Robotic Mars Surface Exploration Mission Proposal

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Abstract

The exploration of Mars represents an important endeavor for advancing our understanding of planetary science, astrobiology, and the potential for human exploration beyond Earth. This report outlines the scope of a robotic Mars surface exploration mission designed to address key scientific questions, align with the Mars Exploration Program (MEP) goals, and inspire public interest in space exploration. The mission will focus on Jezero Crater, a scientifically significant location, and employ advanced robotic systems to collect data on Mars' water history, climate, and geology. The report details the mission's needs, goals, operational concepts, constraints, and landing site justification, ensuring a comprehensive and logical approach to mission design.

Defining the Needs and Goals of the Mission

The mission is driven by the need to answer fundamental questions about Mars, which align with the four overarching goals of the MEP: determining if life ever arose on Mars, characterizing the climate of Mars, characterizing the geology of Mars, and preparing for human exploration (Lindsey, 2024b). To address these goals, the mission will focus on three scientific questions. First, what is the history of water on Mars, and did it ever support microbial life? This question supports the MEP goal of determining if life ever arose on Mars. Jezero Crater, with its ancient river delta and lakebed, is an ideal location to search for evidence of past water and potential biosignatures. Second, how has Mars' climate evolved over time, and what factors drive its current climate? This question aligns with the MEP goal of characterizing Mars' climate. By studying sedimentary layers and atmospheric data, the mission will provide insights into Mars' climatic history and its implications for planetary science. Third, what are the geological processes that have shaped Mars' surface, and how do they compare to Earth's? This question supports the MEP goal of characterizing Mars' geology. Analyzing rock compositions and surface features will enhance our understanding of planetary formation and identify resources for future human missions.

Mission Subject

The mission subject is the Martian surface, specifically Jezero Crater. Data will be collected using a rover equipped with advanced instruments, including spectrometers to analyze rock and mineral compositions, drills to collect subsurface samples, cameras to capture high-resolution images of surface features, and weather sensors to monitor atmospheric conditions. These observations will provide critical data on Mars' water history, climate, and geology, addressing the mission's scientific objectives.

Identifying Stakeholders

The primary stakeholders for this mission include planetary scientists and astrobiologists, who will use the data to advance research on Mars' habitability and potential for life; engineers and mission planners, who will use the findings to design future human missions; and the public and policymakers, who will benefit from the mission's educational and inspirational value.

Development of Operational Concept

The mission will be executed in several phases, beginning with the launch and transit phase. The rover will launch during the 2028 optimal launch window, with a transit to Mars taking approximately seven months. The entry, descent, and landing (EDL) phase will involve the rover landing in Jezero Crater using a sky crane system similar to the Mars Science Laboratory. Once on the surface, the rover will conduct a two-year mission, analyzing rock samples, drilling into the surface, and studying atmospheric conditions. Operational scenarios include traversing the delta, collecting samples, and transmitting data to Earth. Critical events during the mission include successful EDL, deployment of scientific instruments, and sample collection and analysis.

Constraints

The mission faces several constraints, including budget limitations of $500 million, a mass constraint requiring the rover and its instruments to not exceed 1,000 kg, reliance on solar panels for power, which limits operations during dust storms, and limited bandwidth for data transmission. These constraints will shape the design and execution of the mission, ensuring that it remains feasible and cost-effective while achieving its scientific objectives.

Landing Site

The chosen landing site for this mission is Jezero Crater, located at 18.4°N, 77.7°E. Jezero Crater is a scientifically compelling site because it features an ancient river delta and lakebed, which are ideal for studying the history of water on Mars. The delta's sedimentary layers may preserve evidence of past microbial life, while the surrounding terrain offers diverse geological features for analysis. Jezero Crater was selected based on its potential to address the mission's scientific objectives, including the search for evidence of past water activity and potential biosignatures. The lakebed may contain minerals that formed in the presence of water, providing clues about Mars' past habitability, and the surrounding terrain includes impact craters and volcanic deposits, which will provide additional context for understanding Mars' geological history (Lindsey, 2024a).

Scope Summary Page

The scope of the mission is summarized as follows. The need for the mission is to address key scientific questions about Mars' water history, climate, and geology. The goal is to advance our understanding of Mars and prepare for human exploration. The objective is to collect and analyze data from Jezero Crater. The mission involves robotic exploration of Mars. The operational concept includes a two-year surface mission with a focus on sample collection and analysis. Assumptions include the rover operating within its design limits and the landing site yielding scientifically valuable data. Constraints include budget, mass, power, and communication limitations.

Conclusion

In conclusion, this robotic Mars surface exploration mission represents a critical step in advancing our understanding of the Red Planet, addressing key questions about its water history,

climate, and geology. By exploring Jezero Crater, a site with an ancient river delta and lakebed, the mission will search for evidence of past water and potential biosignatures, providing insights into Mars' habitability and evolution. The rover's advanced instruments will collect valuable data on rock compositions, subsurface materials, and atmospheric conditions, contributing to both scientific knowledge and future human exploration efforts. Beyond its technical achievements, this mission will inspire curiosity and innovation, paving the way for humanity's continued exploration of Mars and beyond.

References

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