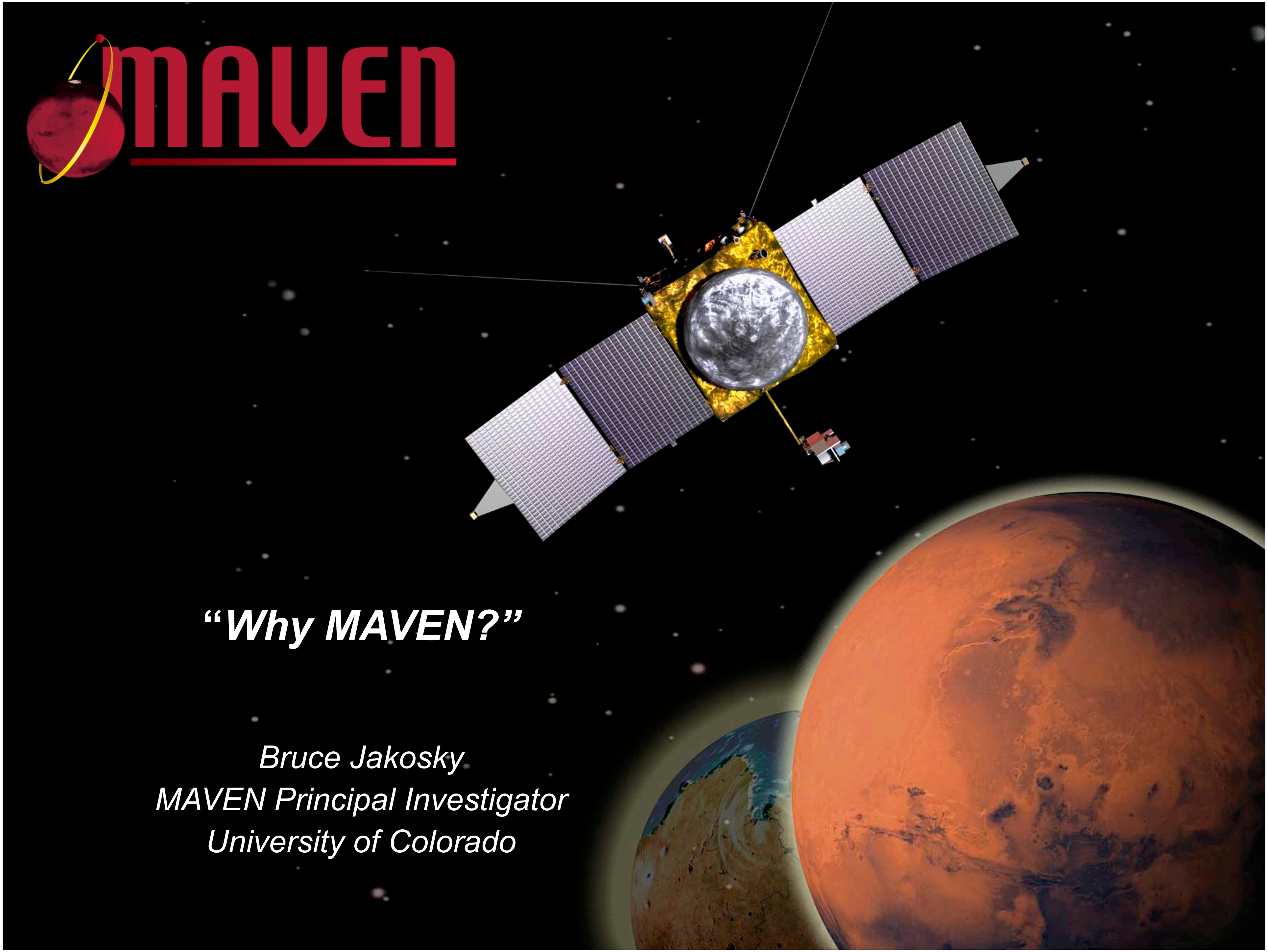
MAVEN

Mars Atmosphere and Volatile EvolutioN

"Teaming For Mars"

NASA Supply Chain Quality Assurance Conference

Oct. 14-16, 2009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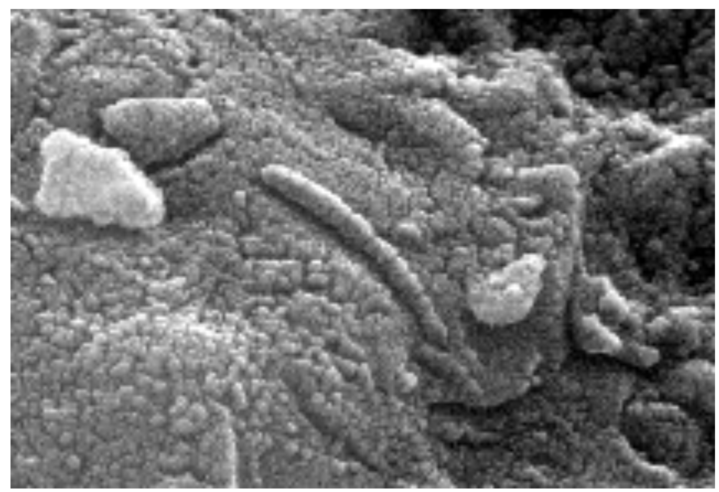
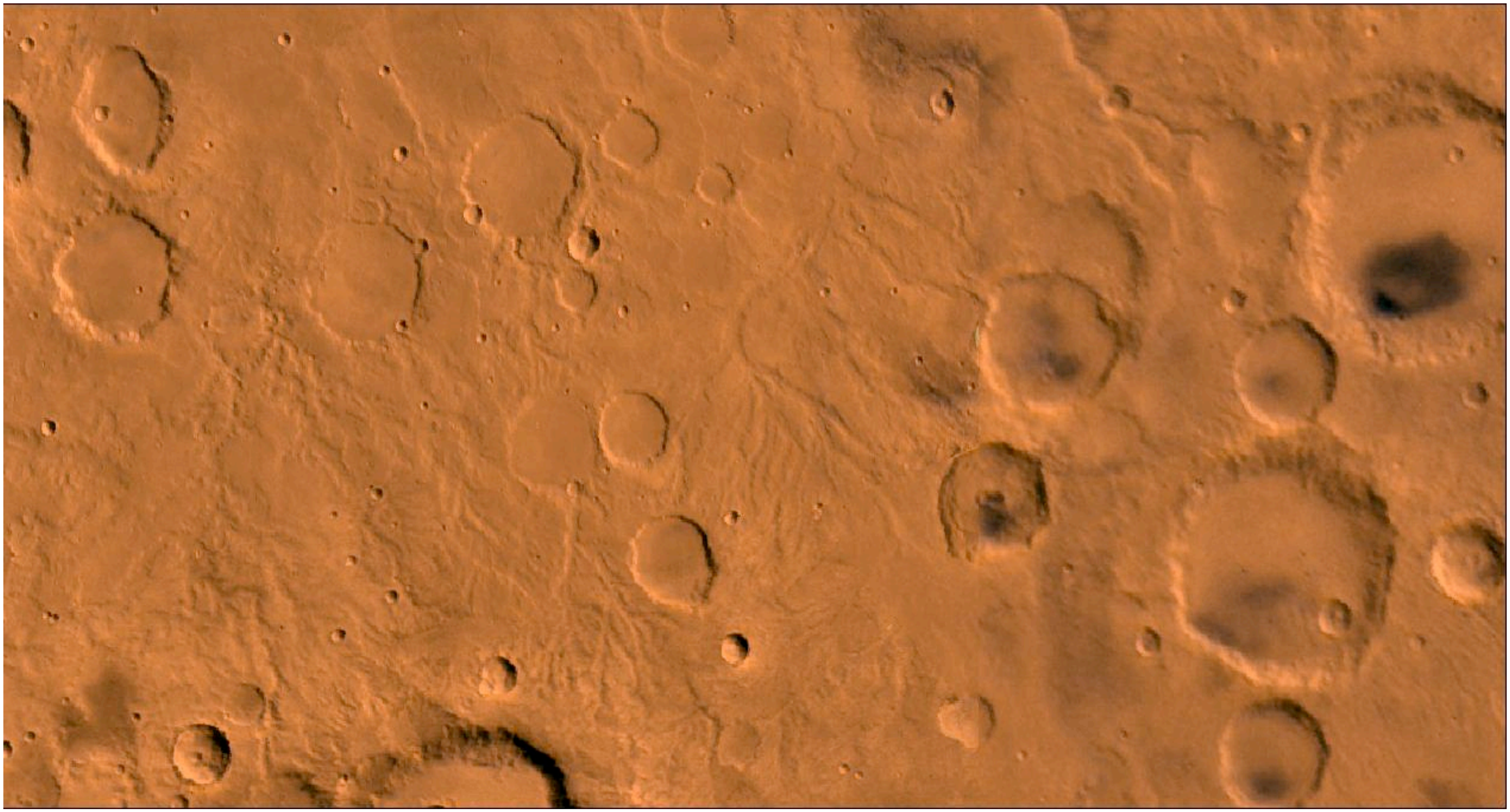
"Why MAVEN?"
Bruce Jakosky
MAVEN Principal Investigator
University of Colorado

Did Mars Ever Have Life?

