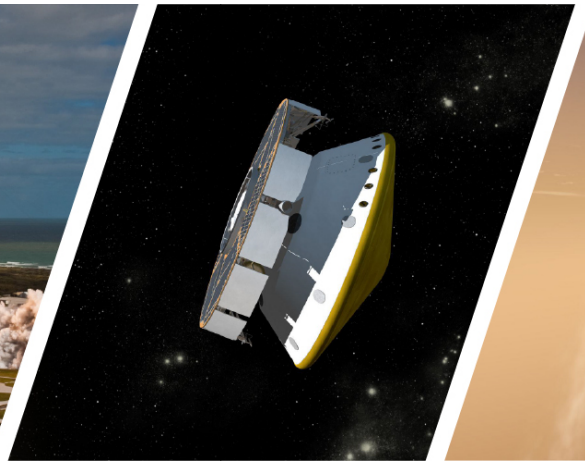
Proposed Mars 2020 Mission
Draft Environmental Impact Statement
Virtual Public Meeting

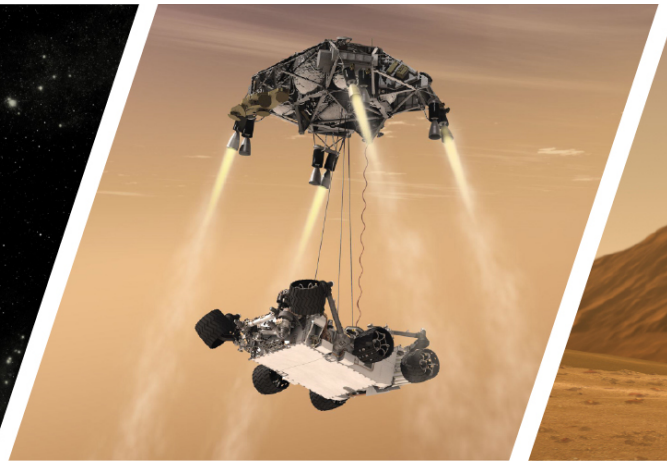
June 26, 2014

1-3 p.m. EDT

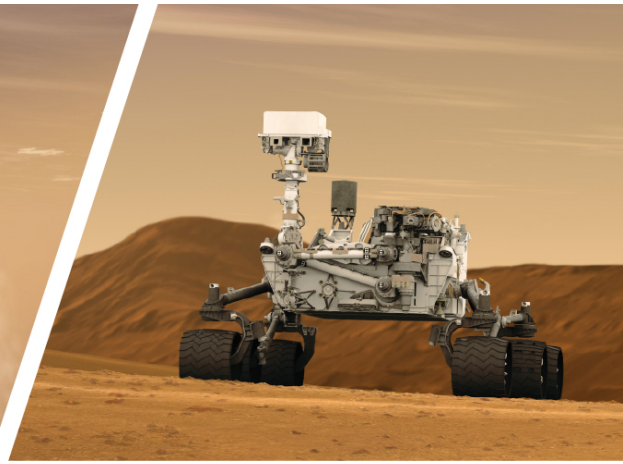
LAUNCH



CRUISE TO MARS



ENTRY, DESCENT & LANDING



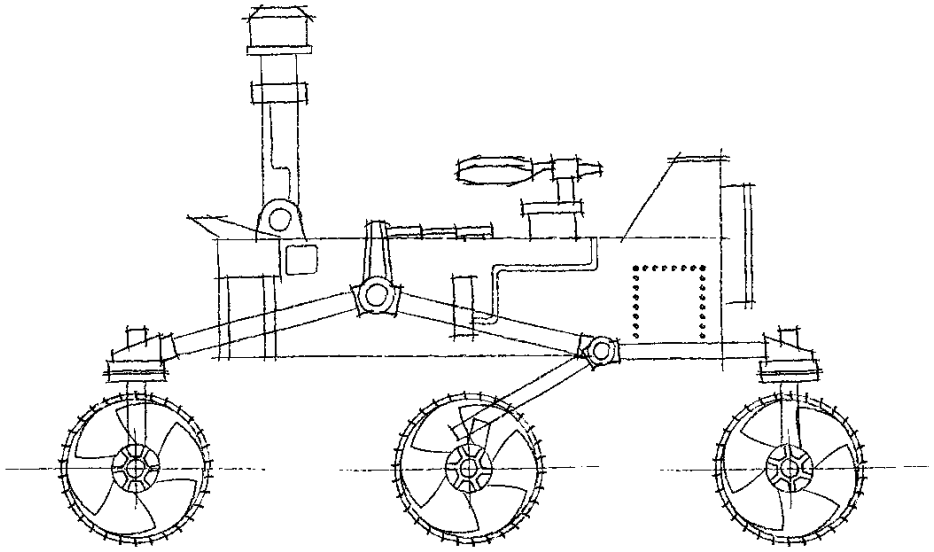
SURFACE MISSION ON MARS

Overview of the NEPA Process

for the Proposed Mars 2020 Mission

Tina Norwood
NASA NEPA Manager

June 26, 2014



Mars 2020 Project

National Environmental Policy Act

- The National Environmental Policy Act (NEPA) was enacted by Congress in 1969
- Created the Council on Environmental Quality (CEQ) which developed NEPA regulations:
  - requires all Federal agencies to consider potential environmental impacts of proposed actions
  - requires public disclosure and consideration of public environmental concerns for proposed actions
  - allows agencies to develop their own NEPA regulations and process www.nasa.gov/agency/nepa

WELCOME TO NASA's FIRST VIRTUAL NEPA PUBLIC MEETING!

NEPA Documentation

NEPA documents are environmental reports that:

- Describe the **purpose** and **need** of the proposed action
- Assess potential environmental impacts *(on Earth)* of a proposed action and reasonable alternatives
- Inform the public and NASA decision makers about these possible environmental impacts
- Require inclusion of a “No-Action” alternative
- Public comments received on draft documents must be considered in preparation of the final documents

Environmental Assessment (EA)

- Finding of No Significant Impact (FONSI)
- Most NASA launches are covered by the Routine Payload EA

Environmental Impact Statement (EIS)

- Record of Decision (ROD)
- *NASA NEPA regulations require an EIS for proposed missions considering the use of a nuclear power system*

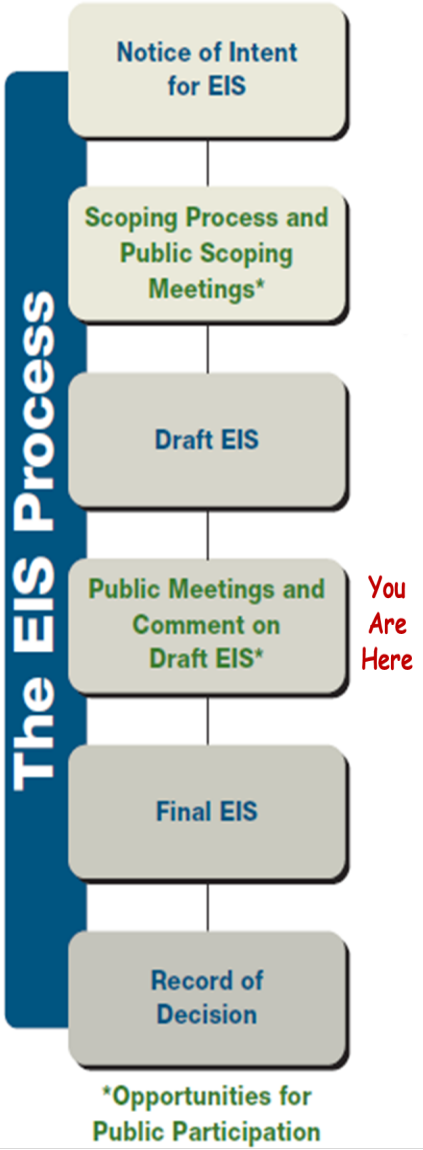
An EIS was prepared for MSL

Launch of Mars Science Laboratory (MSL) – November 2011

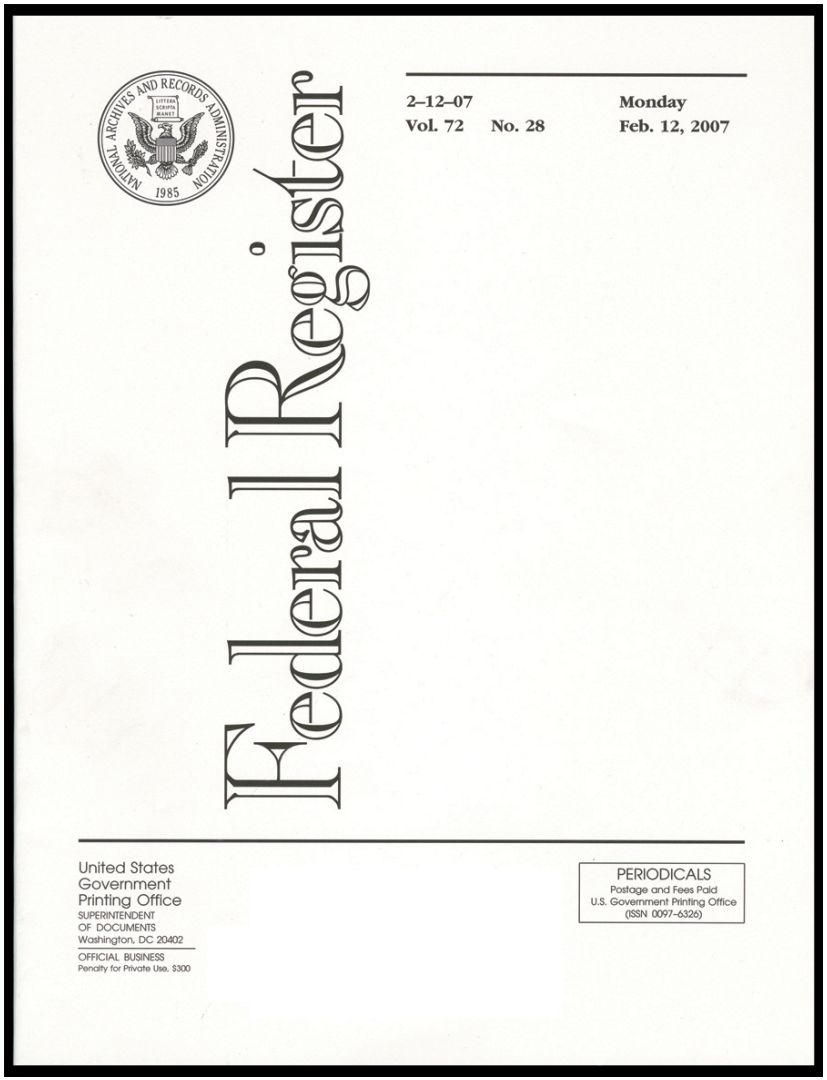
NASA Mars 2020 EIS Process

1. Notice of Intent (NOI) published in Federal Register 09/11/13
2. Scoping period ended 10/30/13
3. Notice of Availability (NOA) of Draft EIS published in Federal Register 06/06/14
4. *Public Meeting 06/26/14*

