Design of an In-Situ Fuel, Oxygen, and Potable Water Supply System on Manned Mars Missions

(Technical Report)

Manned Mars Missions: A Divisive Idea

(STS Research Paper)

An Undergraduate Thesis Portfolio
Presented to the Faculty of the
School of Engineering and Applied Science
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Chemical Engineering

by

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May 5, 2020

Preface

Mars is seen as the next frontier in human space exploration due to its proximity and potential for settlement. Manned Mars missions, transporting infrastructure for settlement, and returning astronauts to Earth would require enormous financial, ideological, and moral commitment.

In-Situ Resource Utilization (ISRU) can negate the costs of shipping hydrogen, oxygen, and potable water to Mars. We propose a Martian ISRU system that uses unit operations to produce these resources, which would otherwise have to be shipped from Earth. In our proposed process, hydrogen is produced from the water gas shift reaction, oxygen is produced from carbon dioxide reduction, and water is drilled from the regolith and desalinated. Oxygen and water production in the proposed system would meet the life-support demands of ten colonists in 1.5-year cycles, and hydrogen and oxygen fuel would be sufficient for a return trip to Earth. Our plant would be expected to run for 18 years, or 12 cycles. The system was modelled on the basis of calculations from Aspen Plus combined with a detailed design of reactors, separators, and ancillary equipment. Since equipment and materials must be transported from Earth, accurate cost estimates are essential. Overall cost calculations indicate that the total cost of the process would range from $1.6 billion to $7.6 billion, depending on whether the process is operated remotely from Earth or by astronauts on Mars, respectively. If all of the fuel and potable water were to be shipped to Mars, the estimated cost would be $9.8 billion, so the proposed ISRU process is cost effective. The largest costs arise from the Kilopower units and the YSZ catalyst for the CO_2 reducer, as they have the highest mass requirements of the components in the

process. In future projects, researchers could seek to optimize their masses. Our proposed system is intended to contribute to ISRU research for manned missions and potential colonies on Mars.

Besides the technical challenges of establishing a human base on Mars, social barriers must also be overcome, as manned Mars exploration is controversial. Supporters include the National Aeronautics and Space Administration (NASA), SpaceX, manned Mars exploration advocacy groups, and individuals who believe that the expeditions are crucial to the survival of humanity. Opponents include the Congressional Budget Office (CBO), environmentalists, people who view the expeditions as unsafe, and individuals who believe the ventures would reinforce social divisions. These groups advance their agendas by publicizing ideological and moral arguments, and through financial means. The level of support for manned Mars expeditions will determine if permanent colonies on Mars will be established.

I would like to thank my advisor, Professor Eric Anderson of the Chemical Engineering Department, for his continuous support and assistance throughout the capstone project. I would also like to thank Professor Peter Norton for his advice on the Science, Technology, and Society (STS) research report.

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