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

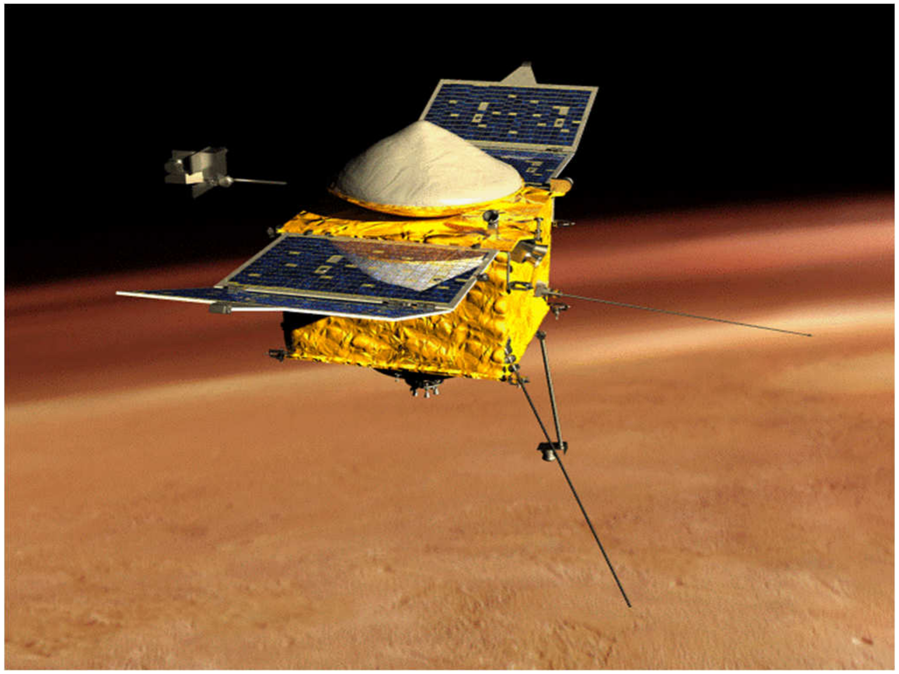
MAVEN

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.



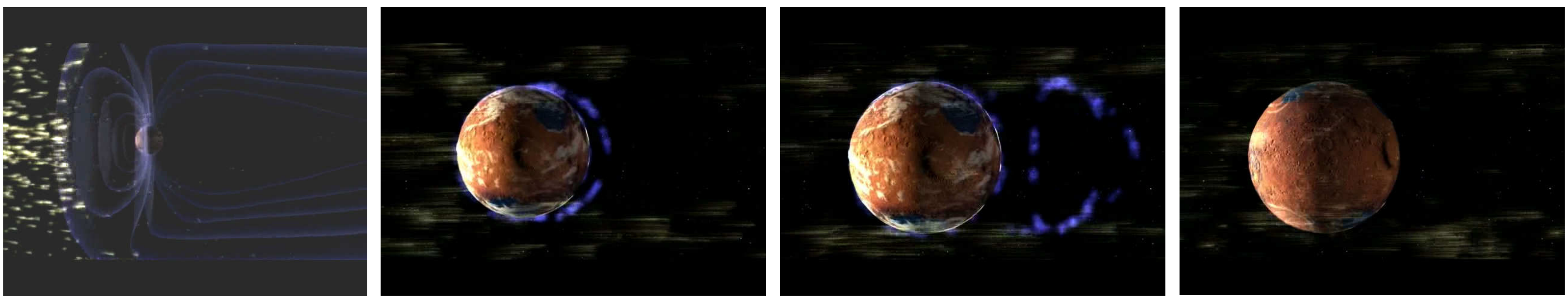
Science Summary


Ancient Valleys

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?

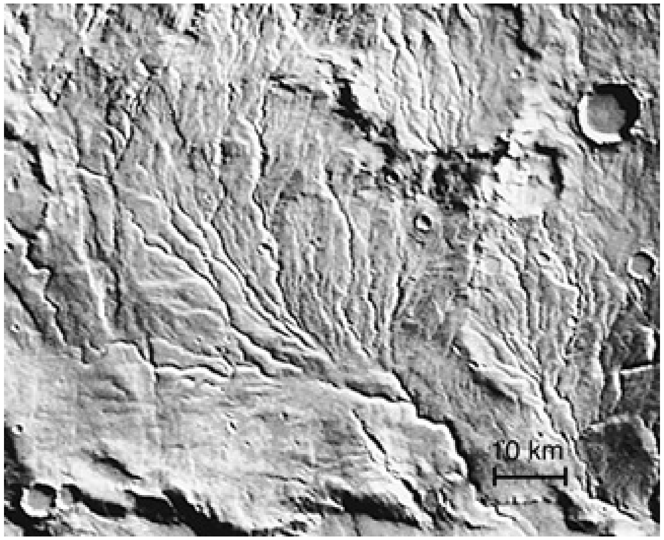
- *H_2O and CO_2 can go into the crust or be lost to space.*
- *MAVEN will focus on volatile loss to space.*

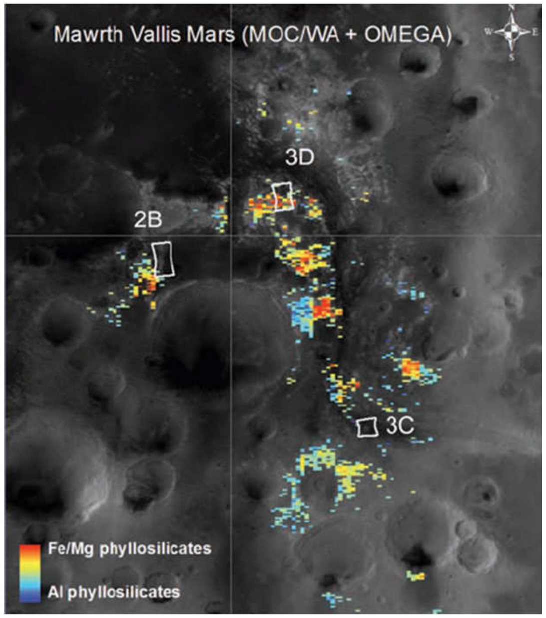


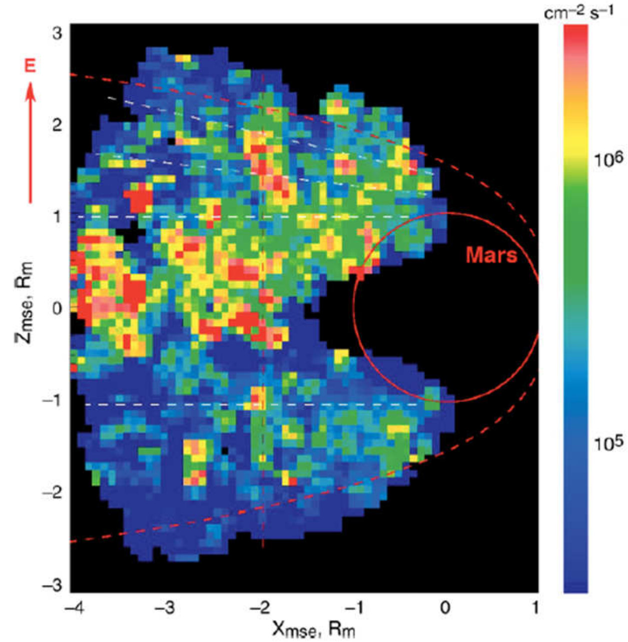
Turn-off of the Martian magnetic field allowed turn-on of solar-EUV and solar-wind stripping of the atmosphere approximately 3.7 billion years ago, resulting in the present thin, cold atmosphere.

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, $^{15}N/^{14}N$, $^{38}Ar/^{36}Ar$).
- Direct measurement of escaping ions at the present epoch (by MEX).

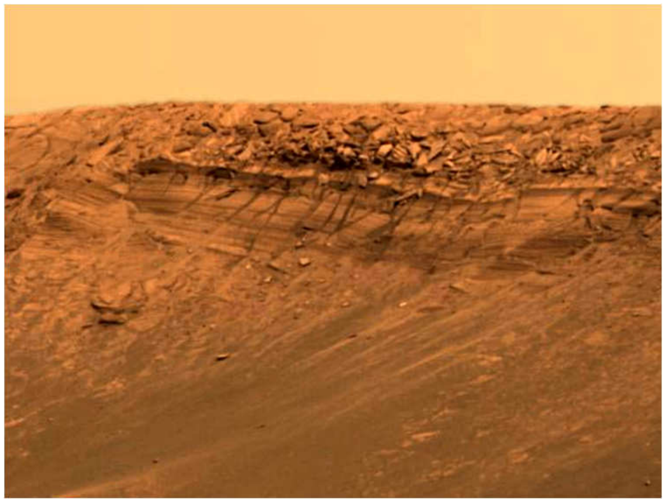






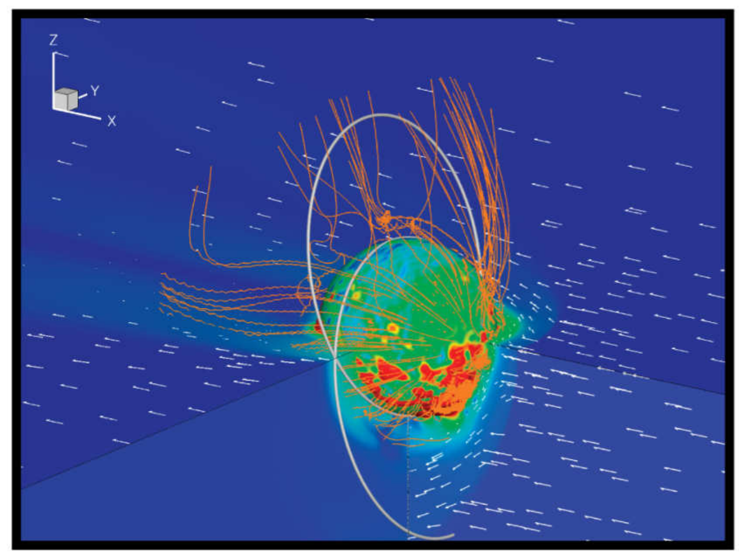
(Bishop et al., 2008; Barabash et al., 2007)

Potential Importance of the Role of Loss to Space

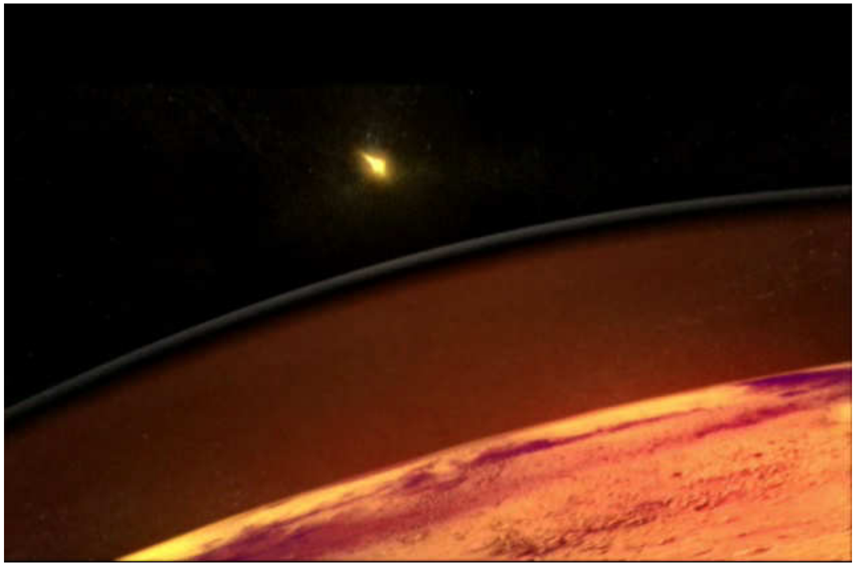


- The history of liquid water and of the atmosphere determine Mars’ potential for life throughout time.
- There is abundant evidence for climate change and atmospheric evolution.
- Loss of atmospheric CO_2, N_2, and H_2O to space has been an important mechanism for atmospheric evolution, and may have 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

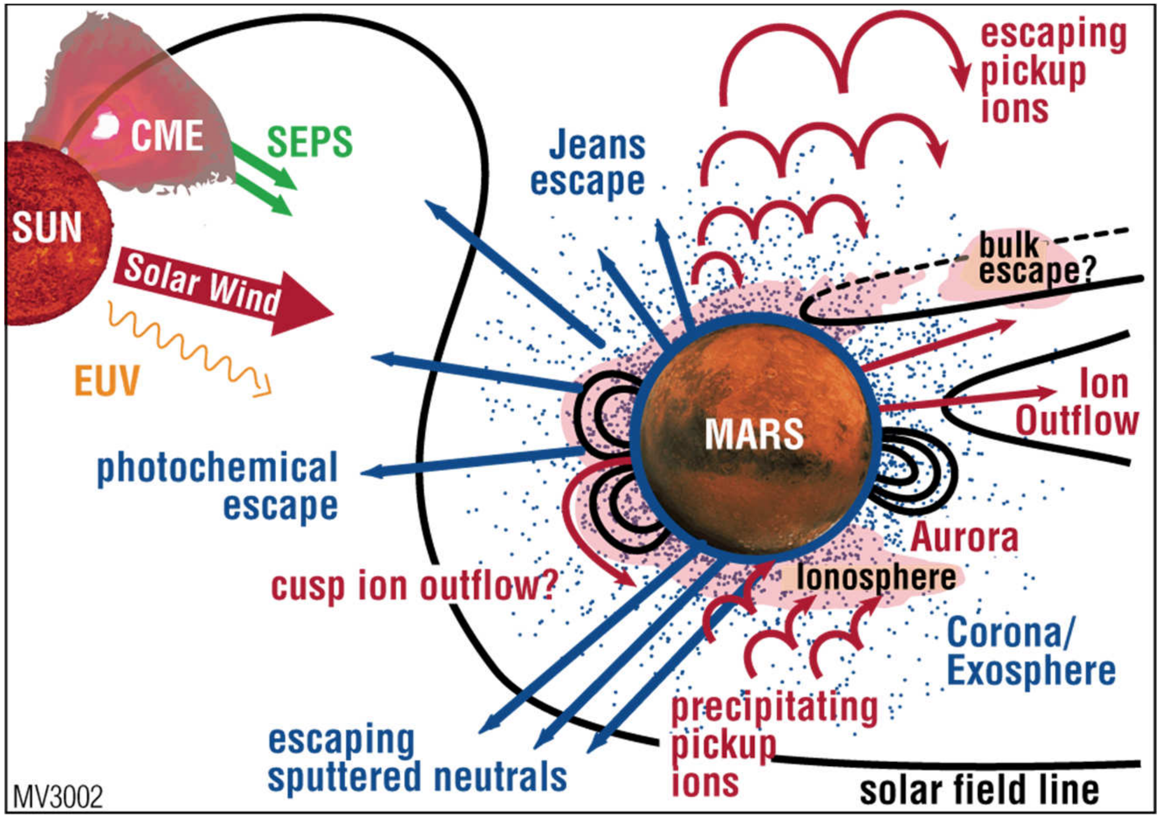


- Determine the structure and composition of the Martian upper atmosphere today
- Determine rates of loss of gas to space today
- Measure properties and processes that will allow us to determine the integrated loss to space through time

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

Solar Input



Plasma Processes

Neutral Processes

- 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

NGIMS

Neutral Gas and Ion Mass Spectrometer; Paul Mahaffy, GSFC

Remote-Sensing Package

IUVS

Imaging Ultraviolet Spectrometer; Nick Schneider, LASP

Particles and Fields Package

STATIC

SEP

SupraThermal And Thermal Ion Composition; Jim McFadden, SSL

Solar Energetic Particles; Davin Larson, SSL

SWEA

SWIA

Solar Wind Electron Analyzer; David Mitchell, SSL

Solar Wind Ion Analyzer; Jasper Halekas, SSL

LPW

MAG

Langmuir Probe and Waves; Bob Ergun, LASP

Magnetometer; Jack Connerney, GSFC

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

IUVS:
- 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

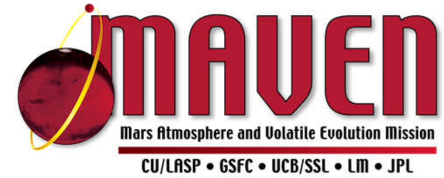
Support through the JPL Critical Data Program:

- 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:

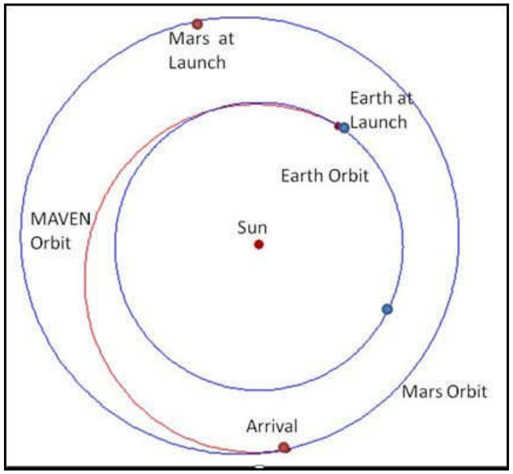
- Participating Scientist Program is being planned for MAVEN; details still being worked out.
- Currently aiming for proposals to be due early in 2013 and for selected scientists to come on board at about the time of launch.
- We are planning for a Fall 2012 MAVEN community workshop to provide opportunity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

