Mars Ion and Sputtering Escape Network (MISEN)

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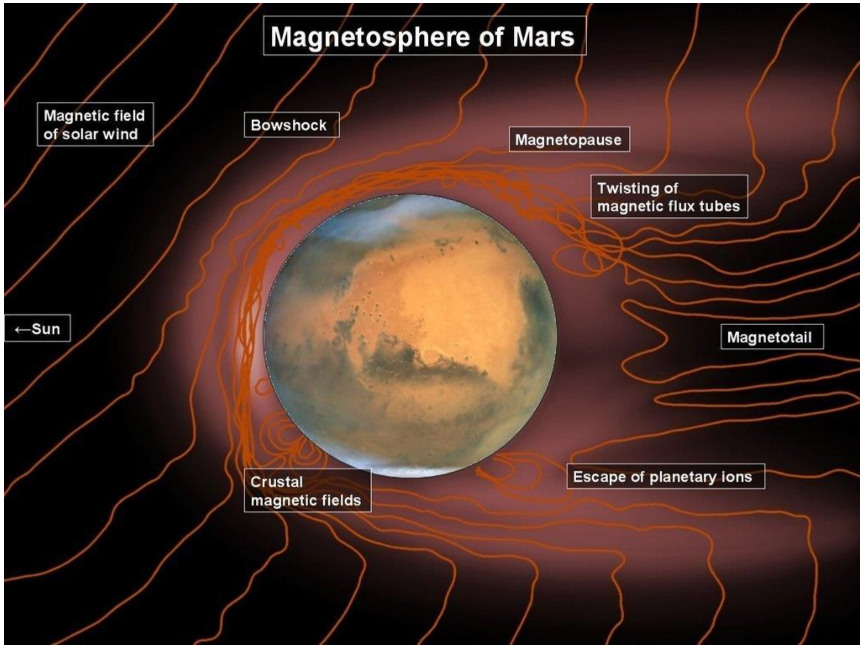
Outline

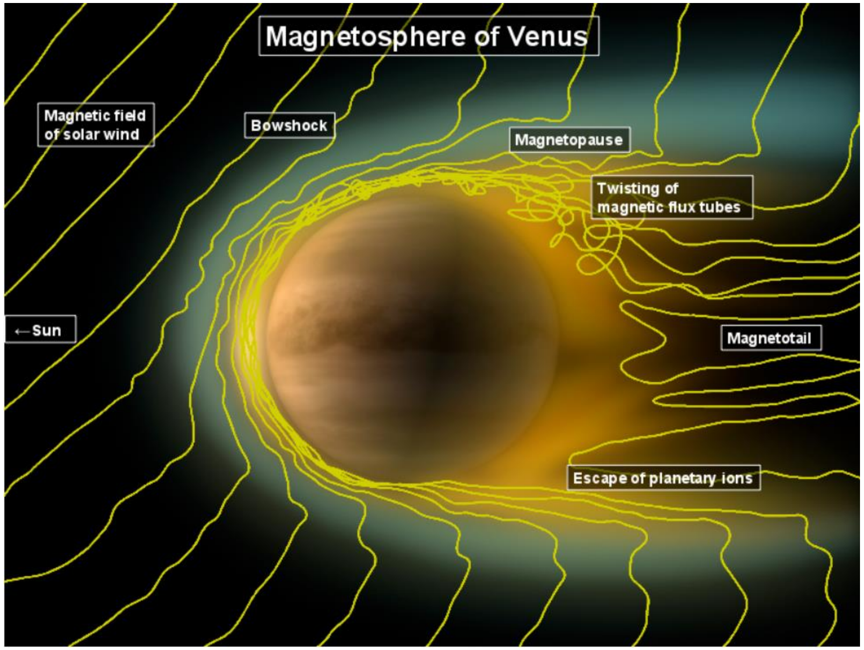
- The Science Gap: why planetary aeronomy needs multi-point measurements.
- The MISEN Mission Concept for PSDS3
  - Science Objectives
  - Science Payload
  - Mission Design/Architecture
  - Mission ops & spacecraft
  - Mission Team

NOTE: two other similar competing missions for SIMPLEX-II: some details omitted

Plasma & magnetic field measurements in planetary environments: why do we care?

- Understand the structure, composition, variability and dynamics of planetary magnetospheres (e.g. MAVEN).





