1. PURPOSE AND NEED FOR THE ACTION

This Draft Environmental Impact Statement (DEIS) has been prepared by the National Aeronautics and Space Administration (NASA) and its cooperating agency, the U.S. Department of Energy (DOE), to assist in the decision-making process as required by: the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4321 et seq.); Executive Order (EO) 12114, Environmental Effects Abroad of Major Federal Actions; Council on Environmental Quality (CEQ) regulations (40 CFR parts 1500-1508); and NASA policies and procedures at 14 CFR part 1216. This DEIS provides information associated with the potential environmental impacts of preparing for and associated with the launch of a proposed Mars 2020 mission, which would employ *in situ* scientific instrumentation to seek signs of past life, select and store a compelling suite of samples in a returnable cache, and demonstrate technologies for future robotic and human exploration of Mars. This document is a Tier 2 mission-specific DEIS under NASA's Mars Exploration Program Programmatic EIS (NASA 2005a). Launch of the Mars 2020 mission would take place at Cape Canaveral Air Force Station (CCAFS), Brevard County, Florida, or Kennedy Space Center (KSC), Brevard County, Florida, during the summer of 2020. The next launch opportunity for this mission would occur during the summer of 2022. Chapter 2 of this DEIS describes the alternatives considered to achieve the Mars 2020 mission.

1.1 BACKGROUND

In response to the recommendations by its advisory and analysis groups, NASA is currently undertaking a long-term systematic program of Mars scientific exploration—the Mars Exploration Program (MEP). To discover the possibilities for past or present life on Mars, NASA's MEP is currently following an exploration strategy known as "Seek Signs of Life."

This science theme marks an evolution in the Mars exploration strategy. It reflects a long-term process of discovery on the red planet built on strategies to understand Mars' potential as a habitat for past or present microbial life. Searching for this answer means delving into the planet's geologic and climate history to find out how, when, and why Mars underwent dramatic changes to become the planet we observe today.

Because water is key to life as we know it, earlier Mars missions (2001 Mars Odyssey, Mars Exploration Rovers (MERs), Mars Reconnaissance Orbiter, Mars Phoenix Lander) were designed to make discoveries under the previous MEP science theme of "Follow the Water." That strategy connected fundamental program goals pertaining to biological potential, climate, and the evolution of the solid planet. Progressive discoveries related to evidence of past and present water in the geologic record made it possible to take the next steps toward finding evidence of life itself.

The Mars Science Laboratory (MSL) mission and its Curiosity rover marked a transition between the themes of "Follow the Water" and "Seek Signs of Life." In addition to landing in a place with past evidence of water, Curiosity is seeking evidence of organics, the chemical building blocks of life. Places with water and the chemistry needed for life potentially provide habitable conditions.

The scientific objectives established by the program to address the goal of answering the question "Did life ever exist on Mars?" are to search for evidence of past or present life, characterize the climate and volatile history of Mars, understand the surface and subsurface geology (including the nature of the interior), and characterize the Martian environment quantitatively in preparation for human exploration. One common thread that links these objectives is to explore the role of water in all of its states within the "Mars system," from the top of the atmosphere to the interior.

The MEP is fundamentally a science-driven program focused on understanding and characterizing Mars as a dynamic system and ultimately addressing whether life is or was ever a part of that system. The MEP further embraces the challenges associated with the development of a predictive capability for Martian climate and how the role of water and other factors, such as variations in the tilt of the planet's polar axis, may have influenced the environmental history of Mars.

The core MEP addresses the highest priority scientific investigations directly related to the Program's goals and objectives. These planned investigations were derived by means of a highly inclusive process involving a large segment of the broad planetary exploration science community. The MEP is currently implemented as a sustained series of flight missions to Mars, each of which will provide important, focused scientific return. NASA is taking advantage of launch opportunities available approximately every 26 months, to evolve a scientifically integrated architecture of orbiters, landers, and rovers. Figure 1-1 provides a timeline of the MEP missions since 1997, including proposed missions through 2020 and cooperative missions with the European Space Agency (i.e., 2016 Trace Gas Orbiter (TGO) and 2018 ExoMars Lander Mission (EXM)). The Mars Atmospheric and Volatile EvolutioN (MAVEN) mission has launched and is expected to arrive in Mars orbit in September 2014. The MEP has launched both orbiting and surface-focused missions with the orbiters providing both investigative and communication capabilities.

