



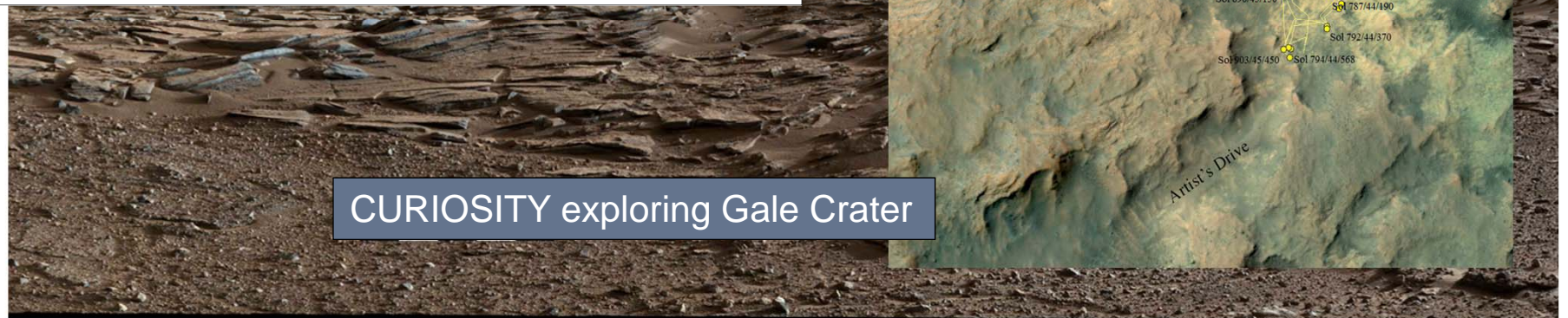
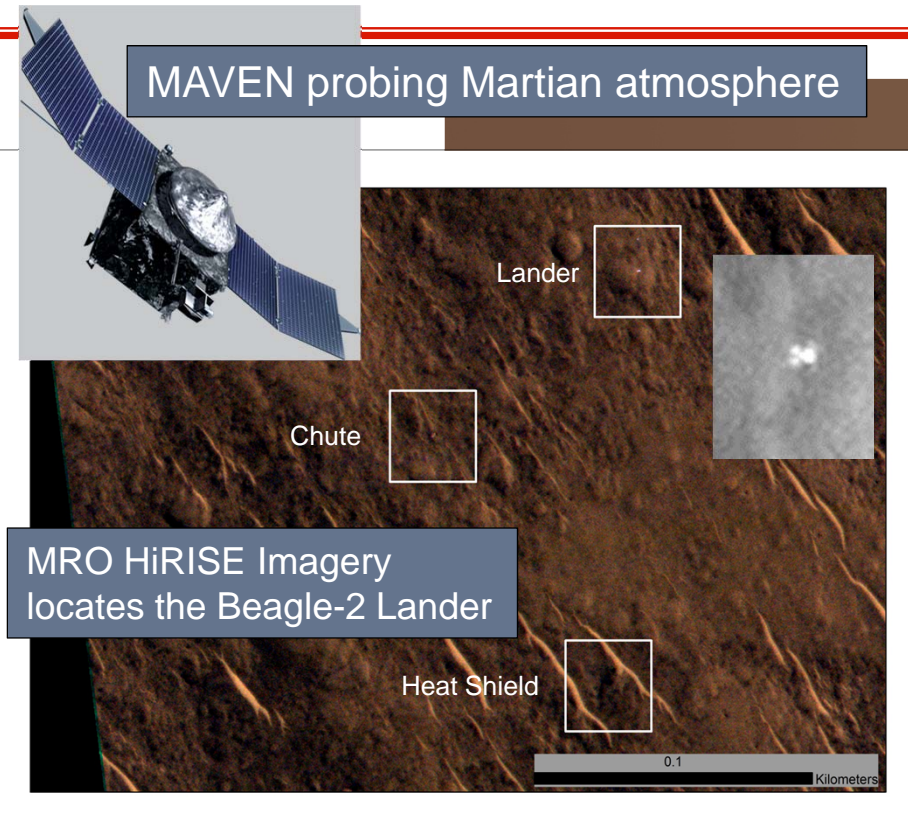
Mars Exploration Program (MEP) Program Update

Presented to:
Committee on Astrobiology & Planetary Science
Space Studies Board
National Research Council