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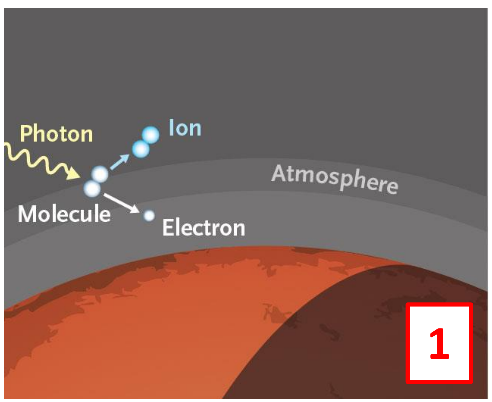

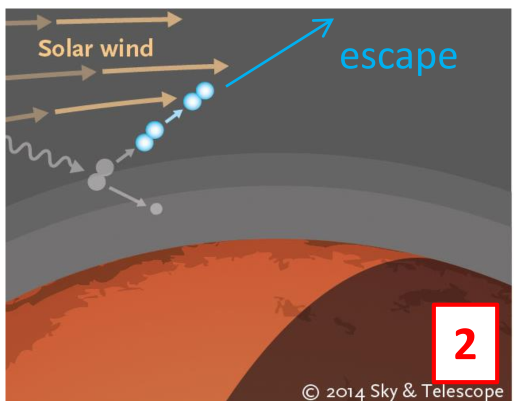

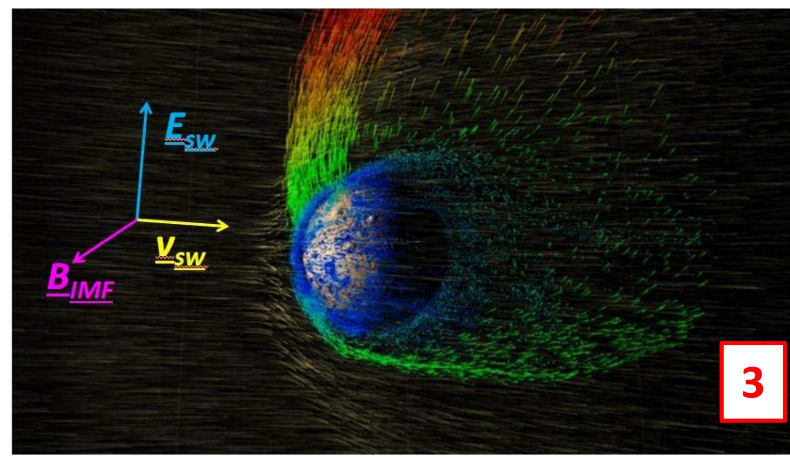

Pickup Ion Escape

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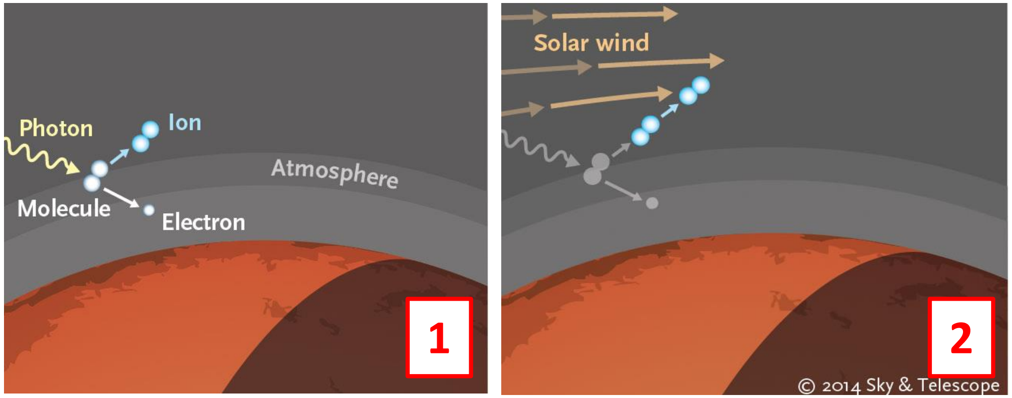

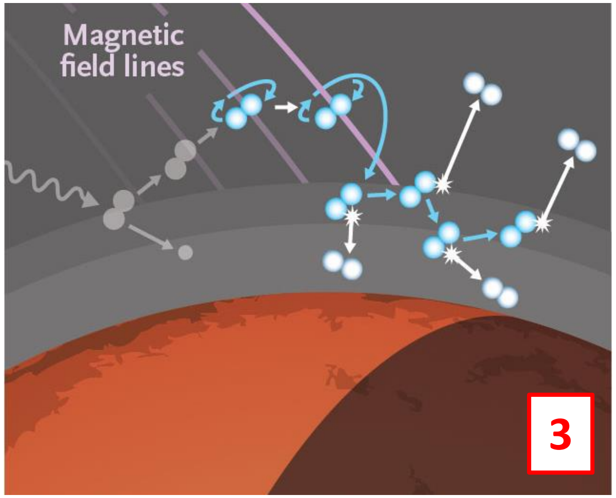

Sputtering Escape

A single measurement platform leaves major questions unanswered

a) spatial and temporal variations in escape fluxes cannot be distinguished

b) responses of escape fluxes to changing solar wind conditions (~1 minute) can only be measured with a time-lag of an hour or (much) more

