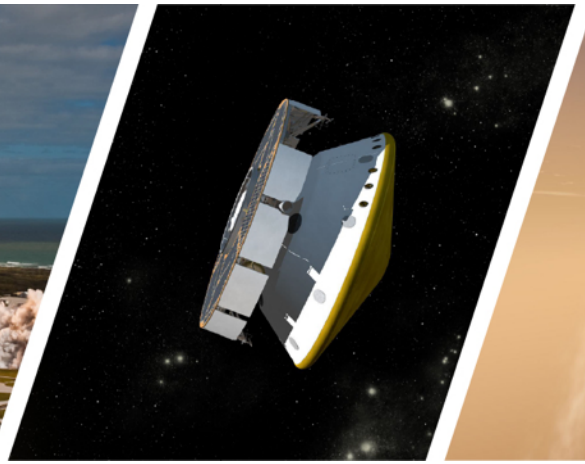
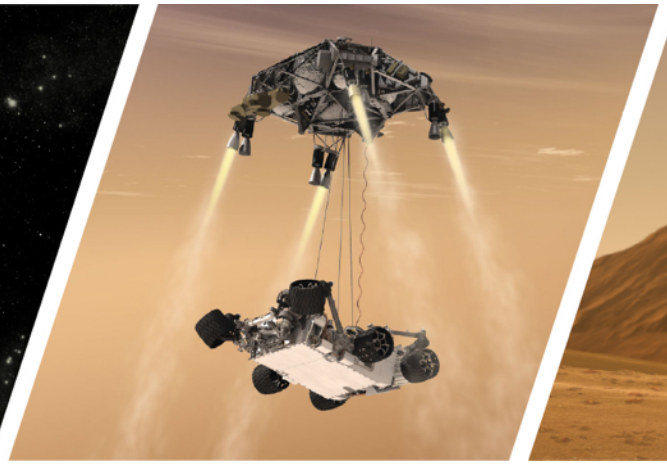
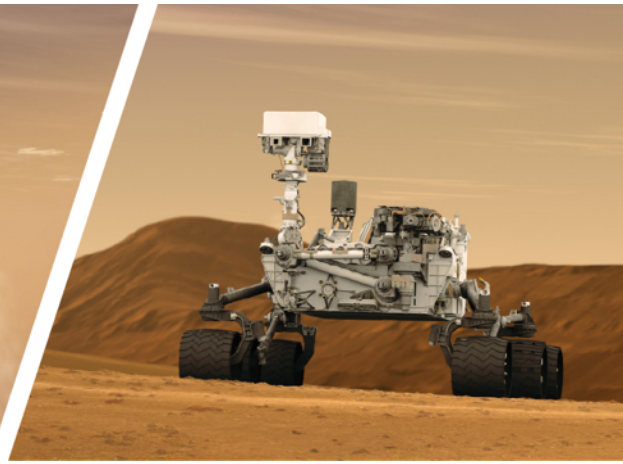
Mars 2020 Mission
Supplemental Draft
Environmental Impact Statement
Public Meeting
November 13, 14, and 15 2019


LAUNCH


CRUISE TO MARS


ENTRY, DESCENT & LANDING

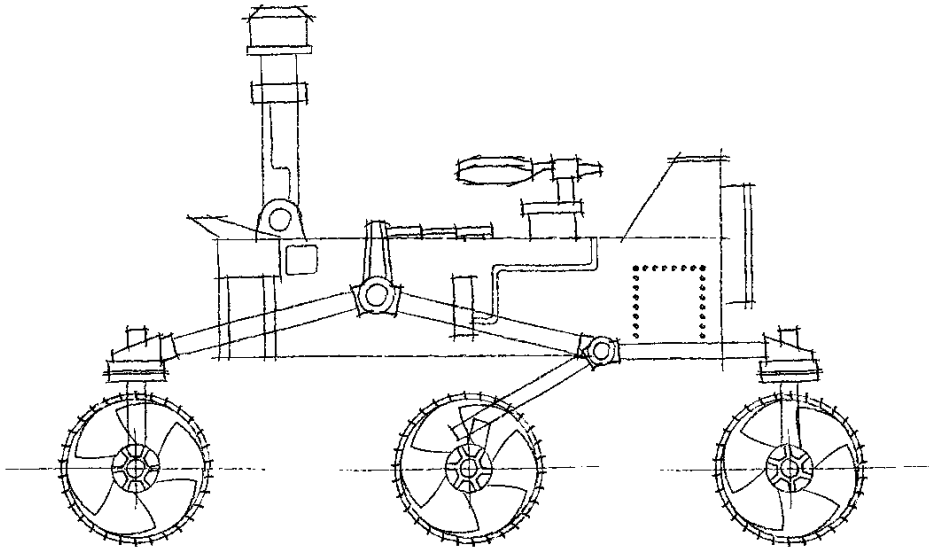

SURFACE MISSION ON MARS

Overview of the NEPA Process

for the Mars 2020 Mission

Tina Norwood
NASA NEPA Manager

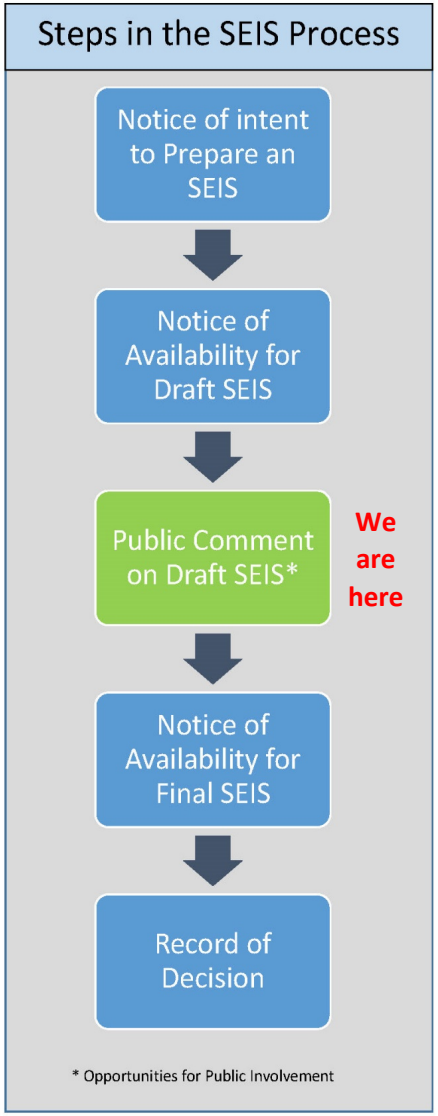
November 13, 14, and 15, 2019



Mars 2020 Project

NASA Mars 2020 SEIS Process

1. Notice of Intent (NOI) for Supplemental EIS published in Federal Register 9/26/19
2. Notice of Availability (NOA) of Draft SEIS published in Federal Register 10/25/19
   - ➢ Requests public comment on the assessment of impacts presented in the Draft SEIS
3. *Public Meetings 13, 14, 15 November 2019*
   Comment period ends 10 December 2019
4. NOA of Final SEIS will be published in the Federal Register
5. Record of Decision (ROD) expected to be signed in Spring 2020



