Propellant Production
by Utilizing In-Situ Resources with a Focus on
Lunar Outpost Sustaining Human Space Exploration

September 13th, 2019
Horizon 2061 Workshop
SpacE Exploration and Development Systems (SEEDS)

Introduction

❖ 3 universities
❖ 39 students
❖ 6 months: full-time split into 3 phases
❖ 3 universities

Tuirn  Toulouse  Leicester
Introduction

“To produce propellant by exploiting lunar in-situ resources and utilising pre-existing systems, providing the propellant to support future human space exploration.”
SpacE Exploration and Development Systems (SEEDS)

**Mission Context**

- Production of propellant
  - Electrolysis of H2O into LOX/LH2
  - Operational in 2035? 2061?

**Where?**
- Shackleton Crater

**Why?**
- Refuelling and Selling

**How?**
- Electrolysis of H2O

**What?**
- Production of propellant
**LUPO timeline**

- **Y - 13**: Start of setup phase
- **Y - 4**: Assembly systems land on the Moon and begin set-up operations.
- **Y - 2**: Crew reaches the Moon to assist during assembly phases.
- **Y - 8**: Start of definition phase
- **Y - 2**: First manned short mission
- **Y**: Precursor robotic mission
- **Y + 1**: First refuelling performed
- **Y + 2**: First manned long-duration maintenance mission
- **Y + 15**: End of nominal operations

**Timeline Details:**

- **Y - 13**: The Unmanned Transfer Vehicle receives the fuel for ascent and descent phases.
- **Y - 8**: Precursor robotic mission on the lunar surface with focus on regolith handling and ISRU.
- **Y + 1**: Crew reaches the Moon to assist during assembly phases.
- **Y + 2**: First manned short mission
- **Y + 15**: End of nominal operations
- **Y**: Installation of systems on the Moon and begin set-up operations.
- **Y - 2**: The PPF starts producing LOX and LH2 from the icy regolith in Shackleton crater.
**Space Exploration and Development Systems (SEEDS)**

**ISRU process**

- Collection and transport
- Cryocooling
- Electrolysis
- Condensation and filtering
- Heating and separation
- Transport

**Transport**
- To Spaceport Storage Facility and lines to Spaceport
- To collection and storage
- Cryocooling
- Electrolysis
- Condensation and filtering
- Heating and separation
- Transport

**Electrolysis**

- \( \text{LH}_2 \) \@ 90K
- \( \text{LH}_2 \) \@ 20K

**Cryocooling**

- \( \text{LOX} \) \@ 90K
- \( \text{LH}_2 \) \@ 20K
- \( \text{GOX} \) \@ 90K
- \( \text{LOX} \) \@ 90K

**Condensation and filtering**

- 930 kg/d O\(_2\)
- 1.10 kg/d H\(_2\)
- 120 kg/d H\(_2\)O

**Heating and separation**

- High power demand
- Remove regolith traces

**Transport**

- To disposal
- To refuel, MTV
- To MTV
- To market, MTV

**Collection**

- 32 t/day
- 10 cm layer in Shackleton PSR
- Rotating tube
- Solar concentrator
- In Shackleton PSR

**Cryocooling**

- LH\(_2\) @ 20K
- LOX @ 90K

**Electrolysis**

- 120 kg/d H\(_2\)O
- 110 kg/d H\(_2\)
- 930 kg/d O\(_2\)

**Condensation and filtering**

- LH\(_2\) @ 20K
- LOX @ 90K

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Space Exploration and Development Systems (SEEDS)

Technology Developments

Power Generation and Management

Automation and Robotic Systems

Large Scale ISRU Technologies for LOX/LH2

Propulsion and Landing Technologies and Support

Technology Developments
Conclusions

Enhancing Human Space Exploration

Mars missions

Lunar services

Technology Development

Profitability
Thank you for your attention!