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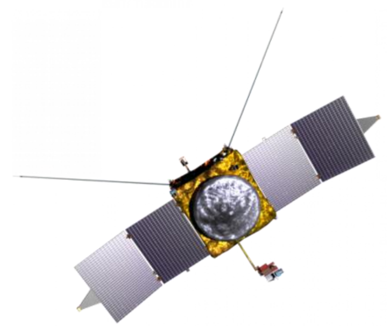
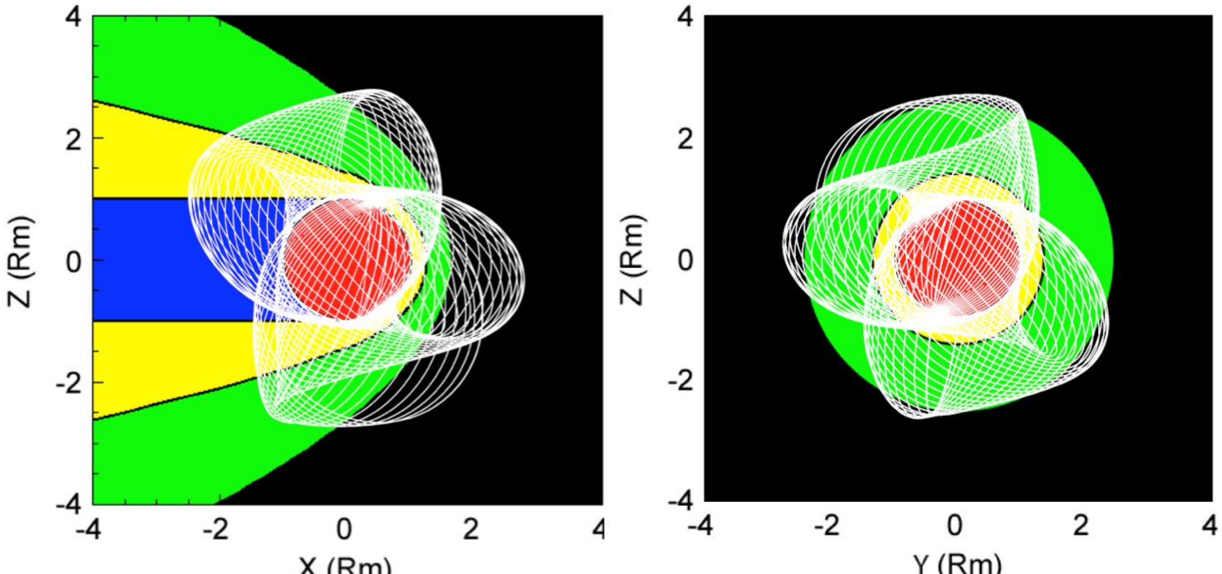
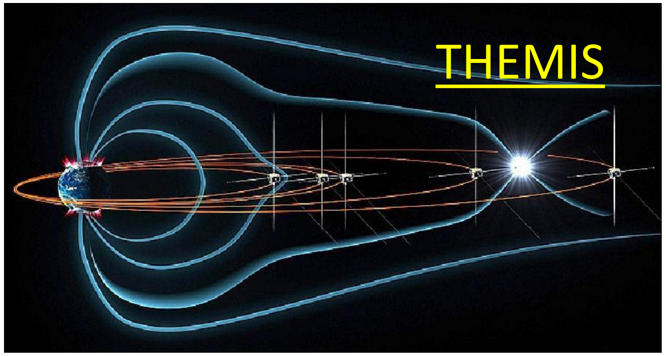
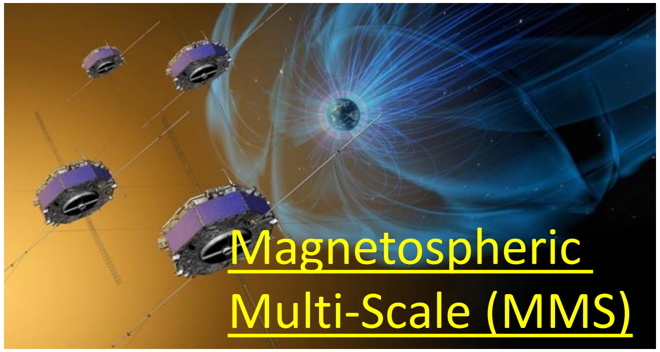