- Mars appears to meet or have met all of the environmental requirements for the occurrence of life:
- Liquid water
- Access to the biogenic elements
- Source of energy to drive metabolism



Valley Networks Suggest Surface Runoff



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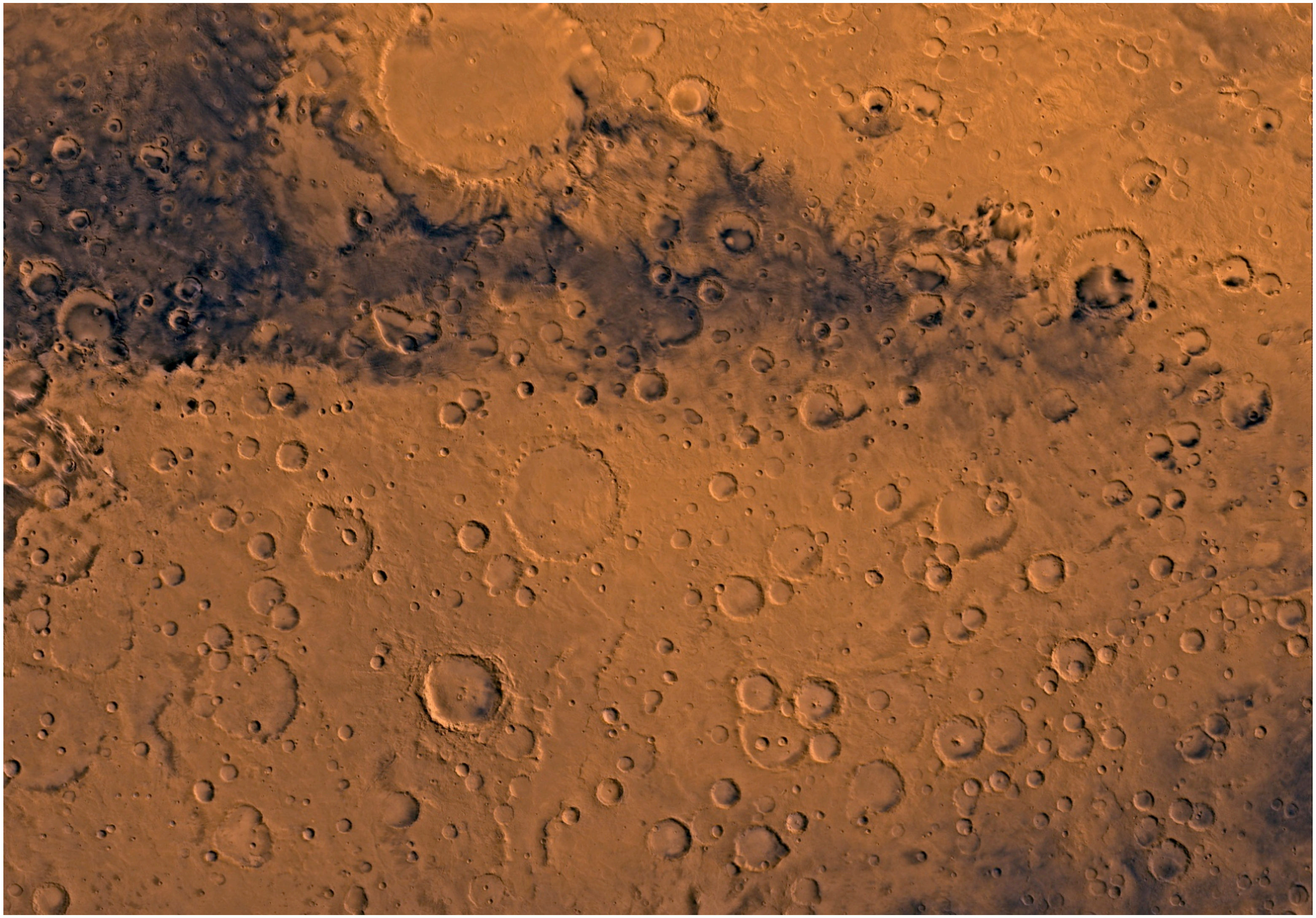
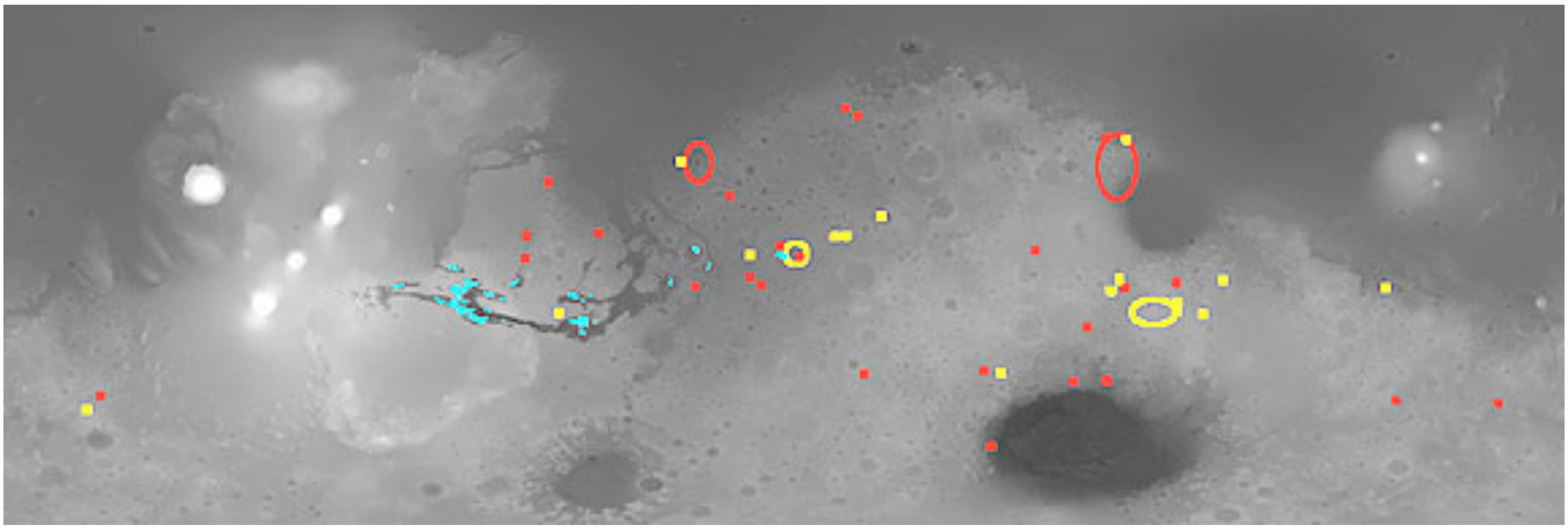
Ancient Terrain Shows Evidence For Surface Erosion By Liquid Water

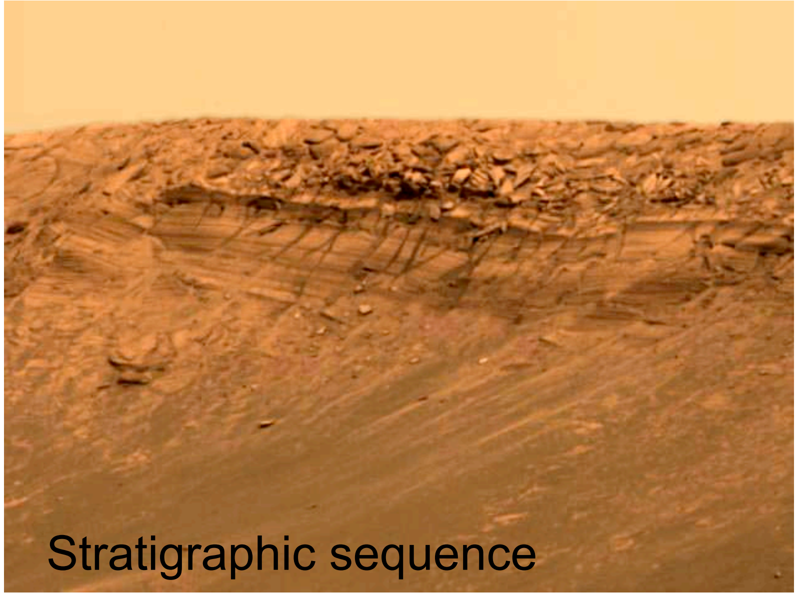


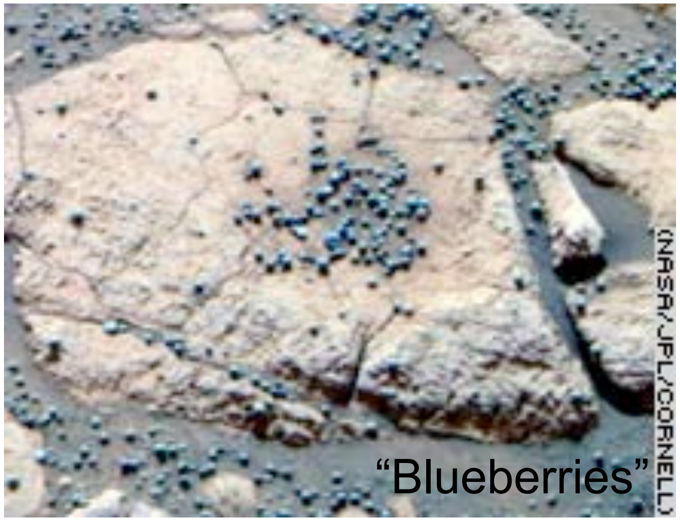
There Is Globally Distributed Mineralogical Evidence For Past Liquid Water



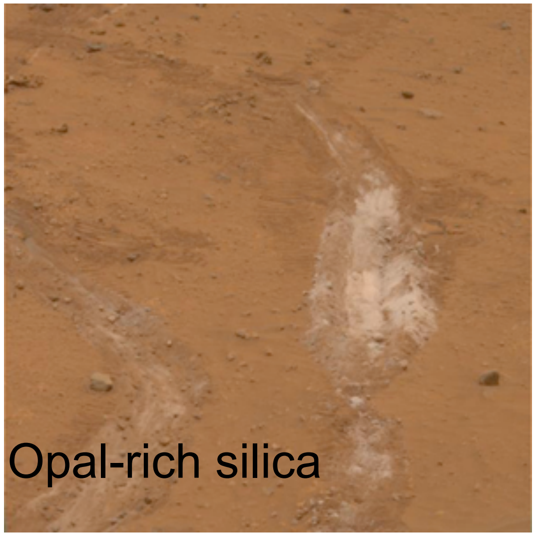
Location of clays and hydrated minerals as identified by the OMEGA instrument on Mars Express.

