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MARS METEOR SURVEY.

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INTRODUCTION

Mars orbiting spacecraft and ground operations, both manned and unmanned, are vulnerable to meteoroids. There is pure scientific interest in knowing the frequency, intensity, and radiants of martian meteor showers. Being in a different orbit than Earth and closer to the asteroid belt, Mars has unknown cycles and intensities of meteoroid hazards. Knowledge of these hazards can help us manage risk in future missions, particularly extended and crewed missions.

METEOROID MEASUREMENT

We propose that instruments be included on one or more Mars landers to identify and characterize the meteoroid flux at Mars.

Instruments: To be most effective, the detectors should be continuously active, day and night, for as long a period as possible. Detectors that rely on energy-intensive transmitters, such as lasers, radio bounce or radar [1], are therefore less desirable. A staring instrument is preferable to one which must rapidly slew to track a meteor (requiring extra mechanical parts and susceptible to failure), and should be able to detect multiple meteors simultaneously.

Power supply. In order to obtain representative samples and reliable long-term statistics, a power supply that can maintain function during the martian night and over the martian winter is highly desirable. Ideally the power supply should provide several years of service.

Camera. A staring full-sky camera can detect meteors directly, at least at night (*meteor* being the flash of light in the atmosphere caused by an infalling meteoroid). It may be possible to detect them in daylight as well, perhaps using an infrared (IR) camera. Ultra-wide angle 180° lenses are expensive and bulky. A small camera staring down at a lightweight spherical mirror can cover the sky just as well and may be better for dust management. The optics need not be of astronomical quality to gather this statistical data, and the small portions of the sky obscured by the camera and its support are relatively insignificant.

Spectrograph. Spectrographic capability would give us information about the elemental composition of Mars' upper atmosphere and the vaporizing meteoroids. Radial velocity can be determined by Doppler shift and combined with transverse velocity to yield a true vector solution of the meteor.

Radio. The ionization created by meteoroid energy generates a radio-frequency (RF) signal. It may be possible to detect this emission and derive certain information from it. A radio (or microwave) detector can work day or night. It may also be able to detect smaller magnitude events than an optical/IR detector. In order to localize the signal, at least three receivers and antennas are required. It may be possible to integrate the antennas as part of a splayed landing gear array. Another possibility is to make the optical camera support legs into antennas. In another experiment, a transmitter could be dropped to send signals to create a whistler effect if there is enough atmosphere for ionization. An Earth-based feasibility study of RF interferometry array would be in order.

Microphone. If a microphone is included as part of another package, some larger, closer meteoroids could produce a sonic boom or other detectable sound. Being able to associate the sound with a detected meteor would help us characterize the nature of sound transmission and attenuation through the martian atmosphere.

Barometer. If a barometer is included as part of a martian weather package, it might also record the sonic boom sometimes associated with meteors or perhaps the pressure gradient from a Martian dust devil. On the other hand a barometric meteor detector might be a reasonable alternative to a global array since impacts over a given threshold would produced barometric flux that was both characteristic and rare. R. Bence

Seismometer. If a seismometer is included in a geology package, on this or other landers, coincidence of a seismic signal with a meteor detection could be a confirmation of impact or the study if Mars is a living planet. Further analysis of the seismic signal could help calibrate the meteor detector. Seismometery requires an array of fixed sensors and the data accumulated is substantial, additionally, for valid seismic measurements on must emplace the sensor in a meaningful way.

Computer. An onboard computer can process the raw data so only a small set of data, consisting of basic meteor identifying parameters and variables, need be included in periodic uploads to Earth. For diagnostic and other scientific purposes, it should be possible to bypass the computer and send broadband raw data to Earth. Perhaps the uploaded signal to earth could be used as the transmitting RF wave.

Infrasound wave detector. The infrasound wave detector would detect long wave sound waves from 20 hertz down to a day or more. On Earth such devices are capable of detecting nuclear explosions continents away.

Meteorite hazard study. In the same way Apollo missions brought back a piece of Surveyor to study micro meteorite impact and radiation hardening, a lander/ rover could study the Viking landers to record the meteorite damage.

SURVEY QUESTIONS

Here are some questions the Mars Meteor Survey might address:

When are martian meteor showers, how extensive are they, what is their density, and where do they come from?

Which meteors come from the asteroid belt and which from comets?

Can we predict meteor showers and storms on Mars?

Will Mars surface operations be exposed to periodic "rains of rock"? (Fig. 1)

What is the cumulative risk to surface and orbital operations at Mars due to meteoroids?

How small can a meteoroid be and still reach the surface of Mars?

Are meteorite falls on Mars different in characteristics or time frames from those on Earth?

Would radio or microwave receivers on Mars be sufficient to detect meteors without a reference transmitter?

Will infrasound detection work in Mars' atmosphere?

What will meteors look like on Mars? Will they have statistically different characteristics than those seen on Earth?

Are there dust zones or gradients in Mars' atmosphere?

Can wind-shear zones or jet streams in Mars' atmosphere affect meteor signals? [2]

How much of atmospheric dust on Mars is endogenic (kicked up from the surface) and how much exogenic (meteoroid)?

Is there a synergy between radio and visible/IR or spectrographic sensors to characterize mass, composition, or other factors of meteoroids or of the martian atmosphere?

Are there statistical differences in composition of Mars meteoroids vs. Earth meteoroids?

Would a marsosynchronous orbiter be able to detect meteor traces on the night side of Mars.

Can the Mars Meteor Survey instruments be used in other studies, such as dust storm analysis, imaging during the landing sequence, etc.?

Does Mars have additional small moons?

FURTHER WORK

Research existing knowledge from Pathfinder and other missions to better understand the martian atmosphere. Find examples of recorded martian meteors, in order to establish parameters for Mars Meteor Survey instruments. Research Earth-based "staring" experiments to identify detection techniques, analysis algorithms, and possible problem areas. Predict possible times for

Mars meteor showers based on known Mars-crossing comets, and compare these predictions to actual results. Cooperate with other researchers and planners to create a specific proposal for flight. Identify sources and acquire funding to build and fly the Mars Meteor Survey instruments and analyze their data. Publish and disseminate results of the experiment. The Oregon L5 Mars Instrument and Science Team (point of contact is MIST chairman, Gus Frederick) would like to work with other professionals in the field to produce the Mars Meteor Survey.

REFERENCES

[1] International Meteor Organization web site <www.imo.net>.

[2] Barnes, J. (2000) Personal communication.