How to Track Progress of the SEIS

There are several ways to keep informed about the SEIS for the Mars 2020 mission:

- Request to be added to the mailing list
- Access the active Web site
- Look for announcements of the availability of the Final SEIS in the Federal Register and in local Florida media

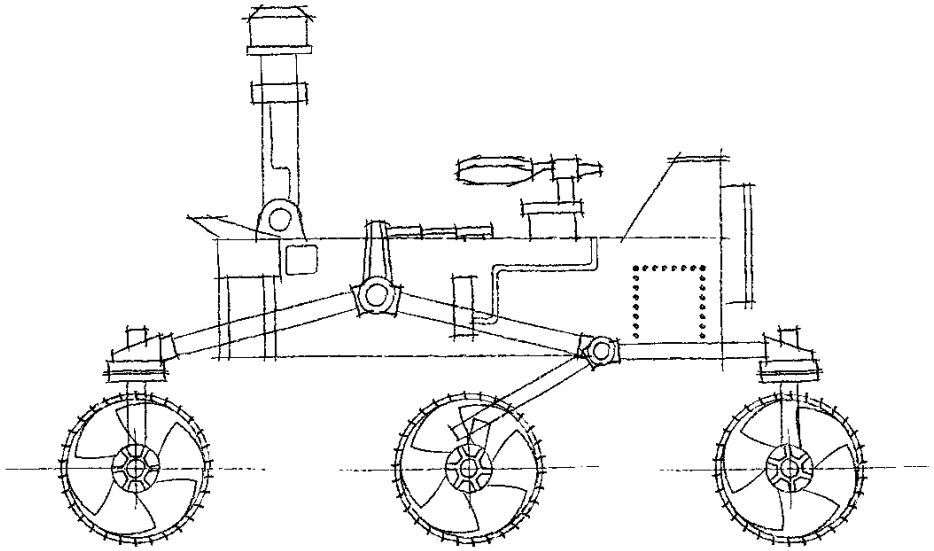
https://www.nasa.gov/feature/nepa-mars-2020-mission

Thank you for participating in the NEPA public comment process for the Mars 2020 mission.

We appreciate your time and input.

Mars 2020 Mission Overview

George Tahu
Mars 2020 Program Executive
NASA Headquarters



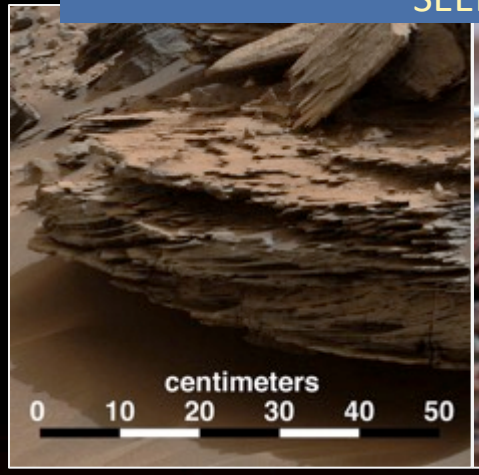
Mars 2020 Project

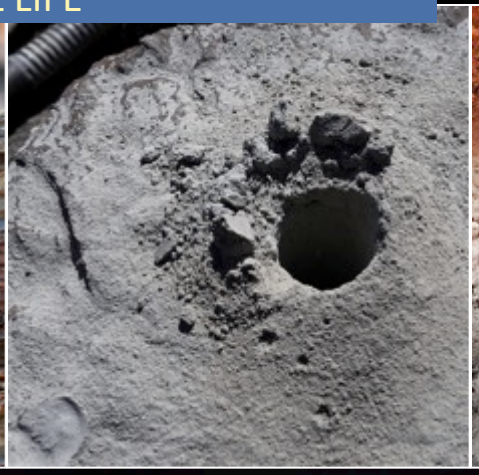

MARS MISSIONS
OPERATIONAL 2001–2019
2020 AND BEYOND
Mars Express (ESA) (2003)
Mars Reconnaissance Orbiter (2005)
MAVEN (2013)
Mars Orbiter Mission (ISRO) (2013)
Trace Gas Orbiter (ESA/RSA) (2016)
Mars Odyssey (2001)
HOPE (UAE)
MMX (JAXA)
Mars Orbiter (China)
Mars Sample Return Orbiter
Mars Lander & Rover (China)
Mars Sample Return Lander
Curiosity Rover (2011)
InSight (2018)
Mars 2020 Rover
ExoMars Rover (ESA/RSA)
Mars Sample Return (China)
Follow the Water
Explore Habitability
Seek Signs of Life
Prepare for Future Human Explorers
U.S. Missions
non-U.S. Missions

Mars 2020 Mission Objectives

SEEKING ANCIENT MICROBIAL LIFE

FUTURE EXPLORATION





GEOLOGY

- Explore an ancient environment on Mars
- Understand processes of formation and alteration

ASTROBIOLOGY

- Assess habitability of ancient environment
- Seek evidence of past life
- Identify locations with high biosignature preservation potential

SAMPLE CACHING

- Capability to collect ~40 samples and blanks, 20 in prime mission
- Include geologic diversity
- Deposit samples on the surface for possible return

PREPARE FOR HUMAN EXPLORATION

- Measure temperature, humidity, wind, and dust environment
- Demonstrate In Situ Resource Utilization by converting atmospheric CO_2 to O_2

Mars 2020 Mission Overview

LAUNCH

- Atlas V 541 vehicle
- Launch Readiness Date: July 2020
- Launch window: July/August 2020

CRUISE/APPROACH

- ~7 month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system (Range Trigger and Terrain Relative Navigation): guided entry and powered descent/Sky Crane
- 16 x 14 km landing ellipse (range trigger baselined)
- Access to landing sites ±30° latitude, ≤ -0.5 km elevation
- Curiosity-class Rover

SURFACE MISSION

- 20 km traverse distance capability
- Enhanced surface productivity
- Qualified to 1.5 Martian year lifetime
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars
- Technology demonstrations for future exploration capabilities

https://mars.nasa.gov/mars2020/

MARS 2020 NEW SCIENCE & CAPABILITIES

HELICOPTER EXPERIMENT

LASER RETROREFLECTOR

SUPERCAM

A laser that can investigate chemical compositions of Martian rocks and soil from a distance

RIMFAX

A ground-penetrating radar to explore beneath the surface.

MMRTG

A plutonium power source supplies electricity to the rover.

MASTCAM-Z

A zoomable panoramic camera.

SHERLOC

An ultraviolet spectrometer to study mineralogy and chemistry. (Its camera is named WATSON.)

MEDA

The rover's weather station, to measure temperature, wind speed and other meteorological factors.

PIXL

An X-ray spectrometer for probing the chemical composition of rocks and dirt close up.