MAVEN's precessing orbit

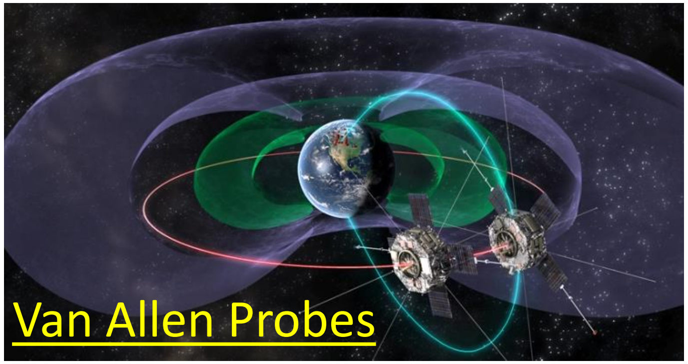


A Multi-spacecraft Revolution





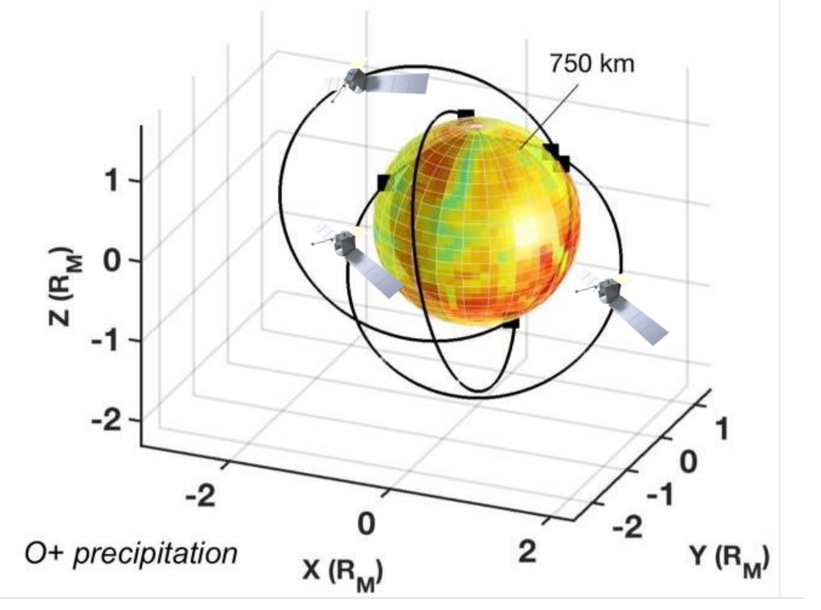
- The same problem faced terrestrial space plasma physics in the 1980s, early 1990s.
- Single spacecraft couldn’t characterize plasma boundary dynamics.
- Multiple spacecraft allow the 3D, time-resolved measurements to create a realistic picture of the magnetosphere and how solar wind conditions affect it.
- Similarly, multiple spacecraft are the next step in understanding the solar wind interaction with unmagnetized bodies like Mars.



MISEN Objective and Concept

- Science Objective: Characterize the magnitude, structure and variability and real-time response to changing solar wind conditions, of ion escape and precipitation at Mars.

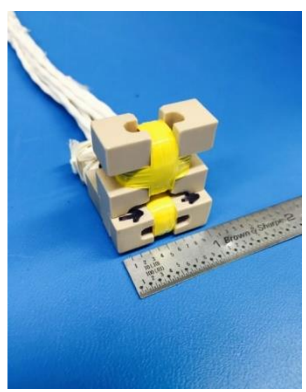
- In-situ measurements of ions, electrons and magnetic field.
- Three smallsats:
  - elliptical orbits (~250 x 7000 km)
  - Spaced in argument of periapsis, RAAN, and phased to ensure:
    - upstream solar wind measurements >90% of the time.
    - Simultaneous measurements of the different plasma regimes surrounding Mars.



Science Payload

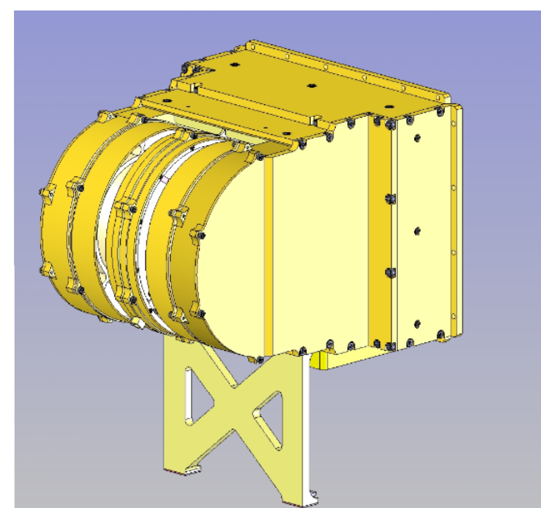
M-MAG (MISEN Magnetometer)

- Developed by UCLA (C. Russell)
- Clone of Insight Mars magnetometer
- Two mounted on boom (90 cm) i.e. gradiometer configuration
- 0.3U, 144 g, 0.8 W per sensor
- ±8000 nT range
- 48 bits per readout up to 64 Hz