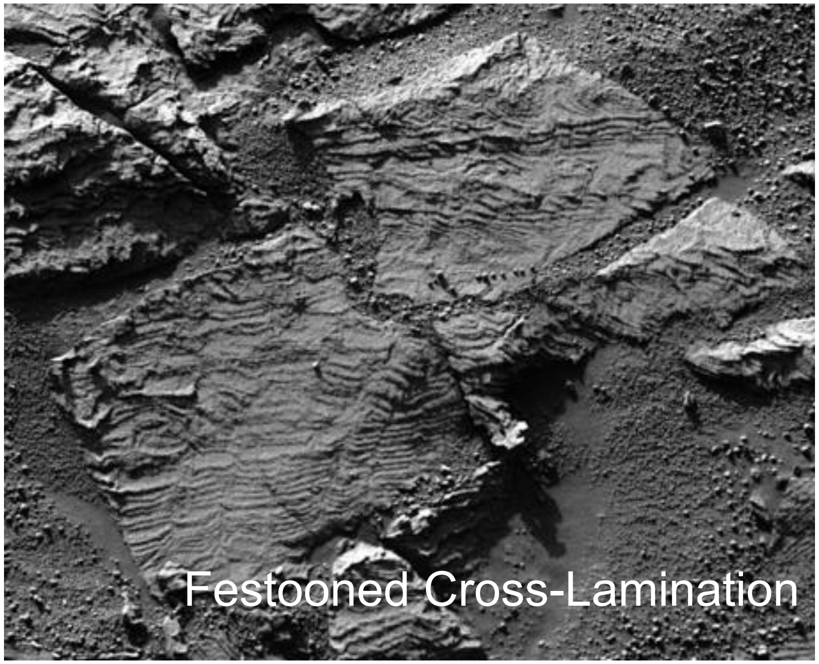
Opportunity Evidence for Past Liquid Water


Stratigraphic sequence



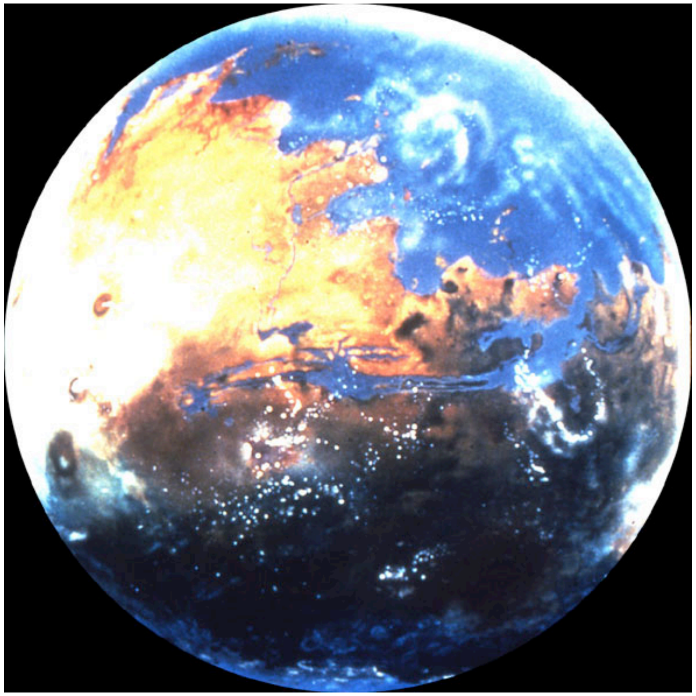
"Blueberries"


Opal-rich silica


Festooned Cross-Lamination

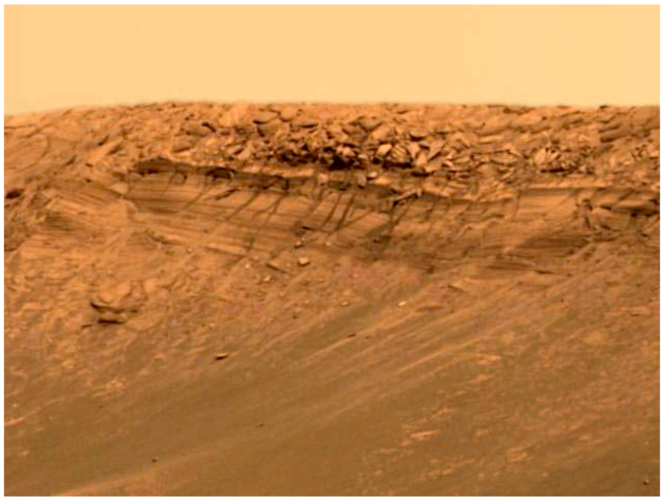
If Liquid Water Is Not Stable Now, Why Was It Stable on Early Mars?

- Temperatures must have been warmer. How warm?
- But the Sun was dimmer then. How to warm up the planet?
- If there was a greenhouse atmosphere, where did the atmosphere go?



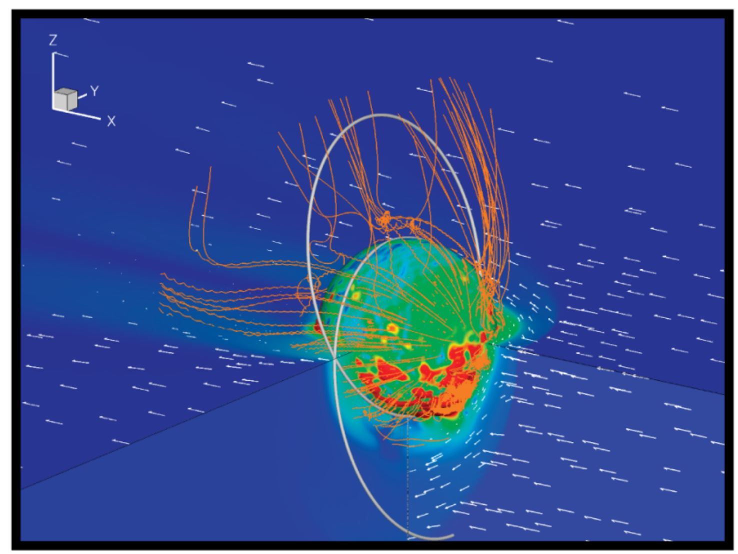
Some have even suggested that there was a global ocean on early Mars

Potential Importance of the Role of Loss to Space

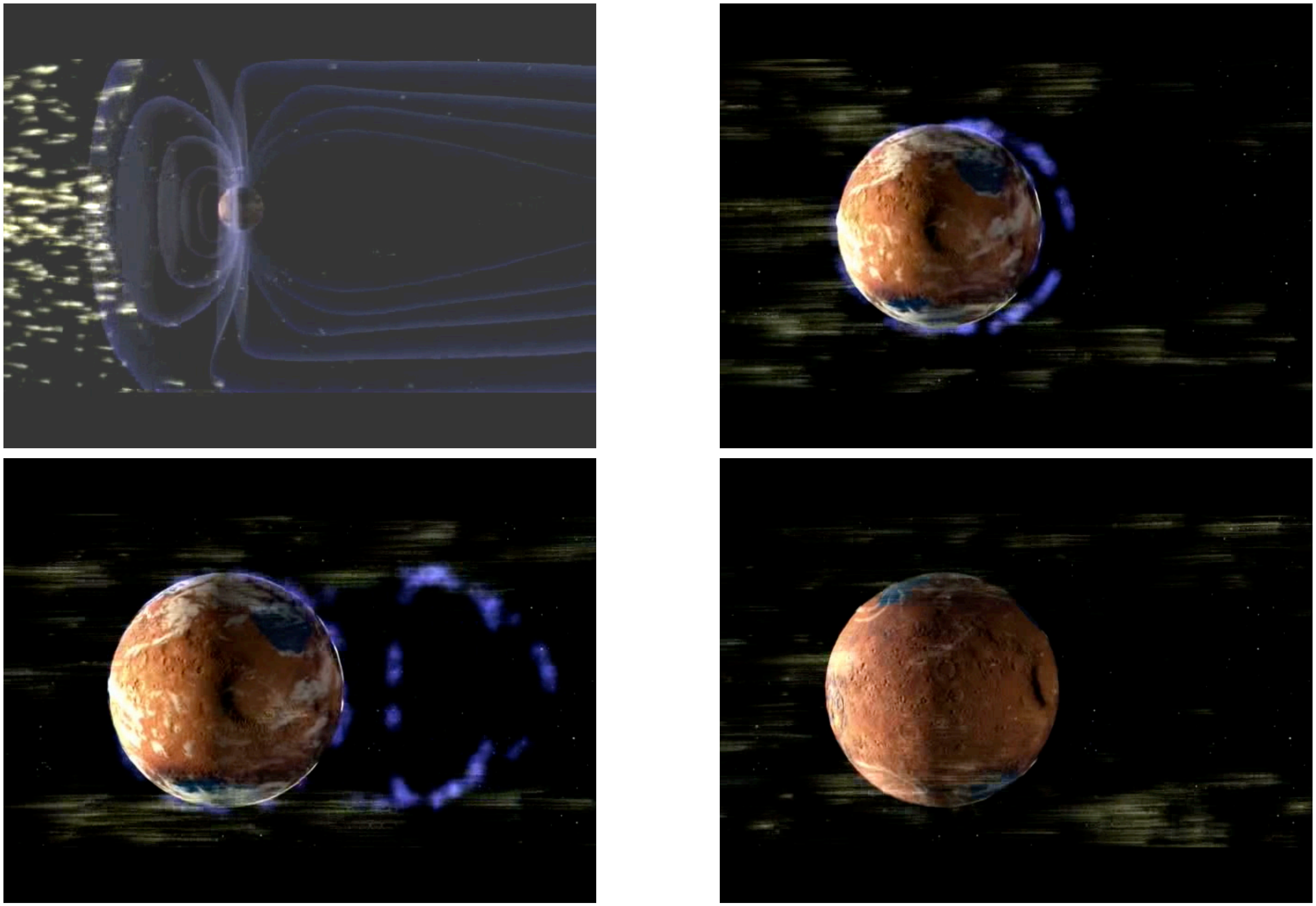


- The history of liquid water and of the atmosphere determine Mars' potential for life throughout time.
- There is abundant evidence for climate change and atmospheric evolution.
- Loss of atmospheric CO_2, N_2, and H_2O to space has been an important mechanism for atmospheric evolution, and may have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