CACHING SYSTEM

Collects and deposits on the surface of Mars sealed tubes of rock and soil samples for future return to Earth

ROBOTIC ARM

The rover arm can extend outwards to make scientific measurements and gather samples. Its instruments can study, in detail, an area about the size of a postage stamp.

MOXIE

An instrument to produce oxygen from carbon dioxide in the Martian atmosphere, as a test for creating resources for future astronauts.

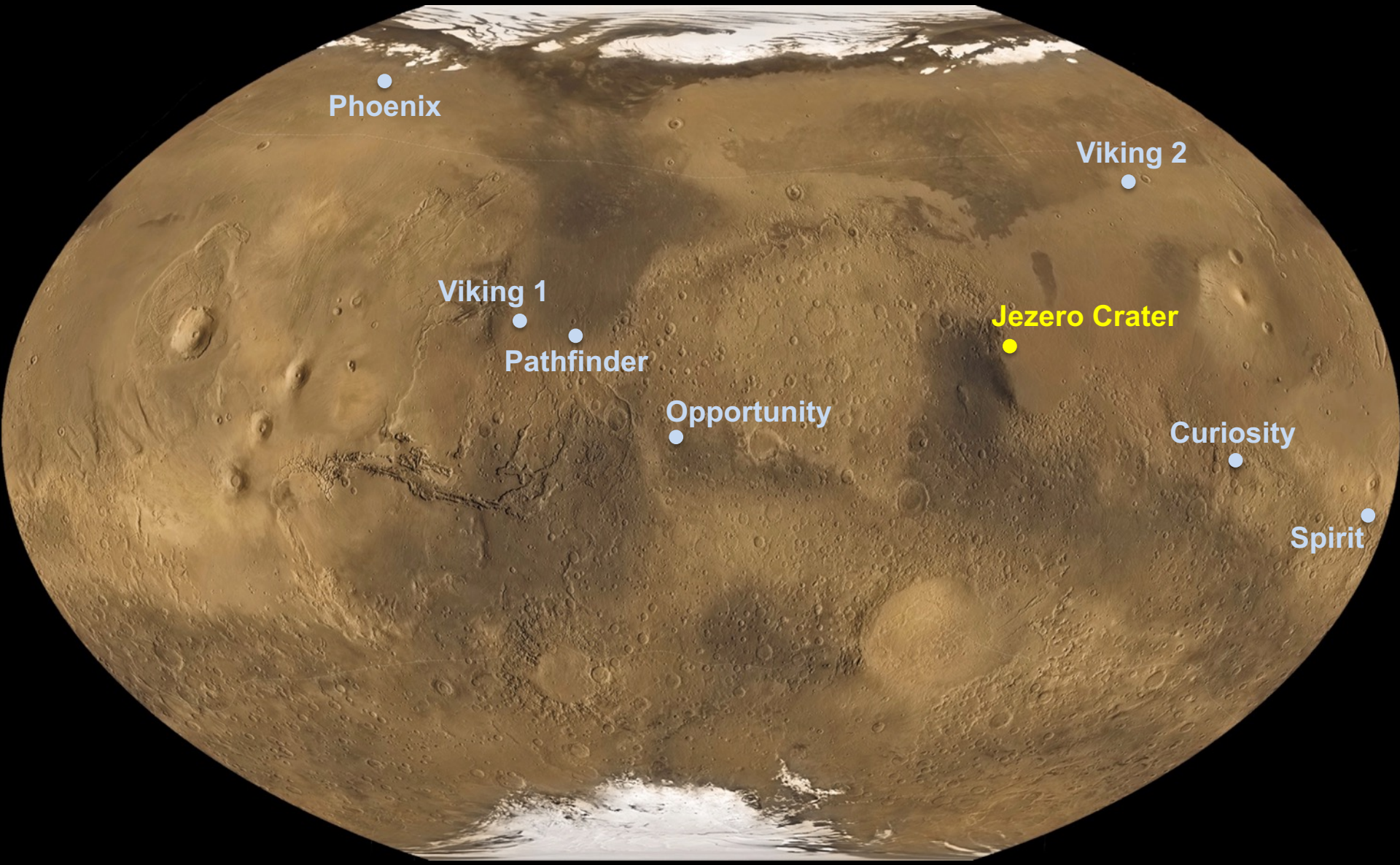
Image credit: Nature magazine

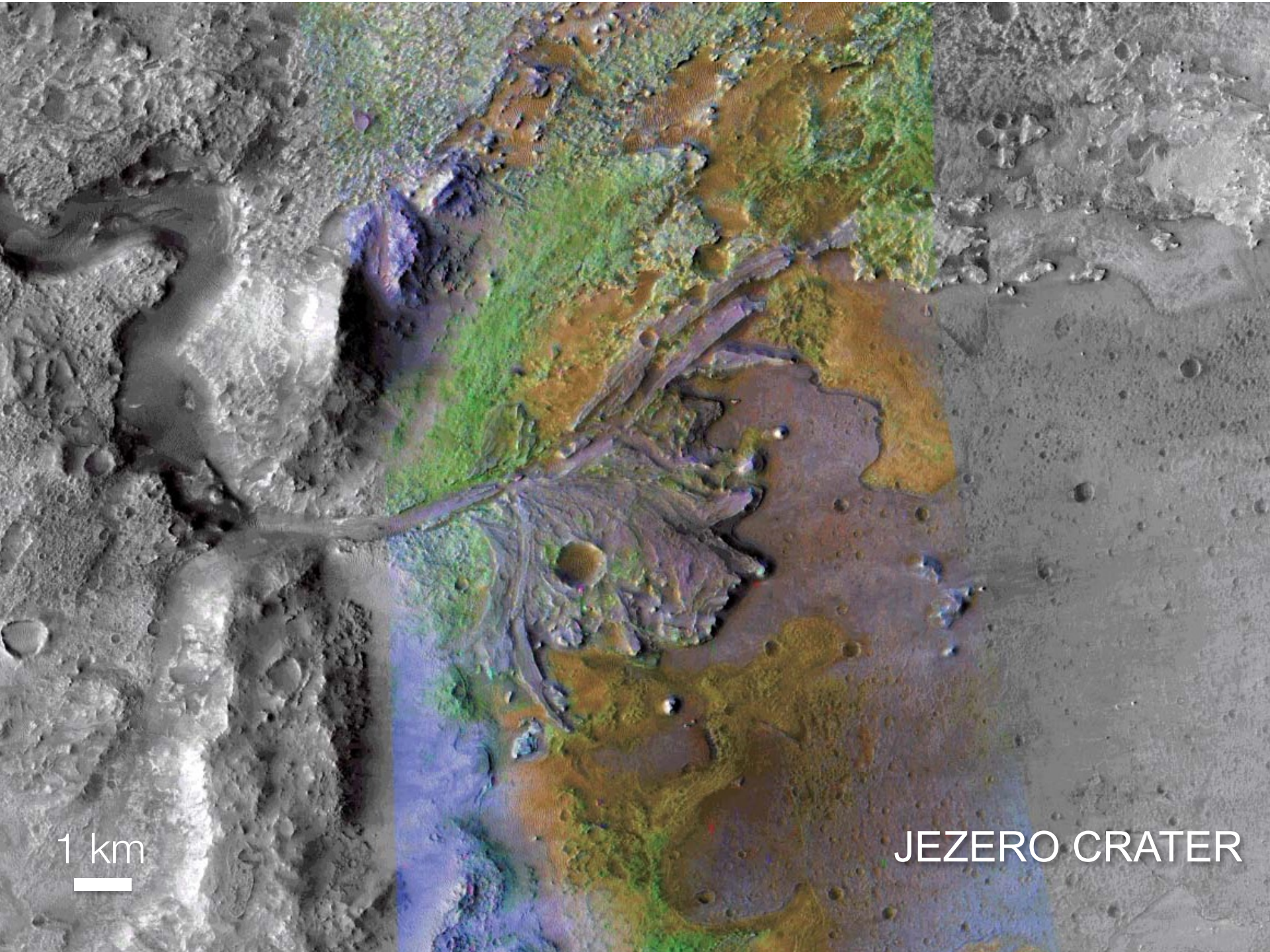
Mars 2020 Rover Instrument Test

Rover and ”Skycrane” Separation Test

