CALIBRATION OF THE IMAGER FOR MARS PATHFINDER (IMP). Devon G. Crowe, Peter H. Smith, Nancy Chabot, Robert Reynolds, Roger Tanner, Lyn Doose, Daniel T. Britt, Robert Singer, James Palmer, Chris Shinohara, Kevin DeVries, and Terry Friedman, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721

Introduction

The Imager for Mars Pathfinder (IMP) is a stereo multi-spectral CCD camera scheduled to land on Mars July 4, 1997. More information on the IMP is available on the World Wide Web at: **http://seds.lpl.arizona.edu/~dcrowe/imp.html**. In order to produce the best data possible to support mineralogical, morphological, and atmospheric studies, the instrument must be both characterized and calibrated. The approach is to first characterize the instrument performance, then create a calibration data base which will allow optimal ground-based data reduction for scientific utility. We will also create on-board calibration which can provide the best possible compression of non-science data for use in support tasks such as rover navigation. On-board calibration and data compression will also provide a back-up mode of science data collection in the event that the high gain antenna is not available, forcing a very low data rate low gain antenna mission. In many cases, the raw instrument performance can be greatly improved by the use of tailored algorithms. One example is the use of a two-dimensional fit to the flat fielding variation as a function of wavelength to allow on-board calibration of field responsivity in each of the 24 spectral filters (17 different wavelengths as detailed in the abstract by Britt, et. al. in this volume) using a single flat field data table. Another example is the use of a centroiding algorithm to allow angular position and distance measurement limited by the signal-to-noise ratio, rather than limited by geometrical optics. The anticipated 0.06 pixel angular resolution requires careful calibration of optical train distortions due to many causes, including objective lens distortion and scale, and non-uniformities of detector response within a pixel. The ultimate goal is to attain the highest level of precision achievable with the Flight Model hardware in radiometric, spectroradiometric, and geometric data collection.

Instrument Characterization

Characterization is distinct from calibration, but is a necessary first step in the process. Among the characteristics of the IMP which must be measured are:

1. Depth of Focus (0.65 m to infinity)
2. Field of View
3. Stereo Alignment (30 milliradian toe-in per "eye")
4. Stereo Cross-Talk
5. Stereo Scale (matched to 0.1 %)
6. Stray Light
7. Geometric Distortions (create a stored correction map)
8. Modulation Transfer Functions (optical train quality)
    - 8.1 On-Axis MTF for each Filter
    - 8.2 Edge and Corner MTFs for each Filter
    - 8.3 MTF as a function of Range (0.65 m to infinity)
    - 8.4 MTF as a function of Pressure (earth ambient to Mars ambient)
9. Dark Current as a function of Temperature (165K to 280K)
10. Electron Well Depths (approx. 125,000 electrons)
11. Spectral System Quantum Efficiency as a Function of Pressure (to Mars ambient)
12. Alt.-Az Pointing Accuracy and Repeatability (accuracy of 5 mrad correctable to ?)
13. Charge Transfer Efficiency
14. Blooming
15. Responsivity Variation
    - 15.1 Integrating Sphere Measurements
    - 15.2 Target Measurements
    - 15.3 Polarization Response
16. Optical Train Diffraction Effects (for each filter)

CALIBRATION OF THE IMP: Devon G. Crowe, et. al.

Calibration

The calibration data set is created from characterization data combined with absolute accuracy measurements. The calibration data will be used for all subsequent data reduction, and may be made available on CD-ROM when the Mars science data is released to the community at large. Three distinct calibration environments exist:

1. Laboratory Calibration
    - 1.1 Radiometric Calibration
        - 1.1.1 Responsivity as a function of Temperature
    - 1.2 Spectroradiometric Calibration
        - 1.2.1 Responsivity as a function of Wavelength and Temperature
    - 1.3 Flat Field Radiometric Calibration Data Sets
    - 1.4 Geometric Calibration (includes AZ-EL)
2. Flight Calibration
3. Mars Site Calibration

Data Reduction

Several products of data reduction will be created for different science and engineering uses.

1. True Color
2. Panoramic Tiling
3. Multi-Spectral Classification
4. Three-Dimensional Classification Mapping of the Martian Surface
5. Atmospheric Studies
6. Solar Recognition

Engineering Model Performance

The IMP Engineering Model was at the University of Arizona from November 8, 1994 through January 16, 1995. During this brief period, a number of characterization tests were performed with three primary goals in mind:

1. Identify possible improvements to the IMP Flight Model
2. Verify and Validate the Flight Software
3. Obtain pointing accuracy and repeatability data for sun search

Several improvements to the Flight Model will be made as a result of these tests, and the data supports hope that the calibrated flight model will achieve several performance benchmarks of significance, including flat field response across the calibrated CCDs within 1% at all wavelengths. The IMP Science Team met during this period, and the IMP was exercised in the University of Arizona Mars Garden which contains earth analogs for some of the mineral and soil types expected to be found on Mars. This exercise highlighted the need for flat field accuracy, leading to improved flat field algorithms.

Conclusions

The fast track schedule of a Discovery Mission means that the IMP Engineering Model was delivered within 6 months of contract award, and the Prototype Model will be delivered within one year of the initial contract, followed 3 months later by the Flight Model, which must be delivered to JPL after a scant 4.5 months of calibration. During that busy calibration effort, the data will be collected upon which the science from the first imaging mission to the surface of Mars in over 20 years will rest.