USE OF MRO OPTICAL NAVIGATION CAMERA TO PREPARE FOR MARS SAMPLE RETURN. M. Adler, W. Owen, J. Riedel, mark.adler@jpl.nasa.gov, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena CA 91109.

Introduction: The Mars Reconnaissance Orbiter carries a working Optical Navigation Camera (ONC) which can be used in a series of experiments to characterize the performance of systems that would be used to locate and track an Orbiting Sample (OS) launched by a Mars Ascent Vehicle. The experiments would search for extinct orbiters about Mars, starting with MGS, to exercise the ability to locate and perform orbit determination optically, and would search for a postulated dust ring and possible undiscovered very small moons of Mars. The data would be used to simulate OS tracking and rendezvous operations of a Mars Sample Return Orbiter (MSRO).

Background: A small (2.8 kg, 6 cm aperture) framing camera was built under Mars Technology Program funding and is currently flying on the Mars Reconnaissance Orbiter. Its primary purpose was to demonstrate high accuracy optical navigation on approach to Mars. The camera has substantial scientific potential in the MRO extended mission. Unlike the other imaging instruments currently orbiting Mars, the ONC is positioned on the zenith deck pointing about 120 degrees from nadir and roughly orthogonal to the direction of motion of the MRO spacecraft. It therefore has a unique vantage point from which to conduct observations of the near-Mars region, including observations of known or unknown objects in that region.

Approach: MGS is in a higher orbit than MRO, roughly the same inclination, but with a different node. We know the orbit plane well enough, but we no longer know MGS's orbital longitude. Twice each revolution, the orbit of MGS will pass through the ONC field of view. The ONC would take one 25.2-second exposure at each of these opportunities. Eventually MGS will pass through the field, and it would be immediately obvious as its motion would be dramatically different from the background stars. The long exposures would minimize the number of pictures to be downlinked and examined, and having trailed images would make the identification straightforward.

Once MGS has been located, shorter pictures aimed at its then-known location would serve to pin down its orbit precisely enough to keep it from becoming lost again. Follow-up observations would be performed periodically thereafter to refine the orbit determination. The same technique could be used to locate other lost assets, such as Mariner 9 and the Viking orbiters.

A predicted dust ring system between Phobos and Deimos has been searched for with Hubble with no success. Rings composed of small particles (a few microns in size) preferentially scatter light forward. Hubble cannot look for forward-scattered light at Mars, but MRO's ONC can. ONC might be able to detect such a faint ring viewing the equatorial region edge-on. The preferred geometry would have MRO in shadow, near Mars's equator, looking off the limb of the planet toward the lit side of the rings. Aiming the camera not far from the dark limb of Mars would provide a view of the whole ring system, if the spacecraft is sufficiently close to the equator, and would maximize the scattering angle. Mars itself should be near an equinox, so that the look direction (around 68-70 degrees from the sun) will be well out of the ecliptic and minimize any possible confusion with zodiacal light.

Unknown small satellites may exist in the inner region of the Martian system. The current-best searches (Viking, Hubble) have claimed limits of roughly 50 to 100 meters with no detections. In the region out to Phobos's orbit, the ONC could detect objects as small as one to a few meters diameter during normal spacecraft nadir-pointed operations (that is, with no special pointing or spacecraft attitude maneuvering), and to roughly tens of meters out to Deimos.

The data returned from the MRO ONC, including observing MGS and possibly others, as well as the noise background, would be used to characterize the signal and noise characteristics of optical tracking. These characterizations would be used in simulations of JPL's AutoGNC software. AutoGNC is the product of continued development of the AutoNav software that was critical for the successful targeting of Deep Impact's collision with Tempel 1. [1] AutoGNC would be used on MSRO to track both MSRO and the OS, and autonomously perform the rendezvous and capture maneuvers. The simulations executed with real world measurement characteristics would reduce the development risk of the MSRO autonomous flight software capabilities.

Benefits: The use of Mars orbit rendezvous for Mars Sample Return is necessary for an affordable mission. For mission success, MSRO must be able to reliably locate and track a small, eventually inert OS using optical means only. The characterization of the ONC on MRO used in this application, including characterization of the background noise, as well as the resulting operational experience searching for orbiters, dust rings, and moons, will greatly reduce the development risk of this critical operation, and build confidence in depending on these techniques for the success of MSR. The data returned can be used to drive simulations of the tracking and rendezvous operation of MSRO, reducing risk in the software development as well. The use of the ONC already in orbit around Mars would be a highly cost effective means of helping to move the goal posts forward for Mars Sample Return.

References: [1] Cangahuala, A., Bhaskaran, S., Owen, W., "Science Benefits of Onboard Spacecraft Navigation" (2012), *EOS, Transactions American Geophysical Union, 93*, 177.