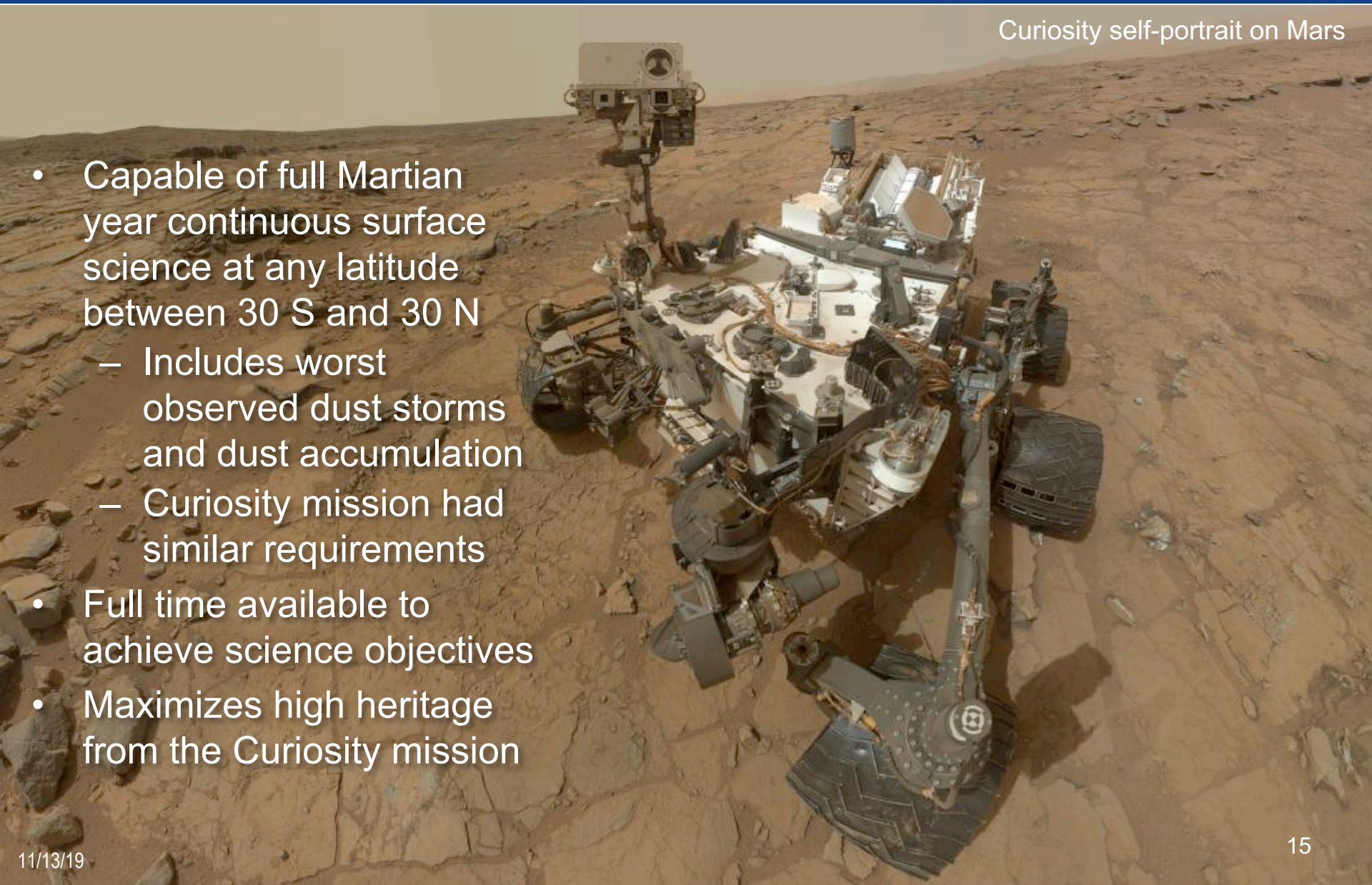
Spacecraft Thermal Vacuum Test

Mars 2020 Landing Site




1 km
JEZERO CRATER

MMRTG Power Alternative: Summary



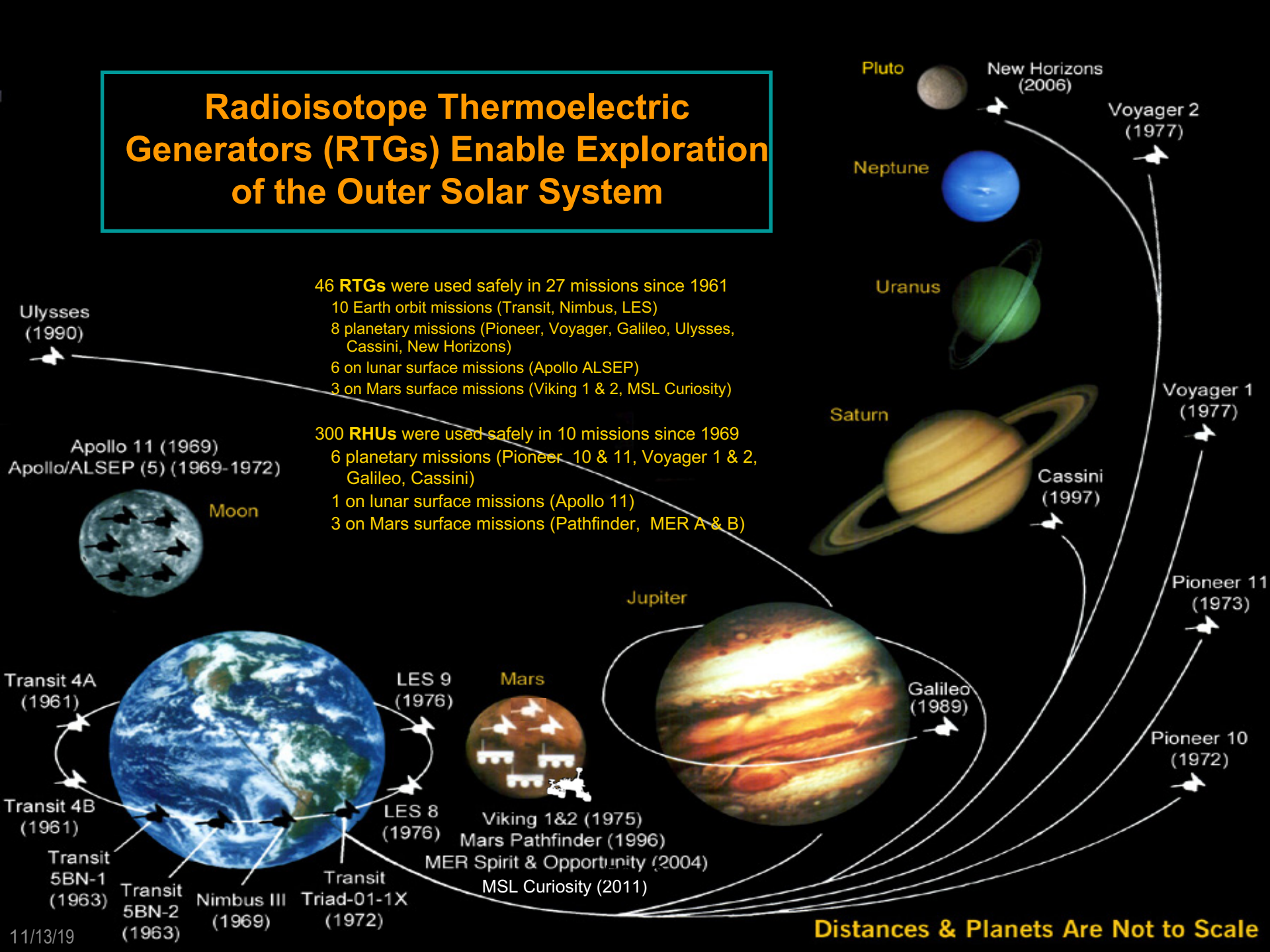
- Capable of full Martian year continuous surface science at any latitude between 30 S and 30 N
  - Includes worst observed dust storms and dust accumulation
  - Curiosity mission had similar requirements
- Full time available to achieve science objectives
- Maximizes high heritage from the Curiosity mission

Radioisotope Power for the Mars 2020 Mission

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Radioisotope Thermoelectric Generators (RTGs) Enable Exploration of the Outer Solar System