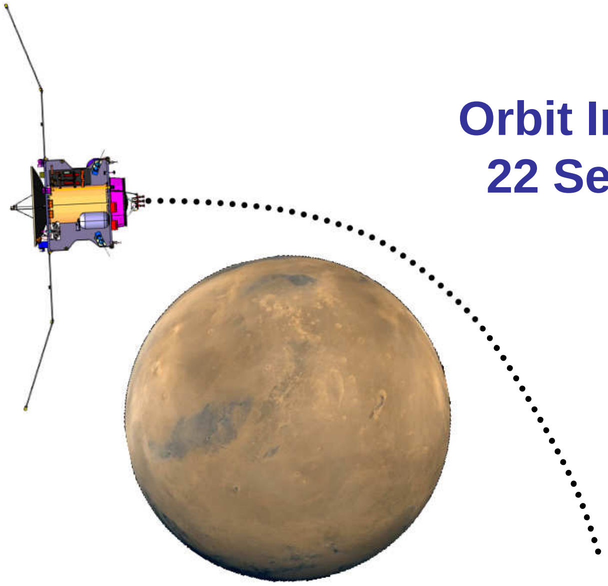
MAVEN Mission Architecture



Launch Window: November 18 – December 7, 2013

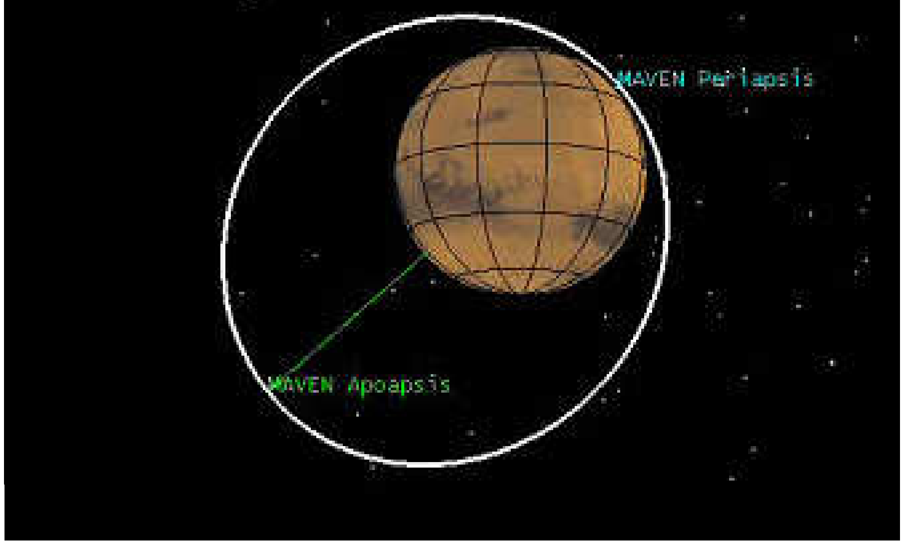
Ten-Month Ballistic Cruise To Mars



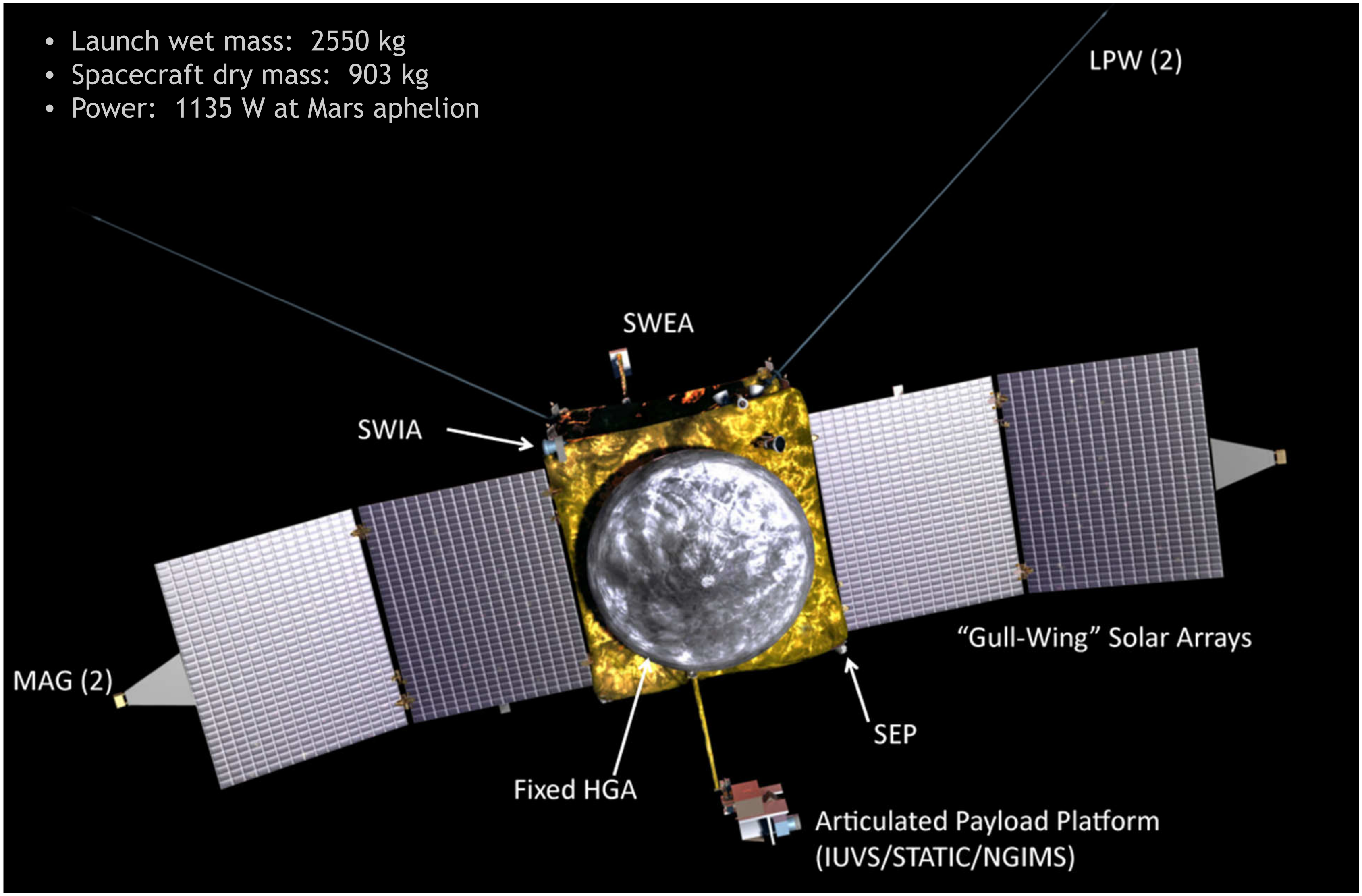


Orbit Insertion: 22 Sept 2014

One Year of Science Operations



The MAVEN Spacecraft



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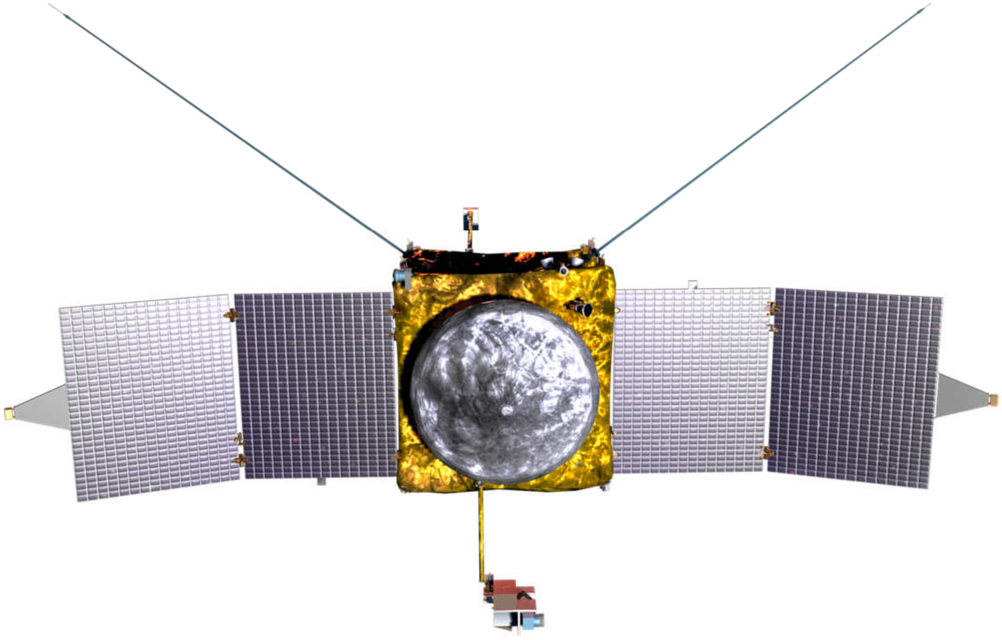
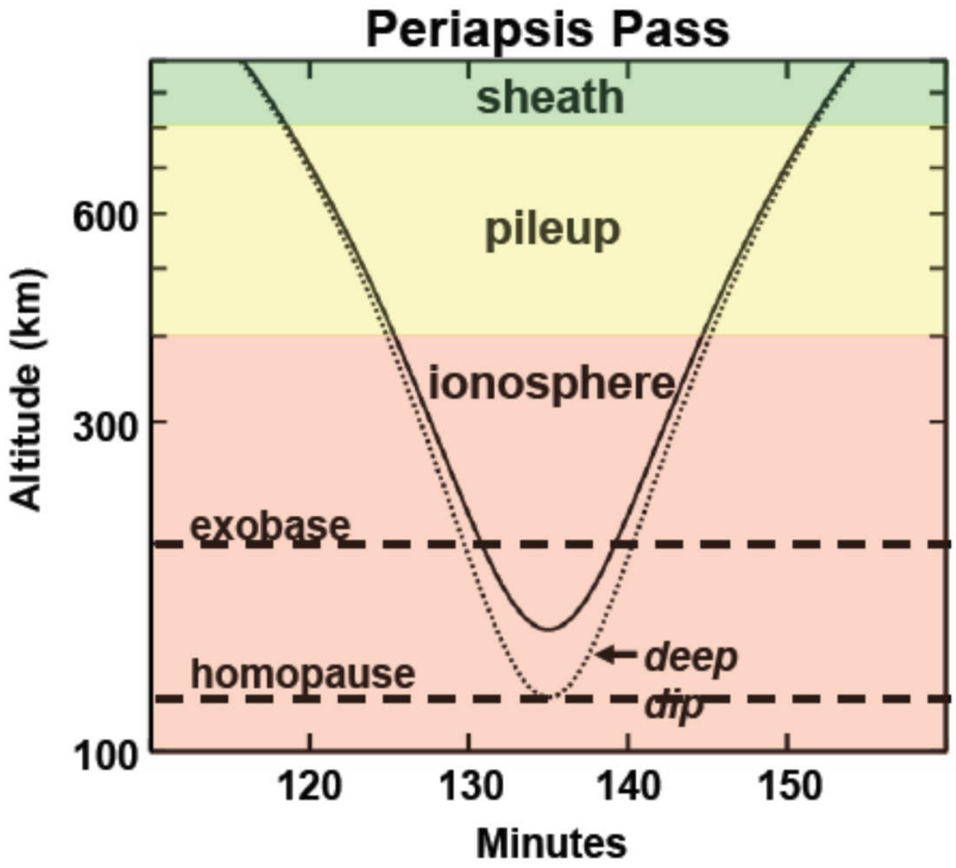


Same weight fully loaded as a GMC Yukon – 2550 kg.

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

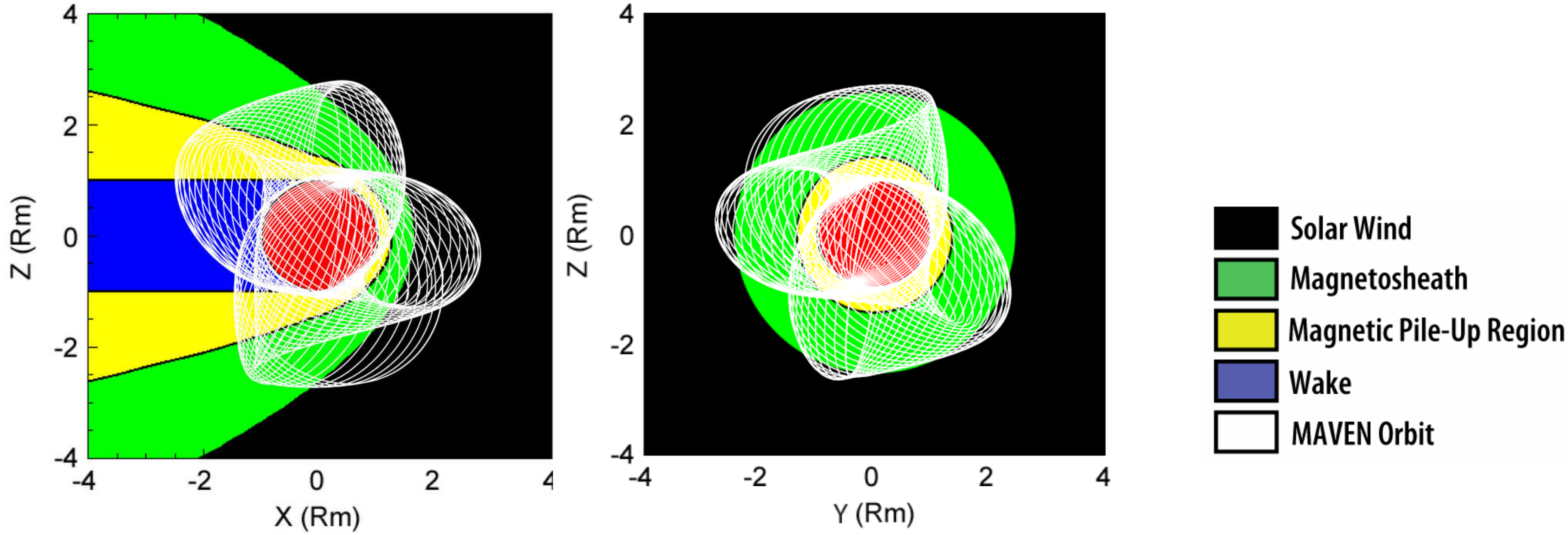
Elliptical Orbit Allows Measurement of All Relevant Regions of Upper Atmosphere

- Nominal periapsis near 150 km.
- Five “deep-dip” campaigns with periapsis near 125 km.



