IMAGER FOR MARS PATHFINDER (IMP)

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Goals of the Investigation

The major science objectives of the IMP experiment include. (1) mapping the morphology and terrain of the landing site. (2) Determination of the mineralogy of the exposed crustal rocks and soil as well as the mineralogy of the weathering products in the soil, dust, and on the surface of the rocks. (3) Observation of time-variable phenomena at the landing site including cloud formation, wind velocity and direction, frost, and the formation/evolution of eolian features. (4) Observation of the properties of the martian atmosphere including measurement of the quantity of atmospheric water vapor and the quantity and size distribution of atmospheric dust. (5) Study the magnetic properties of the martian dust by multispectral imaging of dust accumulations on the magnetic arrays. (6) Multispectral studies of the nighttime martian atmosphere by imaging bright stars and the multispectral study of the mineralogy of the martian moons Phobos and Deimos.

Instrument Description

The Imager for Mars Pathfinder is a binocular CCD-based camera using a Loral 512 x 512 pixel CCD. The camera resembles a 4 by 8 inch cylinder with the long axis aligned horizontally to the plane of the lander (Figures 12 and 13). The square eyes are separated by 15 cm to provide good stereo and ranging performance to support rover operations. The dual optical paths are folded by two sets of mirrors to bring the light to the single CCD. To minimize moving parts, the IMP is electronically shuttered and half of the CCD is masked and used as a readout zone for the electronic shutter. The active half is split into two identical 248x256 pixel sub-arrays for each eye separated by a 12 pixel "dead zone" to minimize cross-talk between the eyes. Readout takes approximately a minute and the data is digitized to 12-bits. The field of view of each eye is 14.4∞horizontal by 14.0∞vertical with a 18 milliradian toe-in in each eye to provide complete viewing overlap at 5 m distance. The toe-in was to assure maximum stereo performance in the zone 2-10 meters from the camera which is the primary area for rover operations, mineralogical observations, and morphological investigations. The lenses are modified Cooke triplets, designed with rad hard glasses and stopped down to f/18 with a 1.04 mm aperture. The effective pixel resolution of these optics is one milliradian per pixel which gives 1 mm per pixel at one meter range. In the optical path of each eye is a twelve-position filter wheel, giving the investigation a total of 24 filters (Figure 12). Both filter wheels are on a common drive shaft so both wheels move together. Four wheel positions (eight filters) are used for atmospheric investigations and eight wheel positions (15 filters and a diopter lens) are used for geological/stereo investigations. The atmospheric filters are designed for direct observations of the sun through the martin atmosphere and include neutral density coatings that reduce transmission to less than 0.1%. The geology positions include three wheel positions for stereo viewing that have the same filter and one position that has a diopter lens to allow close-up viewing of a magnet mounted on the camera tip plate. This provides a total of twelve separate geology filters for visible and near-IR spectroscopy. A listing of IMP filter characteristics and wheel positions is shown in Table 2. The camera cylinder is mounted on gimbals that provide pointability of 360∞in azimuth and -67∞to +90∞in elevation. This assembly is supported by an extendible mast designed and built by AEC Able Engineering. The mast is an open lattice of fiberglass stiffened by wire that pops up 80 cm above its stowed position (Figure 13). This puts the camera at approximately 1.5 meters above the martian surface and extends Pathfinder's horizon to 3.4 kilometers on a featureless plane. A summary of IMP characteristics and specifications is listed in Table 3.

In addition to the camera, the IMP experiment includes two radiometric calibration or photometric targets, a number of magnetic properties targets, three wind socks, four sets of color calibration targets (5 colors each) and one flat field targets (Figure 6). The flat field targets, made of rutile (titanium dioxide paint pigment), are mounted on the tip plate beneath the IMP in view by both eyes of the camera. The radiometric or photometric targets are mounted on top of the electronics box and on the base petal. Each consists of a white (rutile), gray (mixture of rutile and carbon black) and black (carbon black) ring with a shadow post in the center with known reflectances. There are four sets of color targets on the lander (mounted with each photometric and magnetic target) and two on the rover (along the edge of the solar cell). Each set of color targets is composed of 5 silicon squares impregnated with: hematite (red reference), maghemite, goethite, chromium dioxide paint pigment (green) and cobalt blue paint pigment of stable and known spectra. Three types of magnetic targets are mounted on the spacecraft. Two magnetic arrays, each consisting of two blocks of magnesium with permanent "bulls eye" Sm-Co magnets of varying strengths (5, 11, 21, 45, 130 T/m) embedded and a sputtered gray platinum surface. One block contains magnets of Viking strength; the other block carries three of lesser strength (Figure 14). One magnet array is mounted on top of the electronics box, the other on the base petal. The surface of the array is tilted so that only magnetic dust will adhere to the surface. A magnet is also mounted on the tip plate with a magnetic field gradient across it (highest field strength is 130 T/m). A flexible flat magnet is also mounted at the end of each 1 m long rover ramp. The magnets are constructed of thin strips of magnetic material in aluminized Mylar that cover a 10 cm by 10 cm area magnetized to between 23 mT and 49 mT. Three wind socks are mounted at heights of 33.1, 62.4 and 91.6 cm above the petal on the ASI/MET mast. Each windsock (Figure 15) is made of an aluminum cone attached to a steel and aluminum counterweight rod. The 10 cm long socks pivot on gimbal mounts attached to 10 cm long struts extending from the mast.

Data Collection Procedures

Commanding the camera system is accomplished through a sequence of commands that are time tagged and stored in RAM until they are required. These commands can either be from already stored sequences or newly generated sequences that have been unlinked to respond to changed mission conditions. The basic modes follow the operational sequences. The first operation after landing is the release of the launch lock which will allow full operation of all camera functions. Pre-deployed images are taken and stored through the use of the imaging command. The image command includes optional parameters that control the exposure and processing. Everything from the exposure time to the amount and type of data compression are specified and attached to the data set. Sub-framing boundaries and pixel averaging parameters can also be specified. After processing for data compression the packetized images are stored in the telemetry buffer. Several types of data compression are included in the IMP software package. Lossless compression using the Rice algorithm developed at JPL will be the workhorse for the IMP images as long as we have a data rate of several thousand bits per second. For non-science or low data rate scenarios a lossy compression using a modified JPEG compressor developed at the Technical University of Braunschweig will normally be used. Other methods of conserving downlink resources include sub-framing the image. Examples of this are most of the atmospheric science images of the Sun which will be returned as 25x25 pixel blocks centered on the Solar disk. Row and column averages will be used for sky images, as this gives the gradient and the edges of cloud features, but not the high resolution of an image. Pixel averaging can be used where full resolution is not needed. Also, these methods can be used in combinations for highest compression.

Nature of the Available Data Sets

The standard IMP product will be a single image consisting of a header that contains the time-tagged command information, a unique image identifier, and an array of the DN's produced by that image. Although the IMP takes data in a 248x256 pixel format the software can use a variety of tools to compress this data. The major constraint on IMP data sets is the downlink resources available to Pathfinder. Optimistic scenarios put the downlink data rate at approximately 5000 bits per second for several hours per day. As a result large data sets like a color panorama of the landing site will not be returned quickly and many IMP investigations will need to conserve downlink bandwidth by a combination of lossless or lossey compression, subframing, and pixel averaging. Images with the geology filters will be used for panoramas, true color mosaics, multispectral image cubes, and multiple sun angle photoclinometry. Images of the magnetic properties arrays, wind socks, and calibration targets will be subframed to conserve downlink bandwidth. Atmospheric science images of the sun will be sub-framed and averaged. Stereo