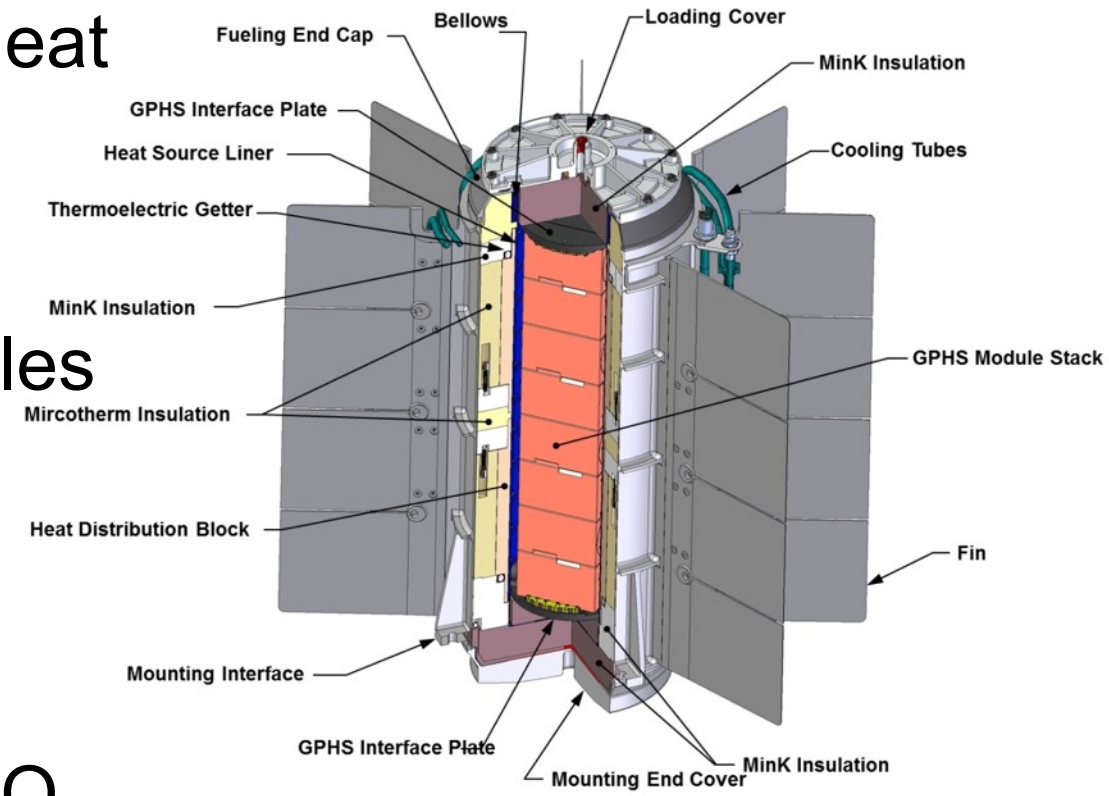
46 **RTGs** were used safely in 27 missions since 1961
- 10 Earth orbit missions (Transit, Nimbus, LES)
- 8 planetary missions (Pioneer, Voyager, Galileo, Ulysses, Cassini, New Horizons)
- 6 on lunar surface missions (Apollo ALSEP)
- 3 on Mars surface missions (Viking 1 & 2, MSL Curiosity)

300 **RHUs** were used safely in 10 missions since 1969
- 6 planetary missions (Pioneer 10 & 11, Voyager 1 & 2, Galileo, Cassini)
- 1 on lunar surface missions (Apollo 11)
- 3 on Mars surface missions (Pathfinder, MER A & B)