MAVEN Orbit and Primary Mission

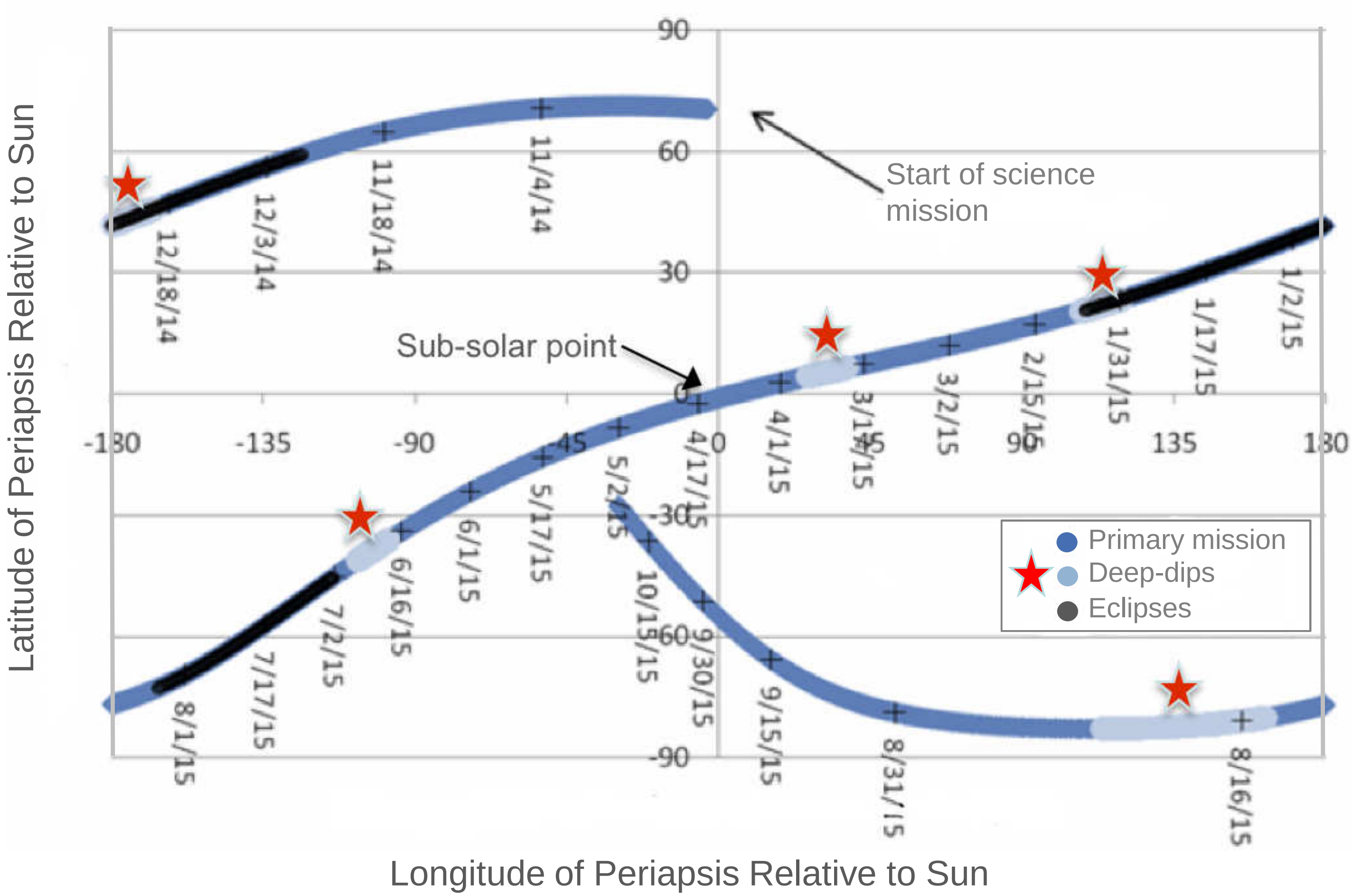
- Elliptical orbit to provide coverage of all altitudes
- The orbit precesses in both latitude and local solar time
- One-Earth-year mission allows thorough coverage of near-Mars space



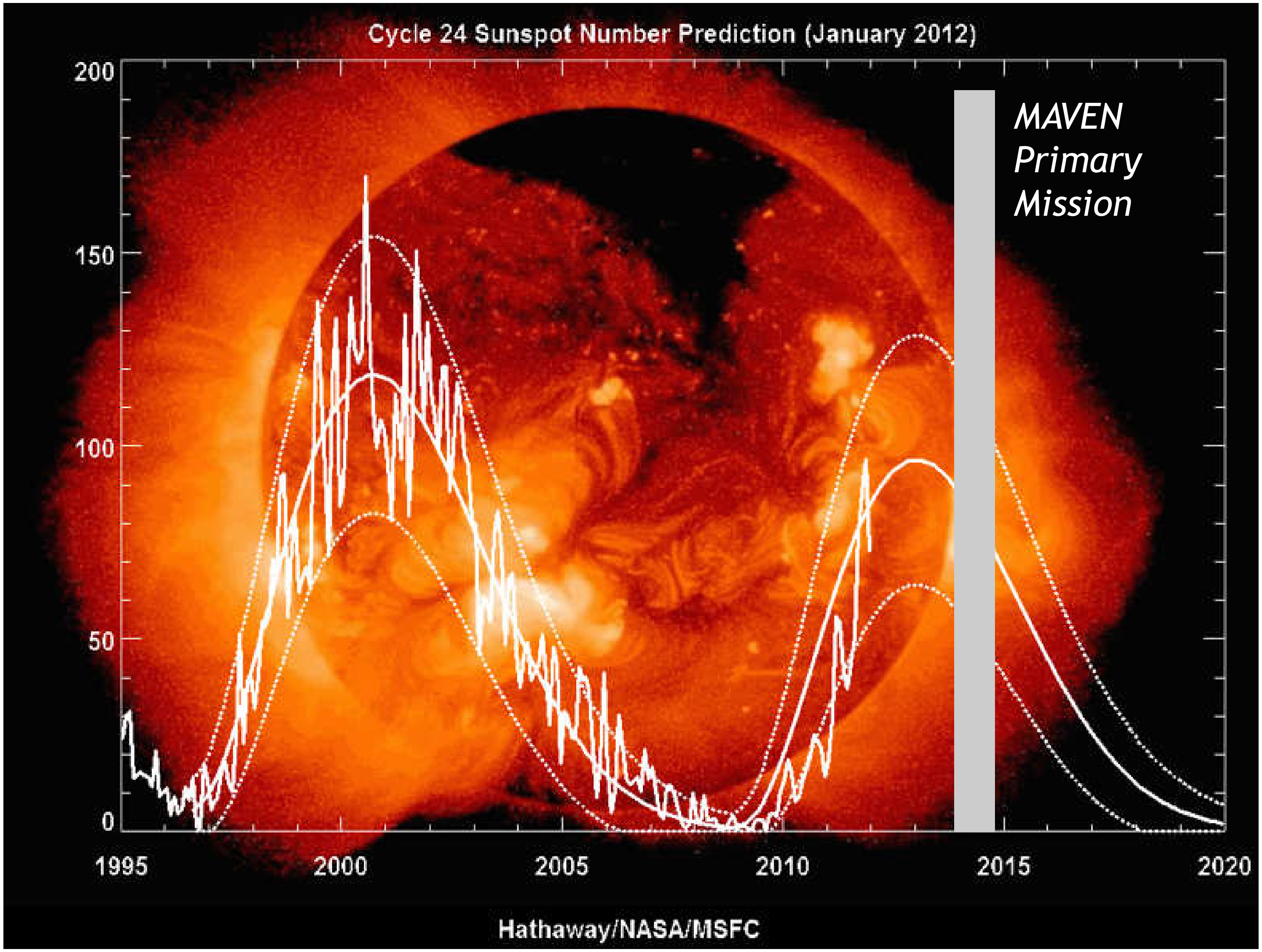
Latitude and Local Time Coverage

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

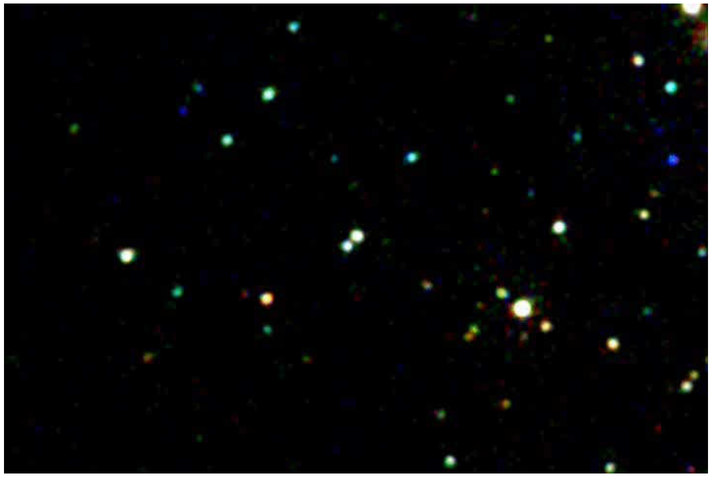
- One-Earth-year mission provides coverage of all local solar times and most latitudes.
- Figure shows periapsis location for each orbit.



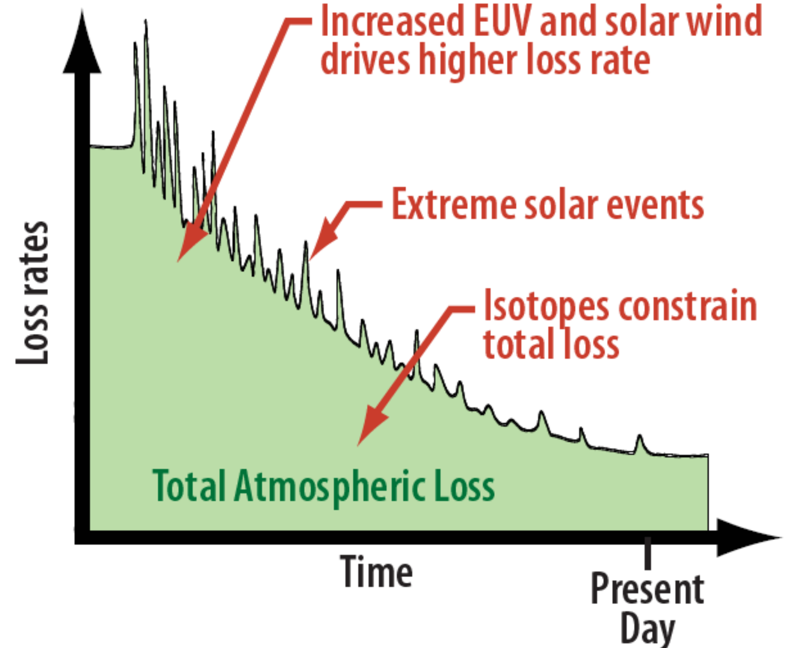
MAVEN's Timing In The Solar Cycle



Constraining the Total Atmospheric Loss Through Time

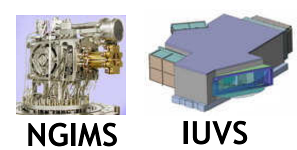


History of Solar Activity



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

Physical & Empirical Models



Isotope Ratios

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

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CU/LASP • GSFC • UCB/SSL • LM • JPL


Lockheed Martin Mission Support Area

• MAVEN utilizes extensive operational facilities at LM (MOC) and LASP (SOC).

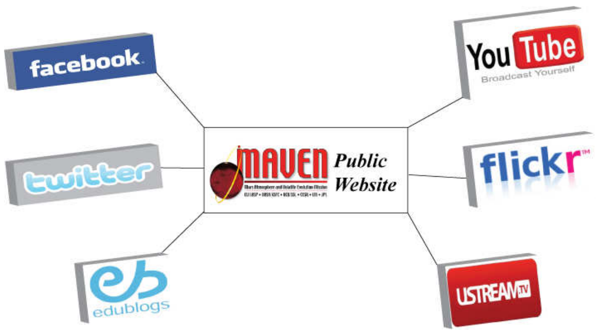
• Both LM and LASP have very experienced operations teams and well-developed procedures.

• All operational phases of the MAVEN mission have been carried out at Mars on previous missions.

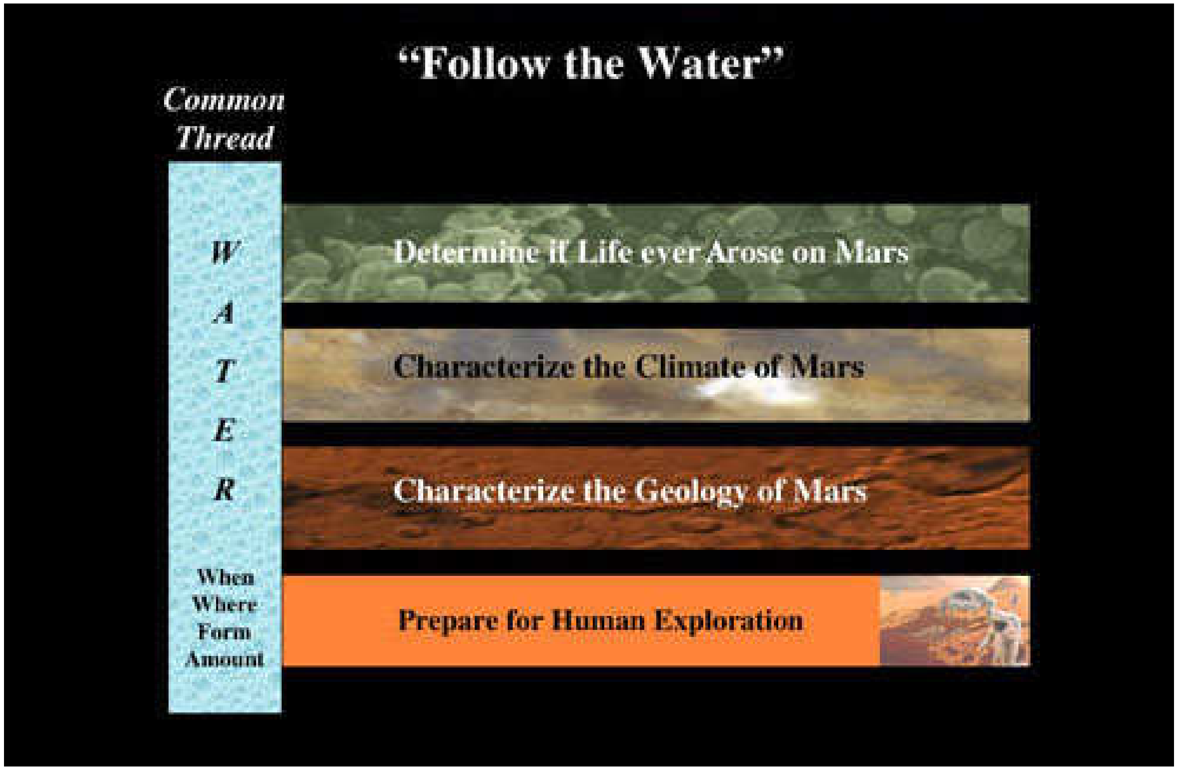
LASP Mission Operations Center

MAVEN Is Committed to a Strong Education and Public Outreach (EPO) Program

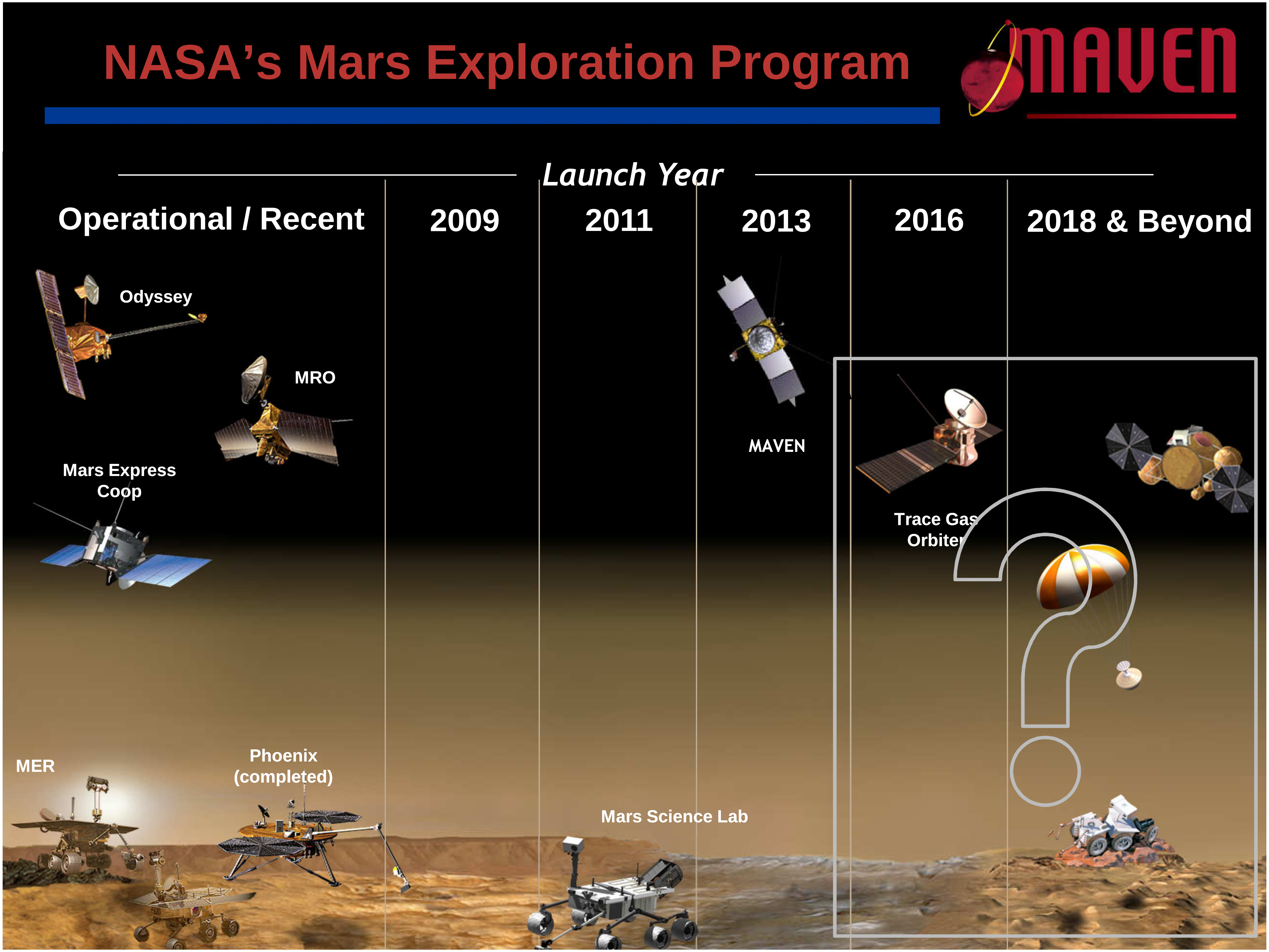
- MAVEN EPO builds on existing high-quality programs and partnerships to bring unique MAVEN products to a wide range of national audiences.
- Our projects include in-class and out-of-class educational materials for K-12 students and educators with an emphasis on underserved/underrepresented audiences: 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.