   Comment period ends 07/21/2014
5. NOA of Final EIS will be published in the Federal Register
6. Record of Decision (ROD) expected to be signed in Winter 2014



Notice of Intent (NOI)



Step 1: Notice of Intent (NOI)
Publication of NOI to prepare an EIS for the Mars 2020 Mission

- First of three notices that CEQ requires be published in the Federal Register (for all EISs)
- The Mars 2020 EIS NOI was published on September 11, 2013
- Informs public of the mission and initiates the scoping period

Mars 2020 EIS Scoping Process

Step 2: Mars 2020 EIS Scoping

The NOI initiated a 45-day period soliciting public input into the scope of the EIS.

- Period ended on October 30, 2013
- Two scoping meetings were held on the Florida Space Coast in October 2013
  - Cocoa Beach Country Club
  - Brevard County Government Center in Viera
- NASA requested comments on environmental impacts of concern to the public and alternatives to the proposed action.
- Issues raised in comments were considered in developing the Draft EIS

Mars 2020 EIS Public Involvement

Step 3: Notice of Availability (NOA) of Draft EIS

- The NOA for the Mars 2020 Draft EIS was published in the Federal Register on June 6, 2014

- Notices published in public media
  - NASA Headquarters, Kennedy Space Center, and Jet Propulsion Laboratory issued media alerts and Web communications
  - Ads placed in Florida newspapers (print and digital)
  - Notices and hardcopies/CDs mailed to State, County and local officials, interested organizations, and other parties

- The NOA requests public comment on the assessment of impacts presented in the Draft EIS.

Draft EIS Public Comment Period

Step 4: Public Comment Period

The NOA initiated a 45-day period soliciting public review and comment on the Mars 2020 Draft EIS.

This virtual meeting today represents the public meeting.

- Comments will be accepted at the end of the presentations through a comment dialog box

Public Comment Period ends July 21, 2014

- Comments may also be submitted in writing, via e-mail or postal mail, or by telephone at any time during the public comment period

All comments should be submitted with the understanding that NASA will publish them in the Final EIS.

Final EIS

Step 5: Notice of Availability (NOA) of Final EIS

The NOA of the Final EIS will be published in the Federal Register. The Final EIS will:

- Contain text changes, as appropriate, to reflect new information and comments on the Draft EIS
- An Appendix with:
  - Copies of written comments and NASA's responses
  - Summaries of concerns expressed orally and NASA's responses
- Be sent to those on the mailing list and also available on the Internet at:

www.nasa.gov/agency/nepa/mars2020eis

Record of Decision (ROD)

Step 6: Record of Decision (ROD)

The ROD will be signed by the Responsible Official (Assistant Administrator for the Science Mission Directorate) at NASA

- The ROD will be issued no sooner than 30 days after issuance of the Final EIS
- The ROD will be sent to those who have requested a copy and will be available on the Internet
- The ROD will contain:
  - NASA's decision
  - The factors that entered into the decision

How to Track Progress of the EIS

There are several ways to keep informed about the EIS 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 EIS in the Federal Register and in local Florida media

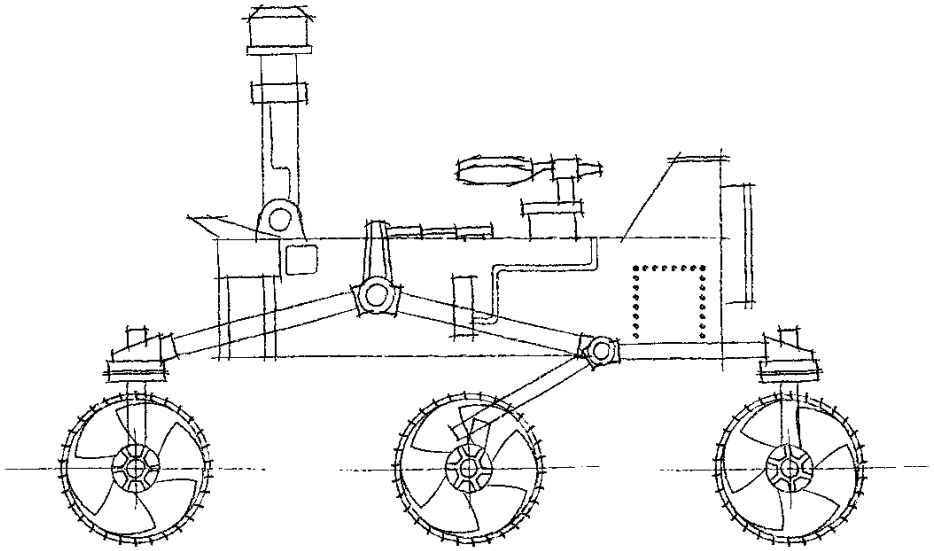
www.nasa.gov/agency/nepa/mars2020eis

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

We appreciate your time and input.

Mars 2020 Mission Science

Ken Farley
Project Scientist
California Institute of Technology/
Jet Propulsion Laboratory



Mars 2020 Project

Current & Future Mars Missions

Operational 2001 - 2014

2016

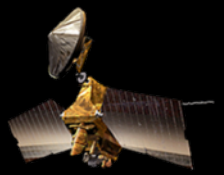
2018

2020

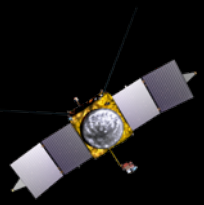
2022

Mars Odyssey

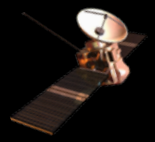
ESA Mars Express
(NASA: MARSIS)



Mars Reconnaissance Orbiter



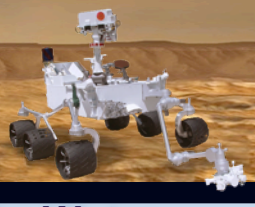
MAVEN



ESA Trace Gas Orbiter
(NASA: Electra)

Opportunity – Mars Exploration Rover

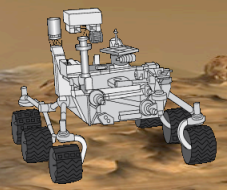
Curiosity – Mars Science Laboratory



InSight

ESA ExoMars Rover
(NASA: MOMA)

Mars 2020 Science Rover



Follow the Water

Explore Habitability

Seek Signs of Life

Prepare for Future Human Explorers

EVOLVING MARS SCIENCE THEMES

Mars 2020 Mission Objectives

Science Objectives

Geologic History

- Carry out an integrated set of spatially-coordinated measurements to fully characterize the geology of the landing site, including contact science

Astrobiology

- Find and characterize ancient habitable environments. Identify rocks with the highest chance of preserving signs of ancient Martian life if it were present, and within those environments. Seek the signs of past life

Select, Collect and Store Samples

- Place rigorously documented and selected samples in a returnable sample cache for possible future return to Earth

Additional Mars 2020 Objectives

Facilitate future human exploration by helping fill in our Strategic Knowledge Gaps, such as assessing local natural resources or potential hazards for future human explorers.

Demonstrate additional technologies required for future Mars exploration.

Measurement Capabilities on the Rover

A competition to select the rover's science and exploration technology instruments is currently in progress by NASA

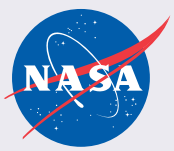
- 58 complete proposals were received
- Announcement of selection likely in mid-summer

For now, the Mars 2020 Science Definition Team suggested the following measurement capabilities for the rover:

- Capabilities to make visual, chemical, and mineralogical observations at a range of spatial scales from outcrop to microscopic.

The scientific observations required to assess geologic history and astrobiology are the same as the instruments required for selecting/documenting samples for a returnable cache

Process for Detecting Past Martian Life



PRE-CONDITIONS THAT MUST HAVE BEEN MET

PAST HABITABLE ENVIRONMENT

Past conditions suitable for the existence of life at the site.

POTENTIAL FOR BIOSIGNATURE PRESERVATION

Past conditions suitable for the preservation of past life in the geologic record.

POSSIBLE EVIDENCE OF ANY PAST LIFE

EXISTENCE OF POTENTIAL BIOSIGNATURE

An observable feature that might be evidence of past life.

PAST LIFE DETECTED

RECOGNITION OF DEFINITIVE BIOSIGNATURE

An observable feature that is confirmed to be evidence of past life.