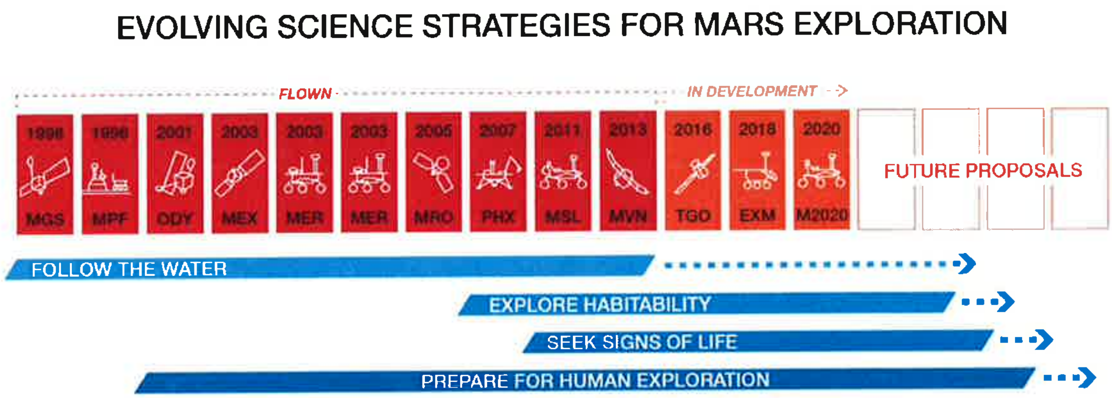
The goals of the MEP are outlined below (NASA 2014b). The science goals described in Section 1.2 for the proposed Mars 2020 mission support these MEP goals.

Determine if life exists or has ever existed on Mars

- Search for life where liquid water was once stable
- Look for energy sources (other than sunlight) necessary to support life
- Look for the signs of life on Mars, telltale markers of current and past life
  - Mineralogical clues indicating the sustained presence of water at one time
  - Environments amenable (similar to sedimentary soils on Earth) to preserving signs of life

Characterize the climate of Mars

- Characterize the current climate and climate processes of Mars
- Characterize the ancient climate of Mars



Landers - PHX: Phoenix
Rovers - MPF: Mars Pathfinder, MER: Mars Exploration Rovers, MSL: Mars Science Laboratory, EXM: ExoMars Rover, M2020: Mars 2020
Orbiting observatories and communications - MGS: Mars Global Surveyor, ODY: Mars Odyssey, MEX: Mars Express, MRO: Mars Reconnaissance Orbiter, MVN: MAVEN, TGO: ExoMars Trace Gas Orbiter
Source: NASA 2014a

Figure 1-1. MEP Missions 1997 - 2020

Characterize the geology of Mars

- Determine the geological processes (wind, water, volcanism, tectonics, cratering, etc.) that have resulted in formation of the Martian crust and surface
  - Identify the composition of surface materials, particularly those that may indicate the presence of water
- Characterize the structure, dynamics, and history of the planet's interior
  - Determine the impact of the magnetic field Mars once had, but no longer has

Develop an understanding of Mars in support of possible future human exploration

- Acquire appropriate Martian environmental data such as those required to
  - Characterize the radiation environment
  - Conduct *in situ* engineering and science demonstrations
- Advance spacecraft technology (e.g., entry descent and landing technology) for astronaut safety.

The MEP also ensures the development and demonstration of technologies required to enable attainment of these goals. Specifically, the program enables new classes of Mars science investigations, including remote astrobiology and new techniques for *in situ* life detection. Technology developments and improvements over the course of the program enable a progressive increase in the payload mass delivered to Mars orbit and to the surface by program spacecraft, enhance the capability to safely and precisely place payloads at any desired location on the surface, and enable full access to the subsurface, surface and atmospheric regions.

Technology improvements envisioned as part of MEP would also enhance long-lived (one Mars year (1.88 Earth years) or longer duration, as a goal) surface science investigations, and support the development of robotic assets to provide a nearly continuous data return from the surface (NASA 2005a).

1.2 PURPOSE OF THE ACTION

The purpose of the proposed Mars 2020 mission is to both conduct comprehensive science on the surface of Mars and demonstrate technological advancements potentially useful for the future exploration of Mars. The overall scientific goal is to address in detail questions of habitability and the potential origin and evolution of life on Mars. In July of 2013, the Mars 2020 Science Definition Team (SDT) outlined a mission concept for the Mars 2020 mission to explore and investigate in detail a site on Mars that likely was once habitable. This team identified four objectives for this mission (Mars 2020 SDT 2013). NASA further characterized these mission objectives in an Announcement of Opportunity (AO) released on 24 September 2013 (NASA 2013d) for the competitive acquisition of payload investigations for the Mars 2020 mission. The four objectives are to:

A. Characterize the processes that formed and modified the geologic record within a field exploration area on Mars selected for evidence of an astrobiologically relevant ancient environment and geologic diversity.