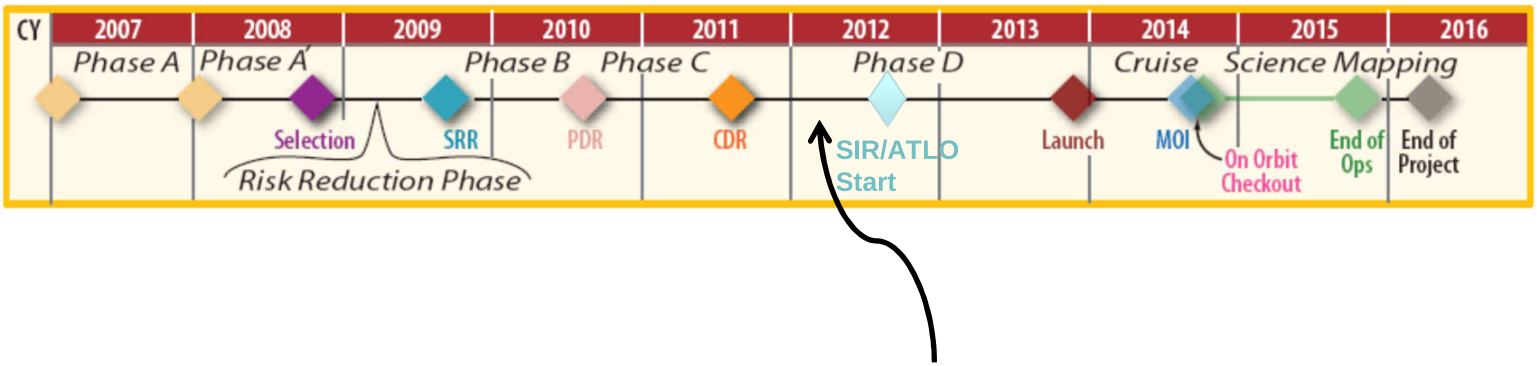
MAVEN Will Continue The Successful "Follow The Water" Theme



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
MAVEN
Launch Year
Operational / Recent
2009
2011
2013
2016
2018 & Beyond
Odyssey
MRO
Mars Express Coop
MAVEN
Trace Gas Orbiter
MER
Phoenix (completed)
Mars Science Lab

MAVEN Schedule



28 February 2012

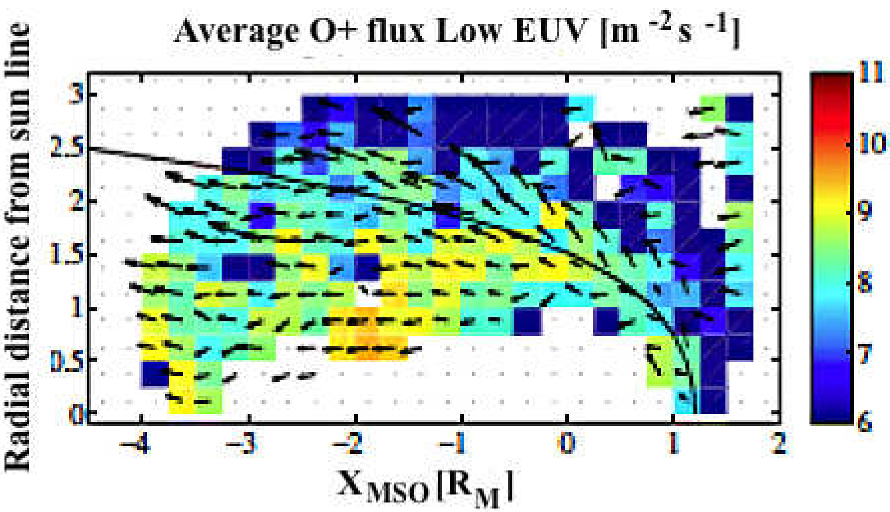
- MAVEN concept developed starting in early 2004
- Proposal submitted in 2006
- Selected for competitive Phase A, early 2007
- Selected for development for flight, Sept. 2008
- Preliminary Design Review held in July 2010
- MAVEN Confirmed in October 2010
- Critical Design Review in July 2011
- As of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

Science Implementation

Joe Grebowsky, Project Scientist

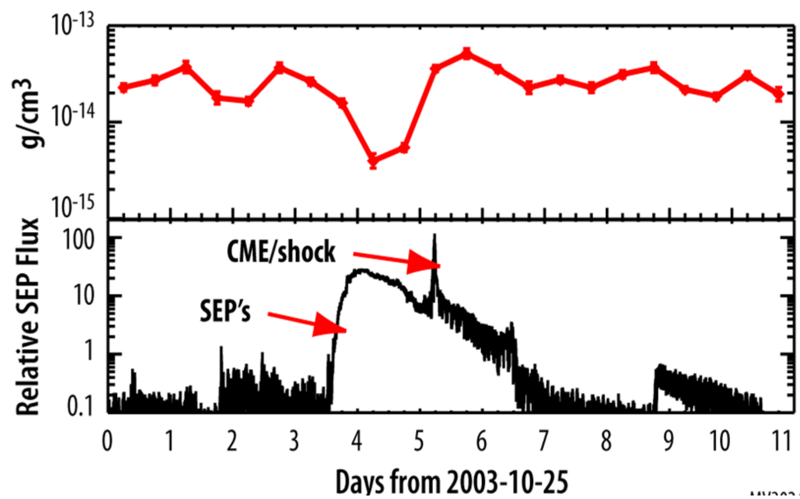
Evidence for Current Loss to Space

- 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



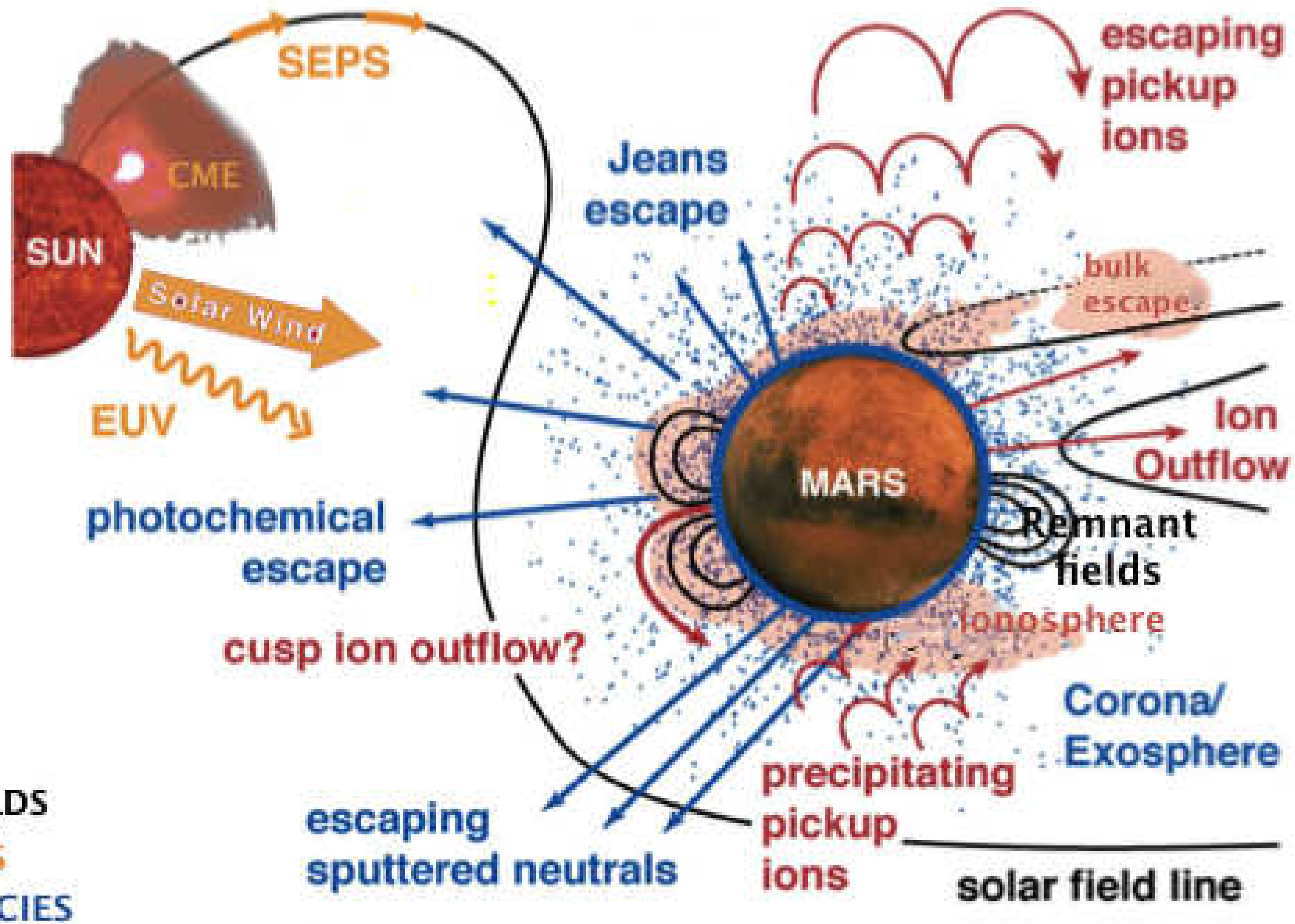
MEX Escape (Nilsson et al., 2010)

Neutral density at 195 km at 2 am



MGS Atmosphere Depletion (Lillis et al., 2006)

Escape Involves EUV, Solar Particles, Magnetic Fields and Neutral Atmosphere



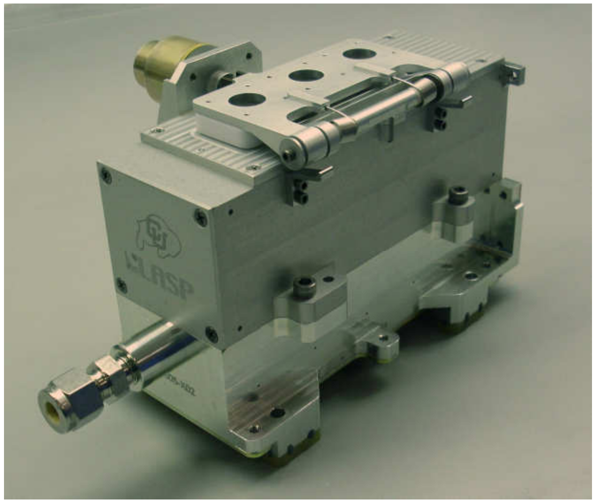
Key:

MAGNETIC FIELDS
SOLAR INPUTS
NEUTRAL SPECIES
ATMOSPHERE PRODUCED IONS

The Instruments

LPW – EUV Monitor

Frank Eparvier, LASP



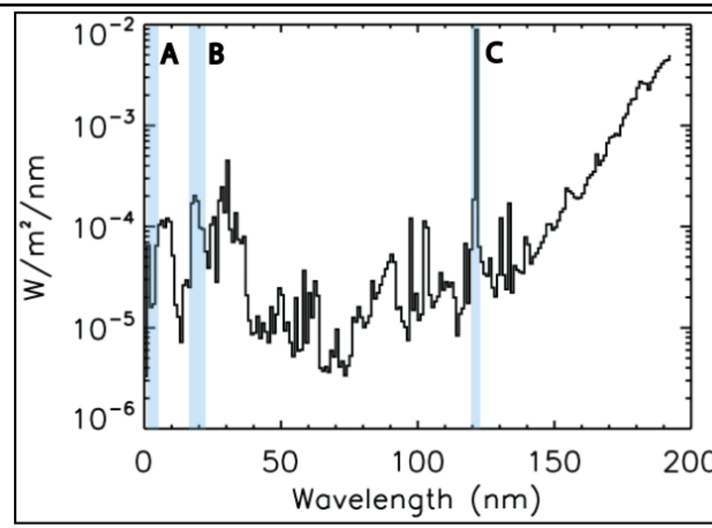
EUV Engineering Model

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).

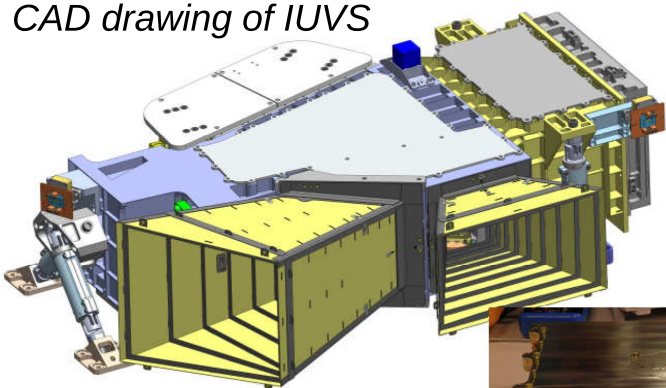


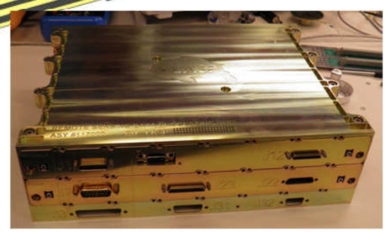
EUV detector bandpasses

Imaging Ultraviolet Spectrometer (IUVS)

Nick Schneider, LASP

CAD drawing of IUVS





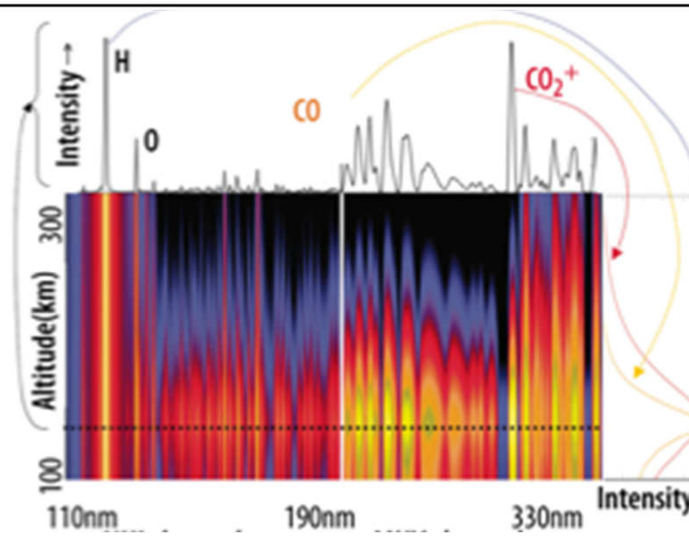
Flight Data Processing Unit

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 200km in nadir viewing
- Detectors: Image-intensified 2-D active pixel sensors
- Most recent heritage from AIM CIPS

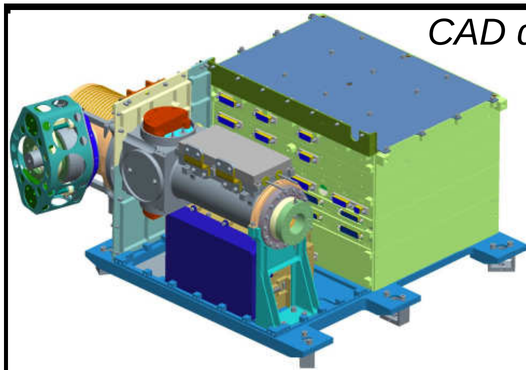


Model spectra and derived profiles

Neutral Gas and Ion Mass Spectrometer (NGIMS)

Paul Mahaffy, GSFC

CAD drawing of NGIMS



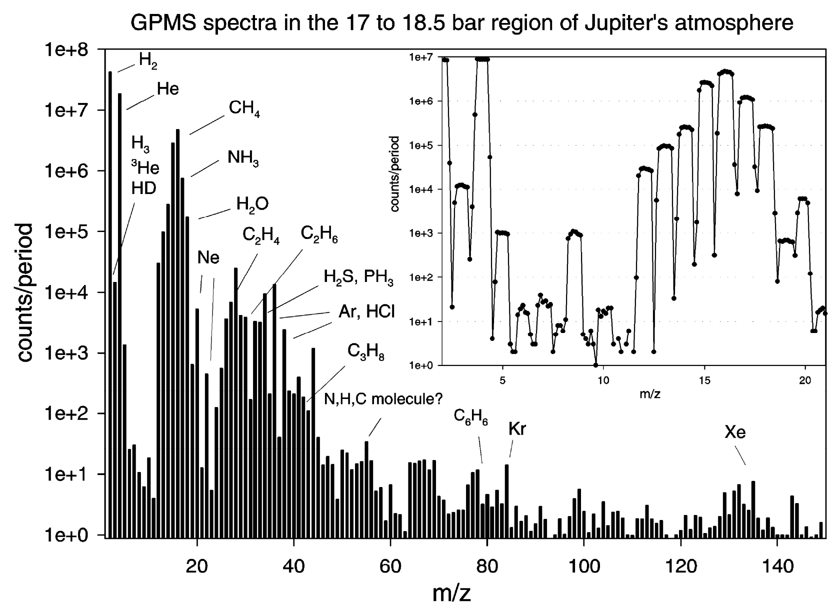
Flight Quadrupole Housing

Measurement Objectives:

- Basic structure of the upper atmosphere (He, N O, CO, N_2, NO, O_2, Ar and CO_2) and ionosphere from the homopause to above the exobase
- Stable isotope ratios, and variations

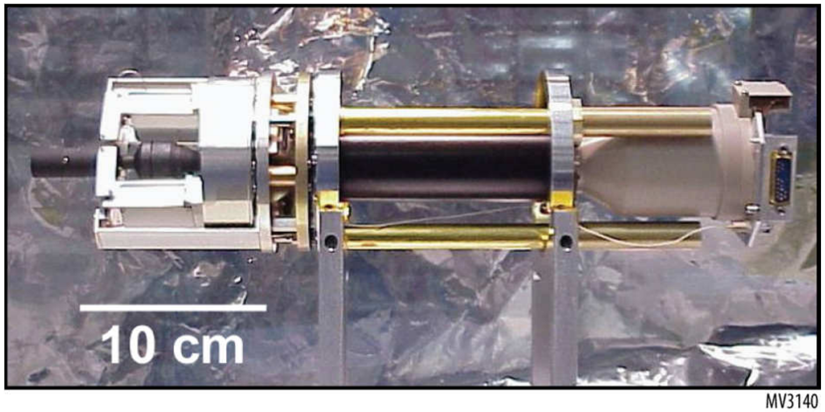
Technical Details:

- 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



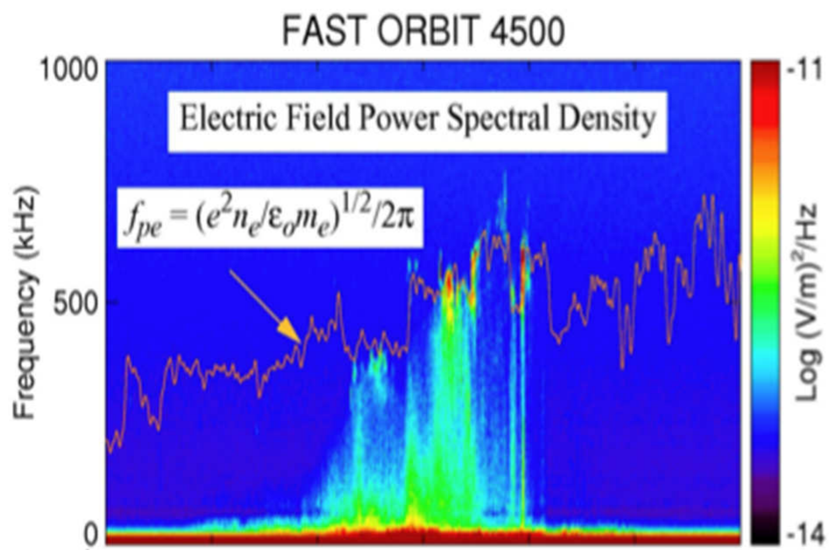
LPW Stacer boom (undeployed)

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 ±50 V range) of sensors
- Low frequency E-field wave power sensing (f: 0.05-10 Hz); sensitivity10^{-8} $(V/m)^2/Hz$ $(f_0/f)^2$ where f_o=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° K
- Heritage from THEMIS and RBSP



Magnetometer (MAG)
Jack Connerney, GSFC

MAG Flight Model

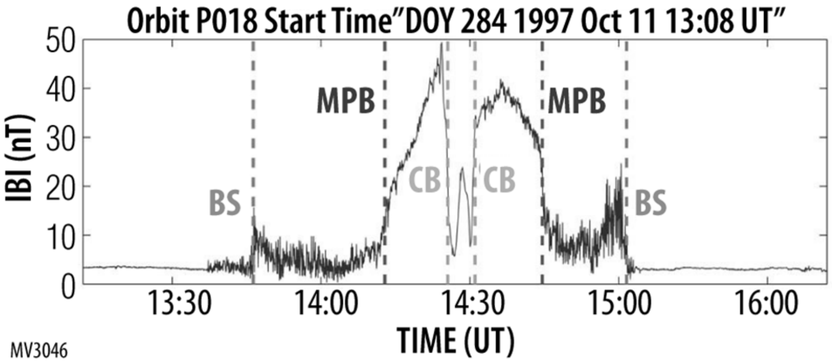
Measurement objectives:

- 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:

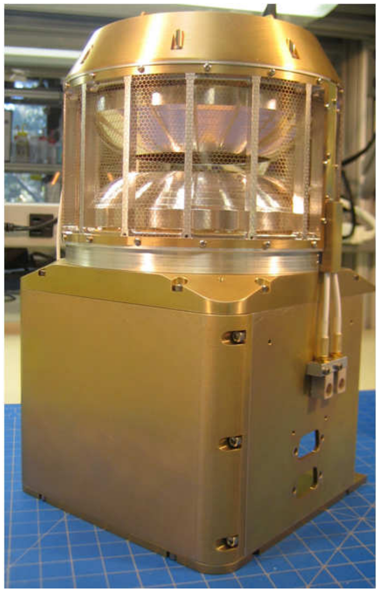
- Magnetic field over a dynamic range of ~ 0.1 nT to ~ 60,000 nT, with 1 sec time resolution (4 km spatial resolution), 1° angular determination, and 5% precision on scalar value
- Heritage: *MGS, Voyager, AMPTE, GIOTTO, CLUSTER, Lunar Prospector, MESSENGER* and others; identical to MAG on *STEREO*

MGS MAG measurements:



Solar Wind Ion Analyzer (SWIA)

Jasper Halekas, SSL



SWIA Engineering Model

Measurement objectives:

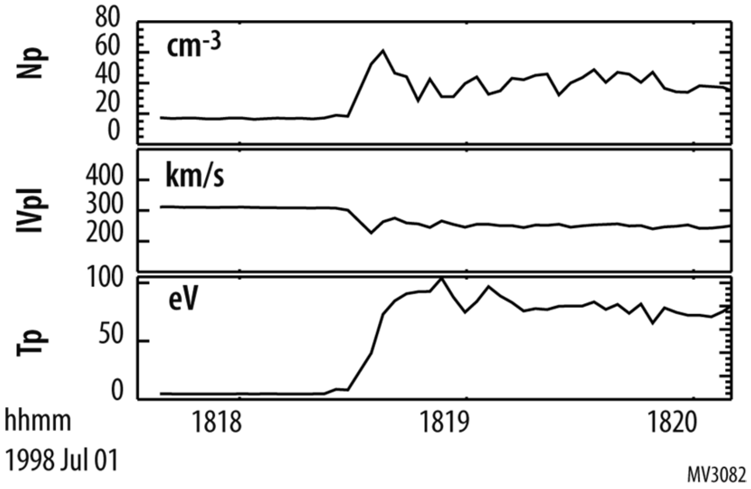
• Density and velocity distributions of solar wind and magnetosheath ions to determine the charge exchange rate and the bulk plasma flow from solar wind speeds (~350 to ~1000 km/s) down to stagnating magnetosheath speeds (tens of km/s).

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.

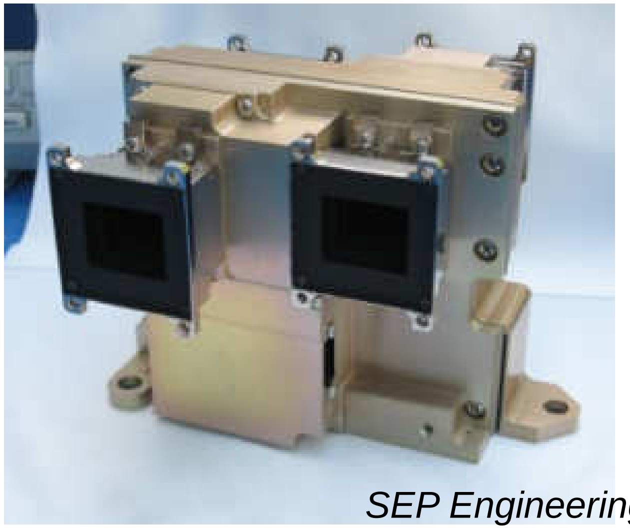
• Heritage from Wind, FAST, and THEMIS.

Similar measurements provided by *Wind*:



Solar Energetic Particle (SEP) Analyzer

Davin Larson, SSL



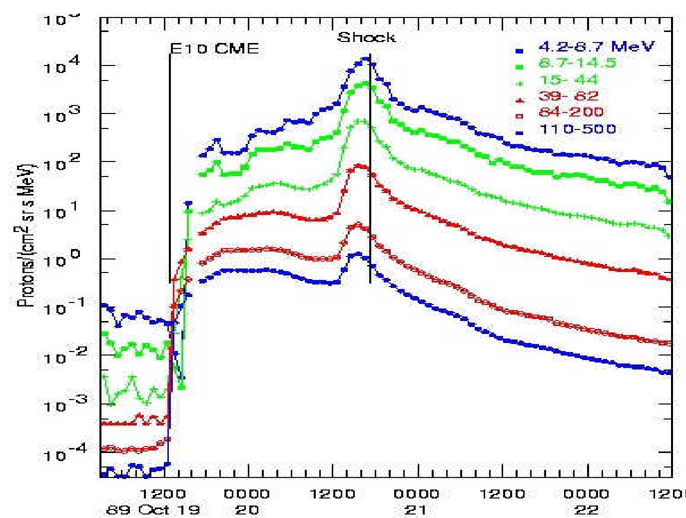
SEP Engineering Model

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

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SWEA Flight Analyzer

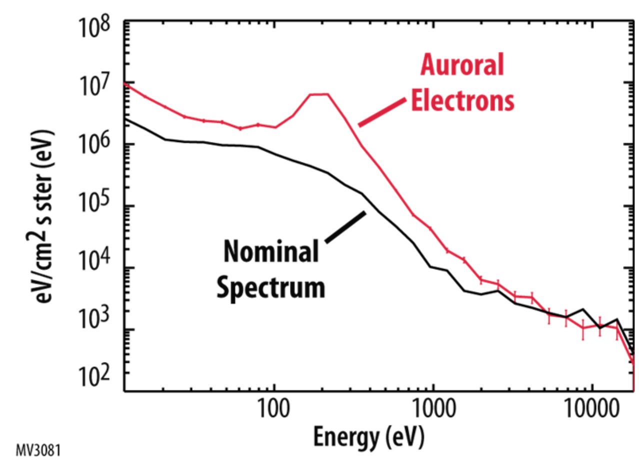
Measurement objectives:

- 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 360º X 130º
- Angular resolution 22.5º in azimuth, better than 14º 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

Mars Atmosphere and Volatile Evolution Mission

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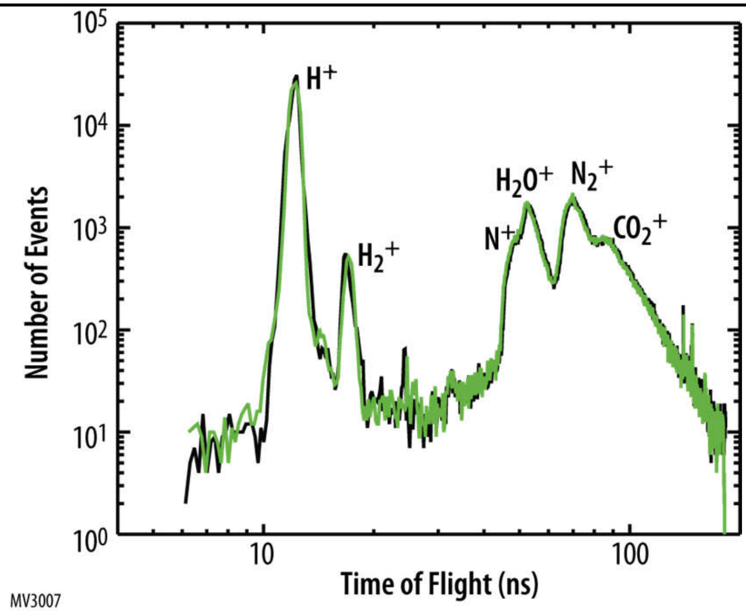
STATIC Engineering Model

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 (5-100eV)
- Pick-up Ions (100-20,000 eV)
- Key ions H^+, O^+, O_2^+, CO_2^+

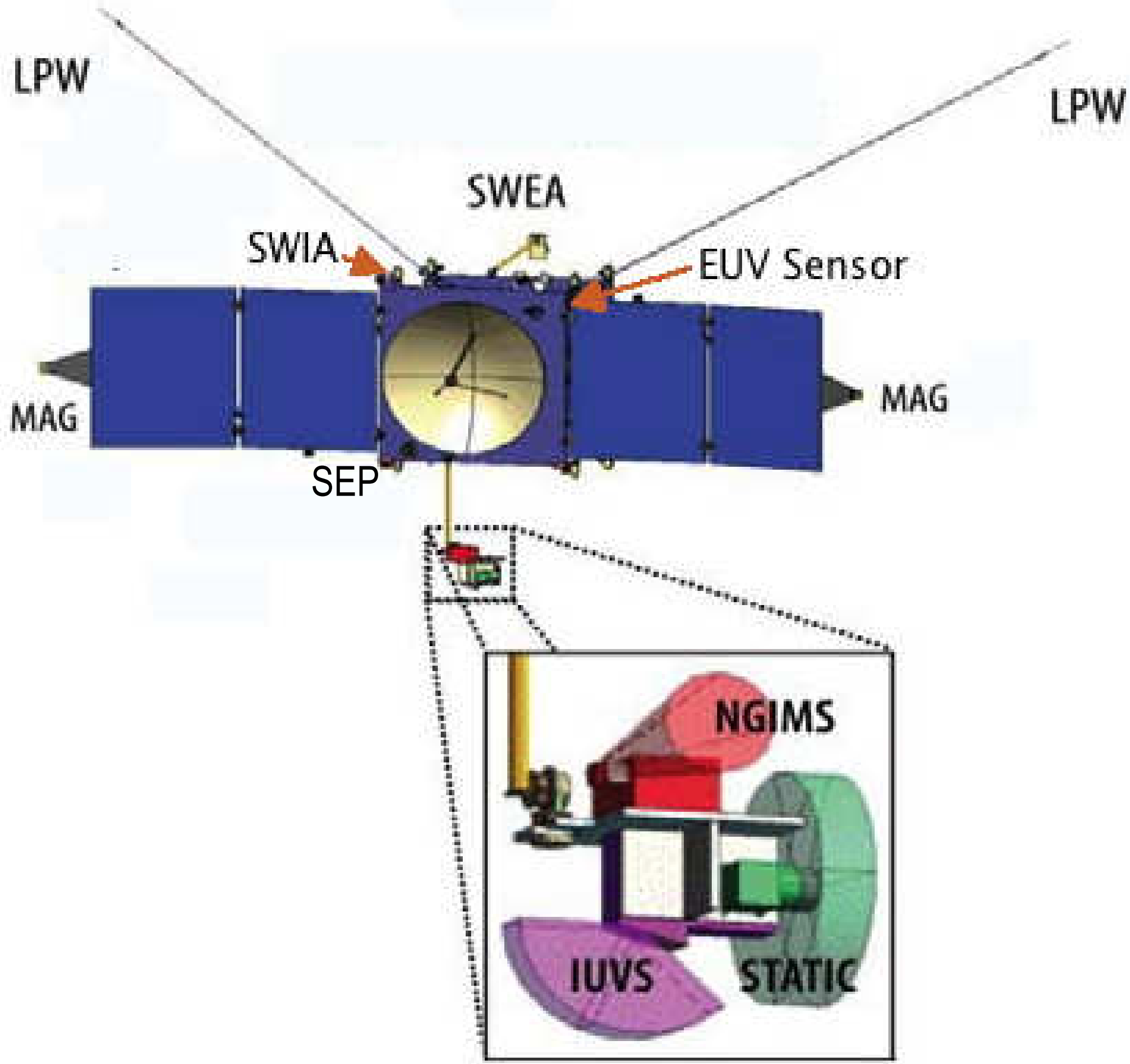
Technical details and heritage:

- Toroidal Electrostatic Analyzer with Time of Flight section
- Mass range 1-70 AMU, $\Delta M/M > 4$
- Energy range ~1 eV to 30 keV, $\Delta E/E$~15%
- FOV 360º X 90º
- Angular resolution 22.5ºX6º
- Energy flux < 10^4 to 10^8 eV/cm^2-s-sr-eV (to 10^{12} w/attenuators for low energy beam)
- Can be oriented to measure either upwelling/ downwelling ions or horizontal flows
- Heritage from Cluster CODIF.