Proposed Mars 2020 Rover

Mars Sample Return

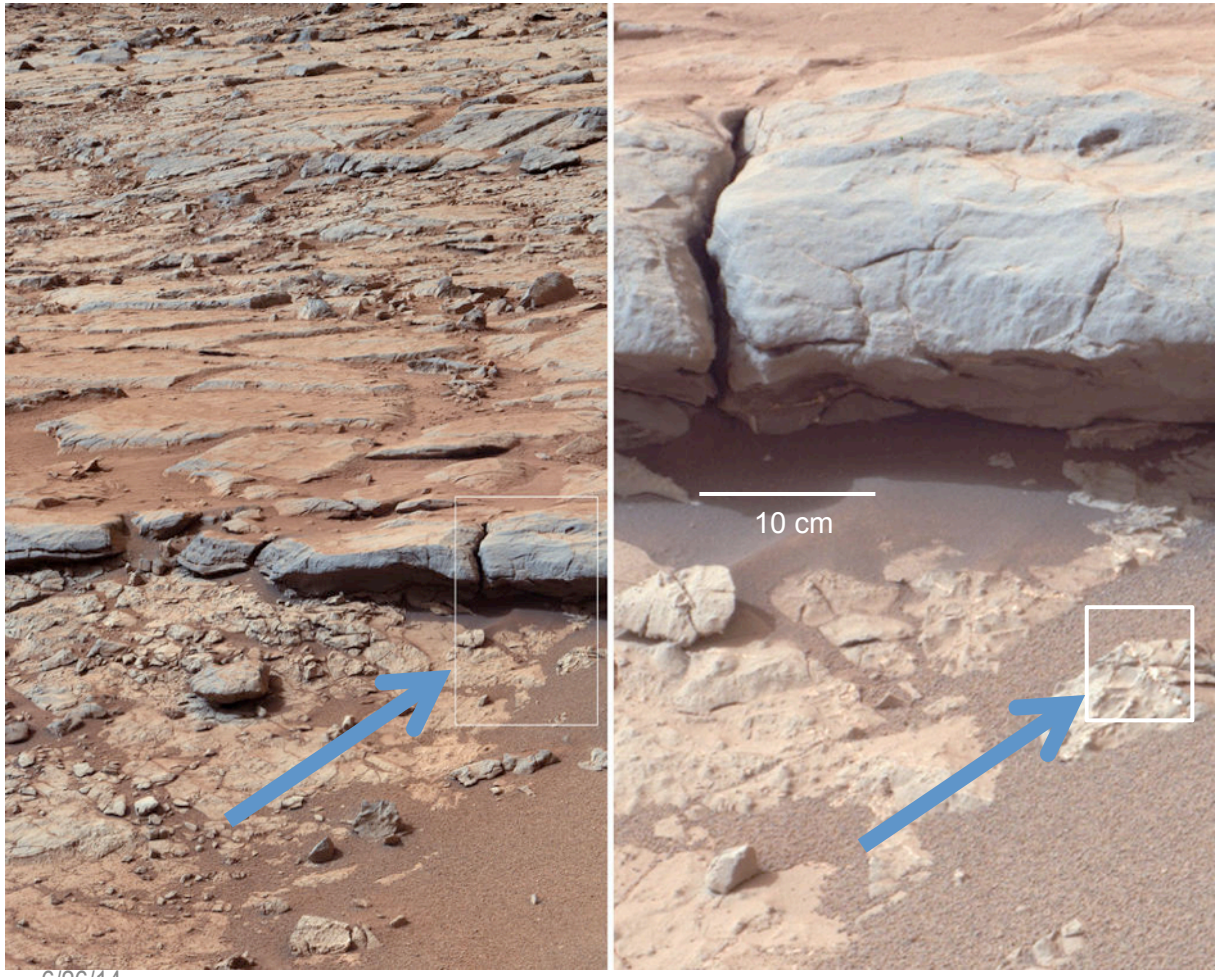
Labs on Earth

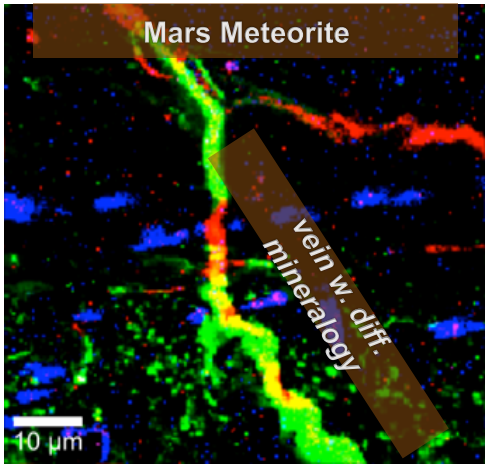
SDT MAJOR FINDING

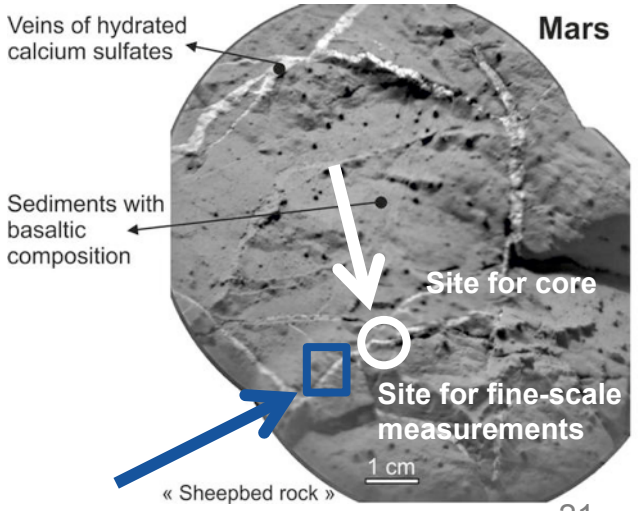
To search for potential biosignatures, it is necessary to (a) identify sites that very likely hosted past habitable environments, (b) identify high biosignature preservation potential materials to be analyzed for potential biosignatures, and (c) perform measurements to identify potential biosignatures or materials that might contain them.

Seeking Signs of Past Life

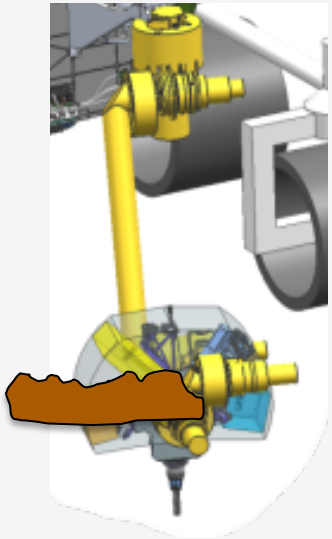
Correlation of variations in rock composition with microscopic structures and textures is critical for geological and astrobiological interpretations.





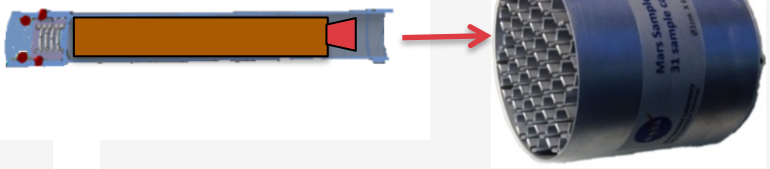


Concept for Acquiring, Storing, and Sealing a Sample



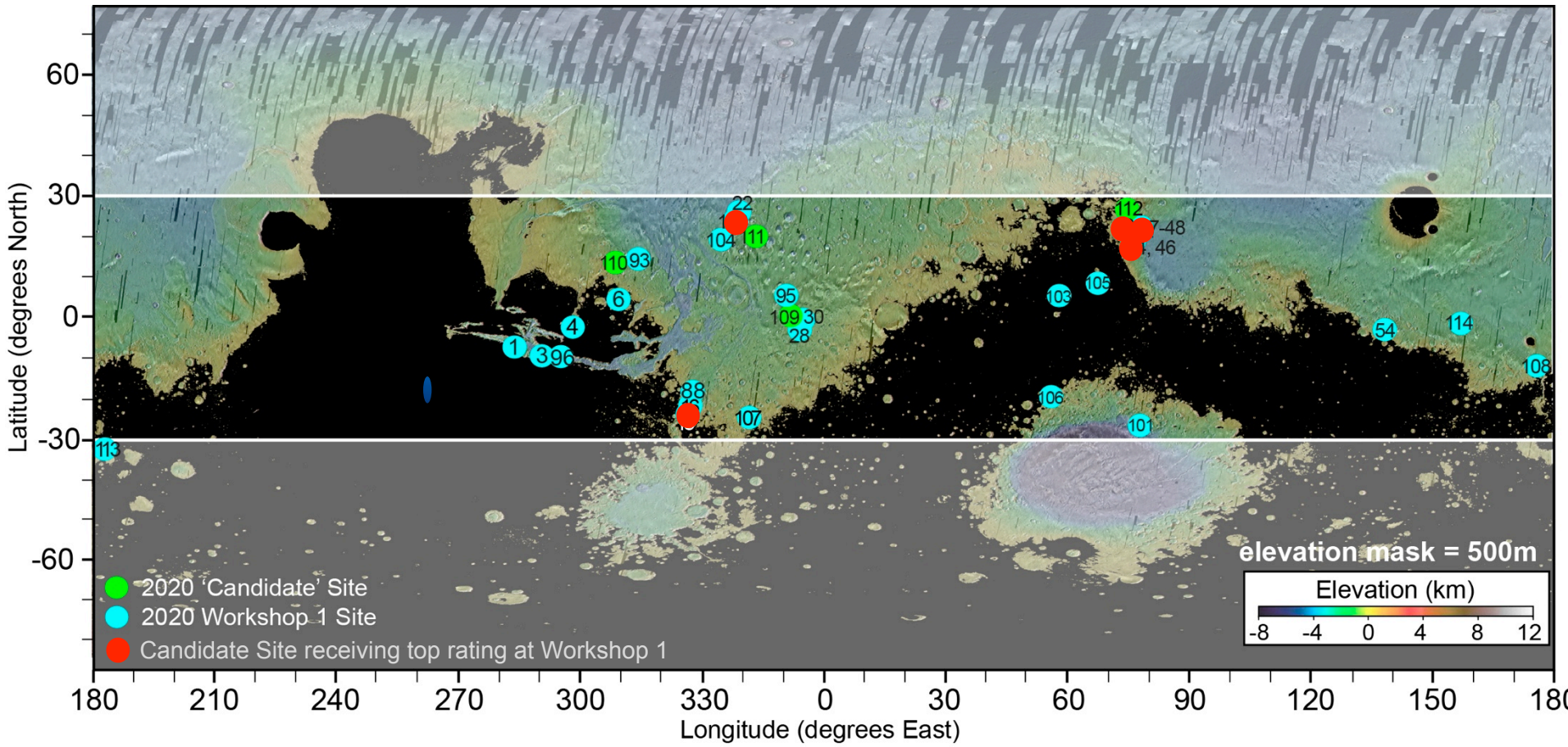
Rover drills a core of pencil-like thickness, 2.2 inches long, directly into a clean tube.