Possible Scenario for Loss of the Early Atmosphere

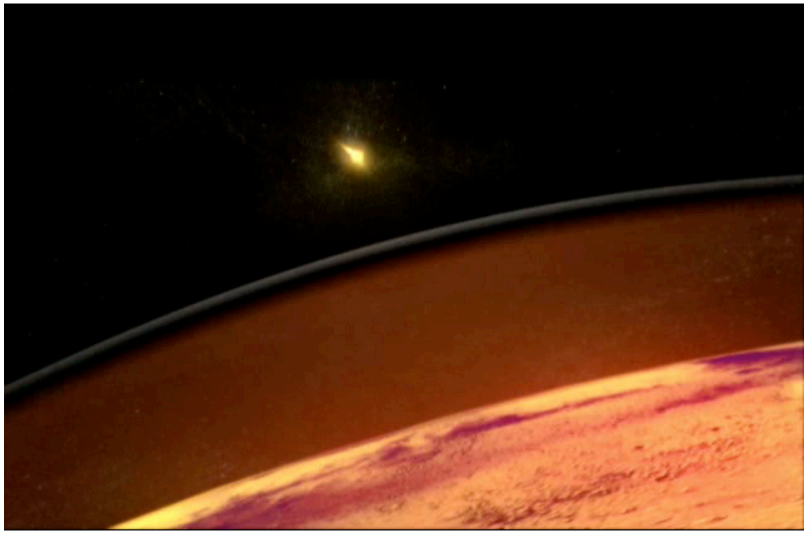


[redacted]

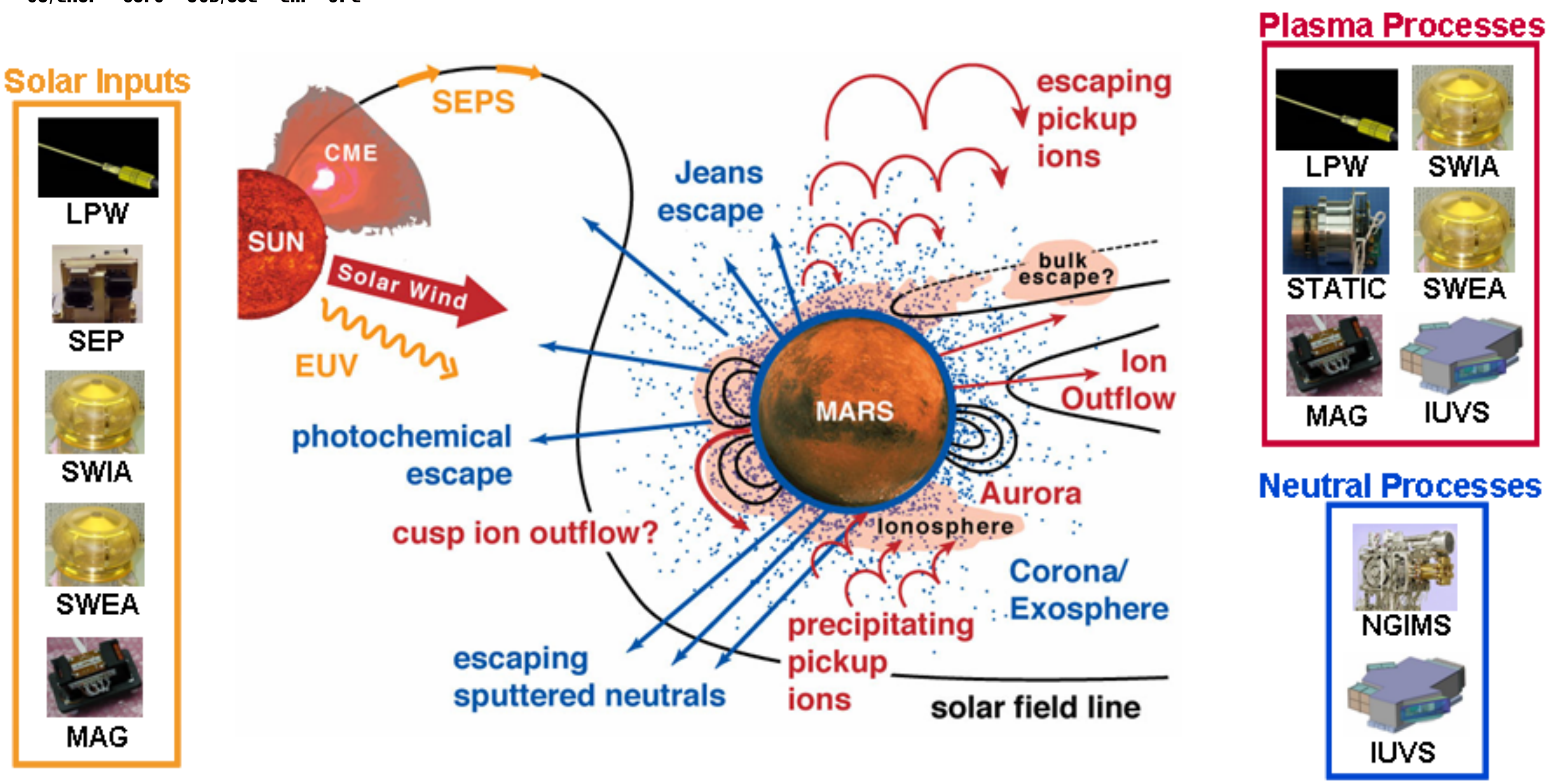
What Science Questions Will MAVEN Address?

MAVEN will determine the role that loss of volatiles to space has played through time, providing definitive answers about Mars climate history:

- What is the current state of the upper atmosphere and what processes control it?
- What is the escape rate at the present epoch and how does it relate to the controlling processes?
- What has the total loss to space been through time?



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.

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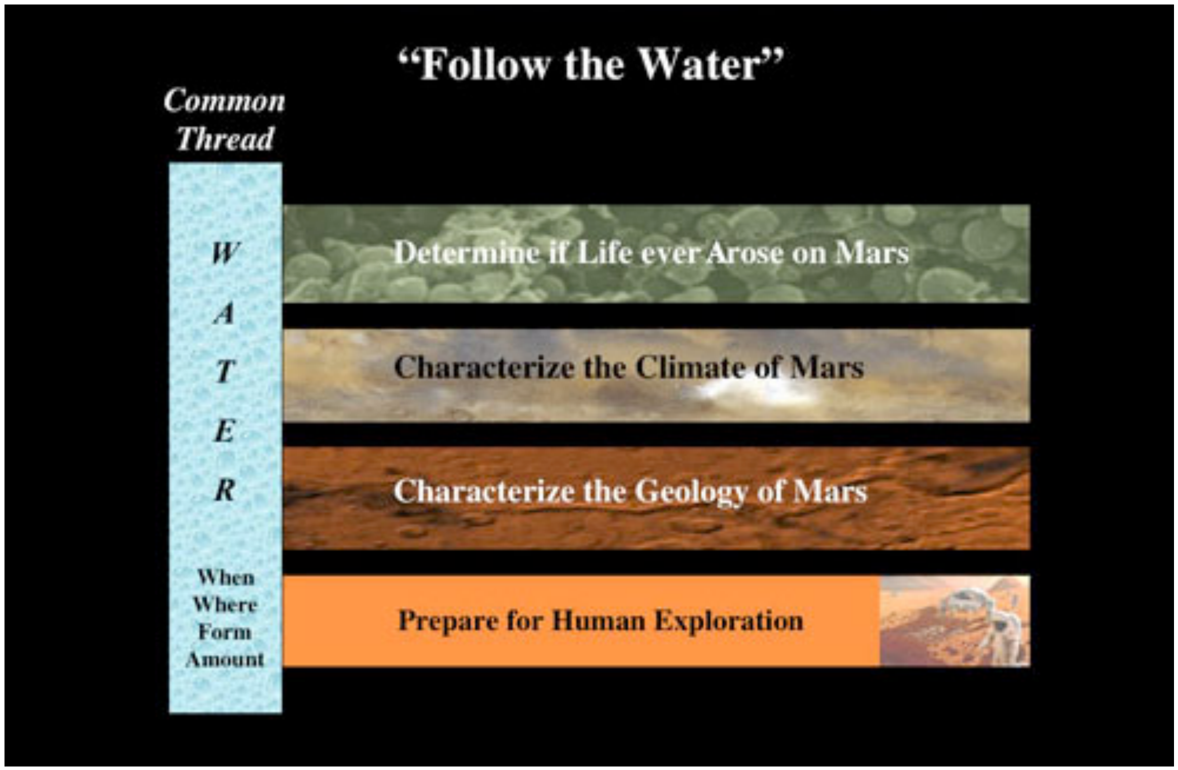
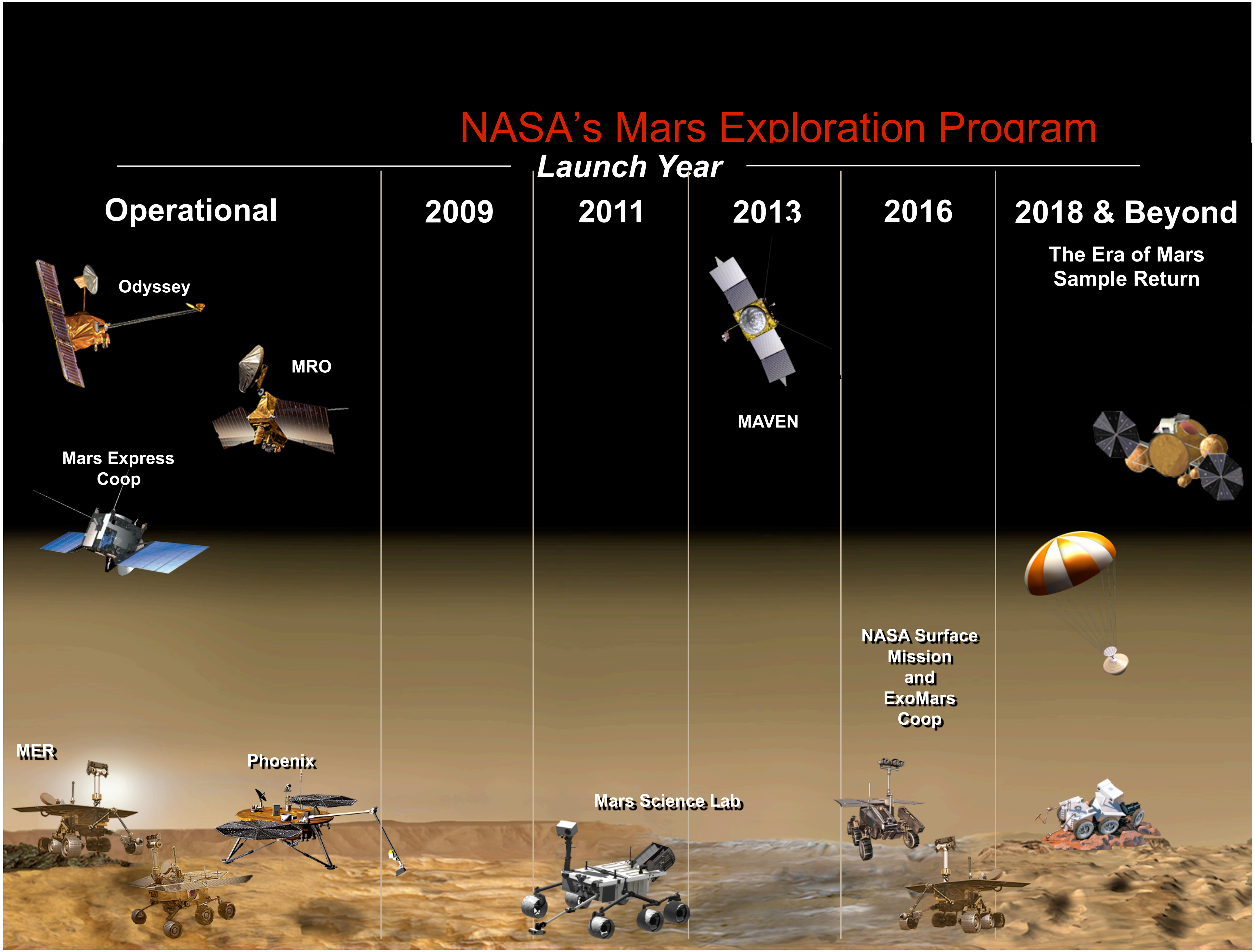
MAVEN will continue the successful "follow the water" theme.



