



Technologies for Mars Exploration

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Mars Exploration Program Timeline

(Prior to release of President's 2013 Budget)



**Operational
2001-2007**

2009

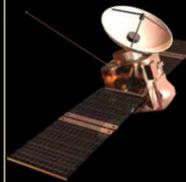
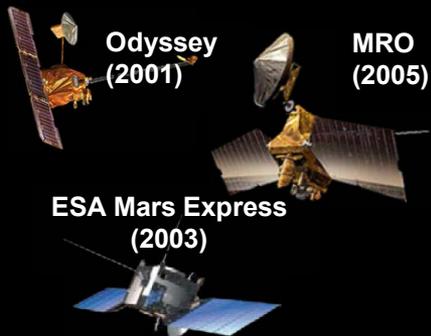
2011

2013

2016

2018

2020's



Odyssey
(2001)

MRO
(2005)

MAVEN
Aeronomy
Orbiter

ESA—NASA
ExoMars
Trace
Gas Orbiter

MSR-Orbiter

Phoenix
(2007)
*Mission
completed*

Mars Science
Laboratory

NASA—ESA
Joint Rover
(MSR Caching
& In Situ
Astrobiology)

MER
(2003)
*Spirit mission
completed*



MSR-Lander

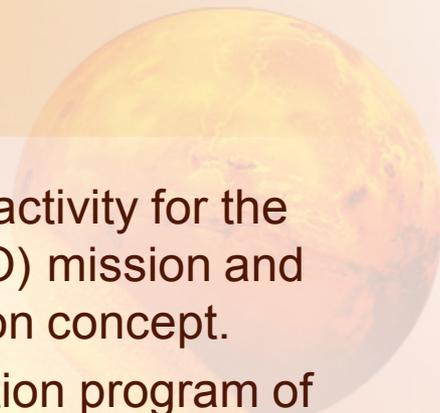
(For Planning and Discussion Purposes Only)

NASA-ESA Joint Mars Initiative

Mars Sample Return



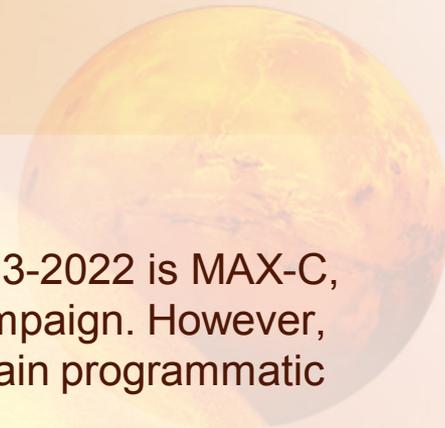
2013 Budget Narrative Extracts



- NASA is terminating further activity on the formulation activity for the NASA/ ESA ExoMars Trace Gas Orbiter 2016 (EMTGO) mission and planning for the previous NASA/ESA Mars 2018 mission concept.
- NASA remains committed to an ongoing Mars Exploration program of robotic exploration missions in support of an **integrated strategy of scientific and human exploration...**
- Mars Exploration program re-planning efforts have begun with a cross-discipline team from the **Science Mission Directorate, Human Exploration and Operations Mission Directorate, and the Office of the Chief Technologist**. This team will engage the broader community in early February 2012 to begin to create a Mars program architecture that includes missions to **synergize science and human exploration goals and objectives, plus opportunities for demonstration of key related technologies.**
- The team will look to **take advantage of the favorable relative location of Mars and Earth in 2018 and 2020**, with pathway options for missions later in the 2020s based on science discovery and human destination requirements.



