The 2013 Mars Atmosphere and Volatile Evolution (MAVEN) Mission

Presentation to the Mars Exploration Program Analysis Group (MEPAG)

Bruce Jakosky, Principal Investigator, CU-LASP
Joseph Grebowsky, Project Scientist, NASA-GSFC
David Mitchell, Project Manager, NASA-GSFC

February 28, 2012

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Project Overview

Bruce Jakosky, Principal Investigator
MAVEN Status In Brief

• **MAVEN is on track technically, on schedule, and on budget.**
• Currently in the middle of build of flight instruments, s/c avionics, s/c structure and propulsion.
• ATLO (Assembly, Test, and Launch Ops) starts this summer.
• 20-day launch window opens on 18 November 2013.
• MAVEN is fully funded in the recently released President’s budget.
Science Summary

Mars’ atmosphere is cold and dry today, but there was once liquid water flowing over the surface. Where did the water and early atmosphere go?

- $H_2O$ and $CO_2$ can go into the crust or be lost to space.
- MAVEN will focus on volatile loss to space.

Turn-off of the Martian magnetic field allowed turn-on of solar-EUV and solar-wind stripping of the atmosphere approximately 3.7 billion years ago, resulting in the present thin, cold atmosphere.
There Is Compelling Evidence For Changes In The Atmosphere And Climate

- Geomorphological and mineralogical features on ancient surfaces indicative of widespread or stable liquid water.
- Isotopic fractionation that is indicative of loss of a significant fraction of the volatiles to space (e.g., enrichment of D/H, $^{15}\text{N}/^{14}\text{N}$, $^{38}\text{Ar}/^{36}\text{Ar}$).
- Direct measurement of escaping ions at the present epoch (by MEX).

(Bishop et al., 2008; Barabash et al., 2007)
Potential Importance of the Role of Loss to Space

- The history of liquid water and of the atmosphere determine Mars’ potential for life throughout time.
- There is abundant evidence for climate change and atmospheric evolution.
- Loss of atmospheric CO$_2$, N$_2$, and H$_2$O to space has been an important mechanism for atmospheric evolution, and may have been the dominant mechanism.

*Only by understanding the role of escape to space will we be able to fully understand the history of the atmosphere, climate, and water, and thereby understand Martian habitability.*
MAVEN Science Questions

- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

*MAVEN will answer questions about the history of Martian volatiles and atmosphere and help us to understand the nature of planetary habitability.*
MAVEN Will Measure the Drivers, Reservoirs, and Escape Rates

- MAVEN will determine the present state of the upper atmosphere and today’s rates of loss to space.
- Essential measurements allow determination of the net integrated loss to space through time.
The MAVEN Science Instruments

**Mass Spectrometry Instrument**

- **Neutral Gas and Ion Mass Spectrometer;**
  - Paul Mahaffy, GSFC
  - **NGIMS**

**Particles and Fields Package**

- **SupraThermal And Thermal Ion Composition;**
  - Jim McFadden, SSL
  - **STATIC**

- **Solar Energetic Particles;**
  - Davin Larson, SSL
  - **SEP**

**Remote-Sensing Package**

- **Imaging Ultraviolet Spectrometer;**
  - Nick Schneider, LASP
  - **IUVS**

- **Solar Wind Electron Analyzer;**
  - David Mitchell, SSL
  - **SWEA**

- **Solar Wind Ion Analyzer;**
  - Jasper Halekas, SSL
  - **SWIA**

- **Langmuir Probe and Waves;**
  - Bob Ergun, LASP
  - **LPW**

- **Magnetometer;**
  - Jack Connerney, GSFC
  - **MAG**
The MAVEN Science Team

Overall science leads:
Bruce Jakosky (PI)
Bob Lin (DPI)
Joe Grebowsky (PS)
Janet Luhmann

NGIMS:
Paul Mahaffy
Mehdi Benna
Wayne Kasprzak

IUUVS:
Nick Schneider
Bill McClintock
Erik Richard
Ian Stewart
John Clarke
Franck Montmessin

MAG:
Jack Connerney
Jared Espley

SWEA:
David L. Mitchell
Christian Mazelle
Jean-Andre Savaud
Dominique Toublanc

SWIA:
Jasper Halekas
Davin Larson

STATIC:
Jim McFadden
David Brain
Bill Peterson
Francois Leblanc

LPW:
Bob Ergun
Greg Delory
Laila Andersson
Frank Eparvier
Tom Woods
Phil Chamberlin
Anders Eriksson