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MEP Highlights at Mars



Mars Exploration Program Status - Summary

Overall, the state-of-the-MEP is good

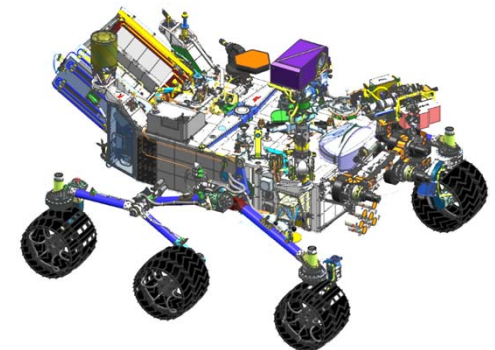
- Our operational assets remain healthy and productive:
 - MAVEN having productive primary mission
 - Odyssey continues to provide thermal imagery and data relay services while drifting to a new orbit to diversify observations
 - MRO continues to provide reconnaissance imaging for surface operations, conduct landing site surveys for the Mars 2020 and ExoMars rovers, and provide mineralogical data
 - Opportunity rover continues to produce valuable ground truth data to validate orbital remote sensing
 - Curiosity is now intensely exploring the base of Mt Sharp in Gale Crater. Percussive drill operations temporarily suspended while intermittent short anomaly being investigated
- Two significant development activities are underway:
 - Mars 2020 has passed SRR/MDR and is proceeding to KDP-B
 - MOMA-MS, a NASA partnered contribution for the 2018 ExoMars Lander, is in flight fabrication and assembly
- We are meeting our international commitments:
 - Continuing to operate our collaborative deep radar sounder (MARSIS) on Mars Express
 - Delivered & integrated 2 Electra payloads to the ESA Trace Gas Orbiter
 - Continue to work towards a 2016 launch
 - ISRO has joined us in Mars orbit. We are looking forward to building a stronger relationship as they consider returning to Mars with a subsequent mission.
 - MAVEN now collaborating with their MOM mission.
- Financially, the program is doing better, but continued attention is needed for the future:
 - In FY15, having received slightly more from Congress than requested, all our planned activities will be funded
 - In FY16, the President's budget again supports MEP well, allowing us to keep Mars 2020 on track

Mars Exploration Program Science

- **Science Increasing Understanding of the Martian System**
 - Comet Siding Spring observations
 - MAVEN measured metallic signatures of comet dust in upper atmosphere
 - Mars Express/MARSIS observed transient comet-induced ionosphere ~100km
 - MAVEN observations revealed new phenomena
 - High-altitude day side dust cloud near terminator
 - Broadly distributed diffuse low altitude aurora reaching deep into the Martian atmosphere
 - Atmospheric energy exchange with solar wind
 - MRO & Mars Express observations expanding understanding of CO₂ in Martian environment
 - Greater presence of subsurface ice
 - High altitude CO₂ ice clouds
 - CURIOUSITY traversed to the slopes of Mt. Sharp and is continuing ongoing analytical measurements
 - Curiosity measured variations in methane abundance on the traverse to Mt. Sharp
 - Now exploring a hypothesis that tilted sediment beds on Gale Crater's plains indicate fluvial transport of sediment toward Mount Sharp, building up from ancient streams & lakes
 - SAM instrument made the first detection of Martian organics and nitrates
 - OPPORTUNITY examining rock diversity on Cape Tribulation overlooking Marathon Valley
- **Progress being made on Landing Site Observations**
 - MRO has satisfied ~50% of all current landing site characterization requests for InSight, ExoMars, & Mars 2020 missions
 - Mars 2020 2nd Landing Site Workshop - Summer 2015

Mars 2020 Update – Phase A Progress

- ❑ Completed the System Requirements Review / Mission Definition Review milestone that marks the end of Phase A
 - Completed instrument accommodation reviews, including implementing design modifications required at selection
 - SRB reported: *“Project is more mature than most in Phase A, ready for KDP-B decision milestone and Phase B start.”*
- ❑ Working detailed engineering and design trades for cache system implementation
- ❑ Heritage hardware (~80-90% of the flight system by mass) is essentially in Phase C/D. Parts buys and procurements for items with low risk of change are proceeding at a fast pace
 - 99% of electronic parts have been ordered allowing early build of heritage flight boards
 - 36 flight boards delivered and in test; 23 flight boards in final assembly; many others in manufacturing queue
- ❑ Published environmental impact statement and issued Record of Decision to baseline radioisotope power system, thus completing compliance with National Environmental Policy Act (NEPA)
- ❑ Upgraded engineering camera design with color and higher resolution than MSL navcam/hazcams
- ❑ Continue to evaluate Terrain Relative Navigation (TRN) capability for potential inclusion