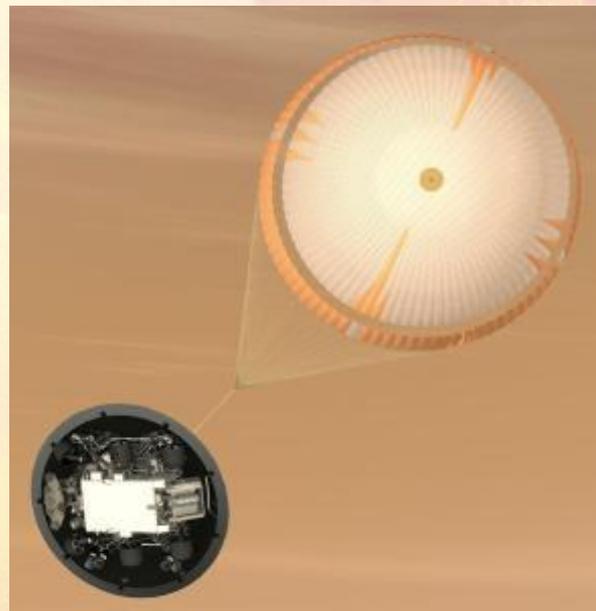
Highlights From the Planetary Decadal Survey Report



- Endorsement of Mars Sample Return
 - “The highest priority Flagship mission for the decade 2013-2022 is MAX-C, which will begin the NASA-ESA Mars Sample Return campaign. However, the cost of MAX-C must be constrained in order to maintain programmatic balance.”
- Strong support for a robust, stable program of technology development:
 - “...a substantial program of planetary exploration technology development should be reconstituted and carefully protected against all incursions ... funded at approximately 6-8 percent of the total NASA Planetary Science Division budget.”
- Identification of key technologies for Mars Sample Return:
 - Sample acquisition, processing, and encapsulation
 - Mars ascent vehicle
 - Autonomy
 - Precision landing
 - In situ instruments
 - On-orbit rendezvous and capture of orbiting sample return container
 - Planetary protection



Entry, Descent, and Landing (1/2)

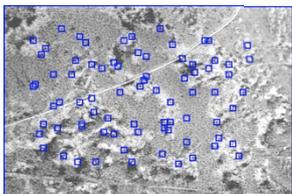




Entry, Descent, and Landing (2/2)