B. Perform astrobiologically relevant investigations on the geologic materials at the landing site:

   1. Determine the habitability of an ancient environment.

   2. For ancient environments interpreted to have been habitable, search for materials with high biosignature preservation potential.

   3. Search for potential evidence of past life using the observations regarding habitability and preservation as a guide.

C. Assemble a returnable cache of samples for possible future return to Earth.

   1. Obtain samples that are scientifically selected, for which the field context is documented, that contain the most promising samples identified in Objective B and that represent the geologic diversity of the field site.

   2. Ensure compliance with future needs in the areas of planetary protection and engineering so that the cache could be returned in the future if NASA chooses to do so.

D. Contribute to the preparation for human exploration of Mars by making significant progress towards filling at least one major Strategic Knowledge Gap[2]. The

[2] Gaps in knowledge or information required to reduce risk, increase effectiveness, and improve the design of robotic and human space exploration missions.

highest priority measurements that are synergistic with Mars 2020 science objectives and compatible with the mission concept are (in priority order):

1. Demonstration of In Situ Resource Utilization (ISRU) technologies to enable propellant and consumable oxygen production from the Martian atmosphere for future exploration missions.

2. Characterization of atmospheric dust size and morphology to understand its effects on the operation of surface systems and human health.

3. Collection of surface weather measurements to validate global atmospheric models.

A fifth objective, identified in the SDT, is to demonstrate improved technical capabilities for landing and operating on the surface of Mars to benefit future Mars missions.

The proposed Mars 2020 mission objectives align with the priorities of the *Decadal Survey* (the Space Studies Board's (SSB's) *Vision and Voyages for Planetary Science in the Decade 2013-2022*) (NAP 2011) for solar system exploration and investigations. It would address several of the high-priority scientific investigations recommended to NASA by the science community.

1.3 NEED FOR THE ACTION

The proposed Mars 2020 mission objectives align with the priorities of the National Research Council's (NRC) 2013 Planetary Science Decadal Survey for solar system exploration and investigations, *Vision and Voyages for Planetary Science in the Decade 2013-2022* (NAP 2011). This report was requested by NASA and the National Science Foundation (NSF) to review and assess the status of planetary science and to develop a comprehensive science and mission strategy that updates and extends the NRC's 2003 planetary decadal survey, *New Frontiers in the Solar System: An Integrated Exploration Strategy*. Drawing on extensive interactions with the broad planetary science community, the report presents a decadal program of science and exploration with the potential to yield revolutionary new discoveries. This report identifies fundamental questions that a planetary exploration program should address, including questions about past or present life in the solar system, and how they relate to a NASA's human exploration program. The Mars 2020 mission would address several of the high-priority scientific investigations recommended to NASA by the science community through the decadal survey.

The MEP forms a vital part of NASA's planetary exploration program. As stated in the NRC document, "Mars presents an excellent opportunity to investigate the major question of habitability and life in the solar system." Not only can we get to and explore Mars (as demonstrated by the success of a series of progressively larger, more complex, and scientifically rewarding missions), Mars holds the promise of providing answers to the questions identified for a planetary exploration program.

The past and current environments on Mars have resulted in conditions that are unique in the solar system (NAP 2011).

- Mars, early in its history, is thought to have had an environment in which prebiotic compounds may have formed and that its environment may have been conducive to the origin and continued evolution of life.
- Mars has also experienced major changes in surface conditions that have produced a wide range of environments.
- Mars has not been subjected to significant atmospheric and geological degradation resulting in the possibility that the early geologic record of Mars has been preserved. This means that there is potential evidence of prebiotic and biotic processes and how they relate to the evolution of the planet as a system.

Because of these conditions, the signs of past life on Mars may have been preserved in such a manner that we can find them. Mars, therefore, provides the opportunity to address questions about past and present life in the solar system such as: "Did life arise elsewhere in the solar system, and if so, how?" "How did Mars evolve into the planet it is today and what can be learned about Earth's evolution?" and "How are the biological and geological history of a planet related?" Progress on these important questions can be made more readily at Mars than anywhere else in the solar system (NAP 2011).

