Design of an In-Situ Fuel, Oxygen, and Potable Water Supply System on Mars
(Technical Paper)

An Analysis of The State of The Esports Player in Society
(STS Paper)

A Thesis Prospectus Submitted to the
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Bachelor of Science, School of Engineering

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In the past decades, a new industry has begun to grow past its infancy and become a billion dollar fixture in not only American but also in global society: Esports (Perez, 2018). This industry has rapidly developed in the last 10 years alone. Where once a video game tournament may have been seen as a quaint novelty, today there are entire leagues of competition for esports reminiscent of those that exist for traditional sports (Consolazio, 2019). With this burgeoning new business comes a new class of professional, the esports player.

Space exploration is an important goal for mankind, a manifestation of the innate human desire to forever move onward and upward. It is my personal opinion that the moon landing is still the greatest achievement in mankind's history, and that this title shall not be unseated until the natural next step in the progression of space exploration, landing a person on Mars. The will to seek out the stars is out there, and the world rapidly approaching a time where the technology will exist to support this vision (Wall, 2015). As such, it is important to begin thinking about the functional mechanisms that may be involved in engineering an extended stay on the red planet. The technical portion of the prospectus will explore the design of a system for in-situ resource utilization in the martian environment.

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

How can we design a cost-effective system on Mars to produce hydrogen/oxygen fuel for transportation to and from the planet, and provide oxygen and water to the inhabitants of a manned outpost?

Our group's capstone advisor is Professor Anderson, and the group members are Craig Doody, Michael Mace, Spencer Plutchak, Sabrina Stenberg, and Rahim Zaman, all of the Chemical Engineering Department. Our project goal is to optimize the utilization of Martian resources to provide water and oxygen to sustain a human colony, and produce enough hydrogen and oxygen fuel for their return trip to Earth. Design work for this project will be continued in the 2020 Spring semester, with the same team.

The National Aeronautics and Space Administration (NASA), other federal space agencies, and private companies plan to send humans to Mars in the next several decades. The costs of material and equipment transportation from Earth will comprise most of the mission costs. According to a NASA report by Kleinhenz and Paz (2017), storage costs could be drastically cut with the use of In-Situ Resource Utilization (ISRU), which will utilize Martian resources for Mars base necessities. These essentials include fuel for a return trip, as well as oxygen and water for a life support system. The process must be economically viable to ensure adequate investment, the importance of which is discussed by Shishko et al. (2015).

ISRU optimizes the use of materials, recycling where possible, as described by NASA (2019). Powell et al. explains NASA has researched optimal ways to provide oxygen and water for a Martian colony, as well as sufficient hydrogen to fuel a rocket for their return trip (2001).

Hydrogen will be obtained using multiple methods and stored for later use, and the Mars Oxygen ISRU Experiment (MOXIE) is the current method proposed to produce oxygen, as reported by Meyen et al. (2016). The water will be mined from the ground, either in solid or liquid form, and purified. Our proposal is to design a continuous process, utilizing available resources, to improve production output and energy efficiency. The hydrogen production will be achieved by reforming methane, collected from the regolith, and from the water-gas shift reaction. These reactions produce carbon monoxide and carbon dioxide, respectively, that can be recycled to increase hydrogen production. MOXIE will generate the oxygen necessary for the colony. Some specifications still undefined include energy sources to keep the processes running for the colony and the equipment to extract the materials from the atmosphere and regolith.

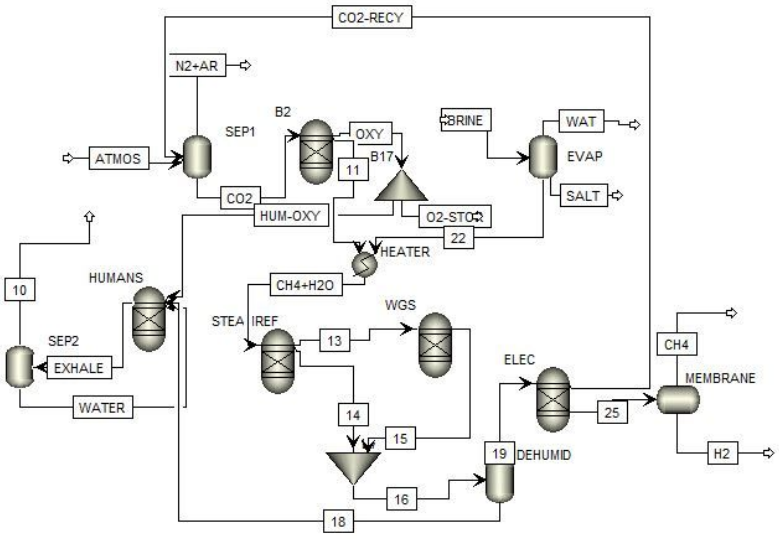

Figure 1. *Process flow schematic including the integral operations of reactions, separations, and storage (Doody, 2019).*

Our system consists of multiple reactor, separations, and storage units, as shown in *Figure 1*. Reactor units will reference literature for kinetic constants, catalytic behaviors, and reactor size, using hand-calculated scaling and approximation techniques when necessary. The reactions involved follow equilibrium behavior, which has several useful models to help predict properties. Separations will be evaluated using AspenTech simulation technology. Size, duty, and cost will come from Aspen calculations, with hand calculations for initial guesses and confirmations. Aspen will also allow our team to optimize energy use in the system, modelling components such as heat exchangers and turbines for energy conservation. Since we do not have means to directly test the system, the Aspen models and reactor calculations will be combined for an overall cost proposal. The costs of operation and transport of our equipment will be compared to the costs of directly transporting our products to Mars.