Terrain Relative Navigation

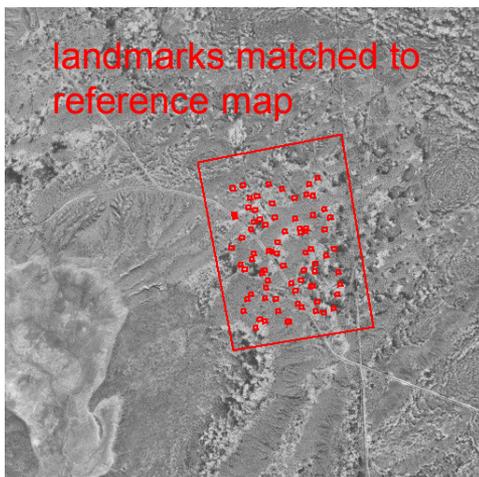
Descent Image



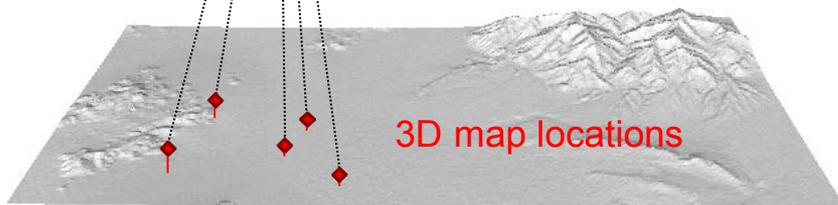
landmarks selected in descent image



Orbital Reference Map



landmarks matched to reference map

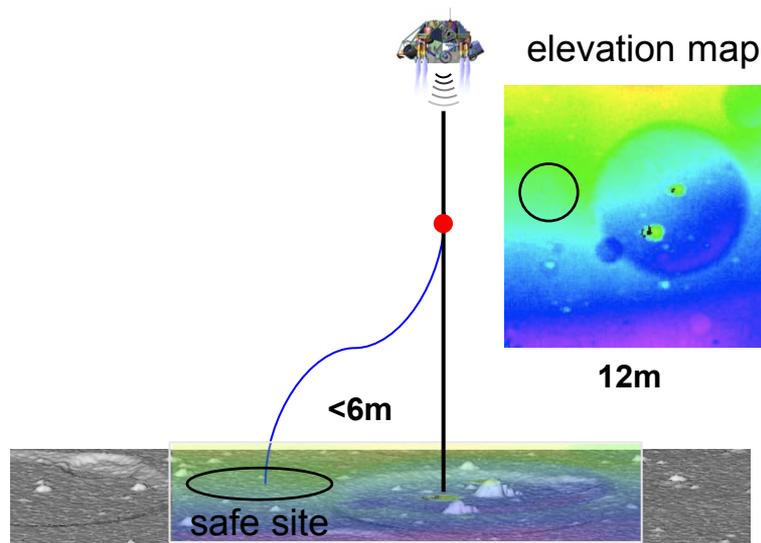


3D map locations

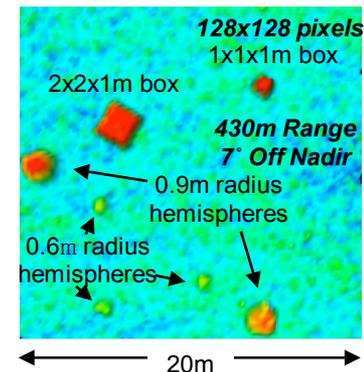


TRN Camera, IMU, and Compute Element

Hazard Detection and Avoidance



ASC Flash Lidar "GoldenEye"

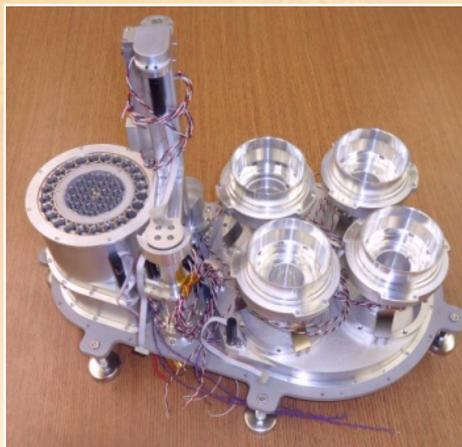
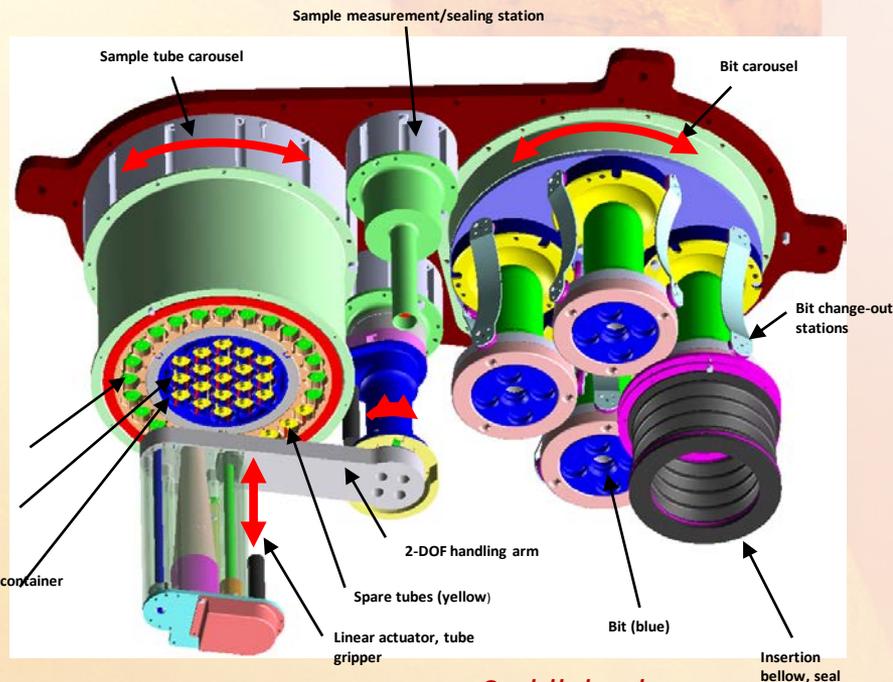




