National Aeronautics and Space Administration

EXPLORE MOON to MARS

Summer 2021 Pathways Presentation

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Mentor: Ray Pitts
UB-E

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Outline

Introduction

- Me
- UB & UB-E

Projects

- OSCAR Suborbital Flight Integration & Preparation
- FY22 CIF: Trash-to-Gas Trash Prep and Feed Mechanism (TtG PFM)
- JSC Lunar Auger Dryer ISRU (LADI): Lunar Regolith Size-Sorter-Hopper

Future Steps

Concluding Remarks

About Me

Hometown: Titusville, FL

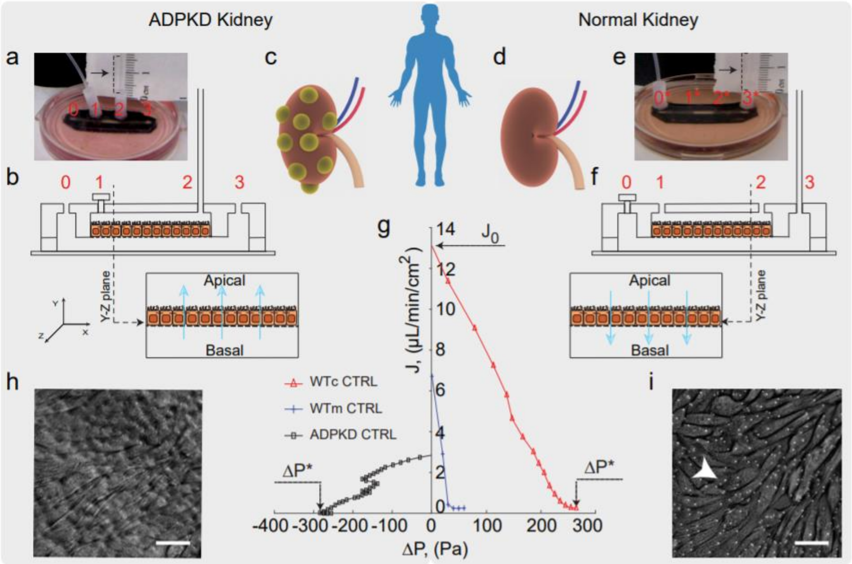
School: Johns Hopkins University (JHU) in Baltimore, MD

Degrees

- BS ‘21, Chemical & Biomolecular Engineering, minor in Environmental Studies
- MS ‘22, Chemical & Biomolecular Engineering—studying diseased and non-diseased kidney cell response to environmental perturbations via calcium dynamics

Extracurriculars: Resident Advisor, Engineers Without Borders, Research

Research Topics: Cell and Tissue Biomechanics, Organ-Chip systems, Polycystic Kidney Disease



Trans-epithelial Fluid Pumping Performance of Renal Epithelial Cells and Mechanics of Cystic Expansion
https://www.biorxiv.org/content/10.1101/727313v1

About UB and UB-E

UB: Exploration Research and Technology Programs Directorate

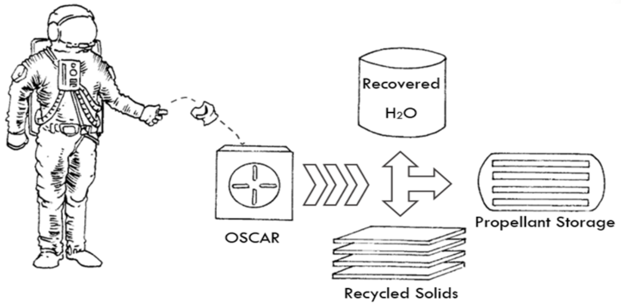
“*Enabling exploration through expertise and innovation*.”

“*Mission/Vision: To lead research, development, testing, and demonstration of advanced flight systems and transformational technologies to advance exploration and space systems*.”

UB-E: Exploration Systems and Development Office

- MSolo: Mass Spectrometer Observing Lunar Operations
- GaLORE: Gaseous Lunar Oxygen from Regolith Electrolysis
- SwampWorks
- OSCAR: Orbital Syngas Commodity Augmentation Reactor

OSCAR Overview



OSCAR Poster; Kathryn Ludden, Ray Pitts, Thomas Cauvel, David Rinderknecht

What?

- **O**rbital **S**yngas **C**ommodity **A**ugmentation **R**eactor

Why?

