and well defined by the five bandpasses from 0.86 to 1.0 µm. For an optically thin frost layer the 0.95-µm band can be difficult to see, depending on the substrate, even though the effect on visual slope and albedo is still large [8].

True Color Imaging: Accurate visual color rendition is important to the mission, for public distribution as well as science. Human color vision is a complicated and apparently not fully understood topic. After extensive research we have concluded that there is no single set of three bandpasses that is accepted as "best" at reproducing the colors that most people see most of the time. (MIPS at JPL has apparently reached a similar conclusion.) One common published system uses primaries of 436, 546, and 700 nm [e.g., 9], while another standardizes on 444, 526, and 645 nm [10]. We propose to use the IMP bandpasses at 440, 530, and 670 nm for standard "true color" imaging.

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GOLDSTONE RADAR CONTRIBUTIONS TO MARS PATHFINDER LANDING SAFETY.

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Goldstone radar can provide topography "profiles," statistical surface roughness, and radar images within a few degrees of the sub-Earth point. Goldstone/Very Large Array (VLA) bistatic radar observations can image the whole disk of Mars with integration times on the order of 10 min before pixel smearing occurs. Data from all these radar techniques can be useful for observing the local surface conditions relating to landing safety issues for Mars Pathfinder. Topographic profiles will be presented from the 1978 opposition (subradar latitude ~10°N), and the 1980–1982 oppositions (subradar latitudes ~20°–22°N) at 13 cm wavelength with a radar "footprint" of ~8 km (longitude) by 80 km (latitude). The 1992–1993 opposition (subradar latitudes ~4°–10°N) has both Goldstone/VLA images and topographic profiles at 3.5 cm wavelength (many of the latter have yet to be reduced).

During the 1995 opposition, additional opportunities exist for obtaining the data types described above at latitudes between 17°N to 22°N (see Fig. 1). Upgrades to the radar system at Goldstone since 1982 will permit higher accuracy for the same distance with a reduced footprint size at 3.5 cm. Since the Arecibo radar will still be in the midst of their upgrade for this upcoming opposition (which starts ~November 1994, with closest approach in February 1995), the Goldstone radar will be the only source of refined radar landing site information before the Mars Pathfinder landing.

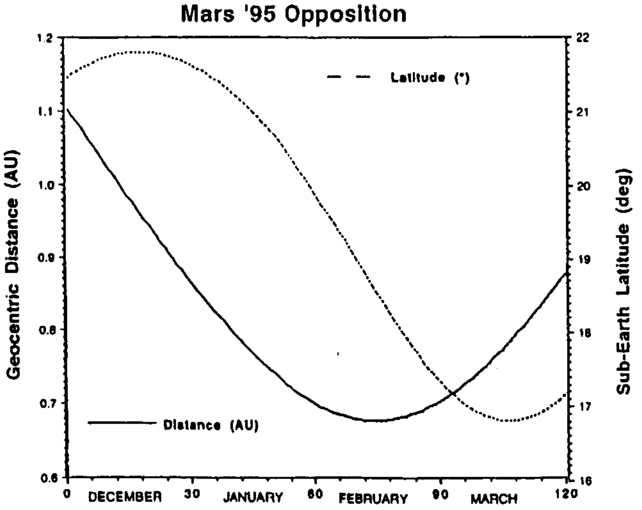

Fig. 1.

N95- 16206

IMAGER FOR MARS PATHFINDER (IMP).

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The IMP camera is a near-surface remote sensing experiment with many capabilities beyond those normally associated with an imager. The camera is fully pointable in both elevation and azimuth with a protected, stowed position looking straight down. Stereo separation is provided with two (left and right) optical paths; each path has a 12-position filter wheel. The two light paths converge onto a single CCD detector that divides its 512 × 256 active pixels evenly between them. The CCD is a frame transfer device that can transfer a frame in 0.5 ms, avoiding the need for a shutter. Because the detector has a high quantum efficiency (QE) and our filters are relatively broad (40 nm FWHM), the camera optics are stopped down to f/18, giving a large depth of field; objects between 0.6 m and infinity are in focus, no active focusing is available. A jack-in-the-box mast elevates the camera about 75 cm above its stowed position on top of the lander electronics housing; the camera is fully functional in its stowed position so that pictures taken of the same object in each position can be compared to give accurate ranging information. The camera is designed, built, and tested at Martin Marietta. Laboratory testing of flightlike CCDs has been done at the Max-Planck-Institut für Aeronomie in Lindau, Germany, under the direction of co-investigator Dr. H. Uwe Keller, who is providing the focal plane array, the pre-amp board, and the CCD readout electronics with a 12-bit ADC. The important specifications for the IMP camera from the point of view of the scientists using the camera are given in Table 1. For comparison the same quantities are also provided from the Viking camera system.

Science Objectives: The primary function of the camera, strongly tied to mission success, is to take a color panorama of the surrounding terrain. IMP requires approximately 120 images to give a complete downward hemisphere from the deployed position. The local horizon would be about 3 km away on a flat plain, so that one can hope to have some information over a 28 km^2 area. At the horizon a pixel covers 3 m, but the resolution improves at closer distances; just outside the lander edge a pixel is 1.6 mm. Therefore, IMP provides the geologist, and everyone else, a view of the local morphology with millimeter- to meter-scale resolution over a broad area. Accurate ranging to local features is obtained with the stereo separation; at a distance of 5 m we can locate a rock to 1–2 cm by cross-correlating edge features. In addition to the general morphology of the locale, IMP has a large complement of specially chosen filters to aid in both the identification of the mineral types and their degree of weathering. Dr. Robert Singer will present both the filters and the scientific goals for this part of the IMP experiment in his talk.