Tube is hermetically sealed.



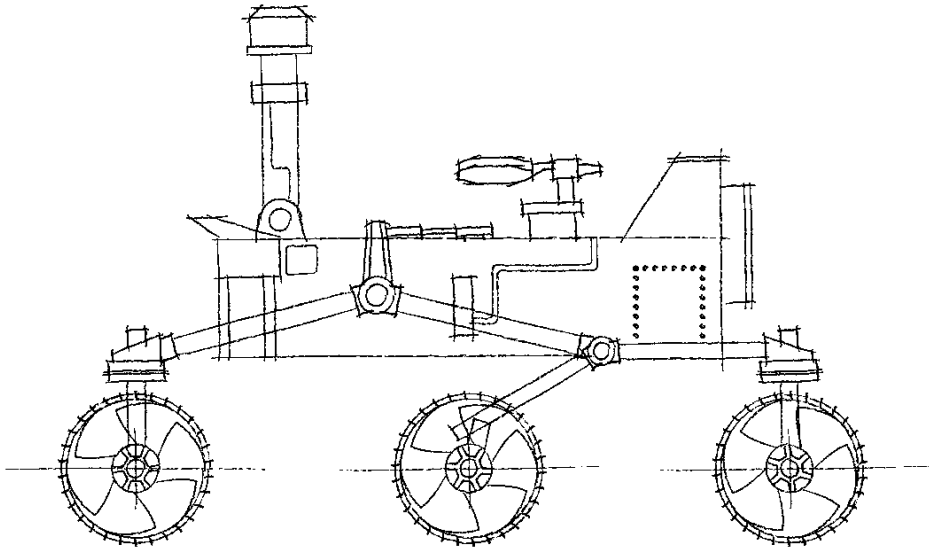
Sealed tube is placed in cache.

Current Candidate Landing Sites



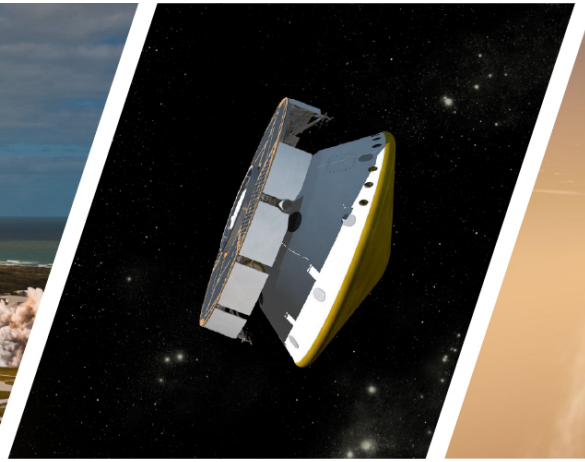
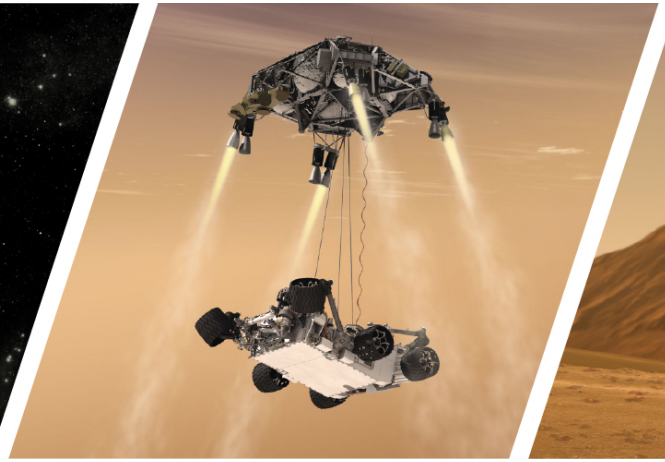
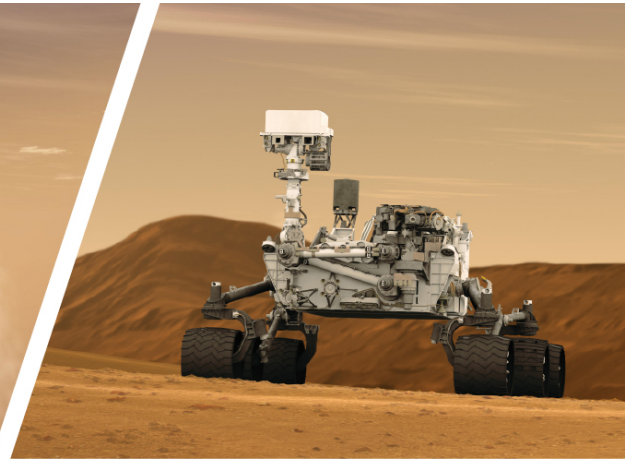
Mars 2020 Mission Overview

Doug Bernard
Project System Engineer
Jet Propulsion Laboratory



Mars 2020 Project

Mission Concept

LAUNCH

- MSL Class/Capability Launch Vehicle
- Period: July/Aug 2020

CRUISE/APPROACH

- 7-month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system: guided entry and powered descent/Sky Crane
- 25x20km landing ellipse
- Access to landing sites ±30° latitude, ≤0.5 km elevation
- ~950 kg rover

SURFACE MISSION

- Prime mission of one Mars year
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

http://mars.jpl.nasa.gov/mars2020/

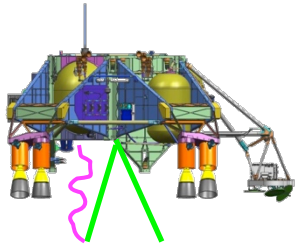
Spacecraft Design Approach

- Leverage successful Curiosity rover and delivery system design, residual hardware, and experienced team.
- Mission concept is predicated on this “high heritage” approach. More than 90% of the spacecraft (by mass) has requirements identical to those for the Curiosity mission.
- ~$200M of residual hardware exists: flight spares, engineering units, electronic parts, testbeds, and support equipment.
- Project has confirmed its ability to buy the same parts and equipment from the top ~25 Curiosity mission vendors.