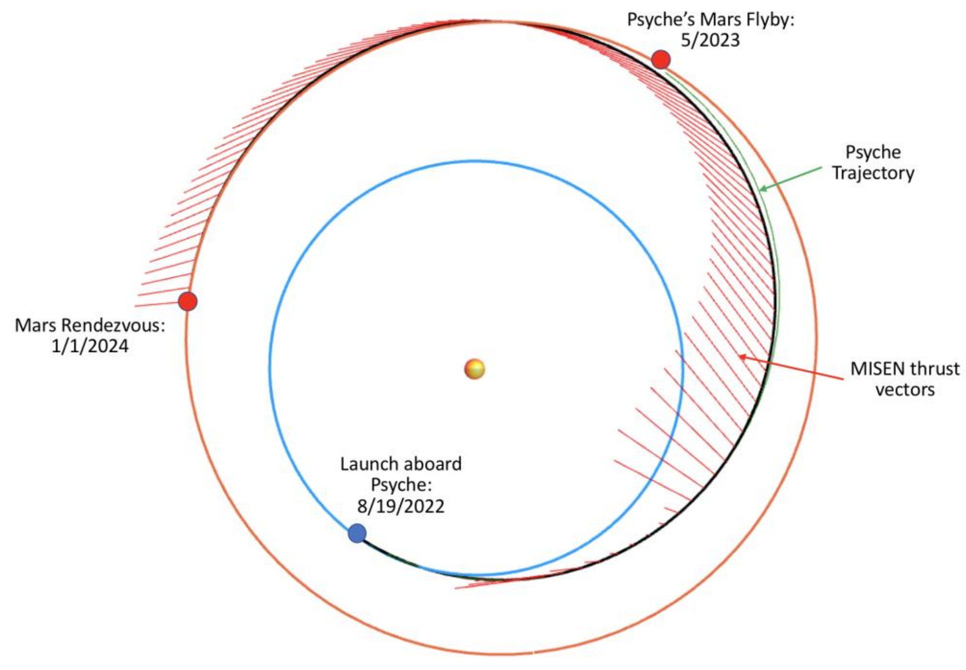
MESA (MISEN electrostatic analyzer)

- UCB/SSL heritage design, ion & electron analyzer
- 1.8 kg, 1.7 W.
- 4π FOV via spinning platform
- 22.5° x 6°, 3 eV-25 keV range
- DE/E = 18%
- Light-vs-heavy mass differentiation achieved through pulse height analysis.



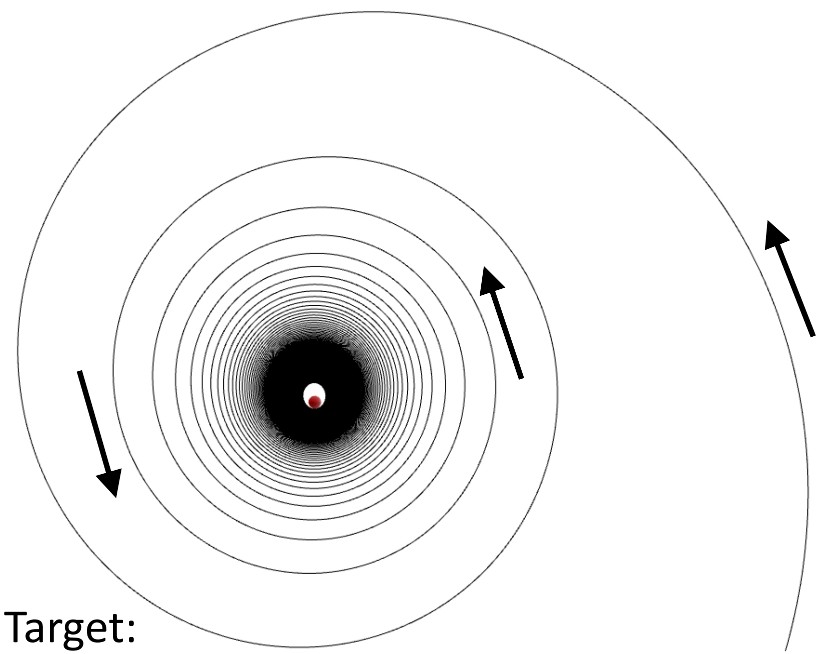
Mission Design 1: Cruise

- Separate from primary on lunar or Earth-escape trajectory.
- Point Mission Design is for Psyche ride-share (launch 08/2022).
- 15 month electric propulsion cruise to Mars rendezvous.
- Near-constant thrusting, no spinning.
- Regular DSN contacts.