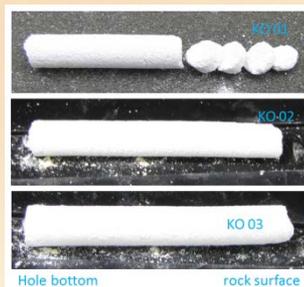
Sample Acquisition and Caching



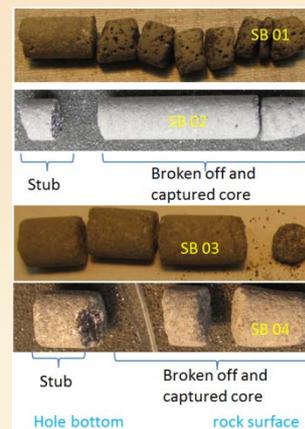
Sample tubes (yellow)



Kaolinite



Saddleback



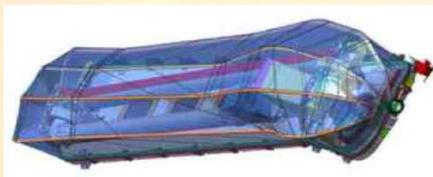


Planetary Protection & Contamination Control

Round-Trip Planetary Protection & Contamination Control



CO₂ Jet Cleaning



Contamination Barriers



Sample Tube Sealing



Contamination Transport Modeling

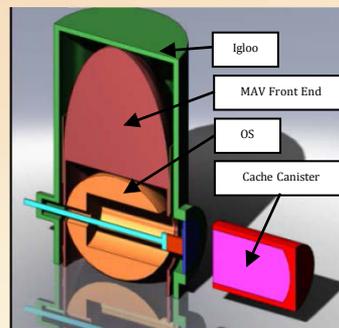
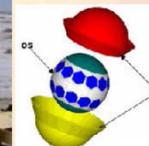