Laboratory spectrum from Engineering Model

Instrument Placement On Spacecraft



Body-mounted instruments point at sun or solar wind:

- EUV (part of LPW)
- SWIA
- SEP

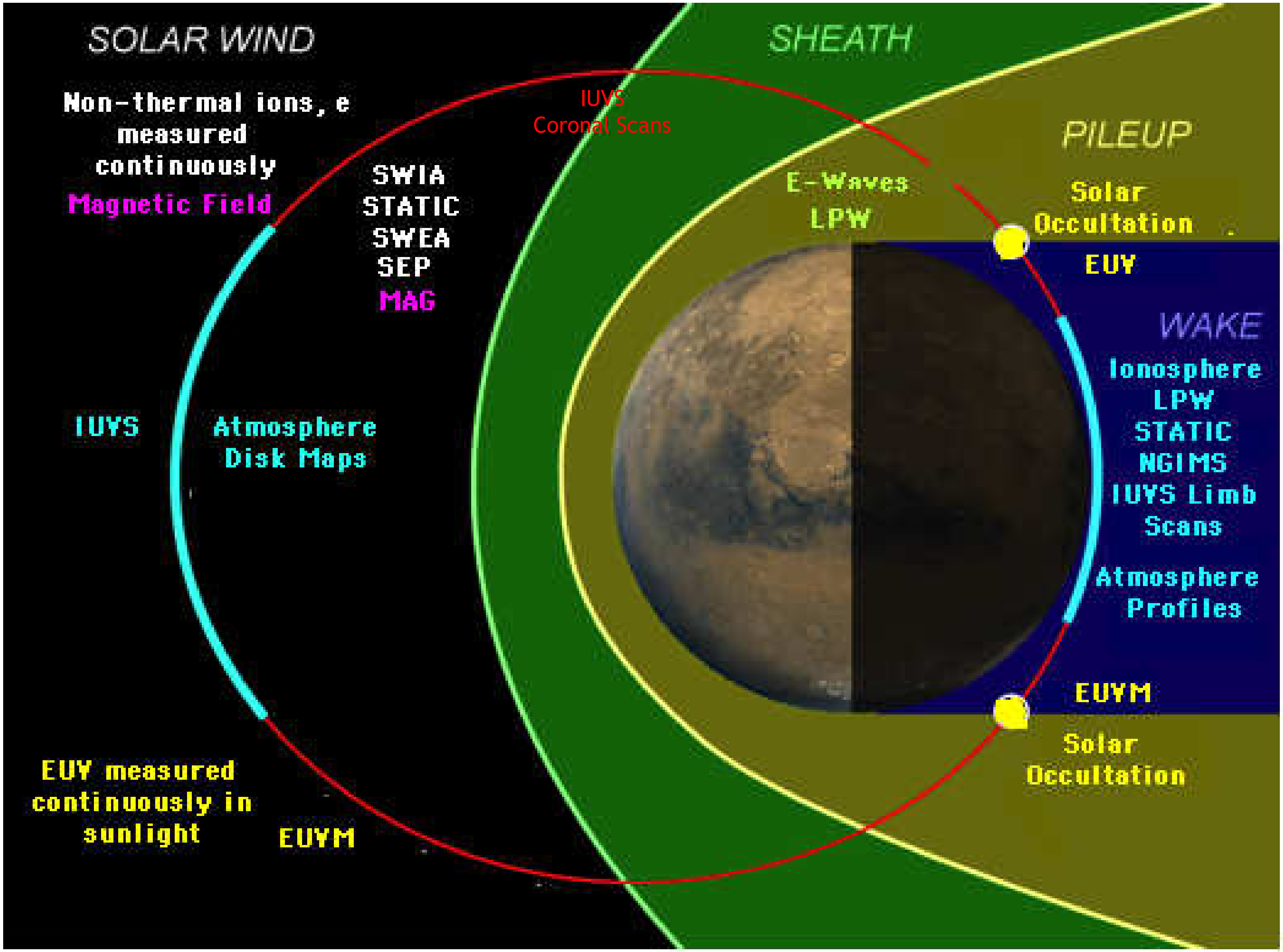
Boom-mounted instruments are isolated from S/C magnetic and electric fields:

- LPW
- SWEA
- MAG (boomlets at end of solar arrays)

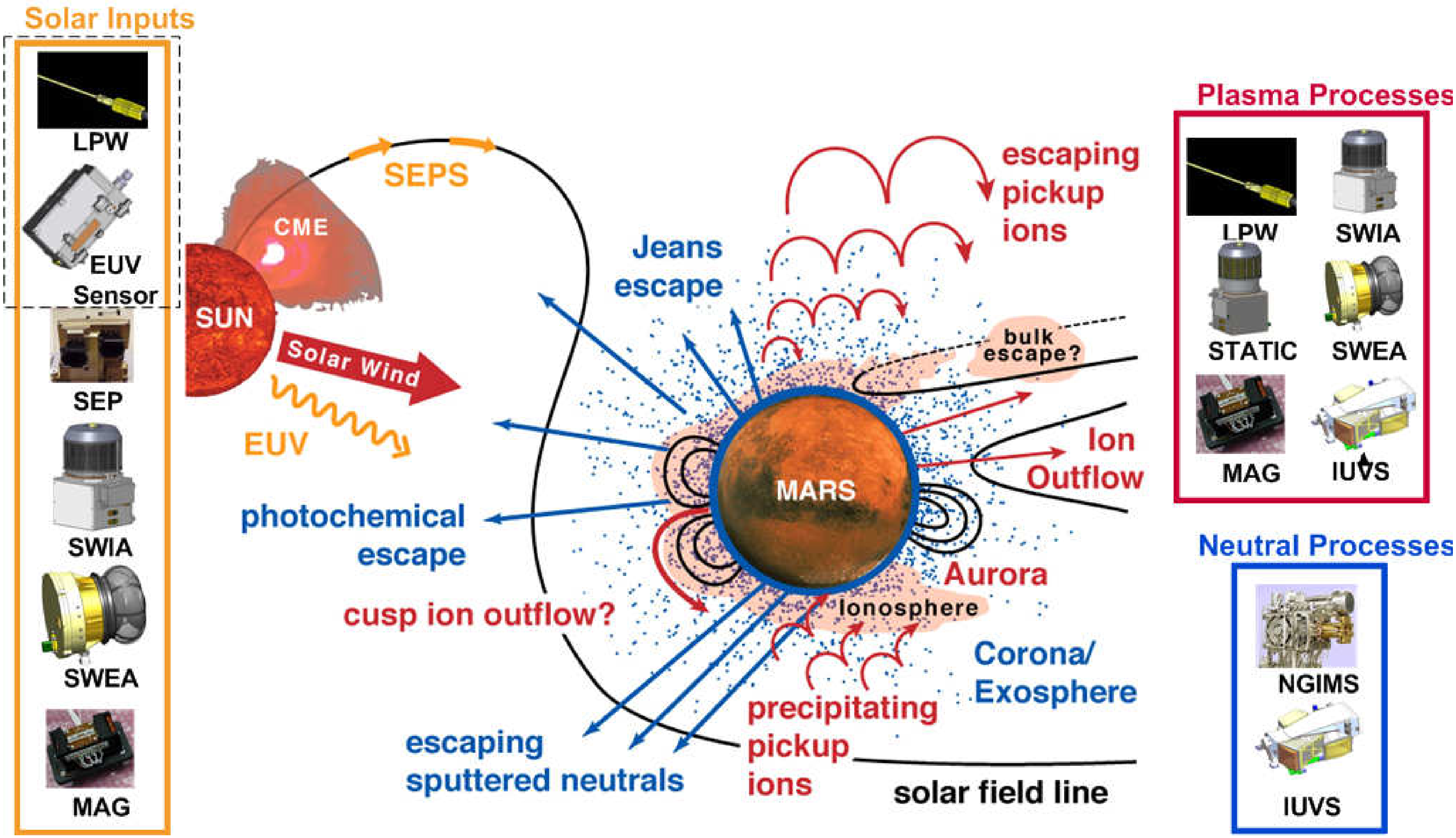
Instruments on Articulated Payload Platform orient w.r.t. planet or ram direction (fields of view are shown):

- IUVS
- NGIMS
- STATIC

Measurements Throughout The Orbit



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

Project Status and Plans

David F. Mitchell, Project Manager

The MAVEN Project's Journey

From Proposal Days…

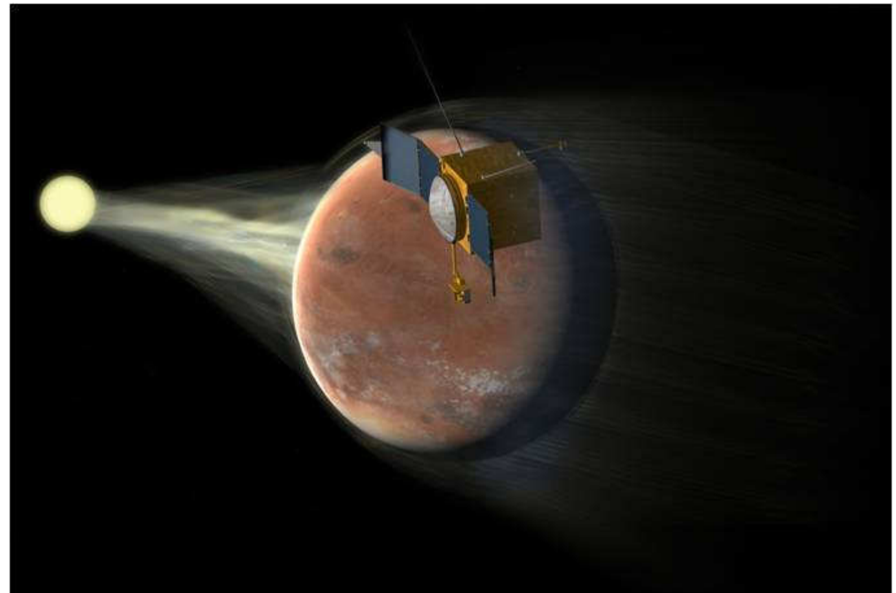
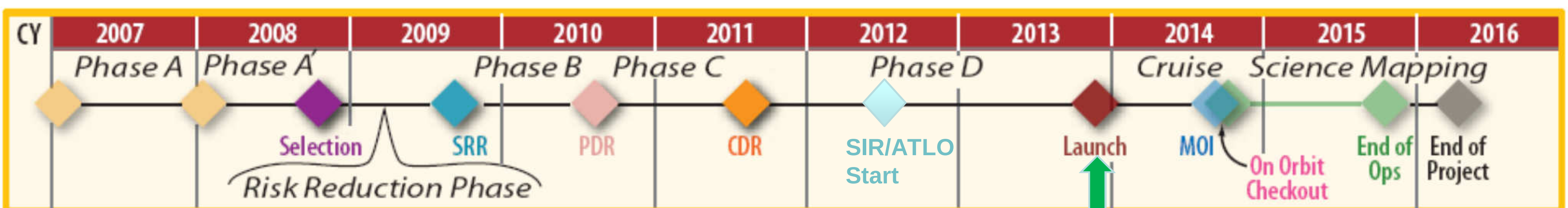


Image Credit: Corby Waste, NASA-JPL

… 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

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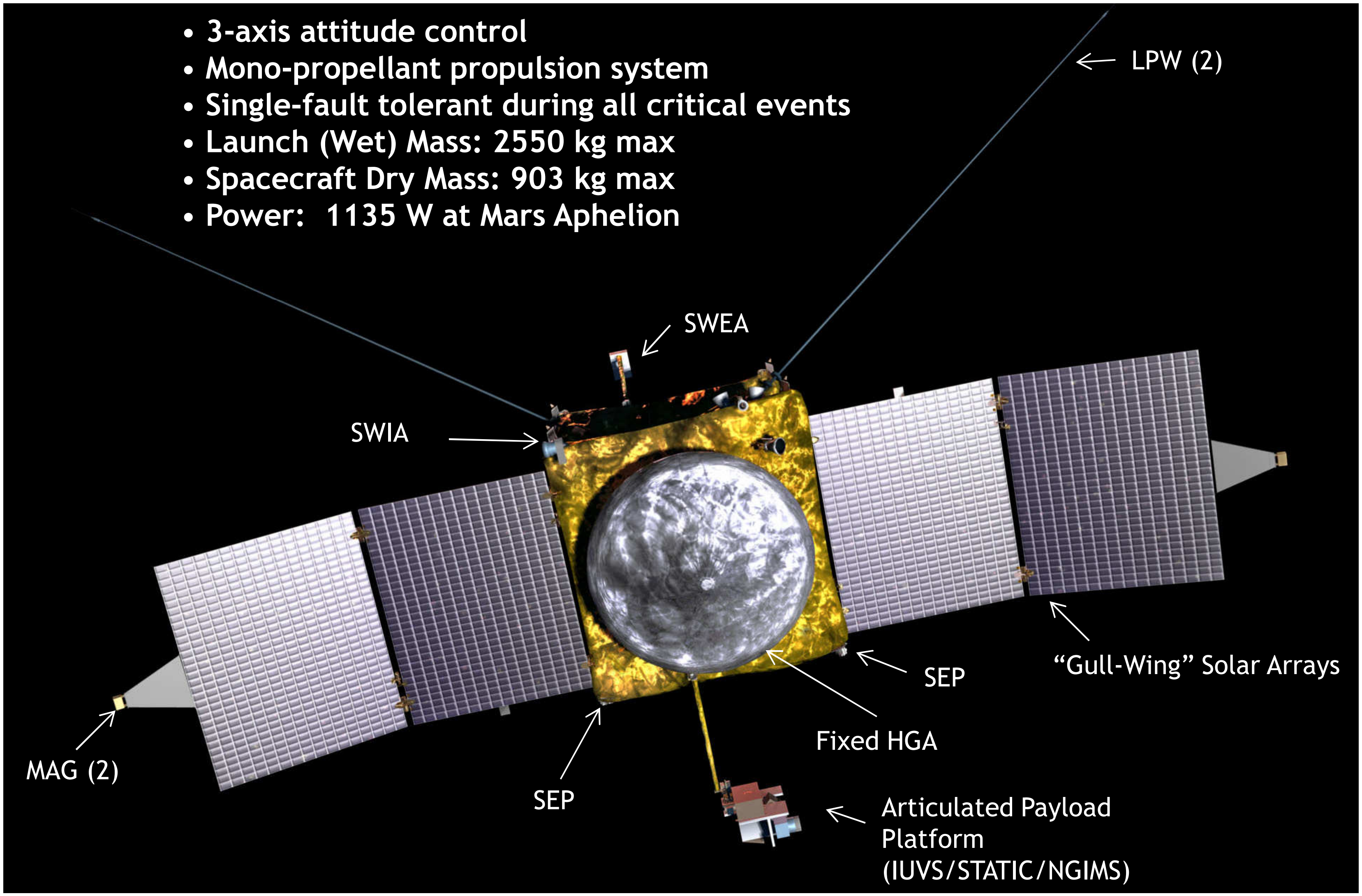
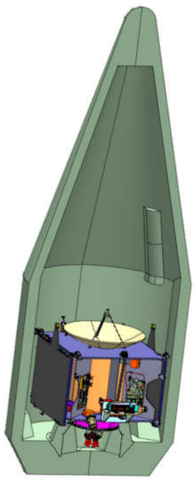
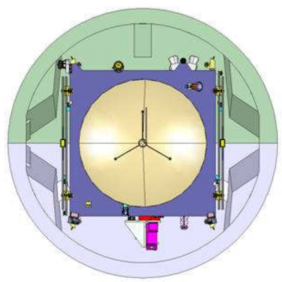
- 3-axis attitude control
- Mono-propellant propulsion system
- Single-fault tolerant during all critical events
- Launch (Wet) Mass: 2550 kg max
- Spacecraft Dry Mass: 903 kg max
- Power: 1135 W at Mars Aphelion



Mission Architecture

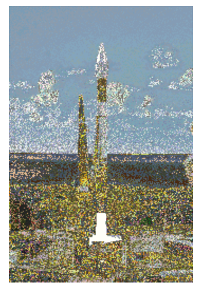
20-Day Launch Period





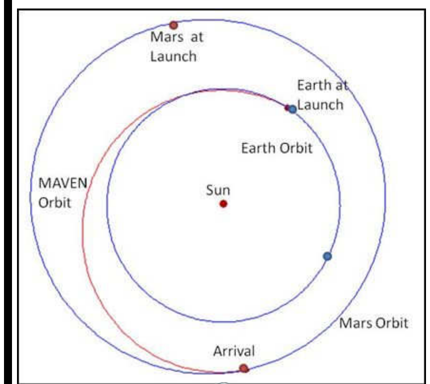
18 Nov 2013 (Open)
7 Dec 2013 (Close)