The IMP team plans to study the atmosphere in several ways. Our baseline filter set includes three solar filters for viewing the solar disk. One of these filters is specially designed to be centered on the deepest lobe of the 935-nm water absorption band; an adjoining continuum filter provides calibration reference. The ratio of the two filters is obtained many times during the course of the day, especially when the Sun is low in the sky and the absorptive path is longest. Although the ratio is estimated to be only 0.98–0.99 for nominal water vapor values, we have gone to great pains to minimize systematic errors, and it is anticipated that the water vapor mixing ratio can be obtained to within 20%.

An additional solar filter at 425 nm has been added for studying the optical depth of the atmospheric dust. The wavelength baseline when combined with the 925-nm continuum filter is a factor of 2; sizes can be accurately obtained for dust particles less than 1.4 µm in diameter by comparing the ratio of optical depths in the two colors to Mie scattering models. The nonsolar filters can also be used for studying the scattering of sunlight from the sky. In this way, the phase function of the dust can be determined and the sizes of larger particles can be estimated. These experiments can be continued into the night by observing Phobos. Other experiments to learn about the atmospheric dust can be easily imagined.

Not only can IMP observe the dust in the sky, we can trap the magnetic portion of that dust onto a series of magnetic targets of varying strength. Dr. Jens Martin Knudsen of the University of Copenhagen in Denmark has developed a special set of targets for the Pathfinder Mission and has shown in the laboratory the usefulness of imaging these targets with the IMP spectral filters to identify which magnetic mineral he has captured. In addition to the spectral information, the magnetic strength of the material can also be determined by seeing which targets have trapped the dust. We currently plan for two sets of targets at different heights: close to the surface and about 0.5 m above the surface.

TABLE 1.

Parameter	IMP	Viking
IFOV (1 pixel)	0.057° (1 mrad)	B&W: 0.04° Color: 0.12°
Frame size	14.4° × 14.4°	line scan
Depth of field	0.6 m - inf	1.7 m - inf
Exposure time	0.5 ms - 32 s	0.4 ms or 25 ms
Pointing	–65° < elevation < +90° All azimuth angles	–60° < elevation < +32° 2.5° < AZ < +342.5°
Stereo	15 cm horizontal 76 cm vertical	80 cm horizontal limited field
Height above surface	1.4 m	1.3 m
Bits per pixel	12	6
Filters	12 per eye	6
Filter bandpass	40 nm typ	100 nm
Camera step size	1.125° both EL and AZ	
Pointing repeatibility	0.09° at any step position	

A final aspect of IMP related to atmospheric studies is the windsock experiment. Dr. Ronald Greeley of Arizona State University is developing and testing small telltales to be place at varying heights between the surface and 0.5 m on one of the antennae. By imaging these targets, both the direction and velocity of the wind can be estimated. Calibration is being done at the Ames Martian Wind Tunnel, where pressure and wind speeds can be simulated; of course, the gravity must be scaled. By including wind socks at several heights the local aerodynamic roughness of the terrain can be determined and the winds can then be accurately extrapolated above the lander site. Viking landers had wind measurements at 1.6 m above the surface only; extrapolation to other heights was very uncertain.

MELAS CHASMA: A MARS PATHFINDER VIEW OF VALLES MARINERIS.

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A Mars Pathfinder landing site in Melas Chasma (Valles Marineris) would yield significant science return, but is outside present mission constraints. In Melas Chasma, Mars Pathfinder could investigate minimally altered basaltic material, sedimentary deposits, chemical weathering, tectonic features, the highland crust, equatorial weather, and Valles mists. Critical issues include (1) nature and origin of the Valles interior layered deposits, important for understanding water as a sedimentary and chemical agent, and for the past existence of environments favorable for life; (2) compositions of little-altered basaltic sands, important for understanding magma genesis and weathering on Mars, and the martian meteorites; and (3) structure and composition of the highland crust, important for understanding Mars' early history. Data from Melas Chasma would provide ground truth calibration of remote sensing datasets, including Phobos ISM.

Mission Constraints I: In the first workshop circular, the landing site was to be "roughly between the equator and 30°N" with a "landing . . . uncertainty of roughly 150 km." In the final circular, the landing site is restricted to "0°N and 30°N . . . within a 100-km × 200-km ellipse along a N74E axis around the targeted site . . ." No hazard-free nominal site in Melas Chasma satisfies these later criteria. However, a hazard-free restricted site to 85 × 170 km at the same orientation can be accommodated (Fig. 1).

Site. The proposed landing site is at 9.75S 72.75W in Melas Chasma, the widest portion of Valles Marineris [1–3]. The restricted site (Fig. 1) is a flat, smooth surface, –2 to +1/2 km in elevation, mapped as younger massive material [1,2]. This surface is probably composed of basaltic sand, very slightly hydrated and oxidized. A thermal inertia of 8–10 × 10^{-3} cal $cm^{-2}s^{-1/2}K^{-1}$ [4] and block abundances of 5–10% [5] suggest sand with scattered blocks (fewer than at VL1) and little dust. A surface of slightly altered basalt or basaltic glass [6] is suggested by its dark (albedo 0.18–0.2) and slightly reddish color [4,7], its abundance of high-Ca pyroxene [8], and the presence of H_2O but little structural OH [7].