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
Launch Year
Operational
2009
2011
2013
2016
2018 & Beyond
The Era of Mars Sample Return
Odyssey
MRO
Mars Express Coop
MAVEN
NASA Surface Mission and ExoMars Coop
MER
Phoenix
Mars Science Lab

MAVEN

“Planning for Mars”

David F. Mitchell
MAVEN Project Manager
NASA Goddard Space Flight Center

Destination Mars

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For the first time in its 50 year history Goddard is managing a mission bound for Mars!

- **The MAVEN “capture” in September 2008 was not achieved overnight**
  - **The team has been developing the concept for 4+ years. CU-LASP, Goddard, UC-Berkeley, Lockheed Martin and JPL are a close knit group intent on successful delivery and spectacular science**

- **Meticulous planning from Day 1 has been the cornerstone of MAVEN. We are now gearing up for the next major gate - preliminary design review - in July 2010**

Project Focus: When you’re headed to Mars with a 20-day planetary launch window, schedule is KING

Applying Past Lessons to MAVEN

- ***Leaving nothing to chance to make the front of a Mars launch window*** – Mars Global Surveryor
- ***Preparing for the unexpected*** - Mars Pathfinder
- ***Delivering instruments early to Spacecraft I&T*** – GOES
- ***Vigorously resisting requirements creep and closing off trade studies early*** – Multiple missions
- ***Architecting a mission with proper reserves (schedule, budget, technical) from the start*** - MAVEN

The MAVEN Team

Close communication between team members is essential to success

Overall Management Approach

- PI-mode mission, PI holds ultimate responsibility for the mission
- Goddard manages the mission for the PI, including:
  - Project management, mission systems engineering, mission design, and Safety & Mission Assurance
- Instrument development is grouped in 3 “instrument packages” closely aligned with institutional responsibilities
  - Goddard – Neutral Gas and Ion Mass Spectrometer (NGIMS)
  - LASP - Remote Sensing – IUVS and RSDPU
  - SSL - Particles and Fields – STATIC, SEP, SWIA, SWEA, LPW, MAG, and PFDPU
- LM provides the spacecraft, instrument integration and mission operations
- CU-LASP provides the science operations
- JPL provides Navigation, DSN, and Electra telecom relay hardware (GFE)

The MAVEN team is an experienced integrated team

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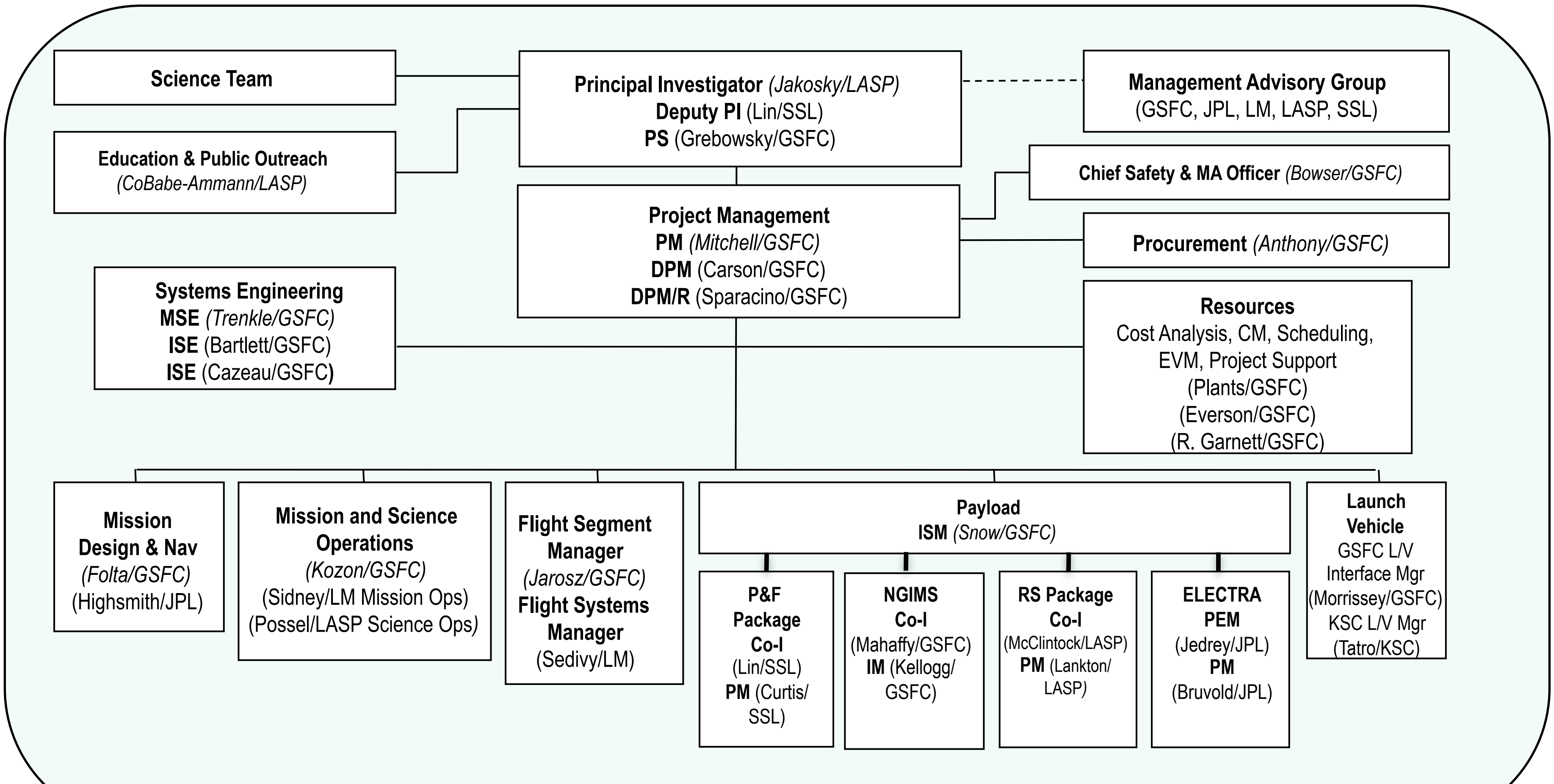
Project Organization Chart