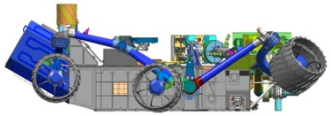
Mars 2020 Baseline Architecture

Cruise Stage

Backshell with parachute



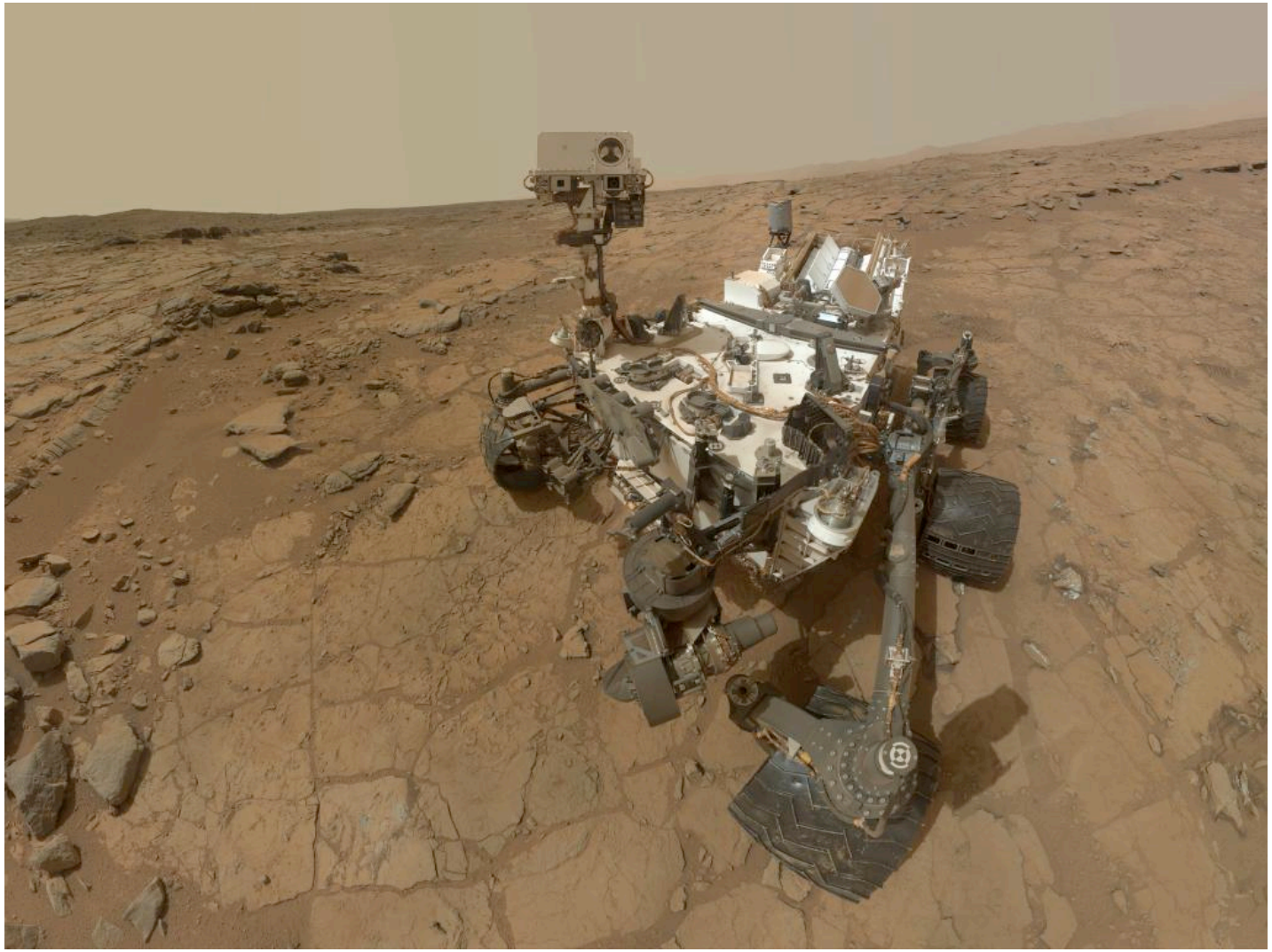
Descent Stage/Skycrane



Rover

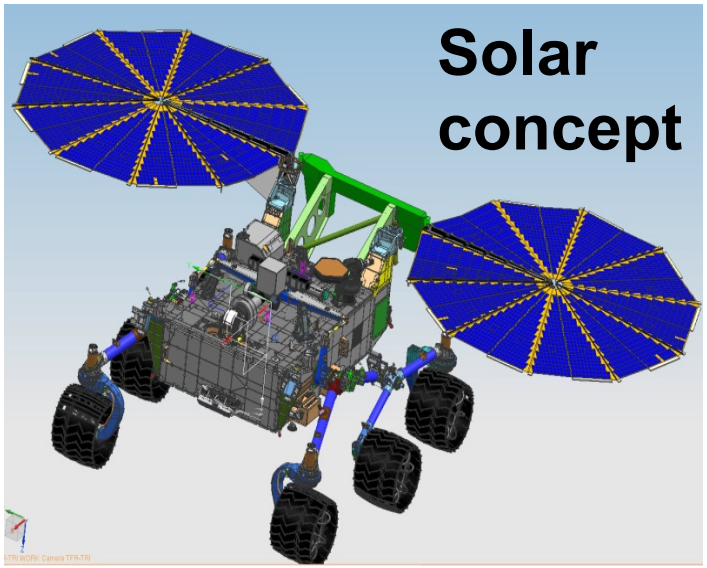
Heat Shield

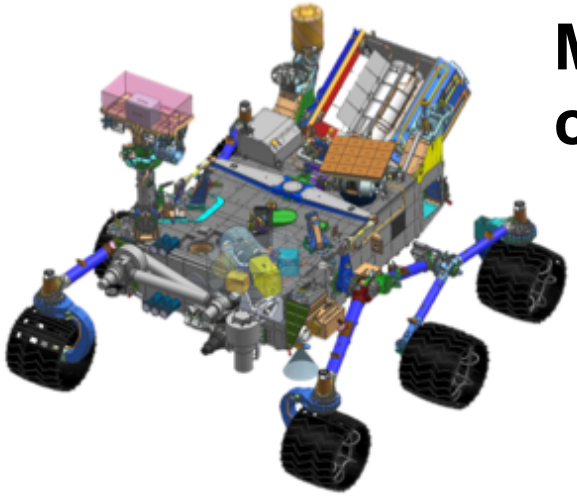
Curiosity self-portrait on Mars



Mission Electrical Power Options

- Solar power
- Solar power augmented with Light-Weight Radioisotope Heater Units (RHUs) for localized thermal control
- A Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)
  - This is the Mars 2020 proposed approach





MMRTG concept

Key Assessment Parameters

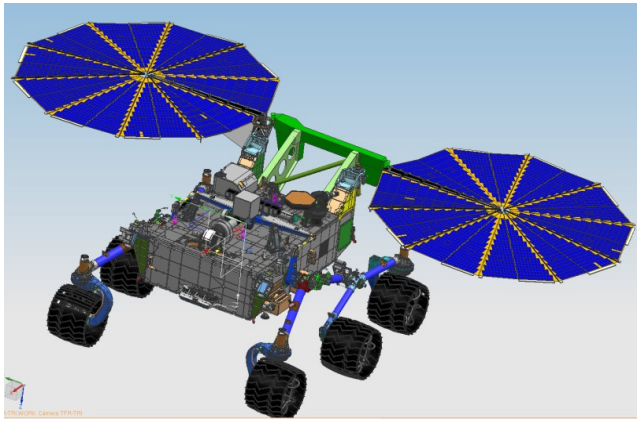
- Operate at landing sites anywhere from 30° North to 30° South latitude
- Operate on the surface of Mars for at least one Martian year (687 Earth days)
- Launch between July and August, 2020, landing on Mars in February 2021
  - This is the fall season for a landing site located in the south and spring for a landing site located in the north
- The thermal and electronics energy usage requirements roughly equivalent to the MSL rover energy usage
- Solar array size limited by inherited MSL aeroshell

Challenges of Solar Power

- **Southern winter coincides with Mars' farthest distance from the Sun**
  - Southern winter survival challenging for high southern latitudes
- **Dust storm season occurs in the second half of the mission for a 2020 launch.**
  - Late enough to allow significant dust buildup on solar arrays, but not late enough to expect mission success prior to a potential dust storm
- **Northern winter includes part of the dust storm season**
  - This makes solar lander winter survival challenging for high northern latitudes in the event of a severe dust storm
- **InSight (the first landed solar-powered mission *designed* to operate for a full Mars Year) is targeting to land within 5 degrees of the equator**
  - Dust storms are likely to occur either before significant dust accumulation or after mission success
- **Spirit and Opportunity were solar powered missions but were not *designed* to survive for a full Mars Year. They landed at 2° S and 15° S latitudes respectively.**
  - Spirit and Opportunity used solar power plus RHUs

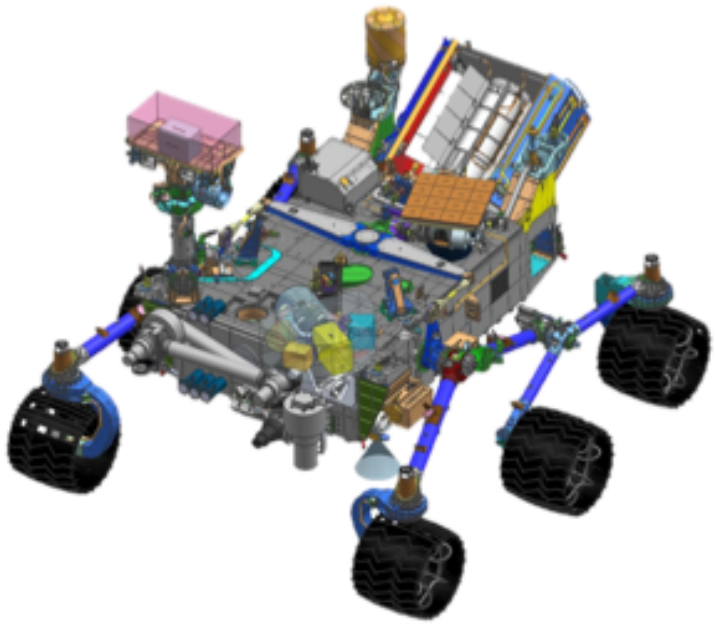
Solar Power alternative: Summary

- **Solar only**
  - Full year survival possible for a narrow range of latitudes near the equator, but only if dust mitigation technology is assumed.
- **Solar plus RHUs**
  - Full year survival possible for broader range of latitudes than solar only
- **Either Option**
  - Best performance near equator
  - Many Northern and Southern latitude sites rated highest by scientists are not viable
  - Invention of new technology to limit dust accumulation on solar arrays would be required to limit risk that mission ends prior to accomplishing science goals
  - Even with dust mitigation technology, science return at accessible latitudes would be significantly degraded relative to an MMRTG mission at same latitude



MMRTG 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



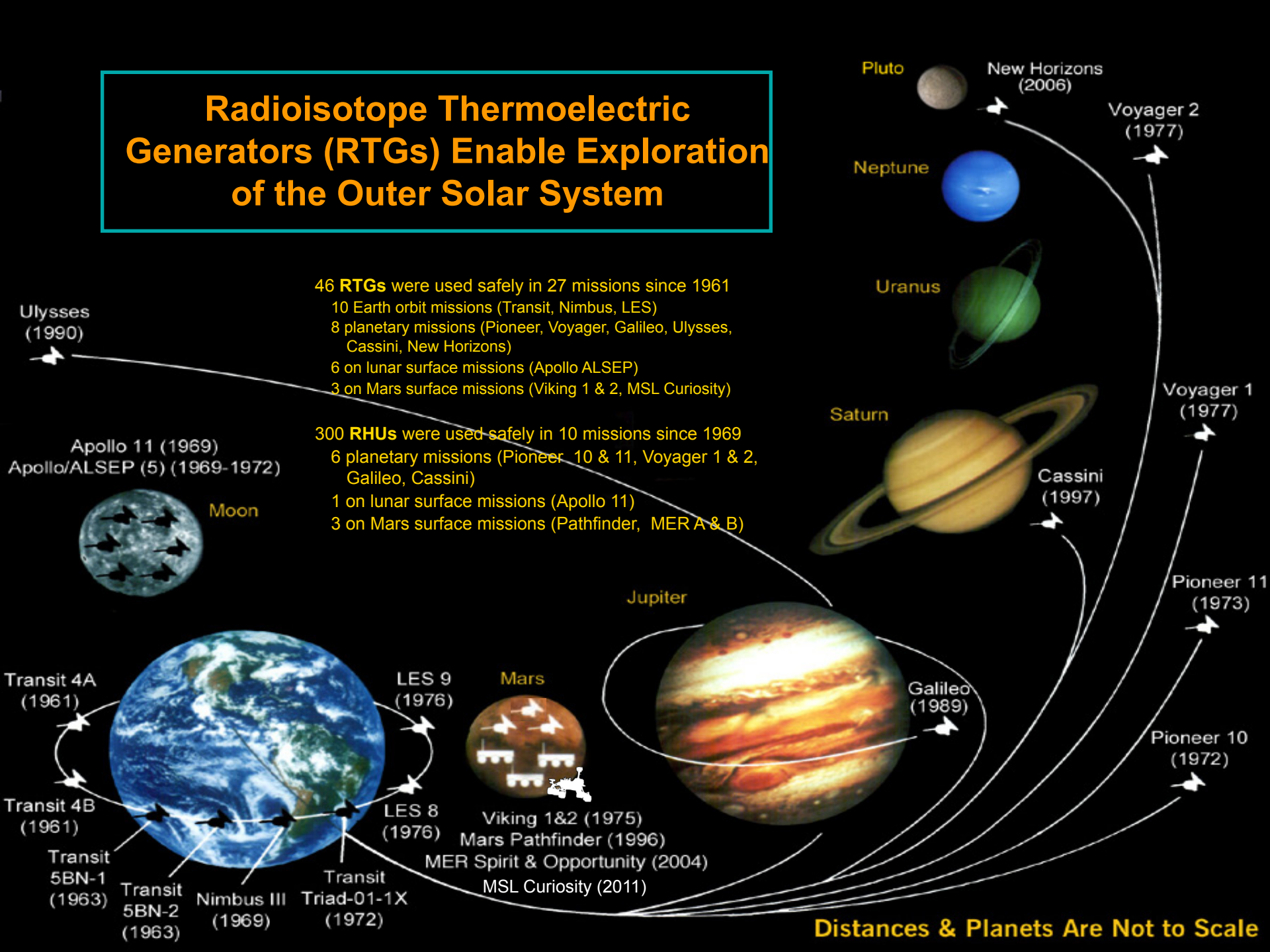
Radioisotope Power System Alternatives for Mars 2020