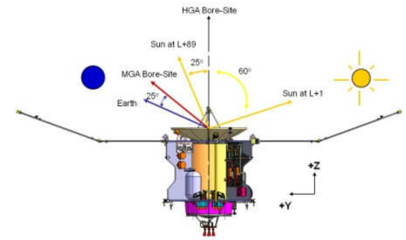
LV: Atlas V 401



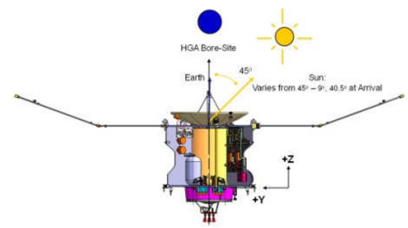
Ten Month Ballistic Cruise to Mars

Type-II Trajectory



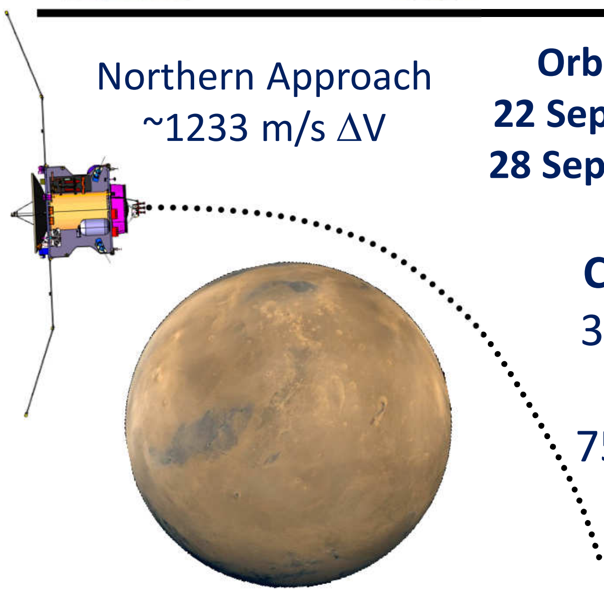


Early Cruise



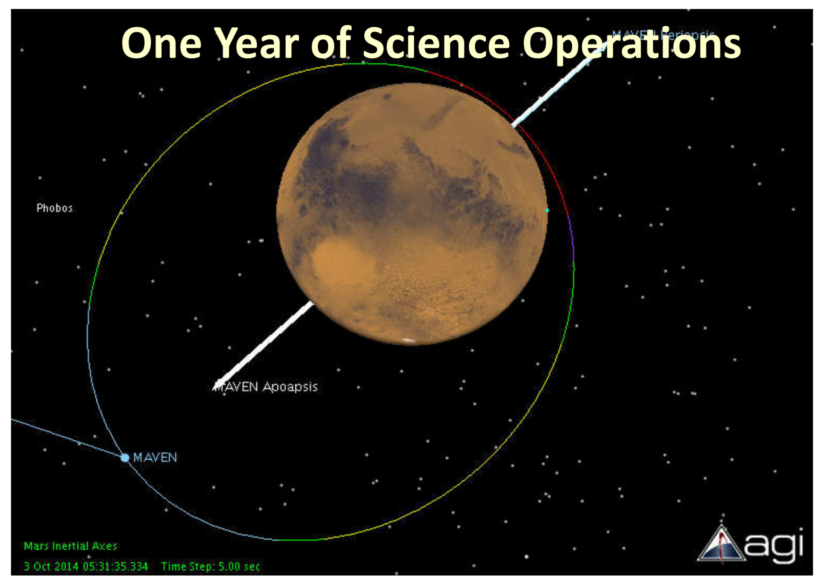
Late Cruise

Northern Approach
~1233 m/s ΔV



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

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



Major Partner Institutions

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CU/LASP • GSFC • UCB/SSL • LM • JPL

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

MAVEN
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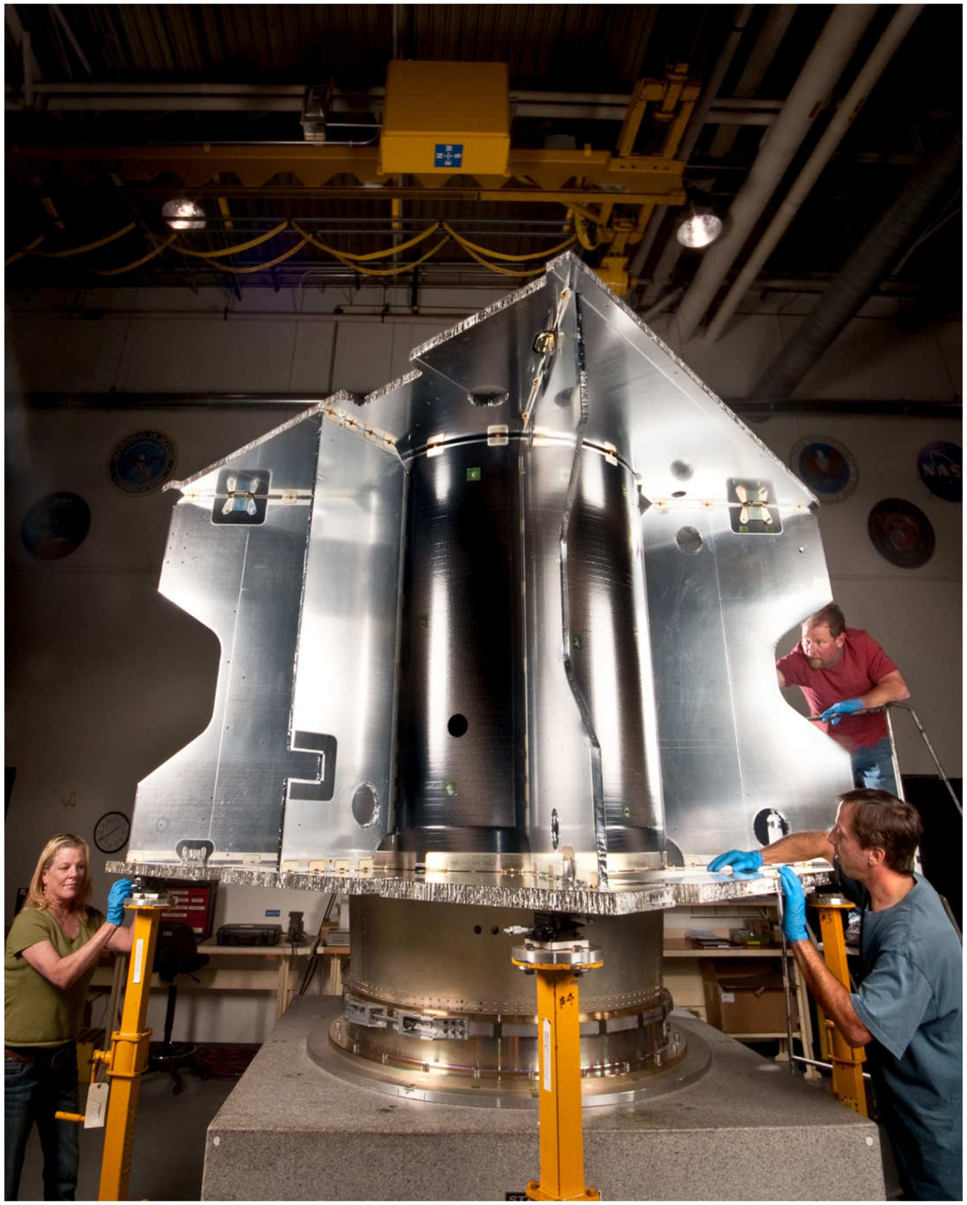

Spacecraft Hardware

Mars Atmosphere and Volatile Evolution Mission
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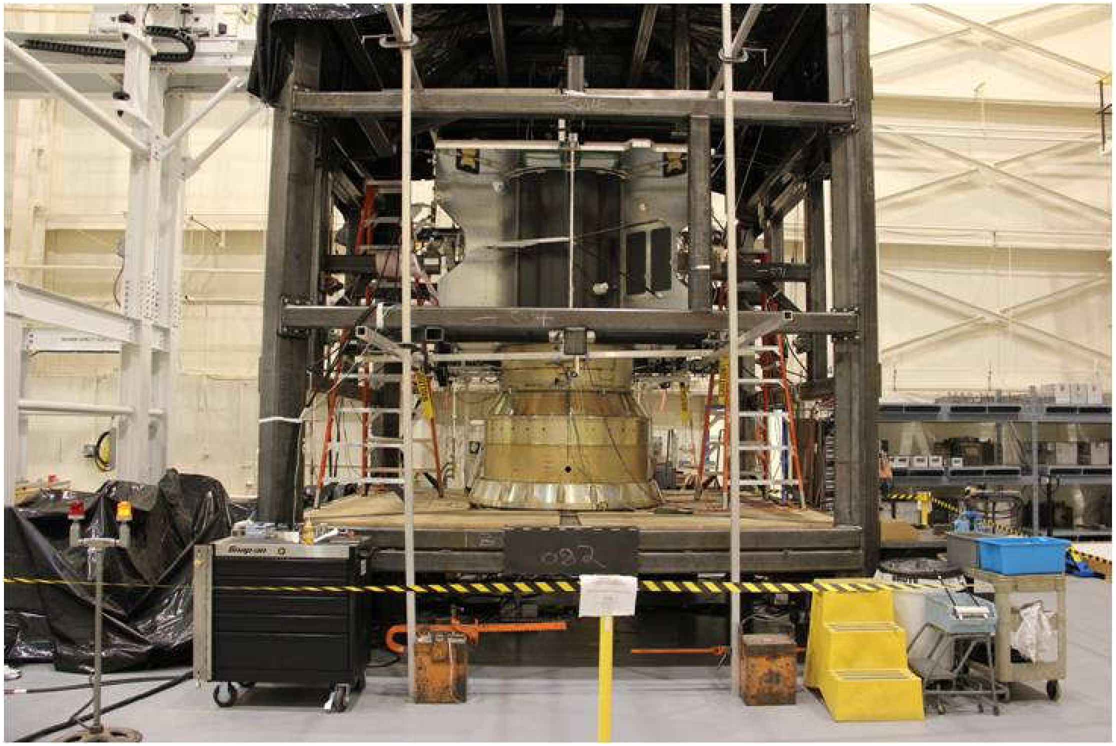
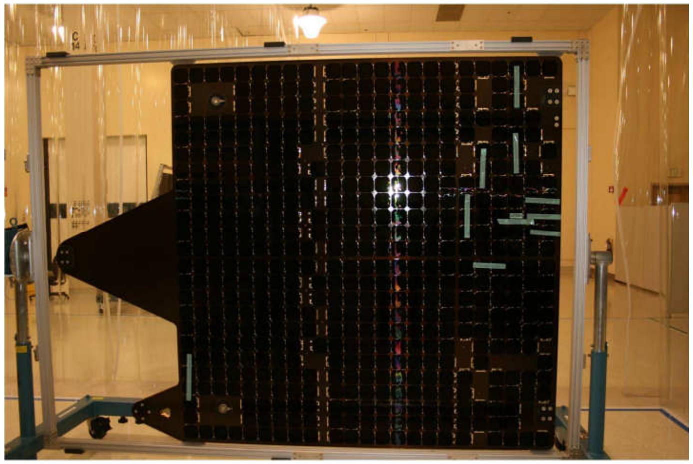


Spacecraft Structure in the Static Test Reaction Chamber

Spacecraft Thrusters



Solar Array (Outboard Panel)

Payload Hardware

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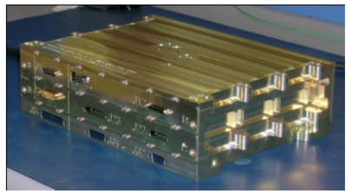
Magnetometer Sensor Flight Model (FM)

Remote Sensing Data Processing Unit (RSDPU)

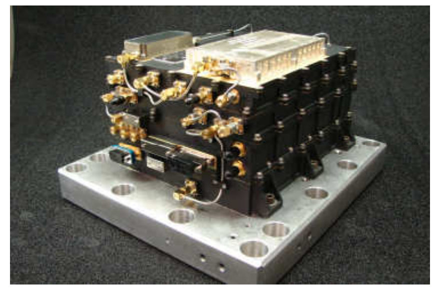


IUVS Spectrograph Case Flight Model

Neutral Gas and Ion Mass Spectrometer (NGIMS) QMS Ion Source Assembly (FM)

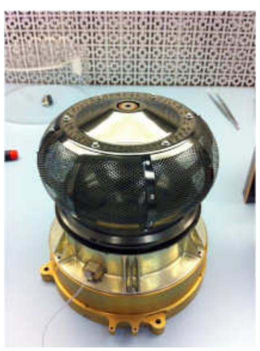
SupraThermal and Thermal Ion Composition (STATIC) Engineering Model (EM)

Langmuir Probe and Waves (LPW) Boom (EM)

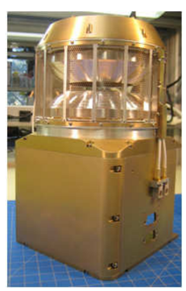


Electra UHF Transceiver Flight Model

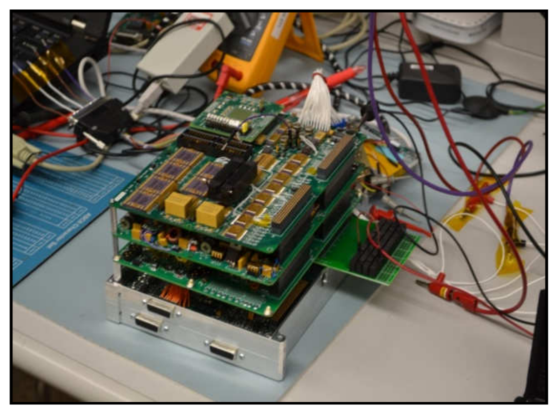
Solar Energetic Particle (SEP) Engineering Model



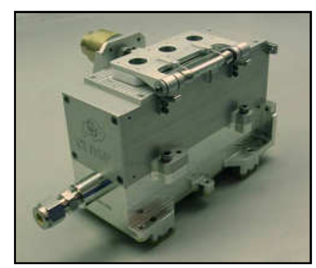
Solar Wind Electron Analyzer (SWEA) Flight Model Analyzer & Pedestal



Solar Wind Ion Analyzer (SWIA) Engineering Model



Particles & Fields Data Processing Unit (PFDPU) Partial Stack



Extreme UltraViolet (EUV) Engineering Model

MAVEN Pre-Environmental Review (PER) and System Integration Review (SIR) Schedule

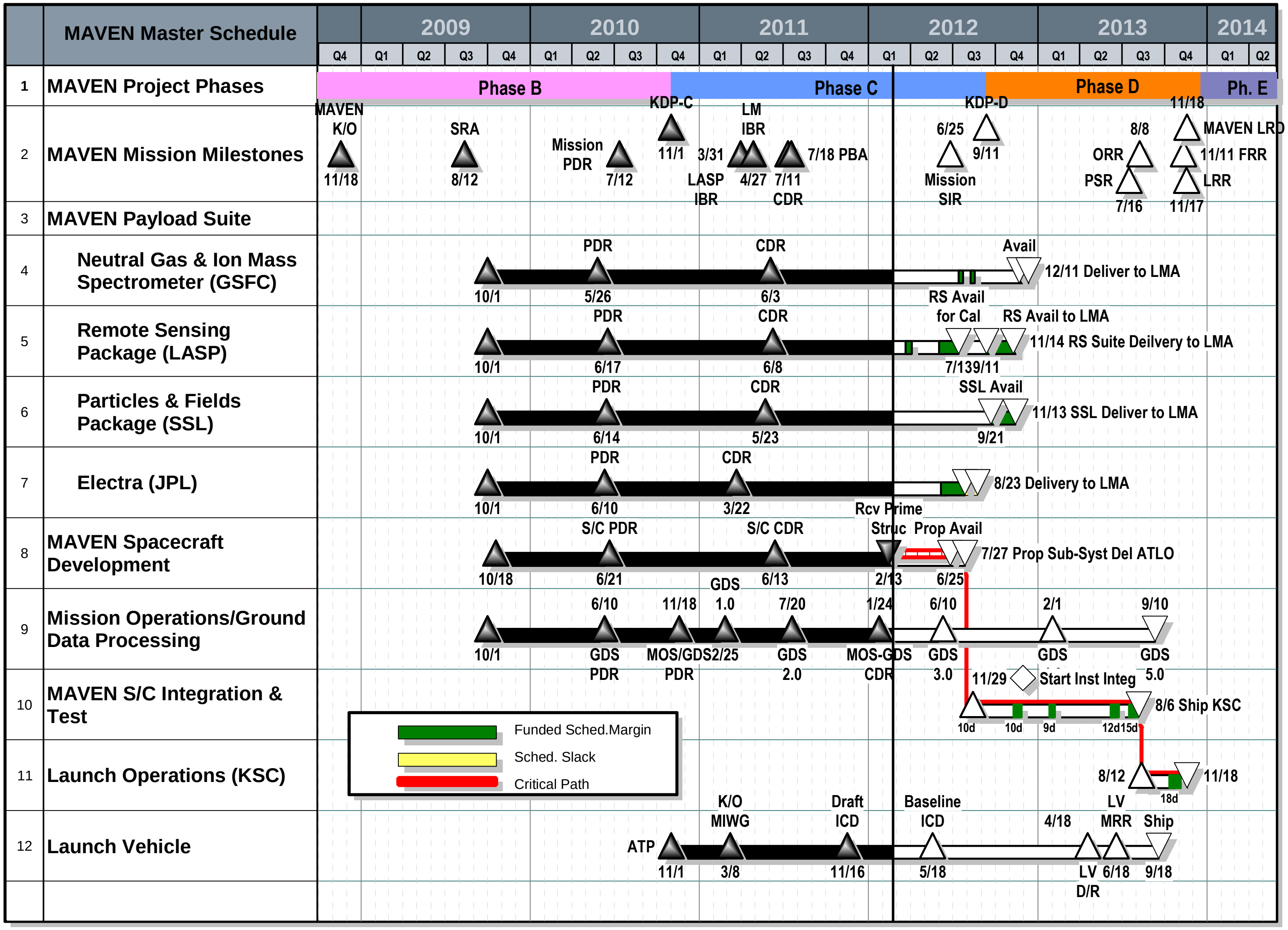
Element	Date
Remote Sensing Package Pre Environmental Review (PER), at CU-LASP	April 10, 2012
Particle & Fields Package PER, at SSL	May 22, 2012
System Integration Review, at Lockheed Martin	June 25 – 28, 2012
NGIMS PER, at NASA-GSFC	August 8, 2012
Key Decision Point-D (KDP-D), at NASA-HQ	~ September 11, 2012
Orbiter PER, at Lockheed Martin	January 25, 2013

