Atmospheric Processing and Sustainability in an Extra-terrestrial Environment

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Description: This project will develop technologies suitable for creating and maintaining long-term sustainable habitats suitable for human expeditions to extra-terrestrial bodies, including the Moon and Mars. An adult human consumes around 35 g h^{-1} of oxygen, which is converted to carbon dioxide upon exhalation. Much of this can be recycled to oxygen through the growth of plants, particularly edible species. Sufficient quantities of oxygen and carbon dioxide must be generated, delivered, and recycled in order to sustain both the human and plant life. Further, the water produced via respiration must be accounted for and used effectively.

The carbon dioxide-rich Martian atmosphere can be a source of the oxygen which is required for habitats, propulsion systems, and power generation. The Mars Oxygen In-Situ Resource Utilisation Experiment (MOXIE) is a payload for the Mars 2020 mission which will demonstrate oxygen production from the Martian atmosphere. Solid oxide electrolysis is expected to generate oxygen at a pressure around 670 Pa and a temperature around 0°C. However, alternative methods for generating oxygen in these otherwise uninhabitable locations are highly sought-after.

The APSE project brings together **theory and simulation** (TS), as well as **experimental** (E) investigations, to develop new approaches for creating sustainable habitats using In-Situ Resource Utilisation concepts. The project objectives are as follows:

- TS1. Develop strategies for the compression, transport, and storage of oxygen, carbon dioxide, and other gases in low temperature environments.
- TS2. Apply energy efficiency concepts including pinch technology to minimise the power requirements associated with gas handling.
- TS3. Using phase diagrams, explore the potential of processes including sublimation and electricity generation during gas expansion for creating energy efficient cyclic processes.

- E1. Explore methods for capturing carbon dioxide and liberating oxygen using microwave heating of minerals.
- E2. Develop practical strategies for the rapid removal of gaseous carbon dioxide in emergency situations, in order to restore a safe atmosphere.
- E3. Understand which geological materials exhibit thermal properties which make them suitable for thermal energy storage.

This project also includes the opportunity of undertaking a three-month placement at Space Application Services, during which time the feasibility of incorporating the outcomes of these investigations into a payload for a rover will be explored.

References:

1. Hinterman, E.; Hoffman, J.A.; Simulating oxygen production on Mars for the Mars Oxygen In-Situ Resource Utilization Experiment. *Acta Astronautica*, **2020**, *170*, 678-385.
2. Sargeant, H.M.; Abernethy, F.A.J.; Anand, M.; Barber, S.J.; Landsberg, P.; Sheridan, S.; Wright, I.; Morse, A.; Feasibility studies for hydrogen reduction of ilmenite in a static system for use as an ISRU demonstration on the lunar surface. *Planetary and Space Science*, **2020**, *180*, 104759.

Qualifications required:

Bachelors or Masters degree in Mechanical, Aerospace, or Chemical Engineering (or equivalent).