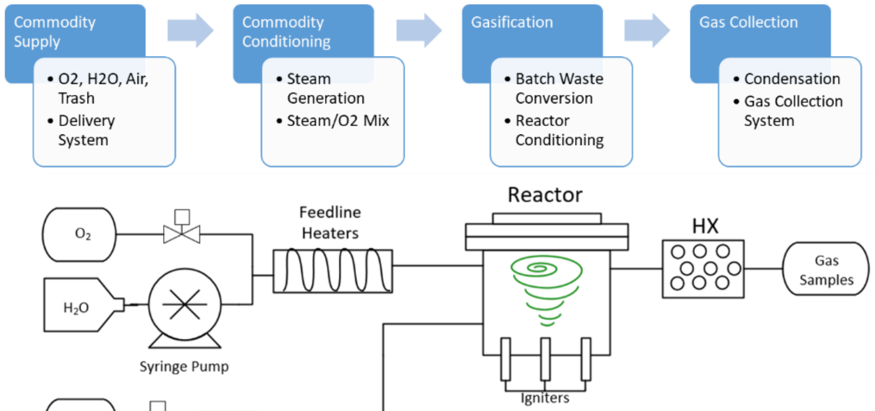
- Current methods of space waste management are comprehensively unsustainable
- Convert trash and human waste into useful gases, enabling long duration human exploration of deep space
- Confirm the operability of a space waste conversion reactor in microgravity

How?

- Incineration and steam reforming
- Reactor heats (600 ° C) the trash under pressure (40 psia) to incinerate it
- Suborbital flight sequence trash conversion: 60-70%
- Long duration trash conversion: up to 90%

$$C_xH_yO_z + O_2 \rightarrow CO + H_2O + (heat)$$

$$CO + \frac{1}{2}O_2 \rightarrow CO_2 + (heat)$$



Ray Pitts, NASA KSC

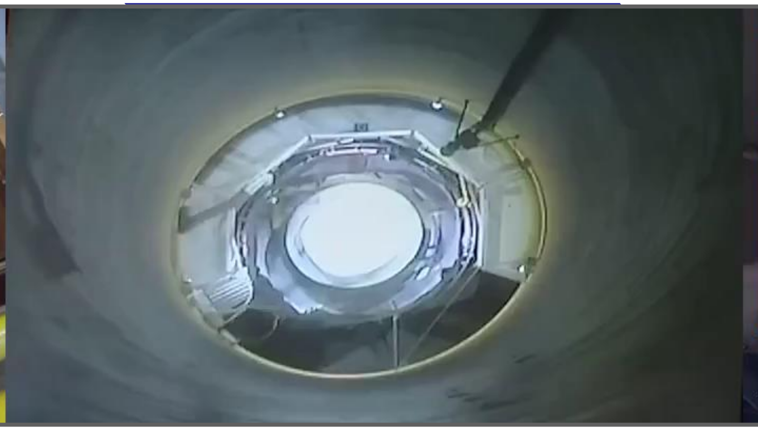
Waste Conversion to Usable Gases for Long Duration Space Missions; Jaime A. Toro Medina, Anne Meier, Ph.D, Malay Shah

OSCAR Timeline

Trash-to-Gas: Determining the Ideal Technology for Converting Space Trash into Useful Products
Stephen M. Anthony and Paul E. Hintze

Ray Pitts, NASA KSC

Pioneering the Approach to Understand a Trash-to-Gas Experiment in a Microgravity Environment
https://doi.org/10.2478/gsr-2021-0006



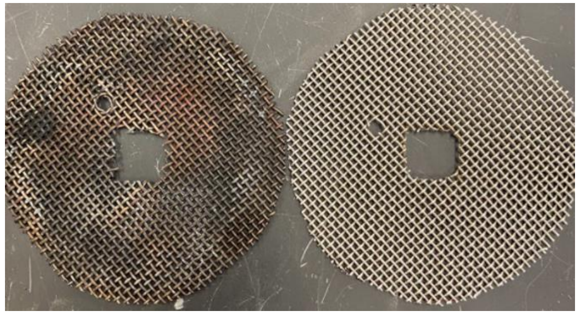
Working with OSCAR

My impact

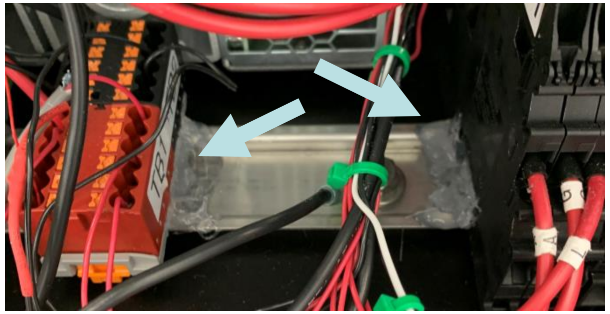
- Mechanics and maintenance
  - Component installations
  - Flight technician simulation
  - Waste simulant preparation
- Final experiments
  - Simulated leak
  - Nominal flight sequence triplicate
  - Injection test
  - Final flight sequence