Distances & Planets Are Not to Scale

Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

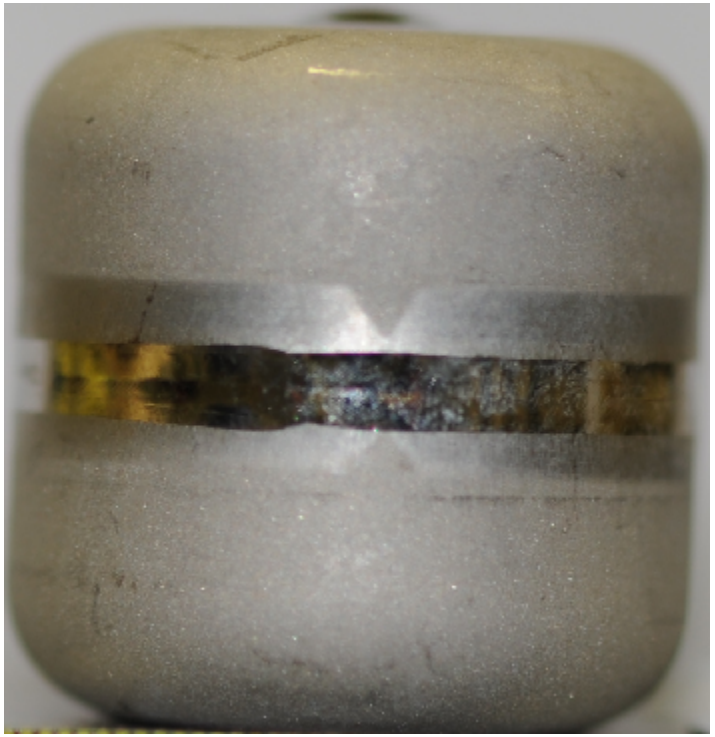
- 2000 W thermal of heat
- 110 W electricity at beginning of mission using 768 thermocouples
- ~26 inches (67 cm)
- ~25 inches wide
- ~95 lbs. (44 kg)
- 10.6 lbs. (4.8 kg) PuO_2 protected within 8 GPHS modules



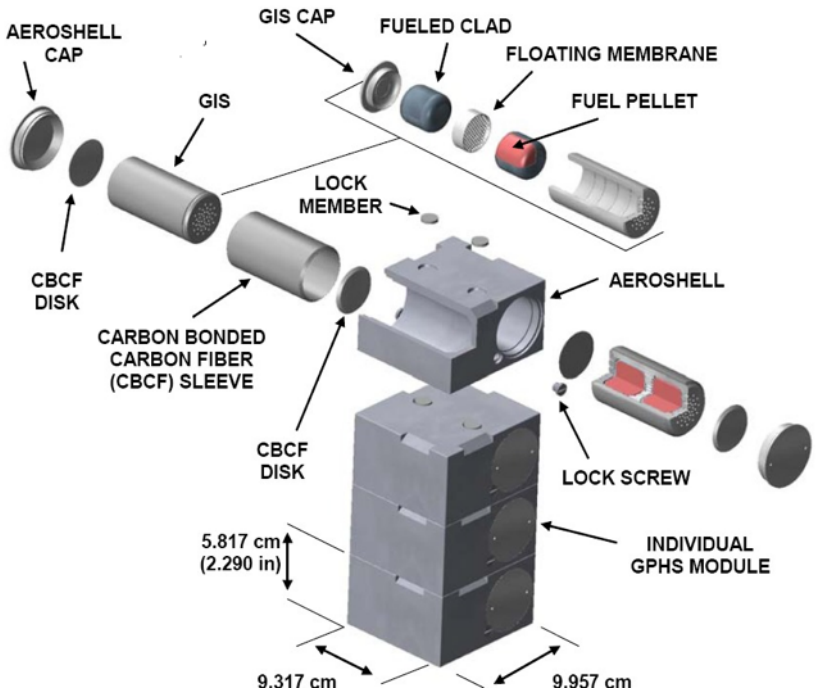
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Key Safety Features of Radioisotope Power Systems

- Ceramic Fuel
  - Very Low Vaporization Rate
  - Generation of Respirable Fines Minimized
  - Highly Insoluble
- Iridium Clad
  - Fuel Containment
  - Impact Protection
  - Corrosion Resistant
  - Material Compatibility
  - High Melting Point (2400 ° C)



Key Safety Features of Radioisotope Power Systems

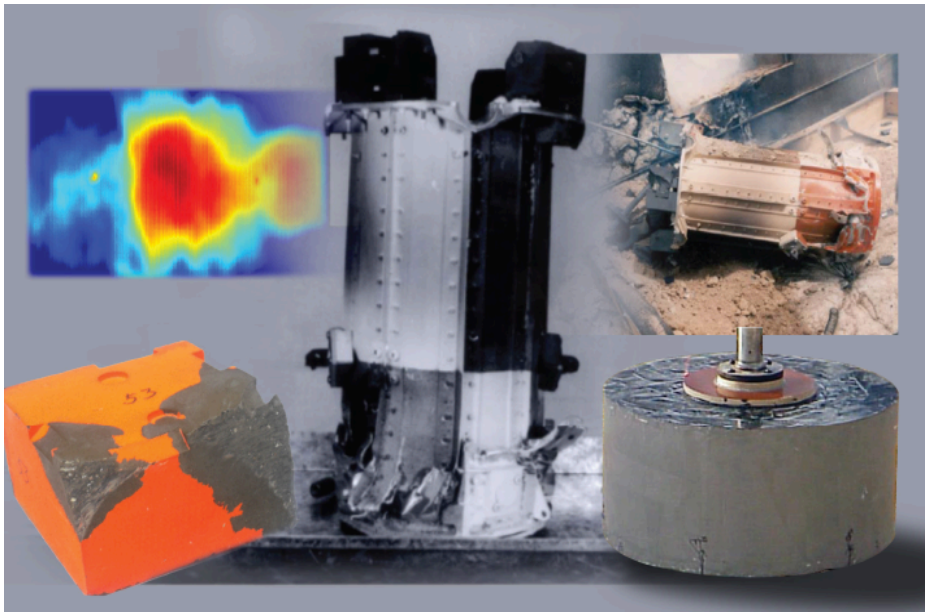


- Graphite Impact Shell
  - Impact Protection
  - Reentry Ablation Protection
- Graphite Insulator
  - Reentry Thermal Protection
- Graphite Aeroshell
  - Impact Protection
  - Primary Reentry Ablation Protection

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Decades of Experience and Testing

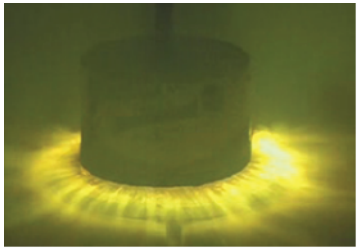
- The current GPHS is an evolutionary improvement of a design that has functioned with extreme dependability for three decades
- Overall, the safety features of RPS have undergone a variety of destructive physical testing and detailed computer simulations since the beginning of the Space Age

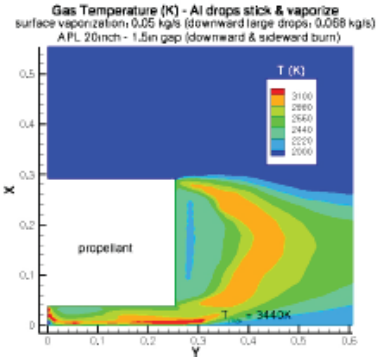


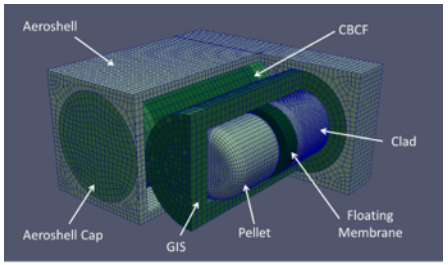
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