SEP:
Davin Larson
Jasper Halekas
Rob Lillis

AAG:
Richard Zurek
Bob Tolson
Darren Baird

IDS:
Tom Cravens
Xiaohua Fang
Jane Fox
Roger Yelle
Andy Nagy
**Additional Scientist Opportunities**

Support through the JPL Critical Data Program:

- Steve Bougher, Univ. of Michigan, *Coupled MGCM-MTGCM Mars thermosphere simulations and resulting data products in support of the MAVEN mission*
- Paul Withers, Boston Univ., *Thermospheric variability observed by past aerobraking missions and radio occultation experiments*
- Scott England, Berkeley, *MAVEN critical data products from MGS MAG/ER*

MAVEN Participating Scientist Program:

- Participating Scientist Program is being planned for MAVEN; details still being worked out.
- Currently aiming for proposals to be due early in 2013 and for selected scientists to come on board at about the time of launch.
- We are planning for a Fall 2012 MAVEN community workshop to provide opportunity to discuss details of the mission, instruments, and science with the science team. Details will be made available as soon as they are finalized.
MAVEN Mission Architecture

Launch Window: November 18 – December 7, 2013

Orbit Insertion: 22 Sept 2014

Ten-Month Ballistic Cruise To Mars

One Year of Science Operations
The MAVEN Spacecraft

- Launch wet mass: 2550 kg
- Spacecraft dry mass: 903 kg
- Power: 1135 W at Mars aphelion
The MAVEN Spacecraft

Same length as a school bus – wingtip-to-wingtip length of 45 ft.

Same weight fully loaded as a GMC Yukon – 2550 kg.

Same length as a school bus – wingtip-to-wingtip length of 45 ft.
Elliptical Orbit Allows Measurement of All Relevant Regions of Upper Atmosphere

- Nominal periapsis near 150 km.
- Five “deep-dip” campaigns with periapsis near 125 km.
MAVEN Orbit and Primary Mission

- Elliptical orbit to provide coverage of all altitudes
- The orbit precesses in both latitude and local solar time
- One-Earth-year mission allows thorough coverage of near-Mars space
Latitude and Local Time Coverage

- One-Earth-year mission provides coverage of all local solar times and most latitudes.
- Figure shows periapsis location for each orbit.
MAVEN's Timing In The Solar Cycle

Cycle 24 Sunspot Number Prediction (January 2012)

MAVEN Primary Mission

Hathaway/NASA/MSFC
Constraining the Total Atmospheric Loss Through Time

History of Solar Activity

- Increased EUV and solar wind drives higher loss rate
- Extreme solar events
- Isotopes constrain total loss

Loss rates

Total Atmospheric Loss

Time

Present Day

Physical & Empirical Models

- Solar wind pickup
- Ion outflow
- Sputtering
- Photochemical and Jeans escape
- Ion bulk escape

Isotope Ratios

- NGIMS
- IUVS
Mission and Science Operations Will Utilize Existing Facilities At LM And LASP

- MAVEN utilizes extensive operational facilities at LM (MOC) and LASP (SOC).
- Both LM and LASP have very experienced operations teams and well-developed procedures.

All operational phases of the MAVEN mission have been carried out at Mars on previous missions.
MAVEN Is Committed to a Strong Education and Public Outreach (EPO) Program

• MAVEN EPO builds on existing high-quality programs and partnerships to bring unique MAVEN products to a wide range of national audiences.

• Our projects include in-class and out-of-class educational materials for K-12 students and educators with an emphasis on underserved/underrepresented audiences: Girls, Hispanic students, Native Americans, and rural populations.

• We are creating multi-direction exchange with the general public through the application of New Media tools—including Twitter, Facebook, tweetups, and professional development for New Media practitioners.
MAVEN Will Continue The Successful “Follow The Water” Theme

MGS, MPF, ODY, MER, MRO, MEx, PHX, upcoming MSL, are focused largely on the history of the surface. MAVEN’s comprehensive approach will provide the history of the atmosphere as the necessary other half of the story.
NASA’s Mars Exploration Program

<table>
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<tr>
<th>Operational / Recent</th>
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<th>2013</th>
<th>2016</th>
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MAVEN Schedule

- MAVEN concept developed starting in early 2004
- Proposal submitted in 2006
- Selected for competitive Phase A, early 2007
- Selected for development for flight, Sept. 2008
- Preliminary Design Review held in July 2010
- MAVEN Confirmed in October 2010
- Critical Design Review in July 2011
- As of today, launch is 1 year, 8 months, 19 days away!
Science Implementation