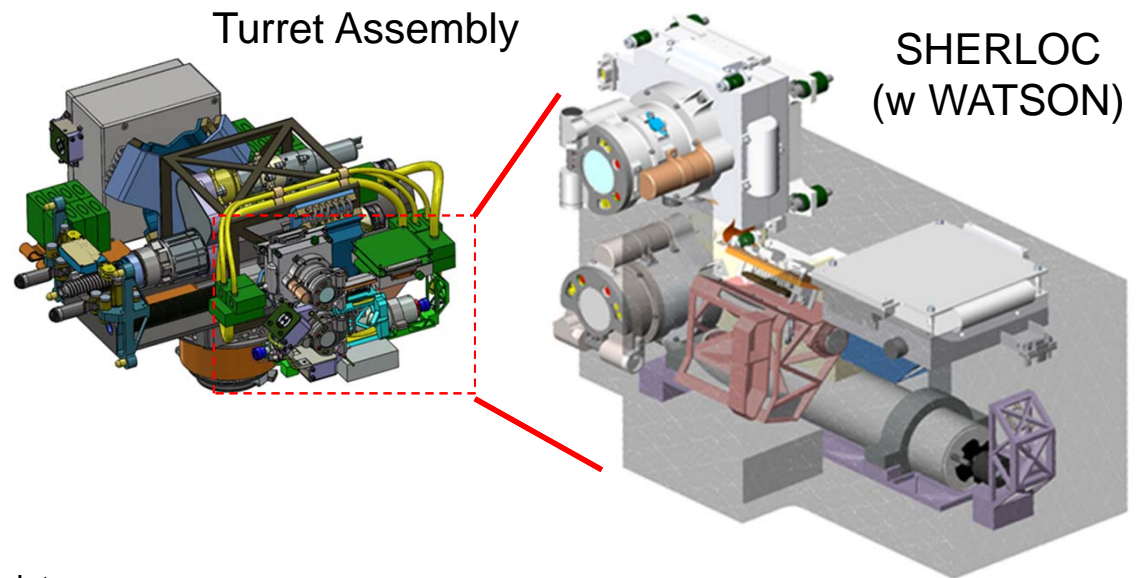


Project has made excellent progress to date, but plenty of challenging work still ahead

Mars 2020 Payload Update

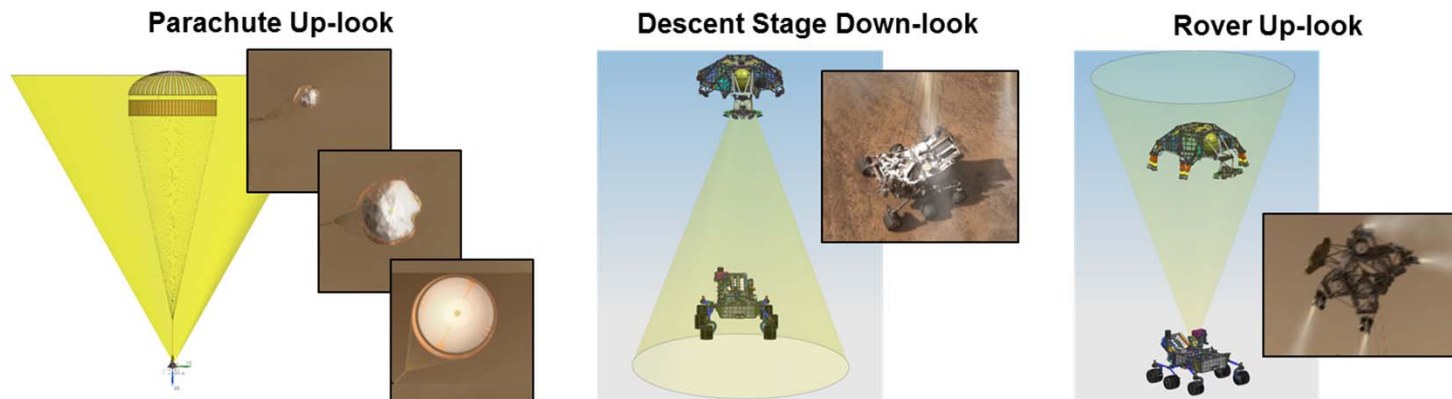
Added Wide Angle Topographic Sensor for Operations and eNgeering (WATSON)

- Augmented turret fine-scale imaging capability by adding MAHLI heritage optic + mux board to SHERLOC instrument
- Provides contextual science and engineering data



Added EDL / Parachute Uplook Cameras

- Improved EDL instrumentation for engineering data
- Parachute up-look, descent stage down-look, & rover up-look cameras