The form of the proposed Mars 2020 mission—a landed rover carrying a suite of scientific instruments—is the result of a desire to maximize the potential science return from the mission. The rover's mobility provides access to a significantly larger area than possible with a landed, stationary mission. As expressed by the Space Studies Board's Committee on Planetary and Lunar Exploration (COMPLEX) (NAP 1999), mobility is essential because evidence for past or present life on Mars will very likely not be so abundant or widespread that it will be available in the immediate vicinity of the selected landing site. Without the mobility necessary to conduct *in situ* exploration, it may not be possible to uniquely characterize a target location. COMPLEX further emphasized the need for very capable mobile science platforms that could carry a suite of mutually complementary instruments, have an extensive range and long lifetime, and have one or more manipulative devices for acquiring and caching samples. Lessons from MER and MSL have demonstrated the advantages of mobility for conducting scientific investigations.

The scientific instrumentation to be carried aboard the rover is being selected to build upon the capabilities of previous missions. Discoveries from earlier missions of the MEP, including NASA's Spirit and Opportunity rovers, Mars Science Laboratory rover Curiosity, the Phoenix lander, Mars Odyssey, Mars Reconnaissance Orbiter (MRO), and the European Space Agency's Mars Express orbiter, point definitively to evidence of a past presence of water on Mars and the presence today of subsurface water ice. Data returned and analyzed from these ongoing missions continue to demonstrate a need for global exploration of the planet. Future exploration efforts could use that information as a basis for investigations intended to take the next step and "Seek Signs of Life."

In 2002, Mars Odyssey found evidence of large amounts of subsurface water ice in the northern arctic plains. NASA's Phoenix Lander mission, first in the series of Mars Scout missions within the MEP, was selected to examine this region in detail. Phoenix arrived at Mars in May 2008 in the beginning of Northern Summer on Mars. Phoenix confirmed deposits of underground water ice. It also found calcium carbonate, which is indicative of the presence of liquid water at one time; and perchlorates, which some Earth microbes can use as food, in the ice-rich soil of the Martian arctic (NASA 2010a).

NASA's MRO mission entered orbit around Mars in March 2006 and, after a period of adjustments to its orbit, began its primary science mission in November 2006. In achieving its scientific objectives, MRO has searched for subsurface water and found safe and scientifically worthy landing sites for the MSL mission and continues to be used for reconnaissance of potential Mars 2020 landing sites.

The Mars Exploration Rovers found signs of the past presence of surface water: minerals that on Earth are formed in the presence of water and overlapping rock layers. The overlapping rock layers, formed as water evaporated, provide evidence that water may have been found on the surface of Mars over long time periods. Besides finding evidence of past surface water, the rovers identified additional chemical elements in the Martian soil that, although not definitive proof of past life, are needed for life (NASA 2013b).

The MSL began to provide new information even before arriving at Mars. During its journey to Mars, Curiosity instrumentation measured cosmic and solar radiation levels—measurements that will help NASA plan and design any future manned expedition to Mars. During the first year of its two Earth year mission, Curiosity found evidence that at one time Mars had an environment that could support microbial life and evidence of an ancient streambed has been found by the rover (NASA 2013c). In addition to landing in a place with past evidence of water, Curiosity is continuing to seek evidence of organics, the chemical building blocks of life. Places with water and the chemistry needed for life potentially provide habitable conditions.

These previous missions have yielded new information on ancient and recent habitability on Mars both globally and locally. To further increase our knowledge of the solar system and of life's evolution here on Earth, future Mars missions would be designed to build upon the findings from these missions to search for life itself in places identified as potential past or present habitats. Like previous MEP missions, this mission would be driven by scientific questions that evolve from discoveries by prior missions.

The goals proposed for the Mars 2020 mission, with its overarching theme to "Seek Signs of Life," build upon this heritage and would improve knowledge of the habitability of Mars from a scientifically promising location. The proposed Mars 2020 mission objectives would also address NASA's strategic goals of continuing to pave the way for future human exploration.

1.4 NEPA PLANNING AND SCOPING ACTIVITIES

On April 12, 2005, NASA published a Notice of Availability of the *Final Programmatic Environmental Impact Statement for the Mars Exploration Program* (PEIS MEP) (NASA 2005a, 70 FR 19102). The Record of Decision for the PEIS MEP was signed on June 22, 2005, enabling continued planning for the MEP, which represents NASA's overall plans for the robotic exploration of Mars through 2020. The PEIS MEP encompasses the launch of at least one spacecraft to Mars during each favorable launch opportunity, which occurs approximately every 26 months. Overall environmental compliance in support of the MEP is addressed in the PEIS MEP, and allows planning to continue for the Mars 2020 mission.