Joe Grebowski, Project Scientist
Evidence for Current Loss to Space

- Direct detection of energetic ionospheric ions moving away from the planet by Mars Express and Phobos Missions
- Mars Global Surveyor observations of atmospheric depletion in response to a Solar Energetic Particle (SEP) event
- All missions lacked relevant measurements

MEX Escape (Nilsson et al., 2010)

MGS Atmosphere Depletion (Lillis et al., 2006)
Escape Involves EUV, Solar Particles, Magnetic Fields and Neutral Atmosphere

Key:

- MAGNETIC FIELDS
- SOLAR INPUTS
- NEUTRAL SPECIES
- ATMOSPHERE PRODUCED IONS
The Instruments
**Measurement Objectives:**

- Solar EUV irradiance variability at wavelengths important for ionization, dissociation, and heating of the upper atmosphere (wavelengths shortward of H Ly-α 121.6 nm)

**Technical details and heritage:**

- Three photometers at key wavelengths representing different temperature solar emissions (0.1-7, 17-22, and 121.6 nm)
- EUV hardware is part of LPW instrument
- Heritage from TIMED, SORCE, SDO and rocket instruments
- Full spectrum (0-200 nm) derived from measurements using Flare Irradiance Spectral Model (FISM).
**Measurement objectives:**
- Vertical profiles of neutrals and ions through limb emissions and lower atmosphere properties from stellar occultations
- Disk maps from near apoapsis.
- D/H and hot oxygen coronal mapping
- Atmospheric properties below homopause

**Technical details and heritage:**
- Imaging spectroscopy from 110-340 nm, with resolution of 0.5 nm
- Vertical resolution of 6 km on limb, horizontal resolution of 200 km in nadir viewing
- Detectors: Image-intensified 2-D active pixel sensors
- Most recent heritage from AIM CIPS
Neutral Gas and Ion Mass Spectrometer (NGIMS)
Paul Mahaffy, GSFC

**Measurement Objectives:**
- Basic structure of the upper atmosphere (He, N, O, CO, N₂, NO, O₂, Ar and CO₂) and ionosphere from the homopause to above the exobase
- Stable isotope ratios, and variations

**Technical Details:**
- Quadrupole Mass Spectrometer with open and closed sources
- Closed source measurements: non-reactive neutrals
- Open source species: neutrals and ions
- Mass range: 2 - 150 Da
- Mass resolution: 1 Da over entire mass range
- Modes: scan entire spectra or adapt to fixed masses
- Sensitivity: 10⁻² (counts/s)/(particles/cm⁻³)
- Heritage from Galileo GPMS, Pioneer Venus ONMS, CASSINI INMS, Contour NGIMS
Langmuir Probe and Waves (LPW)
Bob Ergun, LASP

**Measurement Objectives:**
- Electron temperature and number density throughout upper atmosphere
- Electric field wave power at low frequencies important for ion heating
- Wave spectra of naturally emitted and actively stimulated Langmuir waves to calibrate density measurements

**Technical details and heritage:**
- Cylindrical sensors on two 7-meter booms
- I-V sweeps (at least $\pm 50$ V range) of sensors
- Low frequency E-field wave power sensing ($f$: 0.05-10 Hz); sensitivity $10^{-8}$ (V/m)$^2$/Hz ($f_0/f$)$^2$ where $f_0=10$ Hz and 100% bandwidth
- E-Spectra measurements up to 2 Mhz
- White noise (50 kHz-2 MHz ) sounding
- Thermal Electron density 100 to $10^6$ cm$^{-3}$
- Electron temperatures 500 to 5000$^\circ$ K
- Heritage from THEMIS and RBSP
Magnetometer (MAG)
Jack Connerney, GSFC

Measurement objectives:
• Vector magnetic field in the unperturbed solar wind (B ~ 3 nT), magnetosheath (B ~ 10-50 nT), and crustal magnetospheres (B < 3000 nT)
• Ability to spatially resolve crustal magnetic cusps (horizontal length scales of ~100 km)

Technical details and heritage:
• Magnetic field over a dynamic range of ~ 0.1 nT to ~ 60,000 nT, with 1 sec time resolution (4 km spatial resolution), 1° angular determination, and 5% precision on scalar value
• Heritage: MGS, Voyager, AMPTE, Giotto, CLUSTER, Lunar Prospector, MESSENGER and others; identical to MAG on STEREO

MGS MAG measurements:
Measurement objectives:
- Density and velocity distributions of solar wind and magnetosheath ions to determine the charge exchange rate and the bulk plasma flow from solar wind speeds (~350 to ~1000 km/s) down to stagnating magnetosheath speeds (tens of km/s).