Every segment lead is only one level away from the project manager

NOTE: Leads are shown in Italics

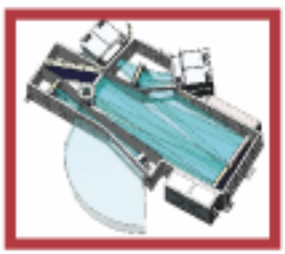
MAVEN Science Instruments

Mass Spectrometry Instrument

NGIMS

Neutral Gas and Ion Mass Spectrometer

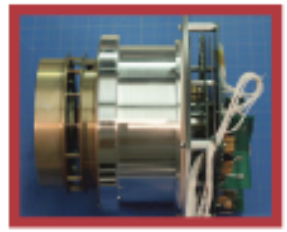
Remote-Sensing Package



IUVS

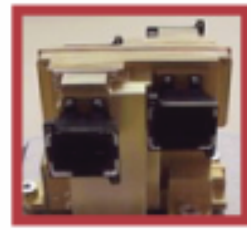
Imaging Ultraviolet Spectrometer

Particles and Fields Package



STATIC

Suprathermal and Thermal Ion Composition



SEP

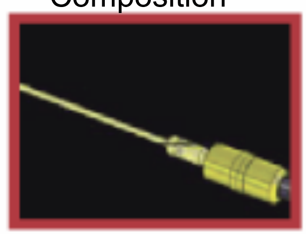
Solar Energetic Particle

SWEA

Solar Wind Electron Analyzer

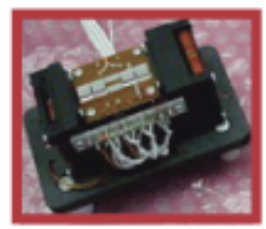
SWIA

Solar Wind Ion Analyzer



LPW

Langmuir Probe and Waves

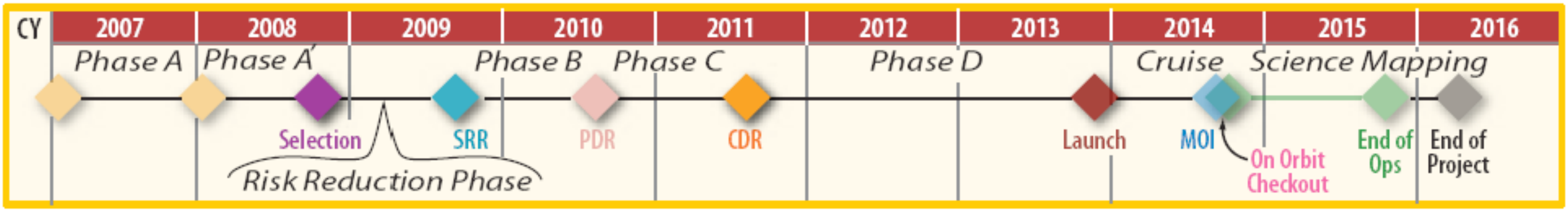


MAG

Magnetometer

The MAVEN instruments are all closely based on similar instruments that have flown on previous missions.

Life Cycle Schedule



5,490 Element Schedule Provides a Detailed Road Map for Completing the MAVEN Mission On-Budget and On-Schedule

Next Steps on the Road to Mars

MAVEN was a big win for CU-LASP, Goddard and the other MAVEN partners. However, we can't rest on our laurels. Challenges, both known and unknown, will present themselves in the 4-year run to launch in 2013. Near term focus areas:

- Refining plans, workarounds/contingencies, and reporting arrangements
  - Now developing the next level of detail in the schedules, metrics, risks, etc.
  - Proceeding with monthly "cadence" of meetings, interactions, reviews
- Retaining the cohesive team as our numbers grow
- Focusing the team on a successful PDR in July 2010 and Confirmation Review in October 2010

Schedule is KING: Every month consumed between now and launch is 2% of our overall schedule. Time is <u>not</u> just money, it is critical to the success of the MAVEN mission

MAVEN

“Teaming for Success”

Mark M. Jarosz
MAVEN Observatory Manager
NASA Goddard Space Flight Center

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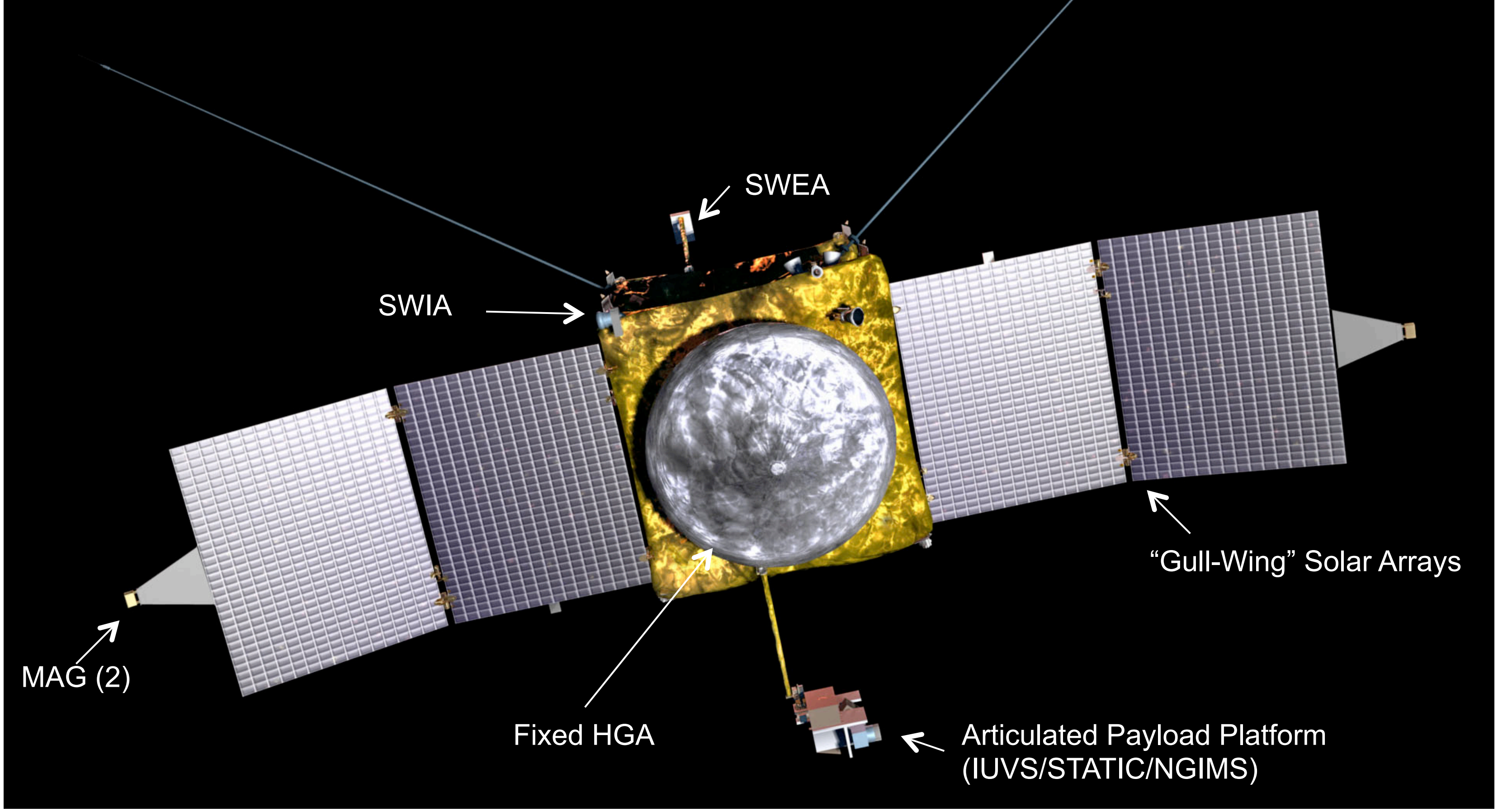
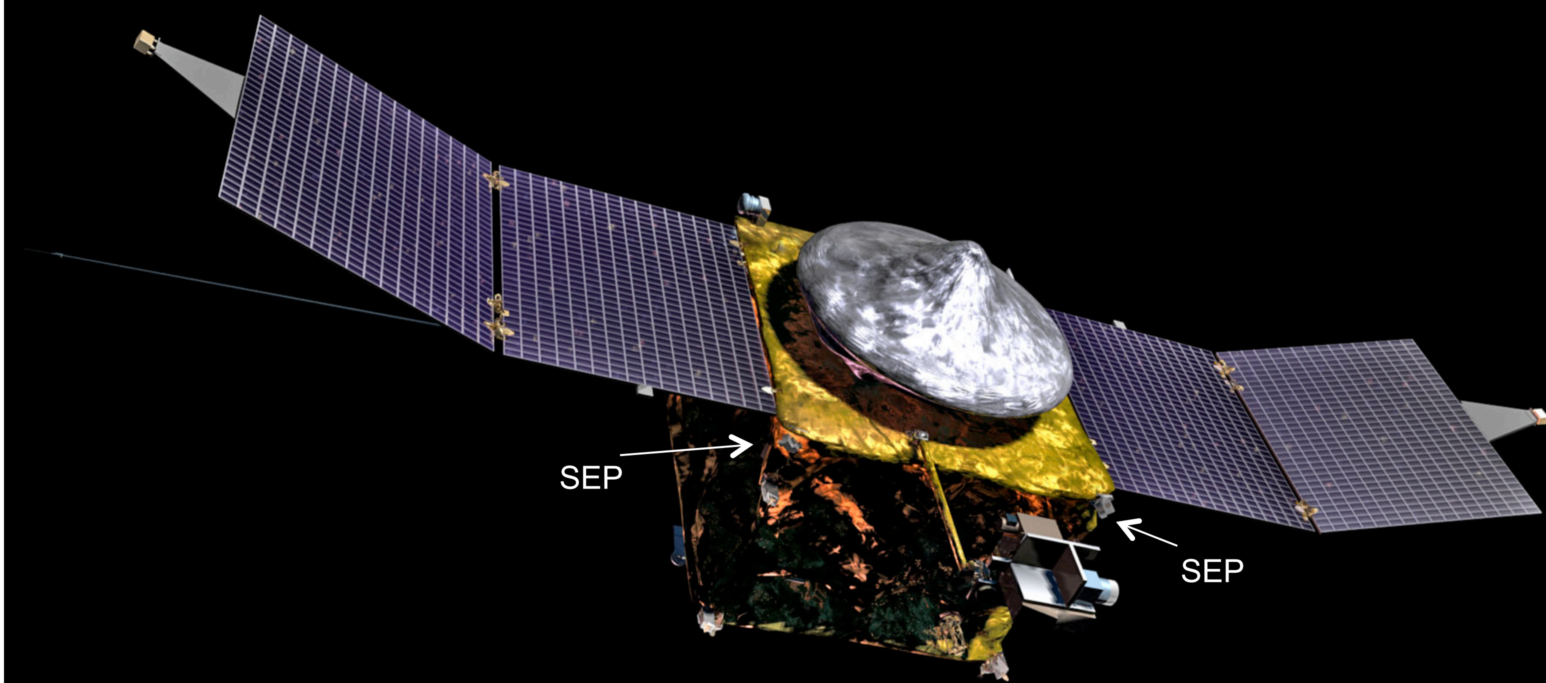
The MAVEN Spacecraft