4/1/2015

Mars 2020 Project-6

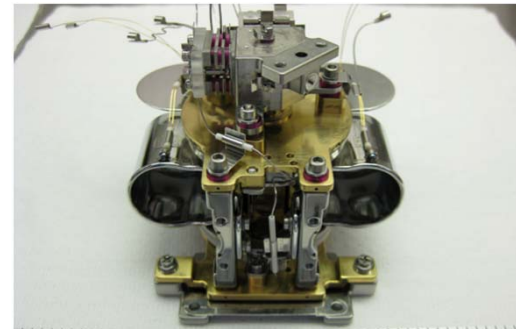
MOMA-MS Development

- **MOMA-MS Progress**

- CDR completed – September 2014
- Flight Model (FM) H/W build underway

- **ExoMars 2018 Mission Progress**

- Mission PDR Completed – October 2014
- System PDR to be completed – May 2015



- **Challenges**

- CNES delivery of MOMA-GC electronics and DLR flight laser significantly delayed due to lack of funding. ESA evaluating impact of delayed delivery on launch schedule vs reduced science if flown without CNES contributions
 - DLR FM laser >10 month delay
 - MOMA-GC FM electronics >17month delay
- MOMA-MS FM delivery to MPS on schedule
 - All schedule reserves utilized
 - Delivery date achievable only if international partner elements can recover lost schedule

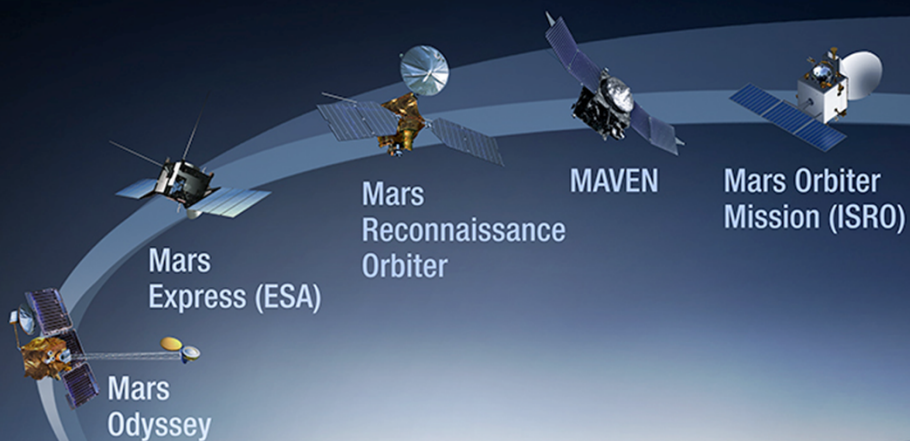
Operational 2001–2015

2016

2018

2020

2022



Follow the Water

Explore Habitability


Seek Signs of Life

Prepare for Future Human Explorers

*Environmental Characterization
Resource and Hazard Identification
Functional Demonstrations at-to-from Mars*

MEP Future Vision

- ❑ **Guiding Themes:** Serve exploration stakeholders through synergistic partnerships:
 - ✓ **Science:** Conduct highest priority science building on Decadal Survey priorities
 - Address keystone scientific questions about planetary habitability and the possibility of life beyond Earth
 - Be agile and robust, able to respond to discovery
 - ✓ **Inform and enable Human Mission design:** Provide knowledge, experience and technology to retire crew safety and operability risks, mature end-to-end systems engineering and continue building operational experience
 - Address key issues to build confidence in round-trip missions to/from Mars
 - Identify and characterize concentrated resources for potential ISRU exploitation
 - Respond to emerging needs
 - ✓ **Infrastructure:** Sustain and improve Mars telecommunications and surface reconnaissance infrastructure
 - ✓ **Technologies:** Capitalize on and validate advanced technical capabilities that inform conceptual designs for future human missions and enable end-to-end Earth/Mars missions with robotic precursors
- ❑ **Implementing Principles:** Timely and responsive approaches that provide affordable solutions:
 - ✓ Incremental steps composed of *Strategic* and *Competed* elements
 - ✓ Leverage and support *integrated partnerships*