Technical details and heritage:
- Proton and alpha velocity distributions from <50 to >2000 km/s, density from 0.1 to >100 cm\(^{-3}\). Energy resolution of ~10% and angular resolution of ~22.5° (4.5° around sun). Intrinsic time resolution of 4 s.
- Heritage from Wind, FAST, and THEMIS.

Similar measurements provided by Wind:
Solar Energetic Particle (SEP) Analyzer
Davin Larson, SSL

Measurement objectives:
- Characterize solar particles in an energy range that affects upper atmosphere and ionospheric processes (~120 – 200 km)
- Time resolution adequate to capture major SEP events (<1 hour)

Technical details and heritage:
- Two dual double-ended telescopes
- Four look directions/species, optimized for parallel and perpendicular Parker Spiral viewing
- Protons and heavier ions from ~25 keV to 12 MeV
- Electrons from ~25 keV to 1 MeV
- Energy fluxes 10 to $10^6$ eV/cm$^2$-sec-ster-eV
- Better than 50% energy resolution
- Nearly identical to SST on THEMIS

Prompt Mev proton enhancement after solar disturbance and at arrival of shock (Reams, 1999)
Solar Wind Electron Analyzer (SWEA)
David L. Mitchell, SSL

Measurement objectives:
- Measure energy and angle distributions of electrons in the Mars environment
- Determine electron impact ionization rates
- Measure magnetic topology via loss cone measurements
- Measure primary ionospheric photoelectron spectrum
- Measure auroral electron populations
- Evaluate plasma environment

Technical details and heritage:
- Hemispherical Electrostatic Analyzer
- Electrons with energies from 5 eV to 5 keV
- FOV 360° X 130°
- Angular resolution 22.5° in azimuth, better than 14° in elevation
- Energy fluxes 10^3 to 10^9 eV/cm^2·s·ster·eV
- Energy resolution 18% (capability for 9% below 50 eV)
- Based on STEREO SWEA

MGS measurements of auroral electrons:
Suprathermal and Thermal Ion Composition (STATIC)

Jim McFadden, SSL

**Measurement objectives:**
- Escaping ions and processes
- Composition of thermal to energetic ions; energy distributions and pitch angle variations
- Ionospheric ions 0.1-10 eV
- Tail superthermal ions (5-100 eV)
- Pick-up ions (100-20,000 eV)
- Key ions H⁺, O⁺, O₂⁺, CO₂⁺

**Technical details and heritage:**
- Toroidal Electrostatic Analyzer with Time of Flight section
- Mass range 1-70 AMU, ΔM/M > 4
- Energy range ~1 eV to 30 keV, ΔE/E~15%
- FOV 360° X 90°
- Angular resolution 22.5°X6°
- Energy flux < 10⁴ to 10⁸ eV/cm²-s-sr-eV (to 10¹² w/attenuators for low energy beam)
- Can be oriented to measure either upwelling/downwelling ions or horizontal flows
- Heritage from Cluster CODIF.

[Image of STATIC Engineering Model]

[Graph of Laboratory spectrum from Engineering Model]
Instrument Placement On Spacecraft

Body-mounted instruments point at sun or solar wind:
- EUV (part of LPW)
- SWIA
- SEP

Boom-mounted instruments are isolated from S/C magnetic and electric fields:
- LPW
- SWEA
- MAG (boomlets at end of solar arrays)

Instruments on Articulated Payload Platform orient w.r.t. planet or ram direction (fields of view are shown):
- IUVS
- NGIMS
- STATIC
Measurements Throughout The Orbit

- Non-thermal ions, e measured continuously
- Magnetic Field
- SWIA STATIC SWEA SEP MAG
- IUVS Coronal Scans
- E-Waves LPW
- Solar Occultation
- Wake
- Ionosphere LPW STATIC NGIMS IUVS Limb Scans
- Atmosphere Profiles
- EUYM
- Solar Occultation

IUVS Disk Maps
Instruments Sample all the Relevant Physics
Measurement Approach Summary

- MAVEN’s orbital period, inclination, and periapsis altitude will provide the best comprehensive coverage of Mars escape-related regions possible for a one-Earth-year mission.
- The instruments, which have high heritage, will sample all escape processes.
- Phasing of the mission on the declining phase of the solar cycle maximizes the range of solar variability inputs needed for extrapolating loss vs. solar inputs backwards in the history of the solar system.
MAVEN

Project Status and Plans

David F. Mitchell, Project Manager
The MAVEN Project’s Journey

From Proposal Days...