Mission Design 2: Spiral Down to Science

- Match Mars' orbit and cross its sphere of influence.
- Each spacecraft guided to its own orbital plane.
- Switch to Mars-centered Conops/Nav
- 11 months of spiraling
- End in science orbits
- Full instrument commissioning



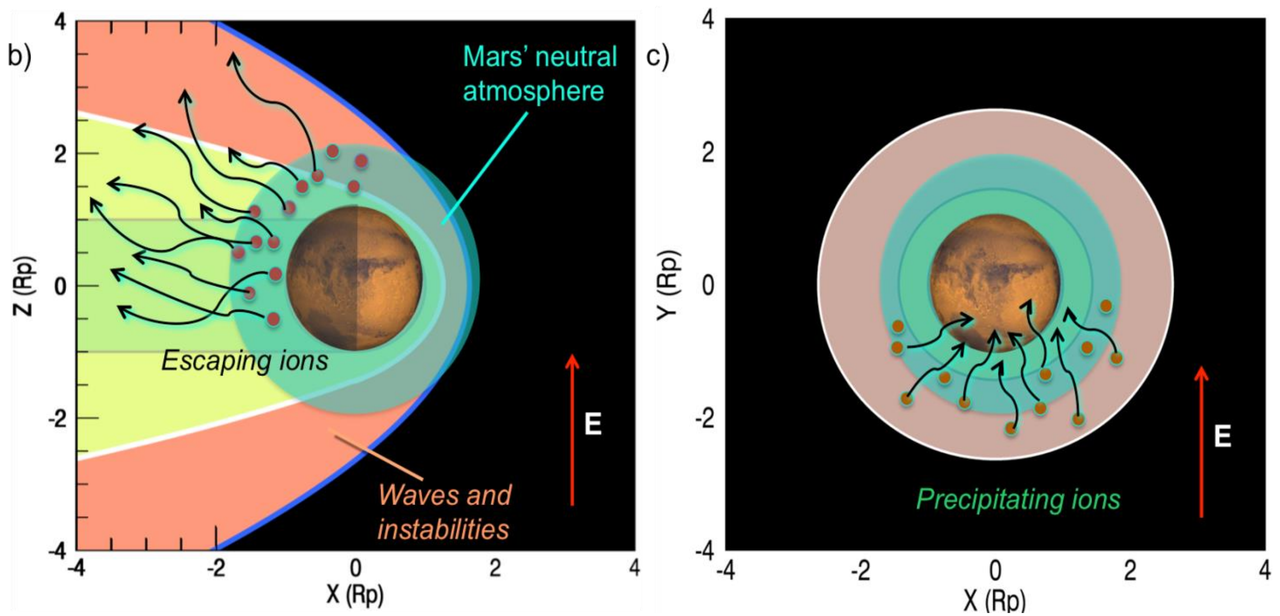
Each spacecraft approaches Mars in its own plane, spiraling to its own target orbit.

Target:
250 x 7000 km

~100,000 km

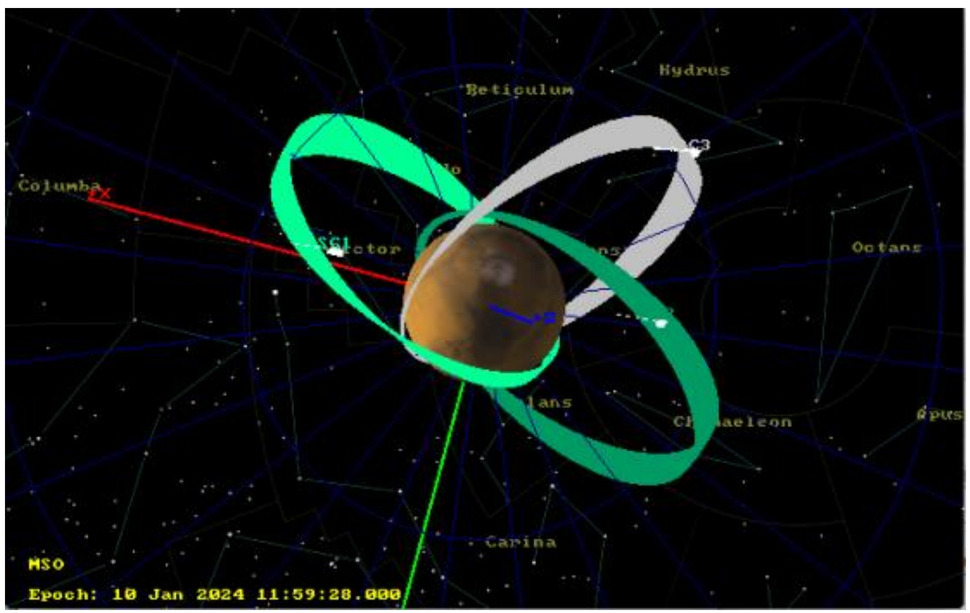
Mission Design 3: Science Orbits

- Elliptical orbits:
  - High enough to ensure outward particles are escaping.
  - Low enough to ensure inward particles are precipitating.



