

Early MAVEN results on the Mars upper atmosphere and atmospheric loss to space

B. M. Jakosky (1), J. G. Grebowsky (2), J. G. Luhmann (3), and the MAVEN Science Team
(1) LASP, Univ. of Colorado, Boulder, USA, (2) NASA/GSFC, Greenbelt, USA, (3) SSL, Univ. of California, Berkeley, USA (bruce.jakosky@lasp.colorado.edu)

Abstract

The Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft went into orbit around Mars on 21 September 2014. After a commissioning phase that included science observations of Mars and of Comet Siding Spring during its close approach, its primary science phase began on 16 November 2014 and will run for a full Earth year, until November 2015. Early results on structure, composition and dynamics of the upper atmosphere and on escape to space will be presented.

1. Introduction

MAVEN has been collecting data since prior to the formal start of the primary science mission in November 2014. The spacecraft and all science instruments are functioning well, and science data is being collected utilizing our planned observing scenarios. The first two deep-dip campaigns have been carried out successfully (February and April, 2015), and the next two are scheduled (July and September).

By the time of EPSC, we expect to have a preliminary understanding of the instrument behavior, operations, and calibrations. We also expect to have sufficient data collected to allow us to reach preliminary conclusions about the state of the upper atmosphere, interactions with the solar wind, escape of atmospheric gas to space at the present epoch, and integrated escape to space over time. These results will be presented at the meeting.

2. Mission objectives

The science objectives of the MAVEN mission are to characterize the upper atmosphere and ionospheric structure and composition, the interactions of the sun and the solar wind with the planet, and the processes driving loss of gas from the atmosphere to space.

Our goal is to understand the chain of processes leading to escape today, learn how to extrapolate back in time, and determine the integrated escape of atmosphere over Martian history.

These goals follow on previous observations that suggest that the early Mars atmosphere was very different from today's, and that it was thick enough to allow liquid water to be present and more stable. MAVEN is addressing the questions of where did the water go and where did the CO₂ go? Loss to space is indicated as being important based on observations of escaping atoms at present, fractionated light stable isotopes most consistent with loss having been important, and the apparent absence of a sufficiently large surface/subsurface reservoir for CO₂.

3. Mission Description

The MAVEN spacecraft is in an elliptical orbit whose altitude ranges from about 150 km to 6200 km above the surface. This orbit allows the spacecraft to pass through the upper atmosphere on each orbit to allow *in situ* observations, and also to make global-scale remote-sensing observations near apoapsis. In addition, we are lowering periapsis to ~125 km for up to four five-day periods during the mission. At the higher densities observed during these "deep-dip" campaigns, we make observations down to the altitudes at which the upper atmosphere transitions to the lower atmosphere. Thus, we sample the entire upper-atmospheric column, all the way out to altitudes at which the solar wind interacts with the planet and its magnetosphere.

The orbit precesses with time, with periapsis moving through local time (sampling the entire range of 0-24H) and latitude (between $\pm 75^\circ$, given its orbital inclination). With this variation, the spacecraft is able to obtain good three-dimensional coverage around Mars and to sample all regions of near-Mars space.

Having had a successful orbit insertion, fuel that had been reserved for a recovery from a problem MOI is now available for an extended mission. With appropriate planning, MAVEN may be able to continue to make science observations for up to a full solar cycle. Of course, the actual longevity will be determined by the fuel usage required for orbit adjustments to ensure that we stay within our periapsis “density corridor” that maximizes the science return.

4. Science instruments

MAVEN has nine instrument sensors collected into eight separate instruments. The sensors can be thought of as being grouped into instruments measuring different aspects pertaining to the goals of MAVEN.

The first group of instruments measures the properties of the solar wind and of the sun that drive the processes in the upper atmosphere:

Solar Wind Ion Analyzer, SWIA (Instrument lead is Jasper Halekas, U. Iowa).

Solar Wind Electron Analyzer, SWEA (David L. Mitchell, U. California Berkeley).

Extreme Ultraviolet Monitor, EUV (Frank Eparvier, U. Colorado Boulder).

Solar Energetic Particle, SEP (Davin Larson, U. California Berkeley).

The second group measures the structure and composition of the upper atmosphere and of the ions in the ionosphere, and also measures isotope ratios that can tell us about the integrated escape to space. In this group, NGIMS measures properties *in situ* at the location of the spacecraft, and IUVS measures them remotely, providing a powerful combination of local and global measurements:

Imaging Ultraviolet Spectrograph, IUVS (Nick Schneider, U. Colorado Boulder).

Neutral Gas and Ion Mass Spectrometer, NGIMS (Paul Mahaffy, NASA/GSFC).

The third group measures the properties of the ionosphere that both drive escape and determine the composition and properties of the escaping ions:

Magnetometer, MAG (Jack Connerney, NASA/GSFC).

Langmuir Probe and Waves, LPW (Bob Ergun, U. Colorado Boulder).

Suprathermal and Thermal Ion Composition, STATIC (Jim McFadden, U. California Berkeley).

With this combination of measurements, we are able to observe the entire chain from solar energy input that drives the processes controlling the upper atmosphere and ionosphere, to the upper-atmosphere response, to the loss of neutrals and ions to space.

6. Summary and Conclusions

The MAVEN spacecraft and instruments are doing well. The data are of high-quality, and all indications as of this writing are that we will be able to address the science questions and achieve the science goals that were the original drivers for the mission. Results will be presented at the meeting.

In addition, MAVEN is on track to being able to carry out an extended mission that would allow us to observe throughout the remainder of a Mars year (including the high-water-abundance northern-hemisphere-summer season) and through different phases of the solar cycle. Observing at these times will have high science value for understanding the Mars environment.