... to Science at Mars

We are tracking right on plan to launch next year!
Management

- Principal Investigator (PI)-mode mission, PI in charge
  - PI operates under a separate LASP contract from NASA Headquarters

- Goddard manages the project for the PI

- Instrument development grouped in packages closely aligned with institutional responsibilities
  - Goddard – Neutral Gas and Ion Mass Spectrometer (NGIMS)
  - Laboratory for Atmospheric and Space Physics (LASP) - Remote Sensing – IUVS and RSDPU
  - Space Sciences Laboratory (SSL) - Particles and Fields – STATIC, SEP, SWIA, SWEA, LPW-EUV (LASP/SSL provided), MAG (GSFC provided), and PFDPU

- Lockheed Martin (LM)-Denver provides the spacecraft, instrument integration and mission operations

- LASP provides Science Operations

- Jet Propulsion Laboratory (JPL) provides Navigation support, Deep Space Network (DSN), and Electra telecom relay hardware/ops (GFE)
The MAVEN Spacecraft

- 3-axis attitude control
- Mono-propellant propulsion system
- Single-fault tolerant during all critical events
- Launch (Wet) Mass: 2550 kg max
- Spacecraft Dry Mass: 903 kg max
- Power: 1135 W at Mars Aphelion

“Gull-Wing” Solar Arrays

Articulated Payload Platform (IUVS/STATIC/NGIMS)
Mission Architecture

20-Day Launch Period
18 Nov 2013 (Open)
7 Dec 2013 (Close)
LV: Atlas V 401

Orbit Insertion:
22 Sept 2014 (Open)
28 Sept 2014 (Close)

Northern Approach
~1233 m/s ΔV

Capture Orbit:
35 hour period
380 km P2
75° inclination

Ten Month Ballistic Cruise to Mars

Type-II Trajectory

One Year of Science Operations
Major Partner Institutions

- Berkeley, CA
- Pasadena, CA
- Boulder, CO
- Littleton, CO
- GSFC, Greenbelt, MD
MAVEN Team at CDR (July 2011)
Project Status

- Successfully completed the “CDR Season” with a total of 32 reviews between February 2011 and January 2012
- Currently building and testing flight hardware across the board with the payloads and spacecraft, as well as with the ground systems
- MAVEN/Atlas V Mission Integration activities are proceeding right on track with planned launch in November 2013
- The Project has maintained solid schedule and cost margins since Confirmation Review in October 2010
Spacecraft Core Structure
Spacecraft Hardware

Spacecraft Thrusters

Spacecraft Structure in the Static Test Reaction Chamber

Solar Array (Outboard Panel)
Payload Hardware

- Magnetometer Sensor Flight Model (FM)
- Remote Sensing Data Processing Unit (RSDPU)
- IUVS Spectrograph Case Flight Model
- Electra UHF Transceiver Flight Model
- Neutral Gas and Ion Mass Spectrometer (NGIMS) QMS Ion Source Assembly (FM)
- Solar Energetic Particle (SEP) Engineering Model
- Extreme UltraViolet (EUV) Engineering Model
- SupraThermal and Thermal Ion Composition (STATIC) Engineering Model (EM)
- Langmuir Probe and Waves (LPW) Boom (EM)
- Solar Wind Electron Analyzer (SWEA) Flight Model Analyzer & Pedestal
- Solar Wind Ion Analyzer (SWIA) Engineering Model
- Particles & Fields Data Processing Unit (PFDPU) Partial Stack
<table>
<thead>
<tr>
<th>Element</th>
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<tr>
<td>Remote Sensing Package Pre Environmental Review (PER), at CU-LASP</td>
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<td>Particle &amp; Fields Package PER, at SSL</td>
<td>May 22, 2012</td>
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<td>NGIMS PER, at NASA-GSFC</td>
<td>August 8, 2012</td>
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<td>Key Decision Point-D (KDP-D), at NASA-HQ</td>
<td>~ September 11, 2012</td>
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<td>Orbiter PER, at Lockheed Martin</td>
<td>January 25, 2013</td>
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<td>MAVEN Master Schedule</td>
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<td>MAVEN Project Phases</td>
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<td>MAVEN Payload Suite</td>
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<td>4 Neutral Gas &amp; Ion Mass Spectrometer (GSFC)</td>
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* Currently holding 97 days of funded schedule margin
Budget Status: GREEN

- MAVEN continues to execute to the budget approved at the Confirmation Review in October 2010
- Recent rollout of the President’s fiscal year 2013 budget shows continuing support for the MAVEN mission
- As of January 31, 2012, the MAVEN Team had expended 46% of the total budget through Phase D. We currently have solid reserves per the plan through launch.