On September 11, 2013, NASA published in the Federal Register (78 FR 55762) a Notice of Intent (NOI) to prepare an Environmental Impact Statement and conduct scoping for the Mars 2020 mission. Public input and comments on alternatives, potential environmental impacts, and concerns associated with the proposed Mars 2020 mission were requested. The scoping period ended on October 30, 2013.

NASA held scoping meetings to solicit written and oral comments on the scope of the Mars 2020 Mission EIS. Two scoping meetings were held in the vicinity of KSC. An open house, town hall meeting format was used for the scoping meetings. This format provided meeting participants the opportunity to familiarize themselves with the proposed Mars 2020 mission and EIS, as well as the NEPA process during the open house, followed by an opportunity to provide formal comments on the scope of the Mars 2020 Mission EIS.

The open house portion of the scoping meetings included displays of a variety of posters and printed material that supported the EIS and NEPA process. Technical experts were available to interact with the public at the various displays. In addition, there were several "floater" experts who provided additional technical expertise where needed. Each display was augmented with supporting written materials such as a fact sheet.

The town hall session followed the open house portion of the scoping meeting. After introductory remarks, presentations were made starting with videotapes by the NASA HQ Mars 2020 Program Executive and the NASA HQ NEPA Manager; and then followed by presentations by team members that were in attendance. In anticipation of the government shutdown, the NASA HQ Mars 2020 Program Executive and the NASA HQ NEPA Manager recorded their presentations at NASA TV in Washington, DC for use during the town hall sessions. At the conclusion of the presentations, the facilitator took leadership of the meeting, guiding individuals through the comment process.

Written comments were also received in response to the NOI. A summary of the comments on the suggested scope of the DEIS include:

- **Comment:** The EIS should discuss the impacts on local flora and fauna, including Mosquito Lagoon (where [in] winter bottlenose dolphin were found) and Merritt Island National Wildlife Refuge.
  Response: Chapter 4 of this DEIS discusses the impacts on local flora and fauna. The impacts of normal launches and the non-radiological impacts of launch accidents on local flora and fauna are addressed in Sections 4.1.2 and 4.1.3. The impacts on local flora and fauna associated with launch accidents that release radioactive material were addressed in the DOE Nuclear Risk Assessment through land contamination and are discussed in Sections 4.1.4 and 4.3.4.

- **Comment:** The EIS should discuss how the mission plans to limit the spread of radiological and non-radiological materials to the environment in a launch accident.

  Response: As discussed in Sections 2.1.3 and 4.1.4.3 (addressing the MMRTG). and 2.3.1.2 and 4.3.4.3 (addressing the LWRHUs), the MMRTG and LWRHUs are designed to contain the radioactive material during normal operations and under a wide range of launch accident conditions. In addition, NASA and the USAF have established a range safety program intended to limit the potential impacts associated with launch accidents (Section 2.1.6.5). For a launch involving radioactive material, NASA would also develop a radiological contingency plan, discussed in Sections 4.1.6 and 4.3.5, to minimize the impacts to the public and the environment should an accident occur.

- **Comment:** The EIS should discuss the risk assessment and results and impacts "to Earth's organisms (humans, flora and fauna, natural resources)." "The potentiality of such a scenario should be analyzed and a quantifiable system should be created in order to ensure that the benefits outweigh the costs of the mission, even if failed."

  Response: The DOE prepared a Nuclear Risk Assessment for the Mars 2020 mission and the results are incorporated in this DEIS. Sections 4.1.3 and 4.3.3 provide detailed assessments of the risks, and a summary is presented in Section 2.6.2.

- **Comment:** The EIS should discuss the nuclear wastes associated with using radioactive power sources.

  Response: Hazardous waste generation associated with this mission is discussed in Section 3.1.9, 4.1.1, and 4.1.2.10. No significant nuclear waste is produced during the activities addressed by this DEIS. Nuclear waste associated with the production of the MMRTG and LWRHUs are addressed in DOE NEPA documentation. Much of this information can be found in references DOE 1993, 2000, 2002, 2002b, 2008 and 2013.

Each of these scoping comments was considered in developing the DEIS.

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