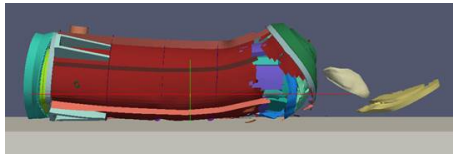
Analysis for Mars 2020

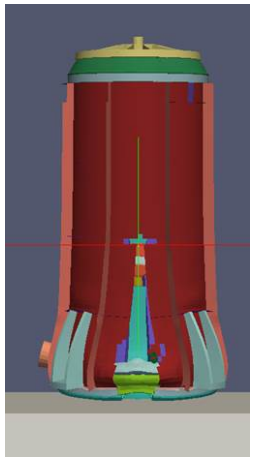
- DOE conducted a thorough safety analysis of the Mars 2020 Mission using the actual flight information chosen by NASA
- Millions of accidents were simulated using RPS safety testing data, meteorology, chemical and environmental models.
- Using state-of-the-art models and recent test data, DOE found that the risk for Mars 2020 is slightly higher than MSL, but within established safety guidelines.

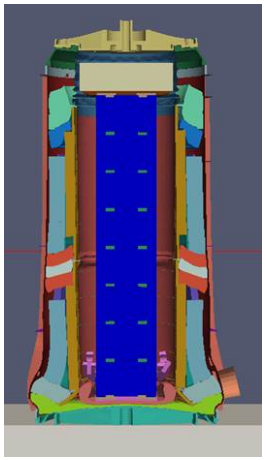






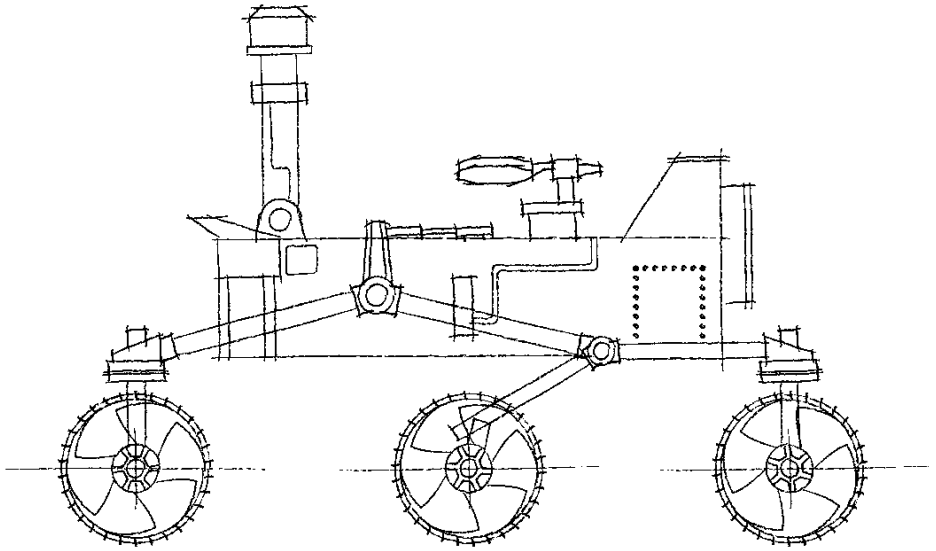






Draft Supplemental Environmental Impact Statement for the Mars 2020 Mission

George Tahu
Mars 2020 Program Executive



Mars 2020 Project

Scope of 2014 FEIS and Record of Decision

The Mars 2020 FEIS (released in 2014) **considered both radiological and non-radiological environmental impacts** from the proposed action—a rover powered by a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)—and alternatives.

The analysis in the 2014 FEIS included potential impacts from:

- Preparation for a Launch
- A Normal Launch
- Possible Launch Accidents

The Record of Decision (issued in January 2015) selected the Proposed Action:

- The Mars 2020 spacecraft would be launched on an expendable launch vehicle from Kennedy Space Center (KSC) or Cape Canaveral Air Force Station (CCAFS), Brevard County, Florida, during a 20-day launch opportunity in July-August 2020.
- Should the mission be delayed, the mission could be launched in August-September 2022.
- The rover proposed for the Mars 2020 mission would utilize a Multi-Mission Radioisotope Thermoelectric Generator to provide electrical power to the rover's battery for the rover to operate and conduct science on the surface of Mars.

Scope of 2019 Draft SEIS

NASA and the Department of Energy have completed a more detailed risk analysis since the risk analysis used for the 2014 FEIS.

Based on the new and updated information associated with postulated launch vehicle accident scenarios resulting in potential release of nuclear material, NASA determined that the purposes of NEPA would be furthered by conducting additional environmental analysis and documentation via a SEIS.

The 2019 Draft SEIS only addresses potential impacts associated with accidents that result in the release of radiological material from the Proposed Action, as well as the No Action Alternative.

Potential impacts from the following activities in 2019 would be the same as those presented in the 2014 FEIS and therefore are not addressed in the Draft SEIS:

- Preparation for a launch
- A normal launch
- Possible launch accidents not resulting in a radiological release

Potential Non-Radiological Mars 2020 Environmental Impacts

- **As addressed in the 2014 FEIS, the Proposed Action would have no significant non-radiological environmental impacts**
  - These impacts have been assessed in previous NASA environmental documentation
  - The assessments include consideration of air quality, water quality, noise, land use, biological and natural resources.
  - A launch vehicle accident near the launch area during the first few seconds of flight could result in the release of the propellants onboard the launch vehicle and the spacecraft, similar to a normal launch.
  - Emissions would not reach levels threatening public health and no significant impacts were identified.
- **In both the 2014 FEIS and the 2019 Draft SEIS the "No Action" Alternative** = No Environmental Impacts

Mars 2020 Launch Probabilities (2014 vs. 2019)

- **2014 FEIS**
  - There was a 97.5% chance of a successful launch on a path to Mars
  - There was a 2.5% chance of a launch accident of any kind
  - There was a 0.04% chance of a launch accident resulting in a radiological release

- **2019 Draft SEIS**
  - There is a 98.7% chance of a successful launch on a path to Mars
  - There is a 1.3% chance of a launch accident of any kind
  - There is a 0.10% chance of a launch accident resulting in a radiological release

- **Changes are due to**
  - New knowledge gained about how the MMRTG is affected by accident scenarios;
  - Updated analytical models and computer simulation input parameters, informed by best available knowledge as well as lessons learned from other missions; and
  - Updates to account for specific design features of the selected launch vehicle.