Ryan Bechtel
Power System Safety Manager
U.S. Department of Energy

Space and Defense Power Systems

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)

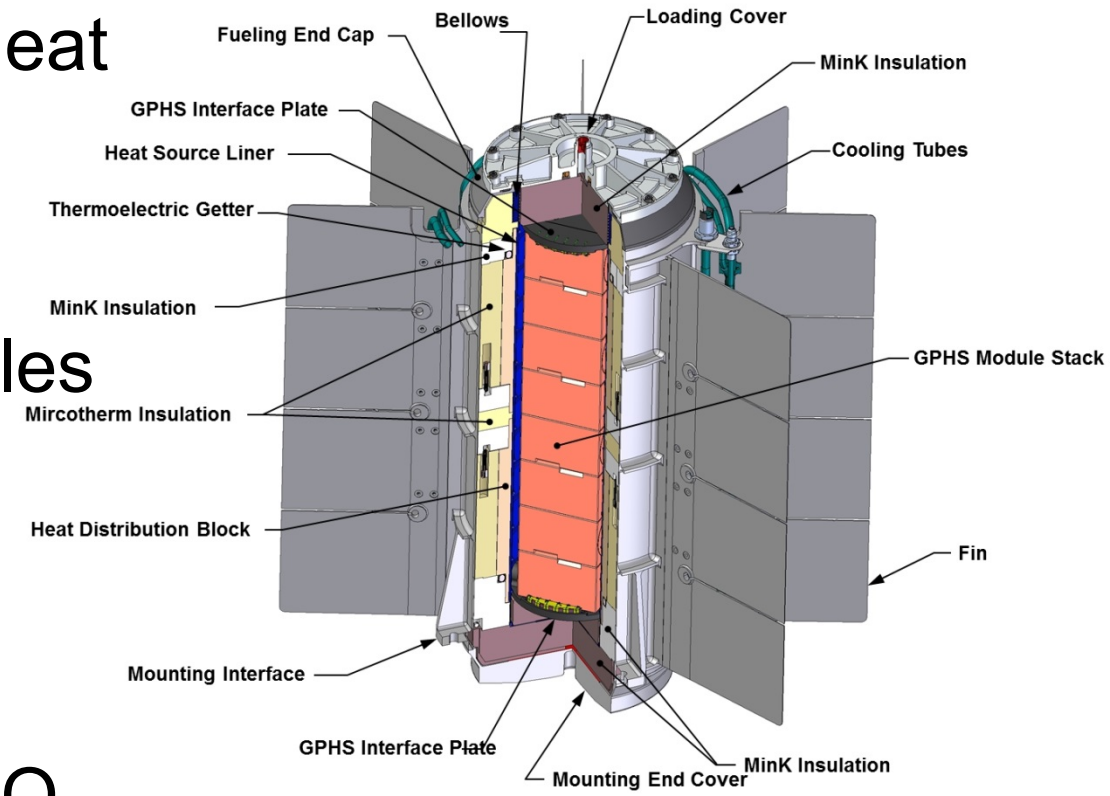
Distances & Planets Are Not to Scale

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Curiosity Rover on Mars

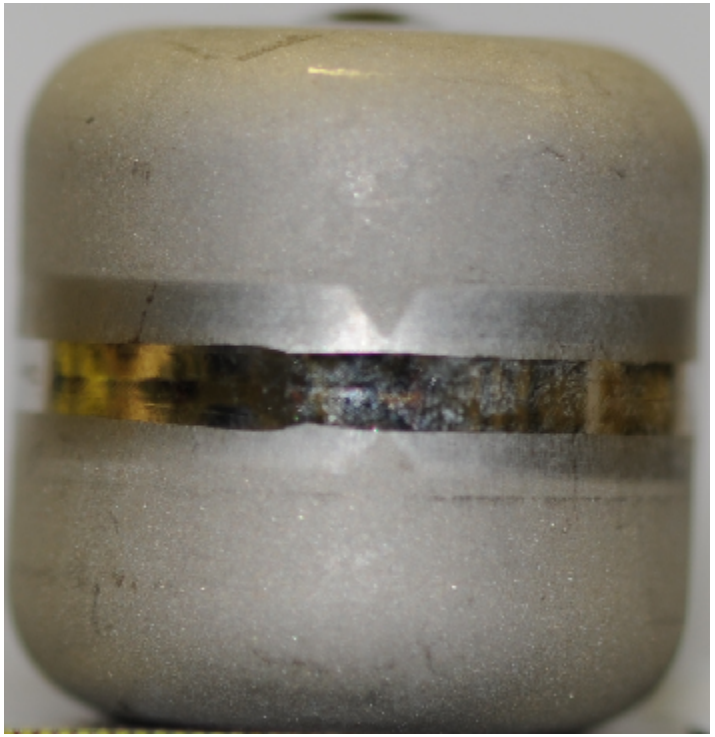
Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

- 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

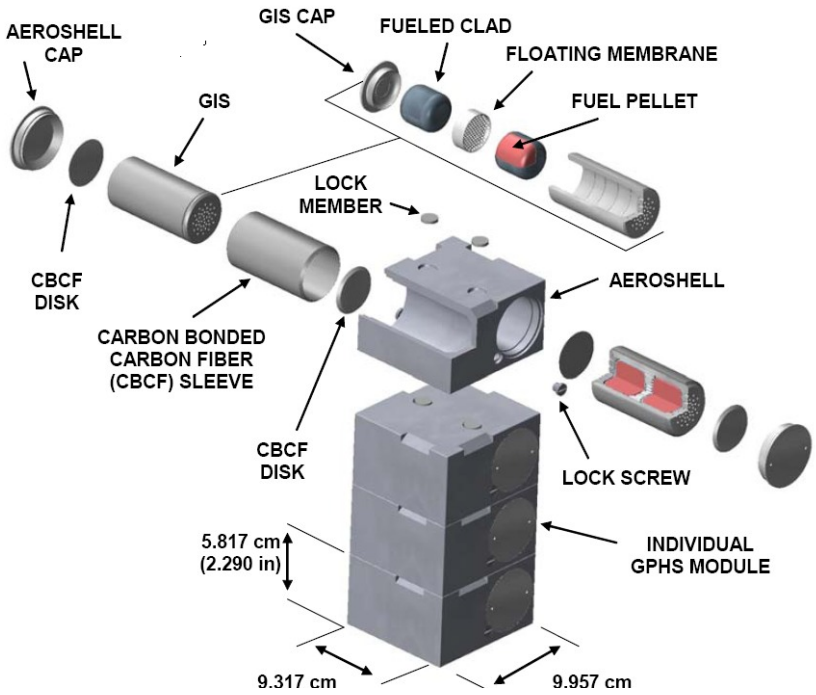


Key Safety Features of Radioisotope Power Systems

- 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

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Radioisotope Heater Units

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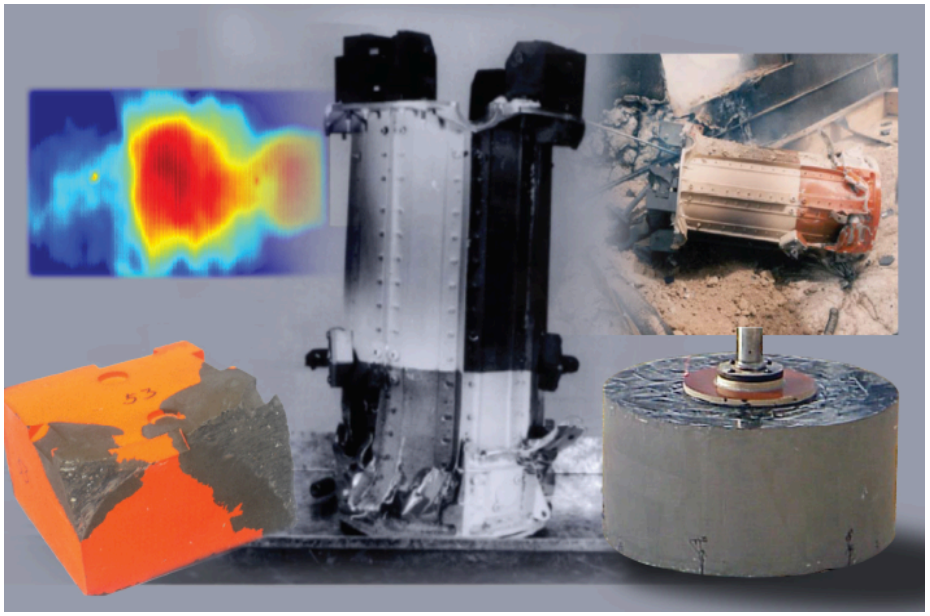
Decades of Experience and Testing