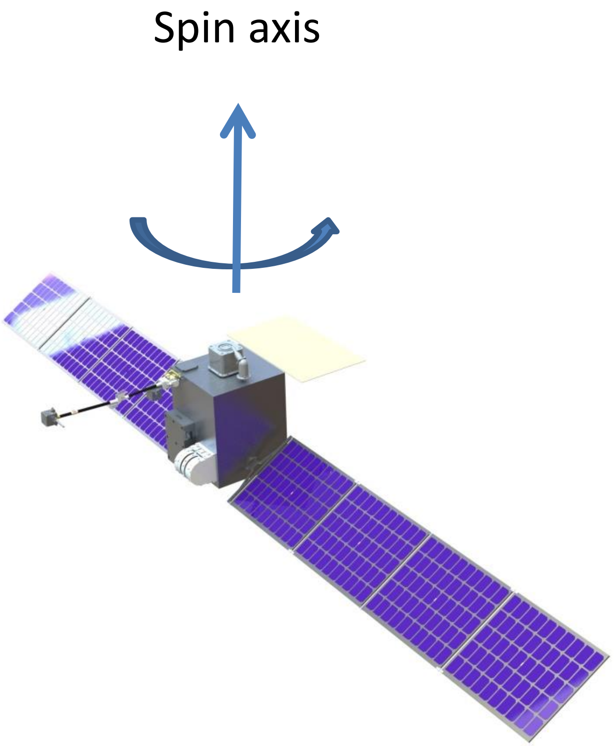
Mission Design 3: Science Orbits

- Elliptical orbits:
  - High enough to ensure outward particles are escaping.
  - Low enough to ensure inward particles are precipitating.
  - RAANs, AoPs chosen so sufficient coverage of Mars’ different plasma regions is maintained as orbits precess over a 1-year primary mission.



Orbits are stable, though will need ~monthly phasing maneuvers

Spacecraft Ops and architecture

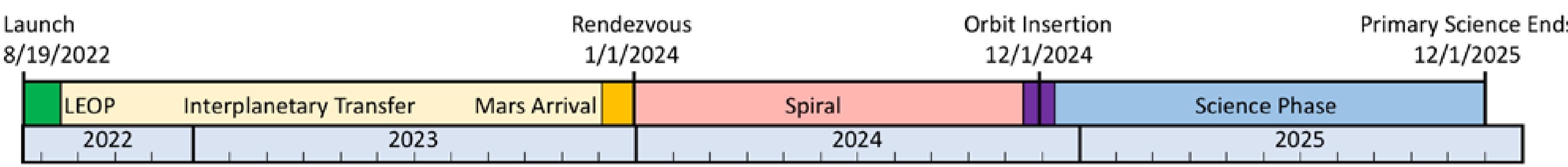


Ops:

- Three axis stabilized until science orbit.
- Spinning at 16s period after that
- Ops are simple: data collection is ‘dumb’ and continues indefinitely
- ~Weekly downlinks

Spacecraft:

- SC volume depends on launch point.
- Gimballed solar panels
- IRIS radio X or Ka-band
- MarCO style antenna



MISEN Study Team

<u>UC Berkeley Space Sciences Lab</u>

- PI: *Rob Lillis*
- Project Scientist: *Shannon Curry*
- Systems Engineering & Management: *Dave Curtis*
- Ion & electron analyzer: *Davin Larson, Roberto Livi, Phyllis Whittlesley*
- Science advisory: *Janet Luhmann*