Clean Mini-Environments



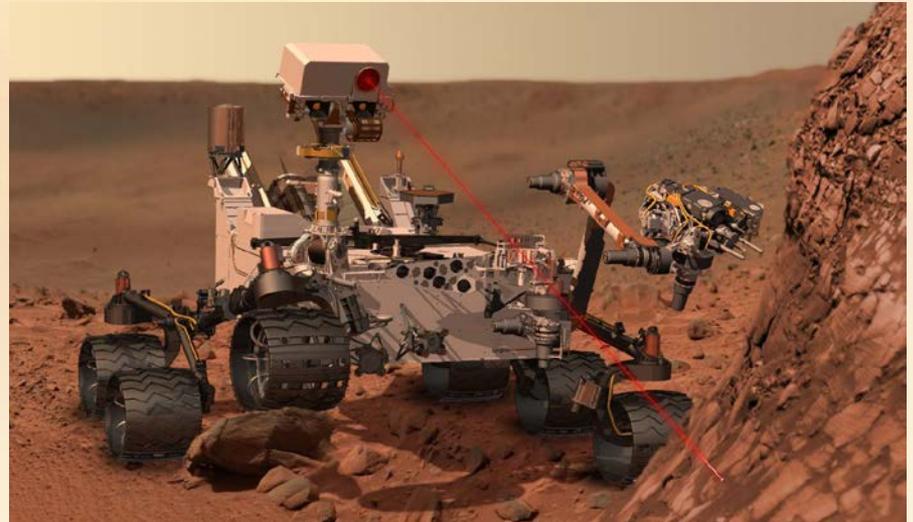
Mars Wind Tunnel

Back Planetary Protection



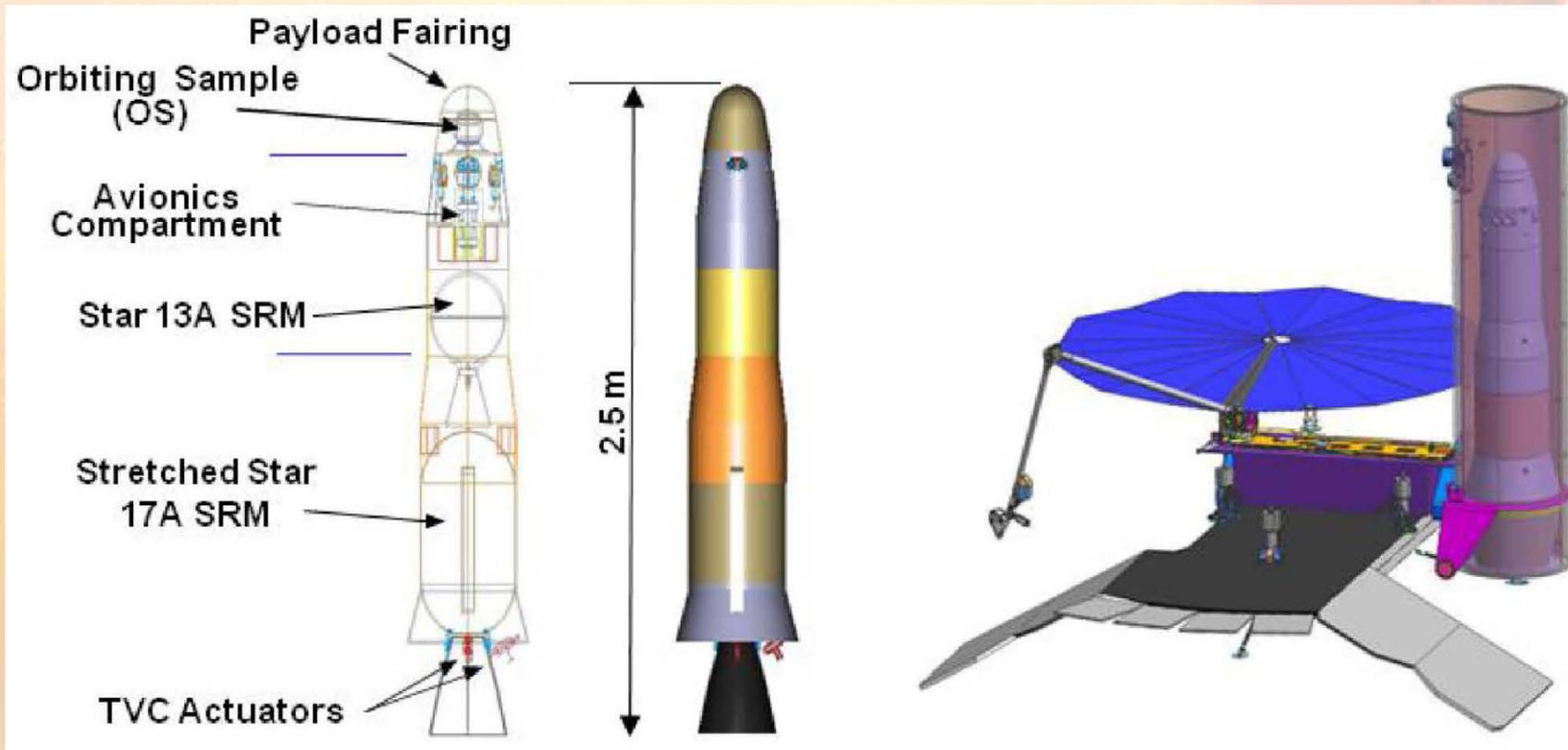


Autonomous Rover Operations





Mars Ascent Vehicle Concept



(Artist's Concept)