- 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



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Analysis for Mars 2020

- DOE conducted a thorough safety analysis looking at two mission alternatives
  - using an MMRTG
  - using solar panels with up to 80 LWRHUs
- Both alternatives were studied for a launch on an Atlas V 541, Atlas V 551, Delta IV Heavy, and Falcon 9 Heavy rocket

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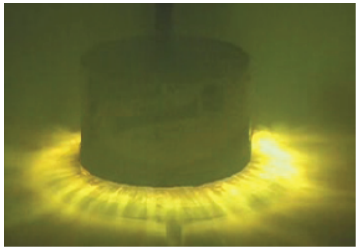
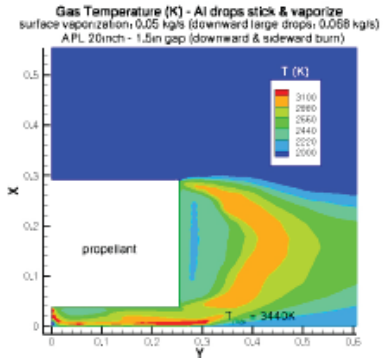
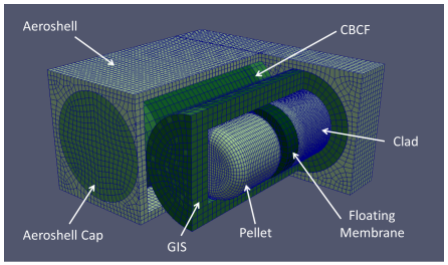
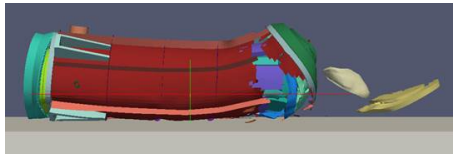
Analysis for Mars 2020

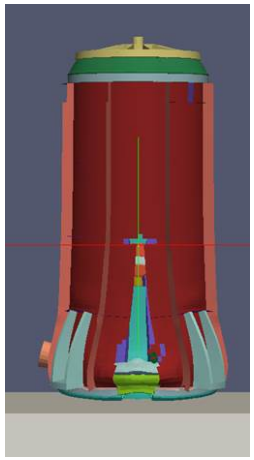
- Over 800 models of MMRTG and LWRHU impacts were performed on one of the world's most powerful supercomputers.
- Over 13 million accidents were simulated using RPS safety testing data, meteorology, chemical and environmental models.
- Using state-of-the-art models and recent test data, DOE found that the risk for Mars 2020 is significantly lower than for previous RTG missions.

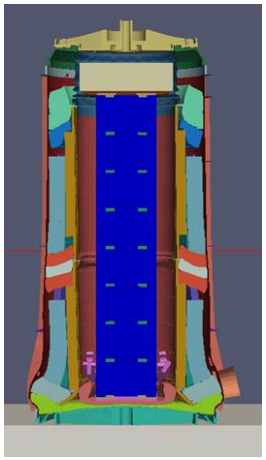






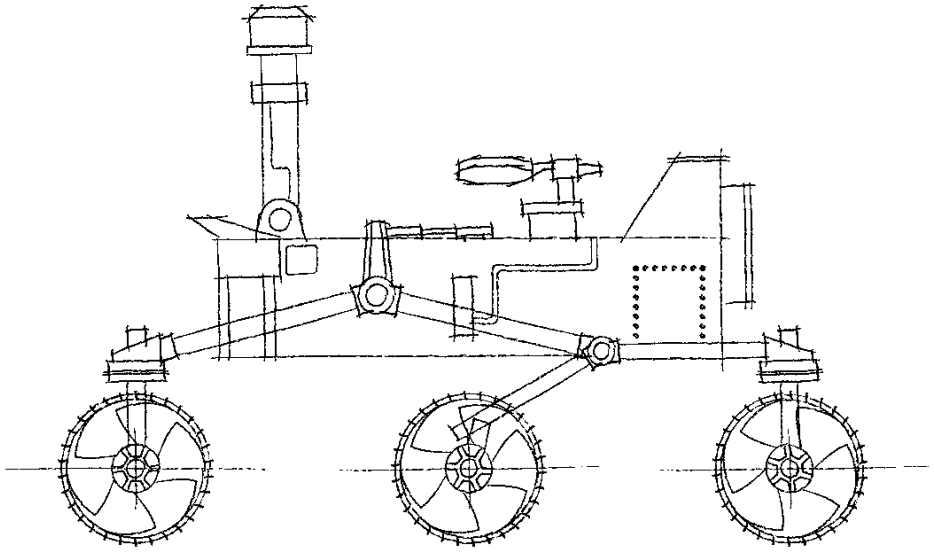






Draft Environmental Impact Statement for the Mars 2020 Mission

George Tahu
Mars 2020 Program Executive



Mars 2020 Project

Mars 2020 Draft EIS: 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.

Mars 2020 Mission Alternatives

- **Alternative 1 (Proposed Action)**: A rover powered by a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)
- **Alternative 2:** A rover powered by solar arrays.
- **Alternative 3:** A rover powered by solar arrays with additional thermal energy provided by Light Weight Radioisotope Heater Units (LWRHUs)
- **"No Action" Alternative:** No Mars 2020 mission would be conducted (in either 2020 or 2022)

Science and Operations Capabilities

- **Alternative 1: MMRTG**
  - Full operability over one Mars year (687 Earth days)
  - Complete access to desired landing site region (30˚ North to 30˚ South latitudes around the planet)
  - No restrictions on operations
  - Highest science return of Alternatives 1, 2, and 3
- **Alternative 2: Solar**
  - No full-year operations for any landing site latitude band
  - Some constrained operations and winter hibernation required
  - Lowest Science Return of Alternatives 1, 2, and 3
- **Alternative 3: Solar Plus LWRHUs**
  - Full-year operability over a limited latitude band (5-20˚ South)
  - Constrained operations and hibernation for at least part of the year
- **“No Action” Alternative**
  - No Science Return

Scope of Draft EIS

The Mars 2020 Draft EIS considers both radiological and non-radiological environmental impacts from the proposed action and the alternatives.

The analysis in the Draft EIS includes potential impacts from:

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

Potential Non-Radiological Mars 2020 Environmental Impacts

- **Alternatives 1, 2, and 3 would have the same 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, biology 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.
- **"No Action" Alternative** – No Environmental Impacts