At the end of this project, we seek to define a process with unit operations that can produce hydrogen, oxygen, and potable water on Mars. Oxygen and water production will meet the life-support demands of 10 colonists for an indeterminate period of time, and the hydrogen and oxygen fuel will sufficiently support a return trip to Earth. Since equipment and materials will have to be transported from Earth, accurate cost estimates are integral to this project. This project will contribute to ISRU research for manned missions, and later colonies on Mars. Future research projects should include drilling designs for water extraction on the Martian surface and living spaces for the colonists.

STS Topic

The field of esports is bigger than ever, and its growth shows no signs of slowing. 2019 was the biggest year ever for esports in terms of viewership, revenue, and tournament size, and is projected to grow by even greater amounts in the near future ("The Incredible Growth of eSports in 2019", 2019). However, this rapid growth is creating questions, among which is the question of what to do with the group arguably most intrinsically tied to this movement, the players. On the surface it seems simple, these are simply the people who play the games, but it is not so easy. The word "esports" seems to imply that the players are athletes, and the United States government has been receptive to this idea, allowing international esports players to be granted travel visas classified for athletes (Tassi, 2013). However esport players are frequently denied P-1A athletic visas for international athletes, to the point that there has been suggestion of granting them P-3 visas for entertainers instead (Brannon, 2018). Clearly there is still contention on whether esports players are "athletes," no systematic consensus has been reached.

There is also the question of the role of the players in the organizations and systems within "esports." In the past years there has been a rise in organized league play in several esports such as League of Legends and Overwatch, and they are starting to resemble similar leagues in traditional sports (Webster, 2018). Unlike in traditional sports leagues, esports players, in North America at least, are slow to unionize. As such, the players are often exploited and do not receive the portion of the growing profits of the industry that they are owed (Tagle, 2019). In this same vein, there is also disagreement over what the contract of an esports player should look like. Attorney Bryce Blum has suggested that for some esports such as *Fortnite* players function as entertainers, and for others such as *Starcraft 2* they function as athletes and should thus

receive different types of contracts (Smith, 2019). In some states, there is even a question of the legality of creating an esports players union, and even the players status as "employees" when playing for their team or for an organization (Seck et al. 2018).

Social Construction of Technology (SCOT) is the primary STS framework that will be used to examine the role of esports players. SCOT was first described by Trevor Pinch and Wiebe Bijker in their 1984 article "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." SCOT as proposed by Pinch and Bijker includes four major components: interpretive flexibility, which is the principle that a technology or artefact can take on different final forms depending on the social context of its formation; relevant social groups, which defines the social groups with different internal definitions of the technology or artefact that contribute to its development; closure and stabilization, the moment when all relevant social groups agree that an artefact has reached an acceptable form and development ceases; and wider context, which examines how the development of the artefact fits into the grander scheme (Klein & Kleinman, 2002). According to Klein and Kleinman, major criticisms of SCOT generally have to do with the inability of the framework to distinguish groups based on relative power, which makes certain questions difficult to answer with this methodology. Pinch and Bijker recommend that the framework can be improved by considering the structure of different groups and of the systems involved in the development of the artefact in question, which remedies some of the issues of SCOT. Despite its limitations, SCOT is a suitable framework for this topic because Esports itself can be considered an artefact in development, which has not yet reached closure and stabilization, so there could be a great deal revealed through an analysis of the relevant social groups and their interacting

structures. Importantly using SCOT could give result in a better idea of the best ways to address the needs of esports players in the industry.

Research Question and Methods

The research question is "What is the role of the esports player and how should they be regarded in our society and under the law?"

I will employ primarily three research methods: Documentary Research, Discourse Analysis, and Policy Analysis. Documentary Research is a necessary utility for any research paper because so much of the information available to researchers is stored in documentary form. Since much of the information required to address the research question is contained in documents and other textual resources, this precise methodology of establishing each document as a viable source will be invaluable. Discourse Analysis will be another important tool to address this research question. The role of the player in the esports industry is a topic that a lot of people have a lot of opinions on, and many of these opinions are expressed on platforms such as Twitter, rather than official publications. For example, MFS ops expressed his opinions on minimum wage laws being extended to esport athletes on July 8th, 2019 (opsqt, 2019). It is necessary to examine discourse on all platforms to get a full scope of the issues. Finally, policy is an intrinsic part of answering this question. How are esports athletes treated by the law in different states and even countries, and why? Therefore Policy Analysis will be a necessary component of thorough research into this topic.

Conclusion

The final deliverable of the technical capstone will be a fully designed system for converting atmospheric gases and surface water on Mars to hydrogen and oxygen, with detailed storage and power systems, considerations for relieving water and oxygen demand of life support systems, and a thorough economic analysis. This design will contribute to a growing body of research and work done across the country and around the world to the end goal of establishing temporary, and eventually permanent human habitation on Mars. The proposal for the design project will be completed by the end of November 2019, and the design itself will be completed by April 2020.

The final deliverable of the STS research will be a research paper that answers the research question, revealing new insights into the role of the player in the esports industry and in society. Hopefully this will shed light on the confusing definition of what constitutes an athlete, and what protections esports players may be entitled to. It is possible that the STS research paper will include recommendations for policy makers. Research is planned to be finished by the end of February 2020, with the writing of the research paper reaching completion in March.

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