadership, we propose establishing standards for describing and documenting key geometric aspects of future space imaging systems. These standards would allow cartographic processing to be carried out without exposing proprietary materials or violate international treaties. The proposed work can be realized in three phases 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:

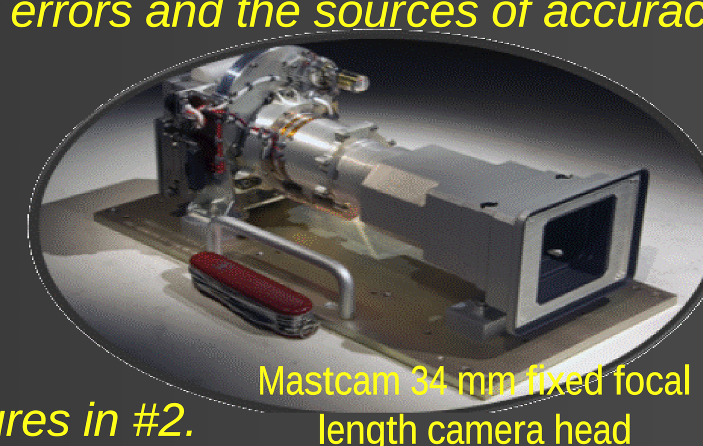
1. *That lack of standards does impose a substantial and unnecessary cost overhead in developing the camera models and adjunct analysis tools and soft-ware development. Conversely, the study would demonstrate that proposed standards would bring about measurable savings on developing the camera model 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.*

Phase 2: Initial Standards Development:

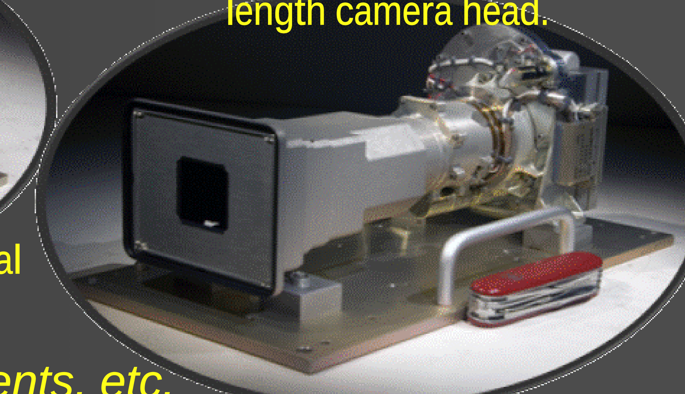
Phase 2 is the core development of the standards, including:

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

Examples: Sensor Type, Number of Rows and Columns in sensor array, Collection Start /End Time, Sensor Position/Rotation in X,Y,Z Components, etc.



Mastcam 34 mm fixed focal length camera head



Mastcam 100 mm fixed focal length camera head.

Phase 3: Implementing the Standards:

Based on the proposed the study in Phase 1, and the standards resulting from Phase 2, the outcome would be transmitted to NASA to formally adopt the standards and publish them to the public. The goal is that these standards would be listed as a requirement in new Announcement of Opportunity (AO). NASA would also stipulate that a calibration report would be submitted for review prior to launch. The USGS Astrogeology Science Center serve as the technical reviewer of the design-stage and pre-launch documentation. Finally, the development of new and more complicated sensors may require periodic standards addendums or amendments.

What camera standards are MOST USEFUL TO YOU!

Conclusion:

Feed back on the needs for such standards, the phasal approach presented, and the desired cost savings outcome are very much solicited for this effort. Specifically in Phase 2, we are particularly interested in feedback and hopefully working closely with the developers of past, present, and notional camera systems to maximize the simplicity and consistency of calibration reports while ensuring these standards capture the details of even the most complex instruments.

Please kindly send feedback and recommendations to Ra'ad Saleh, rsaleh@usgs.gov.

The Mars Reconnaissance Orbiter (MRO) Context Camera (CTX)

Disclaimer: *The work presented in this poster has NO explicit or implied endorsement by any manufacturer or operator of any of the imaging system displayed in this poster.*

The Mars Reconnaissance Orbiter (MRO)

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