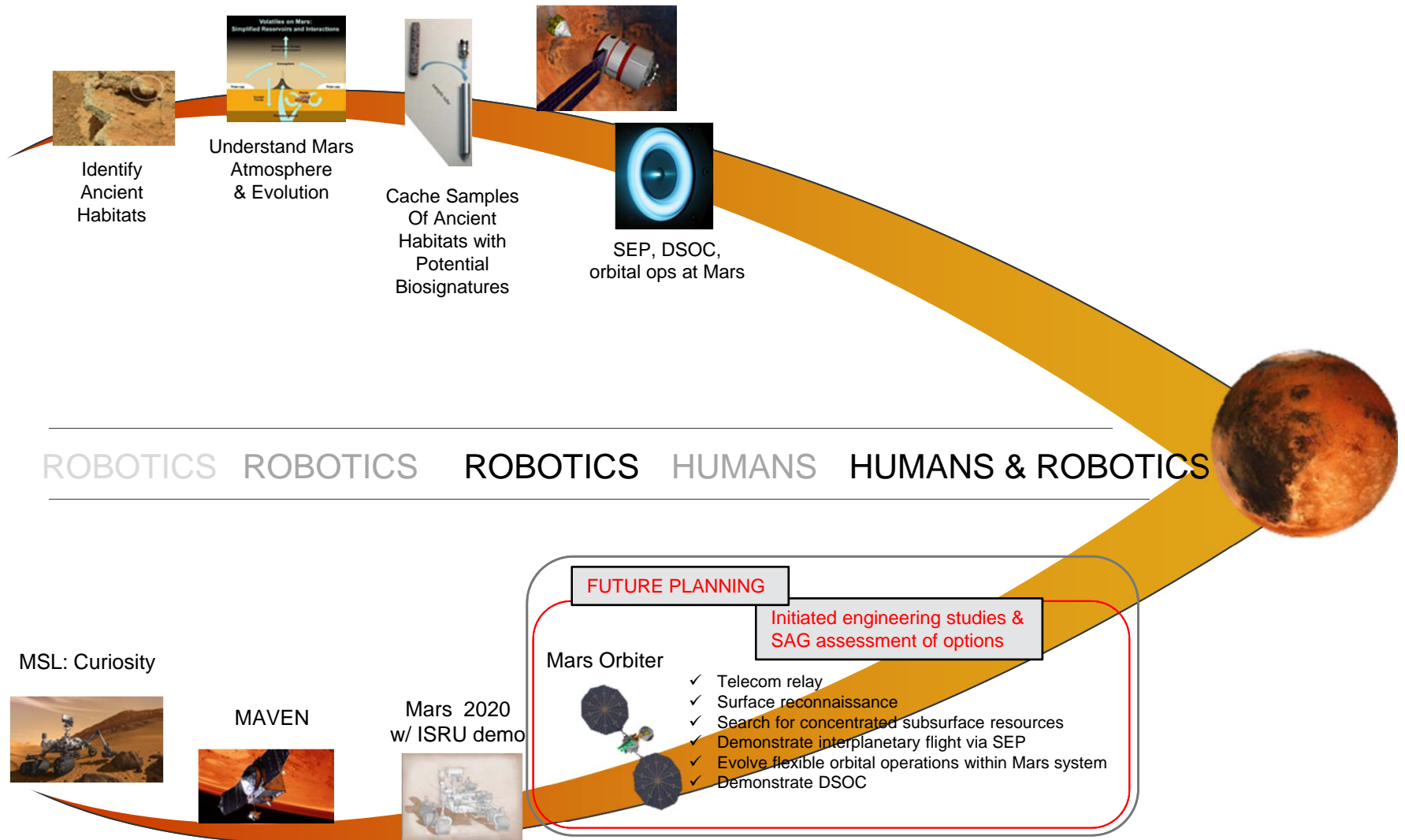


*Initiated a joint
MEP/HEOMD/STMD
working group and
MEPAG SAG to
begin defining
possible pathways*

The 2020's would be a “**transition decade**” that sustains and increases Mars exploration capabilities by embracing new partnerships to leverage and amplify the science driven program elements in a manner that both advances science and promotes technology to help enable broader exploration initiatives across the Agency

Notional Evolution of the MEP

MISSIONS CAPABILITIES



Exploration Partnership Creates the Potential to Affordably Advance Capability

Summary

- ❑ **MEP is healthy and improving**

- ❑ Operational assets returning remarkable science
- ❑ Budget headed towards healthy level
- ❑ Mars 2020 development proceeding well

- ❑ **NRC Decadal Survey science priorities are guiding future planning**

- ❑ Exploring Science/Exploration synergies to produce significant, affordable capability for both
- ❑ Science guided pathways provide natural precursor capability for Exploration needs

- ❑ **The time to begin planning for a MEP future is now** (FY17 Budget cycle)

- ❑ **An Orbiter appears to be the next logical step**

- ❑ Begun studies and assessment of options to identify a possible path forward
- ❑ Examining synergies with HEOMD and STMD that might improve mission productivity

A partnered MEP would be an effective catalyst for focusing the early stages of NASA's *Journey to Mars*