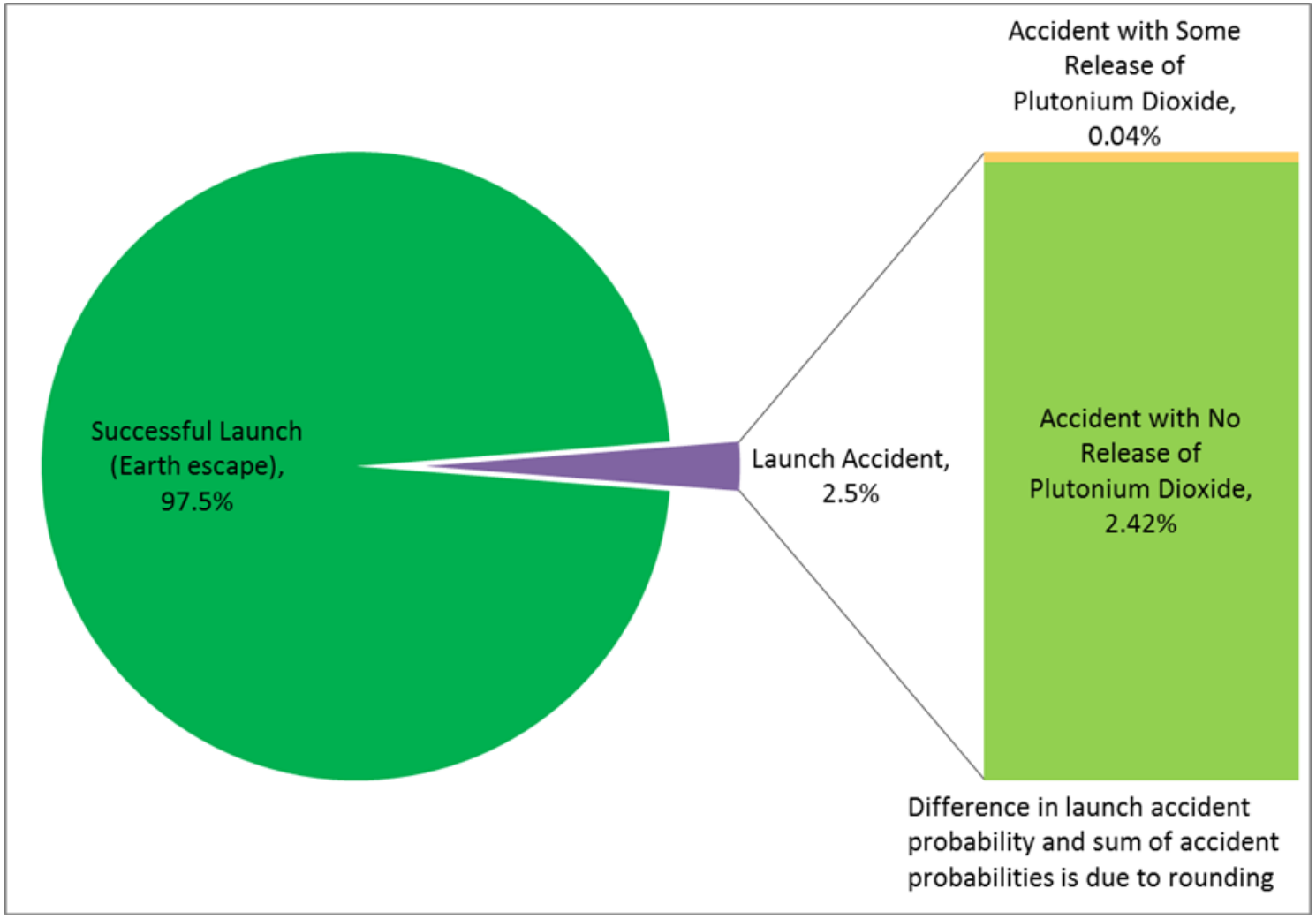
Mars 2020 Launch Probabilities

- **There is a 97.5% chance of a successful launch on a path to Mars.**

- **There is a 2.5% chance of a launch accident of any kind.**

Mars 2020 Launch Accident Probabilities

Alternative 1: MMRTG



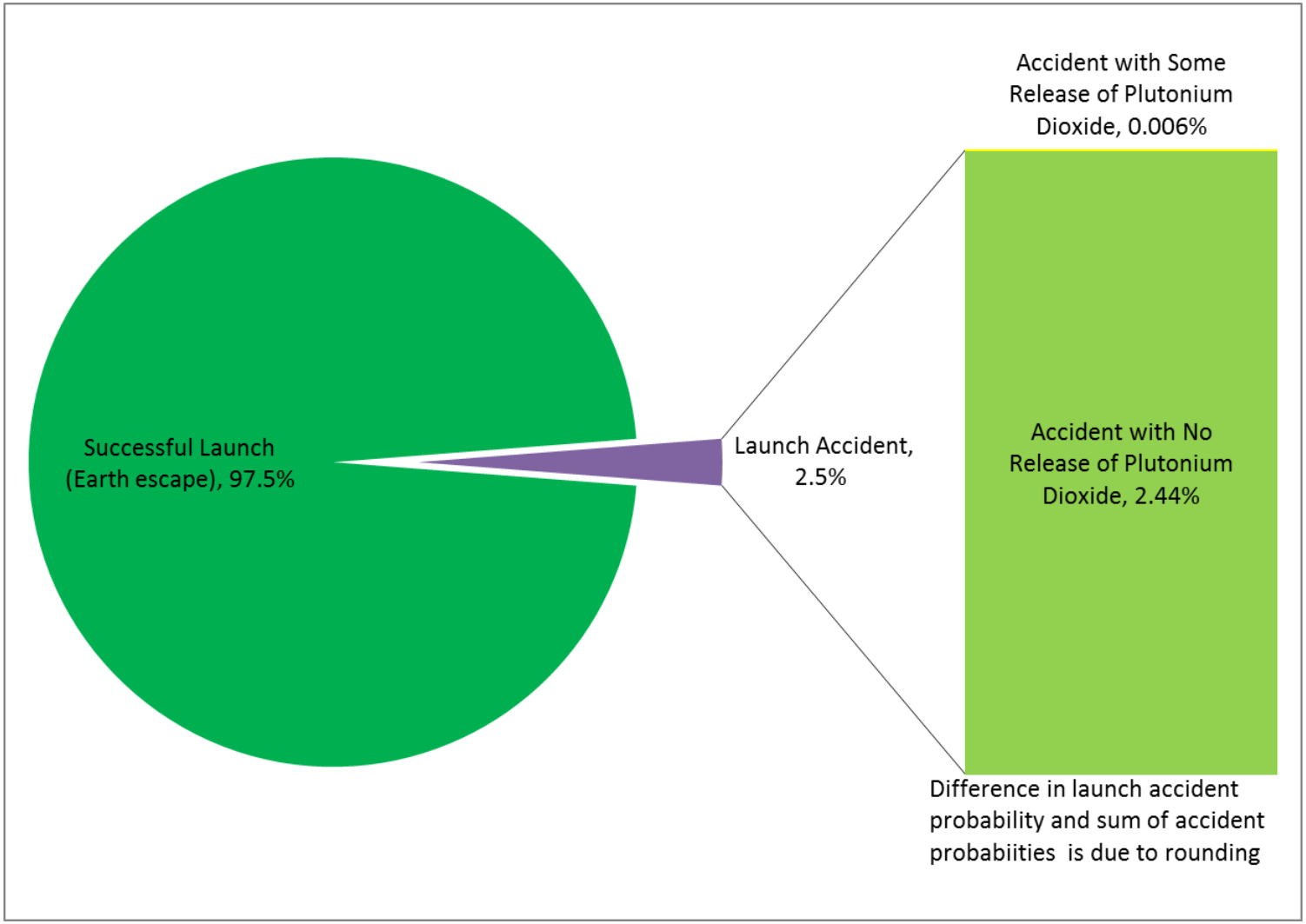
Potential Mars 2020 Environmental Impacts

Alternative 1: MMRTG

- **There is a 1 in 2,600 (0.04%) chance of a launch accident that would release plutonium dioxide.**
  - 1 in 11,000 chance of a launch accident that would result in a release of plutonium dioxide in the launch area.
  - 1 in 3,500 chance of a launch accident that would result in a release of plutonium dioxide outside the launch area.
- **No radiological fatalities** would be expected to occur as a result of any accident.
- The average maximum dose to any member of the public from an accident with a release would equal about 3 months of exposure to natural background radiation for a person living in the U.S.
- An accident in the launch area with release could contaminate, on average, less than 3 square miles in the launch area.

Mars 2020 Launch Accident Probabilities

Alternative 3: Solar Arrays plus LWRHUs



Potential Mars 2020 Environmental Impacts

Alternative 3: Solar Arrays plus LWRHUs

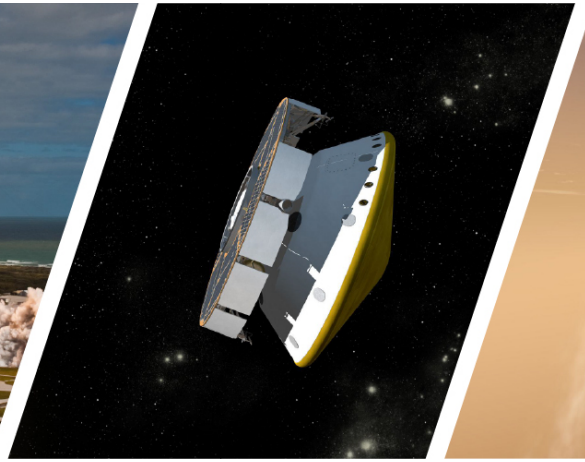
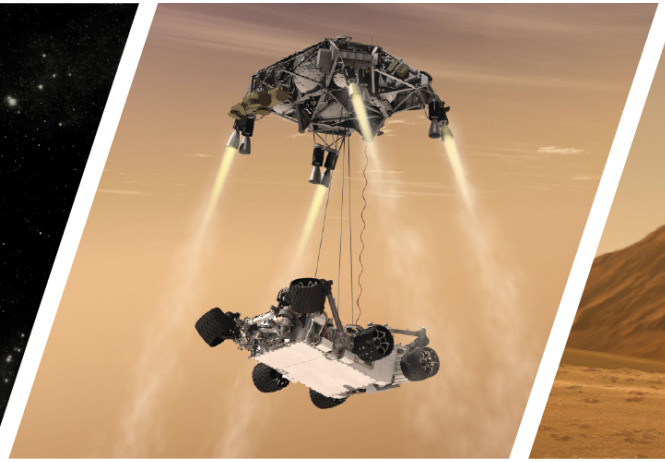
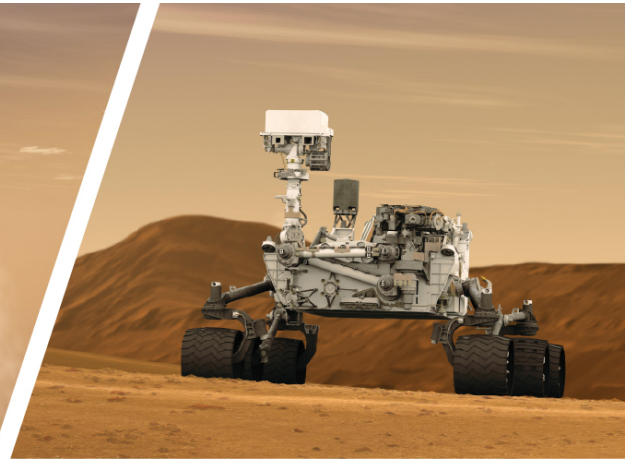
- **There is a 1 in 15,000 (0.006%) chance of a launch accident that would release plutonium dioxide.**
  - There is a 1 in 16,000 chance of a launch accident that would result in a release of plutonium dioxide in the launch area.
  - There is a 1 in 420,000 chance of a launch accident that would result in a release of plutonium dioxide outside the launch area.
- **No radiological fatalities** would be expected to occur as a result of any accident.
- The average maximum dose to any member of the public from an accident with a release would equal about 5 days of exposure to natural background radiation for a person living in the United States.
- An accident in the launch area with release could contaminate, on average, less than one-quarter of a square mile in the launch area.

Potential Mars 2020 Environmental Impacts

Alternatives 1–3: Science instruments on the rover could carry radioactive sources to use in calibrating their measurements

- **There is a 1 in 1,700 chance of a launch accident that would result in a release of radioactive material in the launch area.**
- **No radiological fatalities** would be expected to occur as a result of any accident.
- The average maximum dose to any member of the public would equal about 17 minutes of exposure to natural background radiation for a person living in the United States.
- An accident in the launch area with release could contaminate, on average, less than 0.0005 square miles (a third of an acre) in the launch area.

Summary: Mission Concept

LAUNCH

- MSL Class/Capability Launch Vehicle
- Period: July/Aug 2020

CRUISE/APPROACH

- 7-month cruise
- Arrive Feb 2021

ENTRY, DESCENT & LANDING

- MSL EDL system: guided entry and powered descent/Sky Crane
- 25x20km landing ellipse
- Access to landing sites ±30° latitude, ≤0.5 km elevation
- ~950 kg rover

SURFACE MISSION

- Prime mission of one Mars year
- 20 km traverse distance capability
- Seeking signs of past life
- Returnable cache of samples
- Prepare for human exploration of Mars

http://mars.jpl.nasa.gov/mars2020/