- **Launch (Wet) Mass: 2550 kg**
- **Spacecraft Dry Mass: 717 kg (807 kg w/ cont.)**
- **Power: 1215 W at Mars Aphelion**



The MAVEN Spacecraft



- **3-axis attitude control**
- **Mono-propellant propulsion system**
- **Single-fault tolerant during all critical events**

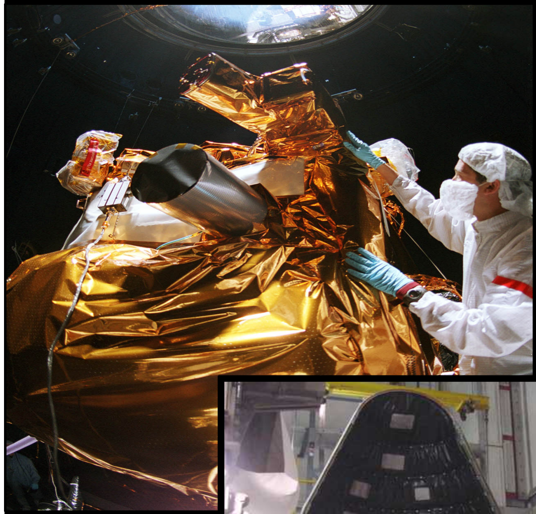
The MAVEN Spacecraft

- The simple spacecraft design is based on several generations of Lockheed-Martin Mars orbiters. MRO spacecraft derivative.
- The Sun-pointing spacecraft with articulated payload platform accommodates both sun-oriented and planet-oriented instruments and their fields of view.
- The spacecraft is optimized to operate effectively in the required orbit and meet the challenges of upper atmospheric science at Mars.
- The spacecraft has large technical margins, an absence of credible single-point failures, and a fault-tolerant Mars Orbit Insertion (MOI) design.
- Smart use of heritage components provides for low implementation risk without over-constraining the design.
- Healthy margins in all areas ensure that implementation issues do not turn into mission risks.

System design emphasizes a low risk approach

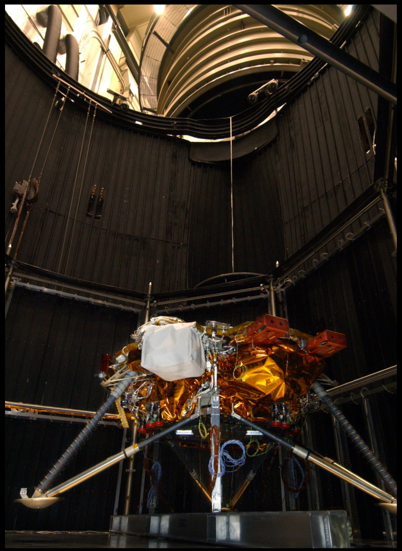
MAVEN

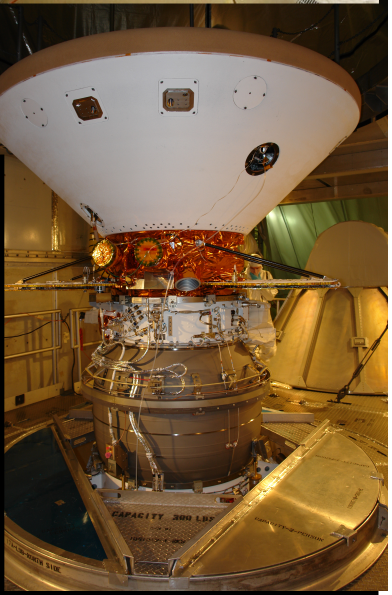
Odyssey



MRO

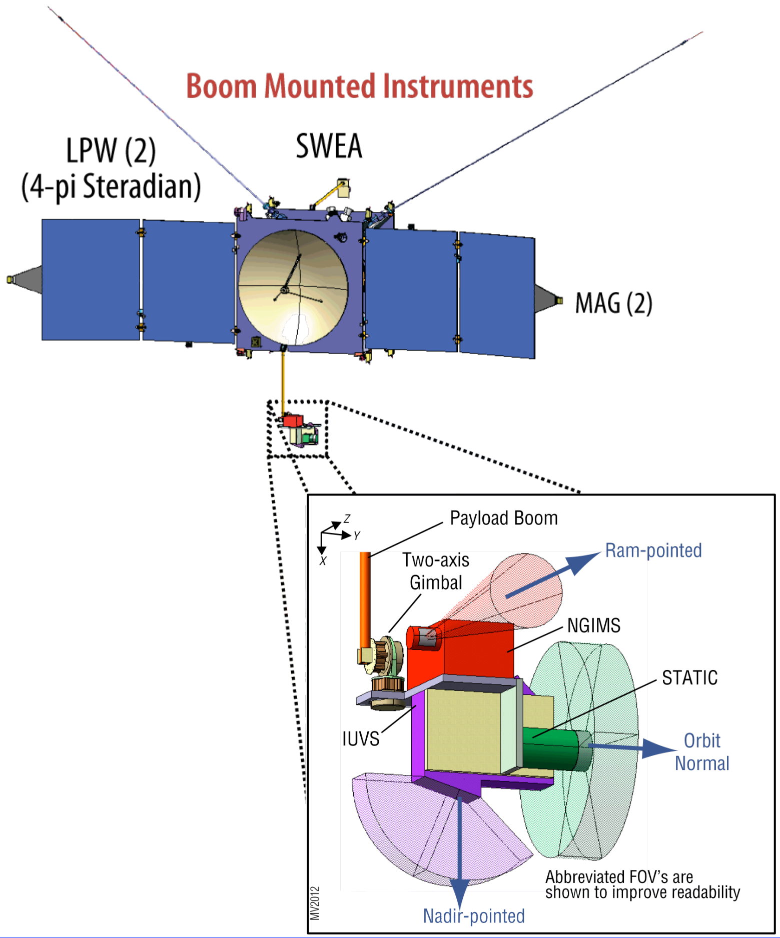
Phoenix

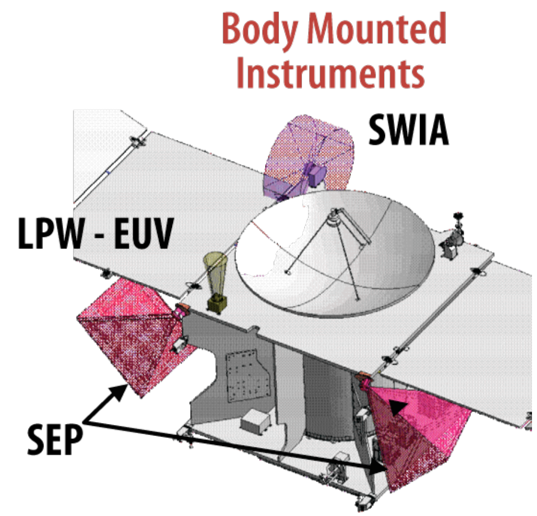




Spacecraft will leverage off LM heritage designs and Mars experience to help find definitive answers about Mars' climate history.

