REPORT OF THE MARS SCIENCE ORBITER (MSO) SCIENCE DEFINITION TEAM. Michael D. Smith[1] and the MSO Science Definition Team. [1]NASA Goddard Space Flight Center (Greenbelt, MD, 20771 USA; Michael.D.Smith@nasa.gov).

Introduction: NASA is considering that its Mars Exploration Program will launch an orbiter to Mars in the 2016 (or later) launch opportunity. To further explore this opportunity, NASA has formed a Science Definition Team (SDT) for this orbiter mission, provisionally called the Mars Science Orbiter (MSO). The purpose of the SDT was to define the scientific objectives of an MSO mission, the science requirements of instruments that are most likely to make high priority measurements from the MSO platform, the desired orbits and mission profile for opticmal scientific return, and potential science synergies with, or support for, future missions such as a Mars Sample Return. The MSO SDT activity was conducted during October – December 2007, with its final report released 15 December 2007.

Executive Summary: The SDT recommends the following three main science drivers for the MSO mission: 1) A new and comprehensive view of <u>Atmospheric Composition</u> to seek evidence for the present habitability of Mars; 2) A vastly improved characterization of the present <u>Atmospheric State</u> to provide new insight into processes that control the martian weather and climate; and 3) An in-depth study of <u>Surface Change Science</u> to better understand the crucial interactions at the surface-atmosphere interface. In addition to the above science objectives, NASA may choose to include a very high (sub-meter) spatial resolution imager necessary for landing site certification and the telecommunications equipment necessary for MSO to serve as a long-term (10 Earth years) asset for the relay of data from, and commands to, future landed spacecraft. Scientifically, the inclusion of the sub-meter resolution imager would augment the range of surface change science that could be addressed, while the long-term telecommunications capability holds promise for an extended period of science operations to cover interannual variability. Both, however, may be beyond the funding envelope described for the mission without a major international contribution. Even without sub-meter scale imaging and extended scientific operations, the MSO mission defined below, with one-meter scale imaging and operating for at least one Mars year, will make major advances in the areas of climate and global habitability.

To achieve the atmospheric science objectives requires a capable suite of instruments, some with capabilities not previously flown to Mars. *The SDT recommends inclusion of remote sensing instrumentation with extremely high sensitivity to a broad suite of important trace gases combined with nearly continuous spatial mapping of key minor constituents and of atmospheric state.* As an existence proof that such measurements can be made, the SDT notes, based on instrumentation already flown to study the Earth's upper atmosphere, that a combination of solar occultation, limb sounding, and nadir mapping observations could provide the required two-tiered approach.

To best achieve all science goals, the SDT recommends a near-circular, high-inclination orbit at an altitude of 300 km with an orbital inclination of 82.5°. This relatively low altitude allows the highest possible spatial resolution for imaging and limb-sounding while the inclination strikes a good balance between a rapid change of observed local time during the course of the mission (favored by lower inclination) and the ability to adequately observe the poles (favored by higher inclination).

The SDT also notes that it is necessary that the spacecraft be able to point accurately and with sufficient stability to regularly acquire solar occultation and limb-geometry observations as often as possible. Furthermore, the continuity and global coverage of atmospheric observations on a repeated, daily basis necessary to fully realize the potential of the mapping portions of the investigations envisioned here require that observations be able to be taken in a nearly continuous fashion (goal of ~85% coverage along the orbit track).

The SDT endorses the planned Science Emphasis Phase, with one Mars year of observations with the science payload, but strongly recommends the goal of extending the phase with science observations to cover additional Mars years to fully leverage the scientific capabilities of MSO. Presently, the Science Emphasis Phase will be followed by a transition to a near-circular, high-inclination orbit at a higher altitude of 400 km for the Telecom Emphasis Phase. The higher altitude satisfies planetary protection requirements, and is also more desirable for telecommunications relay between Earth and future landed missions. MSO science observations should continue in this higher orbit.

The SDT recognizes that the full instrument suite may exceed the baseline cost allocated to MSO science instruments. Cost could be reduced to fit within budget by the potential foreign contribution of an instrument or by descope of the instruments. In particular, most *science* goals could be met within budget if the proposed high-resolution camera were descoped from 30 cm to 1 meter per pixel resolution, although site certification requirements would not.

A concern sometimes expressed about MSO is that it is too focused on a gas or suite of gases that might not be there. Such concerns arise in part from the continuing controversy about the detection (or not) of methane by ground-based or Mars Express observations. The SDT notes the following: 1) the atmospheric objectives of MSO as defined here encompass a much more comprehensive atmospheric survey designed to characterize the variations of known gases (e.g., water vapor, peroxide, and carbon monoxide) as well as to improve *by an order of magnitude or more* the detection limits of gases not yet seen; 2) a measurement which can definitively state that methane is, or is not, present with a detectability threshold orders of magnitude more sensitive than the presently debated values *would be a major finding whether or not methane is detected*; and 3) the first direct, globally distributed measurements of wind and the measurements of temperature and water vapor even in a dusty atmosphere will yield a *major advance in our ability to understand and to simulate (for science and engineering*) the Mars atmosphere, its dynamic processes and transport.

References: The entire report of the Mars Science Orbiter Science Definition Team can be downloaded from http://mepag.jpl.nasa.gov/reports/index.html.