![Approved Project Budget (KDP-C)](image-url)
Project Focus Points

• Successful build and test of hardware at all institutions and ensure a clear path to ATLO (Assembly, Test & Launch Operations) starting this summer. This includes closing out paperwork in a timely manner and not allowing a bow wave of open paper to build up.

• Readying the mission operations, science data, and ground system teams for ATLO support, early rehearsals, and the November 2012 Mission Operations Review.

• Pressures of the 20-day planetary launch window: Working issues as they arise in an efficient and safe manner.

• Maintaining Phase C-D cost levels within plan and ensuring proper reserve levels for all remaining Project phases.

• Keeping the entire team in synch as it evolves across the mission elements (spacecraft, instruments, ground systems, operations, science, launch service) in the run to launch next year.
Project Manager’s Summary

- The MAVEN Project has made significant strides in Phase C
  - The team is very experienced and continues to work well together as we have for the past seven plus years.
  - Spacecraft, instrument and ground systems hardware are being built/tested across the partner institutions; launch service is on track.
  - MAVEN design incorporates significant heritage from previously flown spacecraft and instrument systems. This is now bearing itself out in how things are coming together in early interface tests, hardware build, and overall team execution.
  - We are committed to delivering a successful mission within the cost cap and on schedule. Thus far we have met every one of our major milestones. This is critically important given MAVEN’s tight planetary launch window.
  - With the progress made since CDR, we are well positioned to build/deliver/test hardware, complete Phase C over the next 6 months, and begin ATLO this summer.

MAVEN is on track technically, on schedule and on budget with solid reserves
Want to Follow Us?

We’re on Facebook and Twitter: MAVEN2MARS
and on the web:
http://www.nasa.gov/maven
http://lasp.colorado.edu/maven
Backup Charts
Mission Description

Mission Objectives

• Determine the role that loss of volatiles from the Mars atmosphere to space has played through time, exploring the histories of Mars’ atmosphere and climate, liquid water, and planetary habitability
• Determine the current state of the upper atmosphere, ionosphere, and interactions with solar wind
• Determine the current rates of escape of neutrals and ions to space and the processes controlling them
• Determine the ratios of stable isotopes that will tell Mars’ history of loss through time

Mission Approach

• Obtain detailed measurements of the upper atmosphere, ionosphere, planetary corona, solar wind, solar EUV and SEPs over a 1-year period, to define the interactions between the Sun and Mars
• Operate 8 instruments for new science results:
  Particles and Fields Package (6 instruments):
  SWEA - Solar Wind Electron Analyzer
  SWIA - Solar Wind Ion Analyzer
  STATIC - Suprathermal and Thermal Ion Composition
  SEP - Solar Energetic Particle
  LPW - Langmuir Probe and Waves
  MAG - Magnetometer
  IUVS - Imaging Ultraviolet Spectrometer
  NGIMS - Neutral Gas and Ion Mass Spectrometer
• Fly 75°-inclination, 4.5-hour-period, 150-km-periapsis-altitude science orbit
• Perform five 5-day “deep dip” campaigns to altitudes near 125 km during the 1-year mission

Organizations

• LASP – PI and science team; E/PO; science operations; IUVS and LPW instruments
• GSFC – project management; mission systems engineering; safety and mission assurance; project scientist; NGIMS and MAG instruments
• JPL – Electra Relay; Navigation; DSN; Mars Program Office
• SSL – Deputy PI; Particles and Fields Package management; STATIC, SEP, SWIA, and SWEA instruments; LPW probes and booms (IRAP provides the sensor for SWEA)
• LM – spacecraft; assembly, test and launch operations; mission operations

Launch

• On an Atlas V from KSC between 11/18/13 and 12/7/13
• Mars Orbit Insertion on 9/22/14 (for 11/18/13 launch)

Websites

http://www.nasa.gov/maven
http://lasp.colorado.edu/maven/
Project Organization Chart

NOTE: Leads are shown in Italics
As of October 31, 2011
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<tr>
<th>Acronyms</th>
<th>Definition</th>
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# Acronyms (continued)

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