MAVEN Master Schedule*

Mars Atmosphere and Volatile Evolution Mission

CU/LASP • GSFC • UCB/SSL • LM • JPL

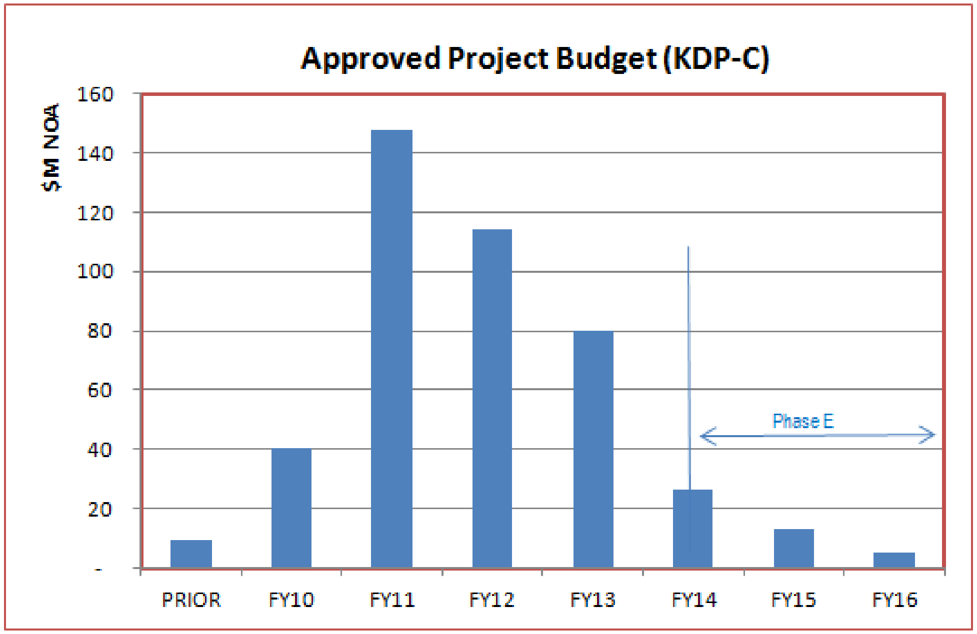
2/22/12



* 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.



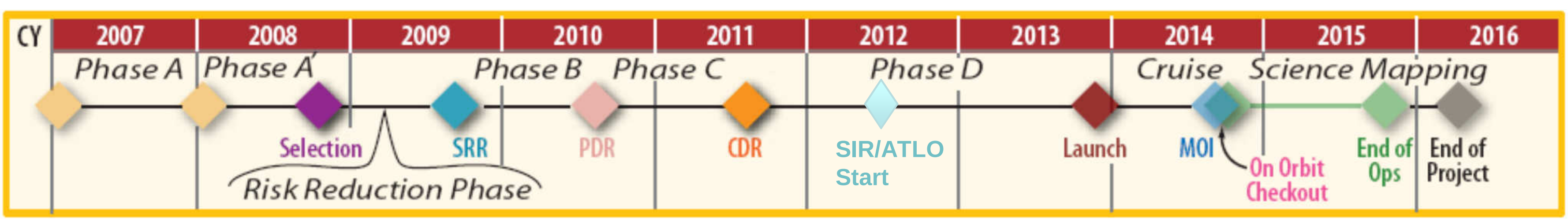
Project Focus Points

- 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



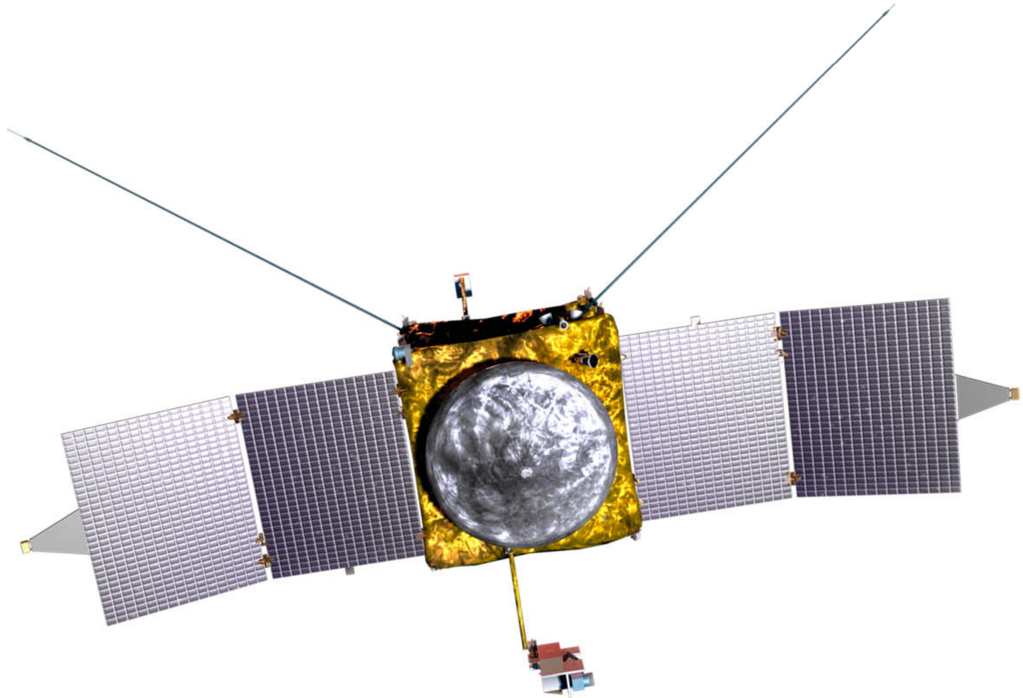
Want to Follow Us?

We're on Facebook and Twitter: MAVEN2MARS

and on the web:

http://www.nasa.gov/maven

http://lasp.colorado.edu/maven

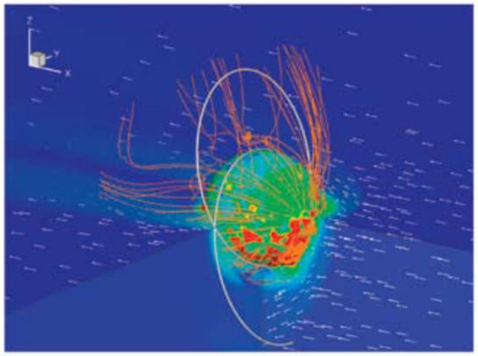


Backup Charts

Mission Description

Mars Atmosphere and Volatile Evolution Mission

CU/LASP • GSFC • UCB/SSL • LM • JPL



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

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)

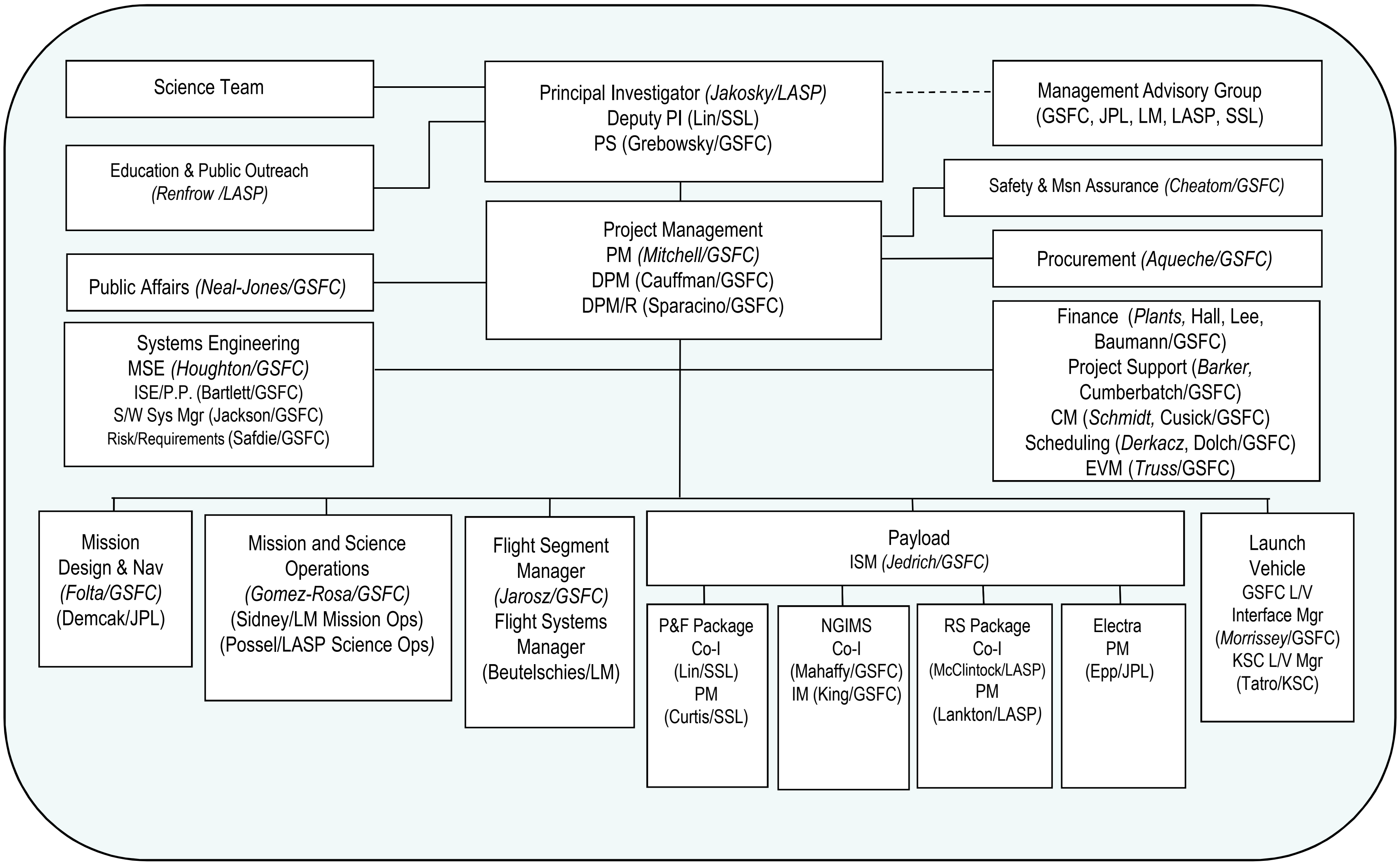
Websites

http://www.nasa.gov/maven
http://lasp.colorado.edu/maven/

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

Project Organization Chart



NOTE: Leads are shown in Italics
As of October 31, 2011

Acronyms

Mars Atmosphere and Volatile Evolution Mission

CU/LASP • GSFC • UCB/SSL • LM • JPL

2-D	2-Dimension
AAG	Association of American Geographers
AIM	Aeronomy of Ice in the Mesosphere
AMPTE	Active Magnetospheric Particle Tracer Explorers
APP	Articulated Payload Platform
Ar	Argon
ATLO	Assembly, Test and Launch Operations
CDR	Critical Design Review
CIPS	Cloud Imaging and Particle Size
Cm	centimeter
CME	Coronal Mass Ejection
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CODIF	Composition and Distribution Function Analyzer
Co-I	Co-Investigator
CU	University of Colorado
CY	Calendar Year
D/H	Deuterium/Hydrogen (ratio)
D/R	Delivery/Receipt
Da	Dalton
deg	degree
DPM	Deputy Project Manager
DPM/R	Deputy Project Manager/Resources
DSN	Deep Space Network

E	Electron
EM	Engineering Model
EPO	Education and Public Outreach
EUV	Extreme UltraViolet
EUVM	Extreme UltraViolet Microscope
eV	Electron Volt
EVM	Earned Value Management
FAST	Fast Auroral Snapshot Explorer
FISM	Flare Irradiance Spectral Model
FM	Flight Model
FOV	Field Of View
FRR	Flight Readiness Review
ft	feet
GDS	Ground Data System
GFE	Government Furnished Equipment
GPMS	Galileo Probe Mass Spectrometer
GSFC	Goddard Space Flight Center
H	Hydrogen
H_2O	Water
He	Helium
HGA	High Gain Antenna
HQ	Headquarters
Hz	Hertz
IBR	Integrated Baseline Review
ICD	Interface Control Document

IDS	Interdisciplinary Science
INMS	Ion and Neutral Mass Spectrometer
IRAP	Institute of Research for Astrophysics and Planetology
ISE	Instrument System Engineer
ISM	Instrument Systems Manager
IUVS	Imaging Ultraviolet Spectrometer
I-V	Current-Voltage sweeps (LPW)
JPL	Jet Propulsion Laboratory
K	Kelvin
K/O	Kick Off
KDP	Key Decision Point
keV	kiloelectron Volt
kg	kilogram
km	kilometer
KSC	Kennedy Space Center
LASP	Laboratory for Atmospheric and Space Physics
LM	Lockheed Martin
LMA	Lockheed Martin
LPW	Langmuir Probe and Waves
LRD	Launch Readiness Date
LRR	Launch Readiness Review
LV	Launch Vehicle
M	Million
m	Meter

Acronyms (continued)

m/s	meter/second
MAG	Magnetometer
MAVEN	Mars Atmosphere and Volatile EvolutioN
MEPAG	Mars Exploration Program Analysis Group
MER	Mars Exploration Rover
MEx	Mars Express
MGCM-MTGCM	Mars General Circulation Model-Mars Thermosphere General Circulation Model
MGS	Mars Global Surveyor
MGS MAG/ER	Mars Global Surveyor Magnetometer/Electron Reflectometer
MHz	MegaHertz
MIWG	Mission Integration Working Group
MOC	Mission Operations Center
MOI	Mars Orbit Insertion
MPF	Microlensing Planet Finder
MRO	Mars Reconnaissance Orbiter
MRR	Mission Readiness Review
MSE	Mission Systems Engineer
MSFC	Marshall Space Flight Center
MSL	Mars Science Laboratory
N_2	Nitrogen

NASA	National Aeronautics and Space Administration
NGIMS	Neutral Gas and Ion Mass Spectrometer
nm	nanometer
NOA	New Obligation Authority
nT	nanoTesla
O_2	Oxygen
ODY	Odyssey
ONMS	(Pioneer Venus) Orbiter Neutral Mass Spectrometer
Ops	Operations
ORR	Operational Readiness Review
PDR	Preliminary Design Review
PER	Pre Environmental Review
PFDPU	Particles and Fields Data Processing Unit
PHX	Phoenix
PI	Principal Investigator
PM	Project Manager
PS	Project Scientist
PSR	Pre Ship Review
RBSP	Radiation Belt Storm Probe
RS	Remote Sensing
RSDPU	Remote Sensing Data Processing Unit
s/c	Spacecraft

S/W	Software
SDO	Solar Dynamics Observatory
sec	second
SEP	Solar Energetic Particle
SIR	System Integration Review
SOC	Science Operations Center
SORCE	Solar Radiation and Climate Experiment
SRA	System Requirements Assessment
SRR	System Requirements Review
SSL	Space Sciences Laboratory
SST	Solid State Telescope
STATIC	SupraThermal And Thermal Ion Composition
STEREO	Solar Terrestrial Relations Observatory
SWEA	Solar Wind Electron Analyzer
SWIA	Solar Wind Ion Analyzer
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIMED	Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics
UHF	Ultra High Frequency
UT	Universal Time
V	Velocity
W	Watt