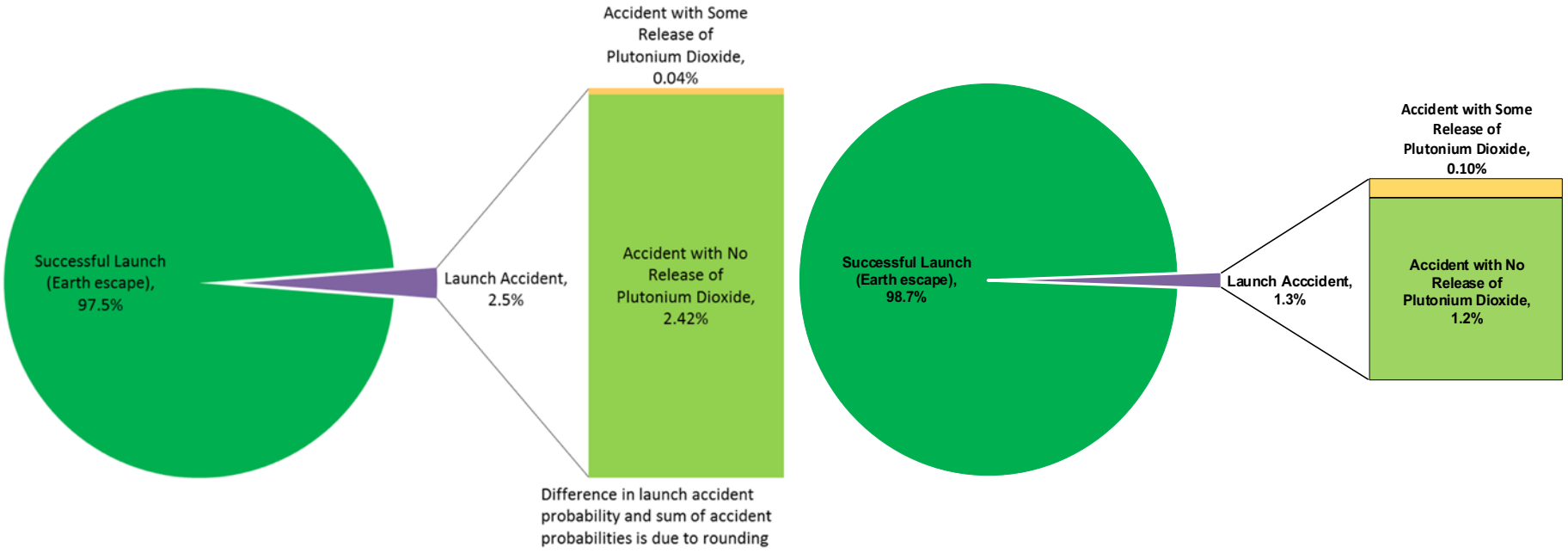
Mars 2020 Launch Probabilities (2014 vs. 2019)

2014 FEIS: 1 in 2,600 (0.04%) chance of an accident with release of plutonium dioxide.

- 1 in 11,000 chance of a launch accident with release in the launch area.*
- 1 in 3,500 chance of a launch accident with release outside the launch area.

2019 SEIS: 1 in 960 (0.10%) chance of an accident with release of plutonium dioxide.

- 1 in 1,100 chance of a launch accident with release in the launch area.*
- 1 in 12,000 chance of a launch accident with release outside the launch area.



* Launch area is defined as within 62 miles (100 kilometers) of the launch pad.

Estimated Consequences from an Early Launch Area Accident With a Release of Plutonium Dioxide (2014 vs. 2019)

- **The average radiation dose to the maximally exposed individual, assuming no mitigation measures are taken**
  - 2014 estimate: 60 millirem (equivalent to about 2 months of natural background radiation)
  - 2019 estimate: 210 millirem (equivalent to about 8 months of natural background radiation)

- **Land area that could potentially need evaluation for action (such as monitoring or cleanup)**
  - 2014 estimate: 7.4 km^2 (about 3 square miles)
  - 2019 estimate: 79 km^2 (about 31 square miles)

- **Within the entire group of potentially exposed individuals, the estimated incremental cancer fatalities over a 50 year period, assuming no mitigation measures are taken**
  - 2014 estimate: 0.29
  - 2019 estimate: 0.52

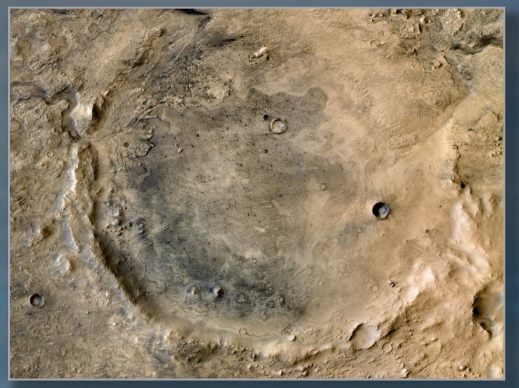
Contingency Planning & Safety

- Even though the chances of launch accidents are small, NASA prepares contingency response plans for every launch it conducts.
- NASA establishes a radiological assessment and command center that deploys monitoring equipment and field teams prior to launch of a radioisotope power system.
- In the unlikely event of an accident, this team would assess if and how much radioactive material was released, as well as possible location, in order to prepare recommendations for protective action if needed.
- The State of Florida and county and local governments would determine an appropriate course of action (such as sheltering in place, avoiding land areas, or no action required), if a release of radioactive material occurred outside federal property.

Mars 2020 Launch Window Opens:
July 17, 2020

https://mars.nasa.gov/mars2020/

Landing at Jezero Crater
Feb 18, 2021

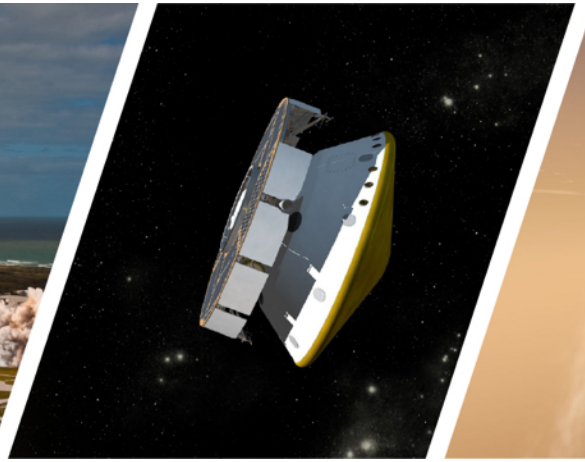


Mars Science Laboratory (MSL) launch – November 2011

Mars 2020 Draft SEIS Public Meeting

If you are logged in to the virtual meeting on 15 November 2019, please enter your comments in the "Q&A" window

LAUNCH



CRUISE TO MARS

ENTRY, DESCENT & LANDING

SURFACE MISSION ON MARS

Comments may also be submitted until December 10, 2019 via

Email: mars2020-nepa@lists.nasa.gov
Recorded phone message: 202-358-0016
Postal mail: Mr. George Tahu, Planetary Science Division
Science Mission Directorate, Mail Suite 3E46,
NASA Headquarters, Washington, DC 20546-0001