RETURNED SIGNAL FROM SPHERE COVERED WITH RETROREFLECTORS ILLUMINATED WITH LASER LIGHT

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A future Mars mission will return a sample of Martian soil to Earth for further analysis. In one mission concept, the sample will be placed in a softball-size spherical container, and sent into orbit around Mars. A rendezvous spacecraft will then capture the container and return it to Earth.

Coarse, long range location of the sample container will be accomplished using a solar-powered radio beacon. However, final detection and orbit maneuvers will require position knowledge beyond the capabilities of the radio beacon scheme. Accordingly, a laser radar is baselined as the close-approach rendezvous sensor. To increase the laser radar's signal return, retroreflectors will be placed on the surface of the sample container in spaces not occupied by solar cells. In addition to improved accuracy at short range, a second advantage of the laser radar is that it will continue to operate during the 40% of each orbit when the radio beacon is not powered because the sun is occluded by Mars.

This work focuses on the placement of the retroreflectors to improve the chance of detection. In particular, the number, distribution, and orientation of the retros must assure coverage of the entire 4\pi solid angle. Such coverage essentially demands that, for some set of orientations, more than one retro will contribute to the laser radar return signal. If the laser light is coherent, these multiple returns will give rise to interference effects. Small changes in the relative position and orientation of the sample canister with respect to the laser radar may produce large variations in the returned signal. To increase the probability of quickly locating the container, the retroreflectors must be placed so as to maximize the minimum signal returned in any orientation. The placement problem is complicated since the locations of the retroreflectors are limited to areas not occupied by solar cells, radio antennae, etc. The methodology used to optimize the return under these constraints is discussed.

Our approach to identifying optimal retro configurations relies heavily on computer simulations. A plausible retro configuration, constrained by predefined locations of solar cells, radio antennas, etc. is identified. We then simulate the complex electromagnetic field from individual retroreflectors, taking into account variables such as distance, shape of the retroreflector aperture, observation angle, and Gaussian beam profile. These individual fields are summed to produce the final interference pattern.

We present simulations of the interference pattern from a promising retro configuration with illustrations. Monte Carlo simulations of the distribution of the returned signal are also shown. A physical model of the sample container with retroreflectors has also been constructed. The returned signal from this model has been determined experimentally. Results of the experiments are compared to the simulations.