Instruments Located for Maximum Performance





Highly capable spacecraft
- emphasizes heritage
- selected redundancy

Open Bus Architecture with Clear Payload Fields of View

Flight System Block Diagram

MAVEN
Mars Atmosphere and Volatile Evolution Mission
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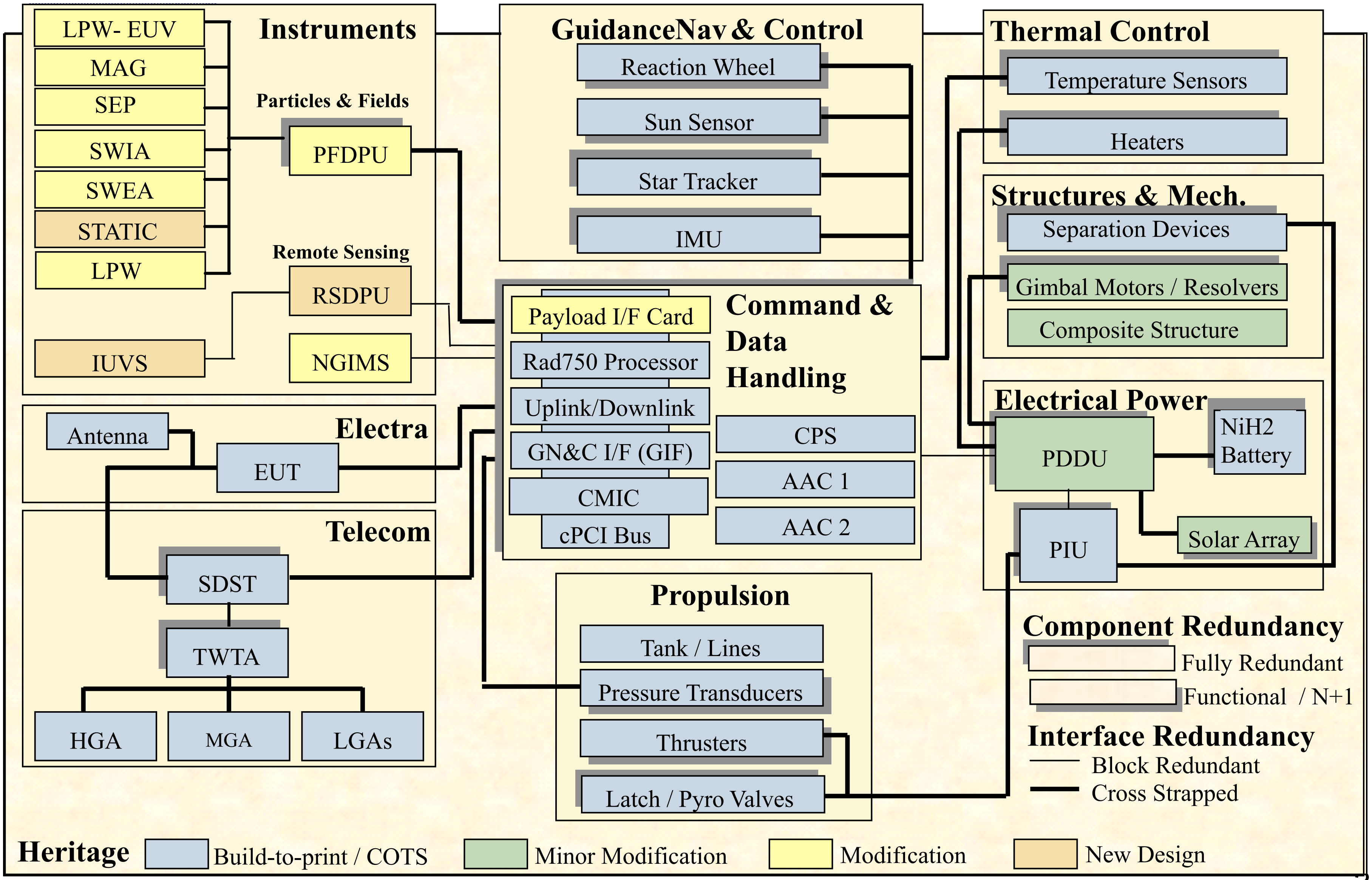


Launch Vehicle / Strategy

Launch Vehicle Description

- EELV Class Launch Vehicle – Vehicle type is TBD
- S/C currently Maintains Compatibility with Delta IV / Altas V
  - Maximum Injected Mass = 2720 kg
  - 4m Fairing
  - 47 in Clamp band I/F
- MAVEN Launch Mass = ***2550 kg***

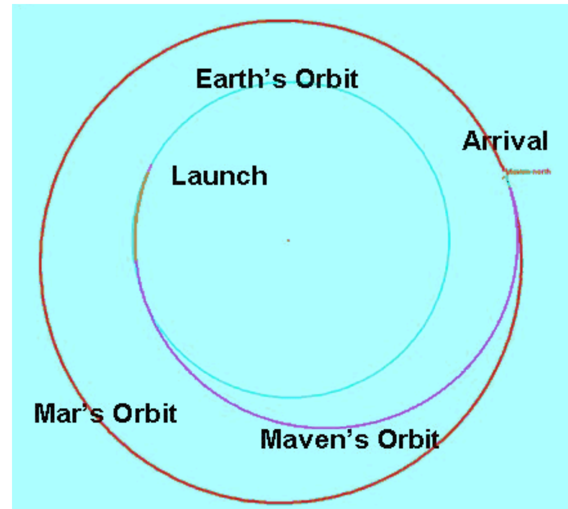
Launch Strategy

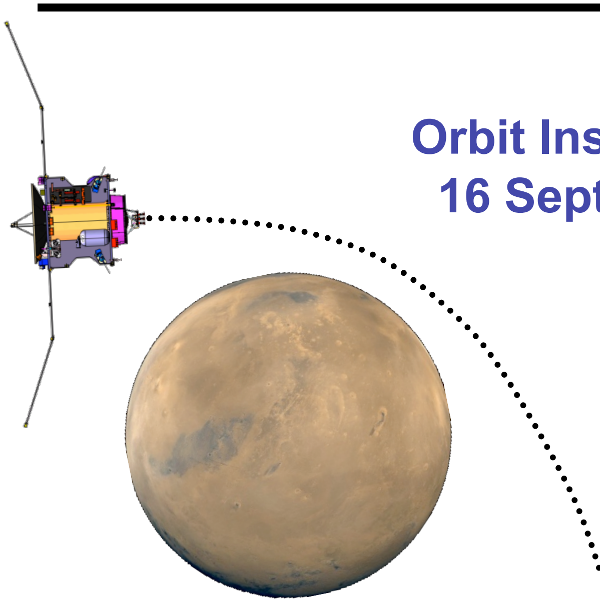
- Launch Period: 11/18 - 12/7/2013 (20 days)
- Daily Launch Window (compatible with either):
  - 2 Hour Continuous (Atlas V)
  - Instantaneous (Delta-IV)
- Additional LV capability will be used to extend Launch Period, Launch Window, etc. when LV provider is selected

MAVEN Mission Architecture

Launch:
November 18, 2013

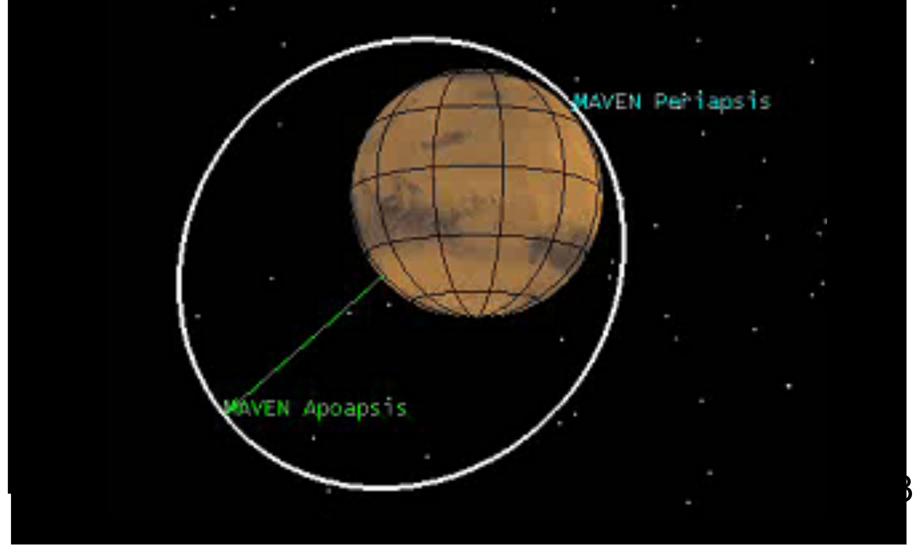
Ten Month Ballistic Cruise to Mars





Orbit Insertion:
16 Sept 2014

One Year of Science Operations



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Mission and Science Operations Will Utilize Existing Facilities

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 by the MAVEN operations team.

LASP Mission Operations Center

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Safety & Mission Assurance

S&MA team has worked together successfully since project inception:

- Membership includes all MAVEN partner institutions
- Training and certifications per NASA Standards; Flow down requirements to all levels; Closed loop problem/failure reporting
- SMA Teams have flight experience and past working knowledge (strong teams)
- ***Mission Assurance Requirements (MAR) discussions took place early in Phase A which helped create a better MAR document – Approved and released***

Emphasis on Quality, Software, Parts, Materials, Safety, Reliability

- Project and Developer engineering teams working side-by-side (including Control Boards)
- Independent non-biased teams assessing hardware and software integrity

Supporting Oversight Organizations:

- NASA Contractor Assurance Service (NCAS) – Dedicated to the MAVEN Project
- Defense Contract Management Agency (DCMA)
- NASA Independent Verification and Validation Facility (NASA IV&V)

Integrated S&MA Team Ensures Open Exchange of Information and Consistent Processes Across the Organizations

Teaming

- CU/LASP, GSFC, LM and the rest of the MAVEN partners had significant presence during proposal development. Goal is to maintain that strong team relationship.
- COTR Roles and Responsibilities
  - Maintain “Balance” of contract duties vs. team relationship
- Capitalize on “All” team members expertise
  - Badgeless Environment
  - Empowerment
- Insight vs. Oversight
  - Don’t overlook other ways of doing business.
  - Open minded perspective
  - Look at lessons of missions such as MRO, STEREO, GOES, Quickscat, etc.
- Try to avoid the typical Government/Contractor relationship
  - Bring something to the table – “don’t just eat at it”
  - Like Marriage – “Communication is Key”
- Evaluate and adjust operating modes of doing business at key milestones in the project life cycle (i.e. Phase C/D, ATLO, Launch Ops)

“Teaming Makes it Happen”

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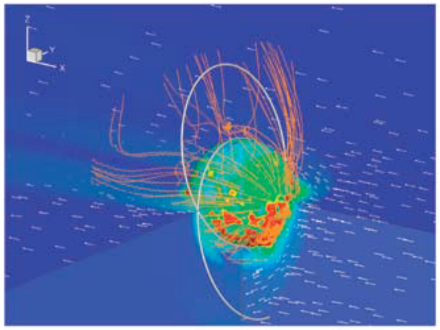
Mission Description Summary



Mission Objectives

Determine the role that loss of volatiles from the Mars atmosphere to space has played through time, allowing us to understand the histories of Mars' atmosphere and climate, liquid water, and planetary habitability

- Determine the current state of the upper atmosphere, ionosphere, and interactions with the 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
- SSL – Deputy PI; Particles and Fields Package management; STATIC, SEP, SWIA, and SWEA instruments; LPW probes and booms (CESR provides the sensor for SWEA)
- LM – spacecraft; assembly, test and launch operations; mission operations
- JPL – navigation; DSN (Mars Program Office is at JPL)

Launch

- To be launched from KSC on an EELV between November 18 and December 7, 2013
- Mars Orbit Insertion on September 16, 2014 (for 11/18 launch)

Website http://lasp.colorado.edu/MAVEN

Mission Overview

- 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 previously unobtainable 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