<u>UCLA Earth and Space Sciences</u>

- Magnetometer: *Chris Russell*
- MHD modeling: *Yingjuan Ma*

<u>Advanced Space LLC</u>

- Mission Design & Navigation: *Jeff Parker & Nathan Parrish*

<u>Tyvak LLC</u>

- Spacecraft bus & subsystems: *Jordi Suig-Puari, Angelo Lopez*

<u>University of Colorado Boulder</u>

- Science advisory: *David Brain*

Summary

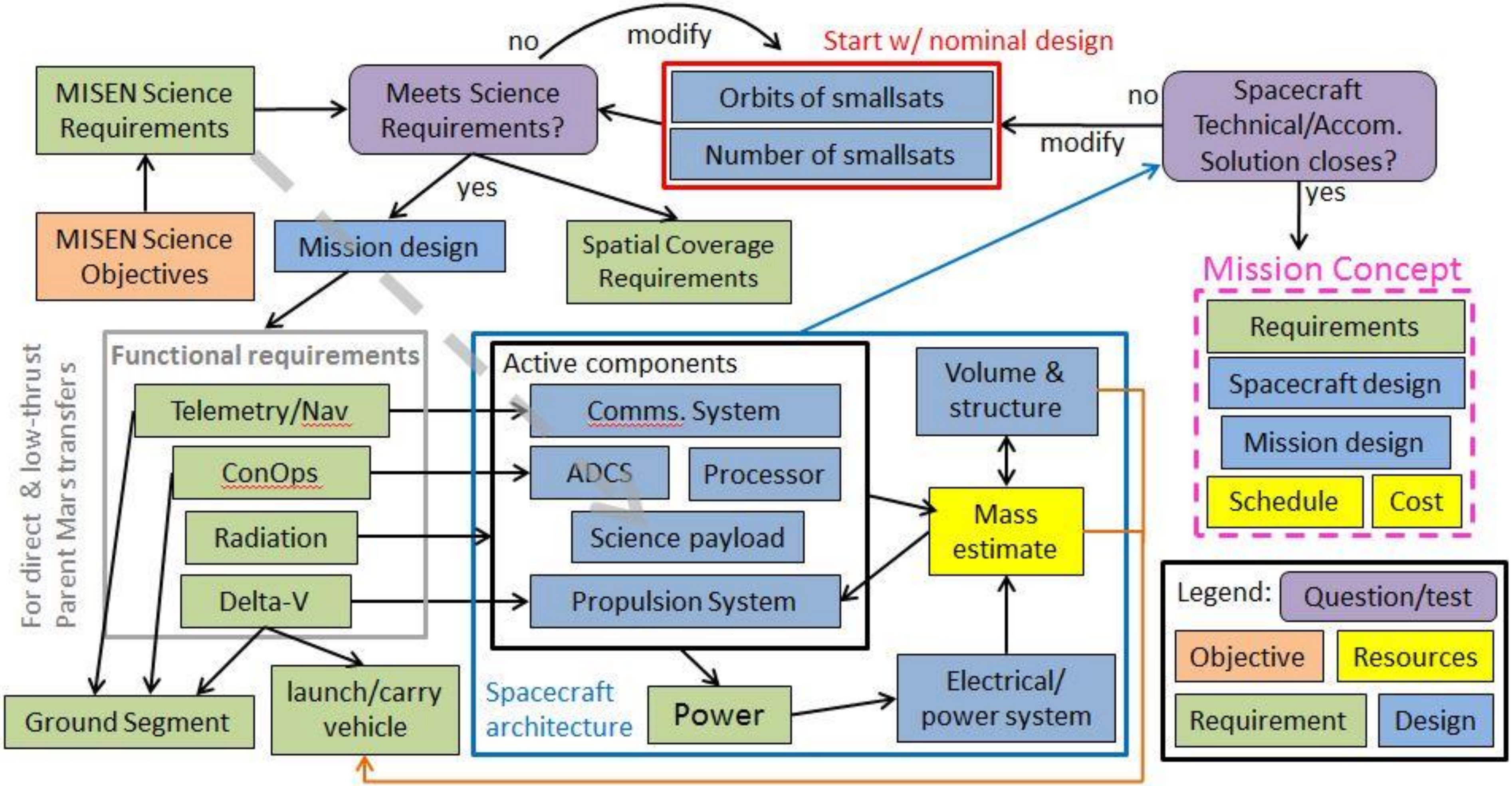
MISEN will:

- Provide simultaneous multi-point measurements of the Martian plasma environment.
- Elucidate the real-time response of the this environment to solar wind changes & disturbances (CMEs, SEPs etc)
- Reveal for the first time the global structure of ion and sputtering escape and how and why it varies.
- Build on MAVEN's legacy for a fraction of the cost.

THANK YOU to the PSDS3 Program!

BACKUP SLIDES

Feasibility Study flowchart



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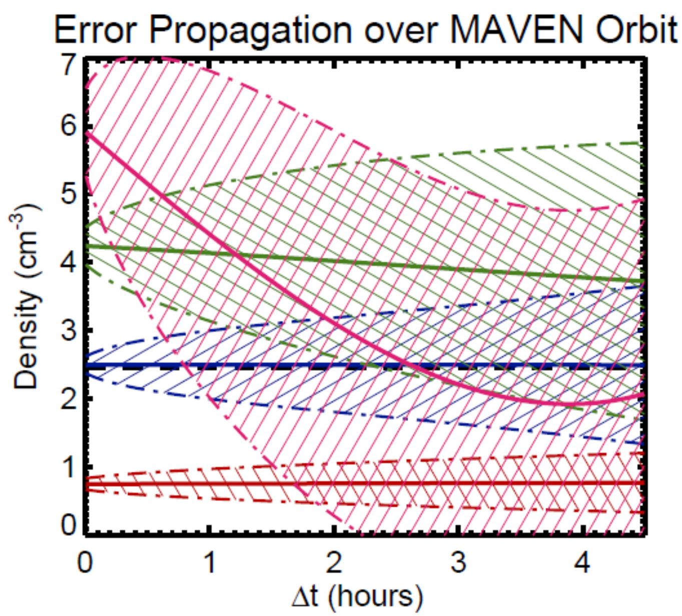

Credit: M. Marquette