Next steps

- OSCAR goes on second suborbital flight aboard Blue Origin's New Shepherd
- Fall 2021—flight data analysis
- Scale-up—full size OSCAR



Ray Pitts, NASA KSC



Personal photographs

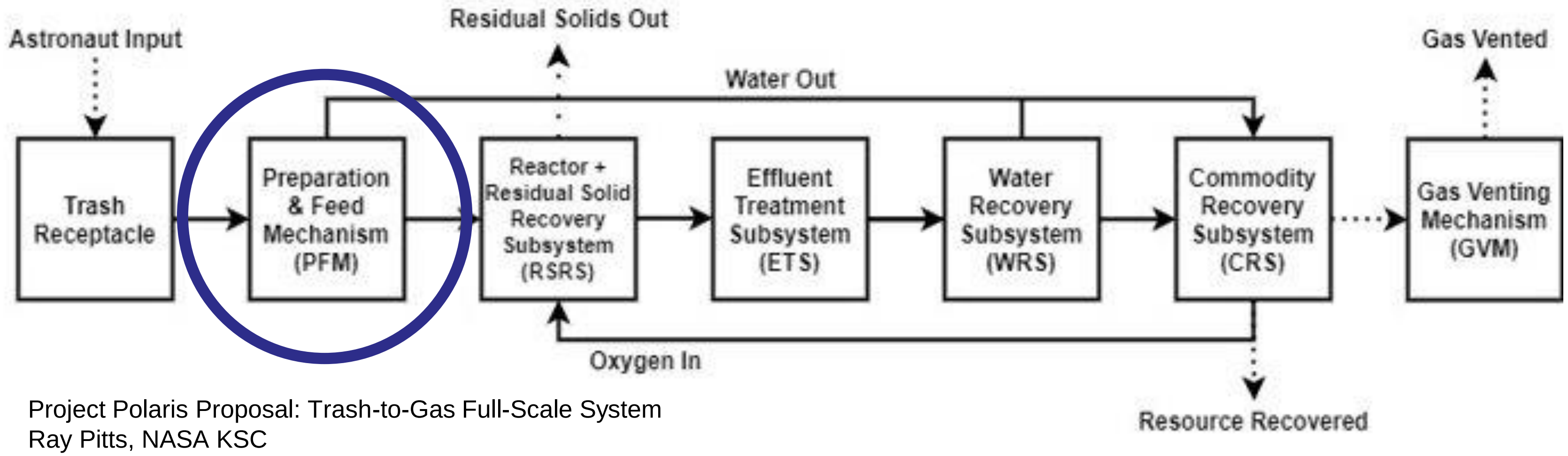
TtG FSS PFM Overview

Project synopsis

- **T**rash-**t**o-**G**as **F**ull-**S**cale **S**ystem for compatibility with long duration space missions
  - 4 astronauts producing 5.8 kg/day of waste
  - Waste conversion to gas that can either be vented overboard or used by the crew
  - Reduction of waste mass and volume reduction can be achieved
  - Recovery of solid and liquid residuals

Our focus

- **P**reparation & **F**eed **M**echanism (PFM)
- Identification of a system for preparing and feeding trash for use in TtG FSS resulting in maximal gasification and resource recovery



Project Polaris Proposal: Trash-to-Gas Full-Scale System
Ray Pitts, NASA KSC

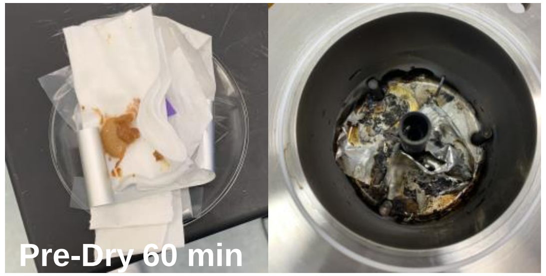
TtG PFM Work

Experiments

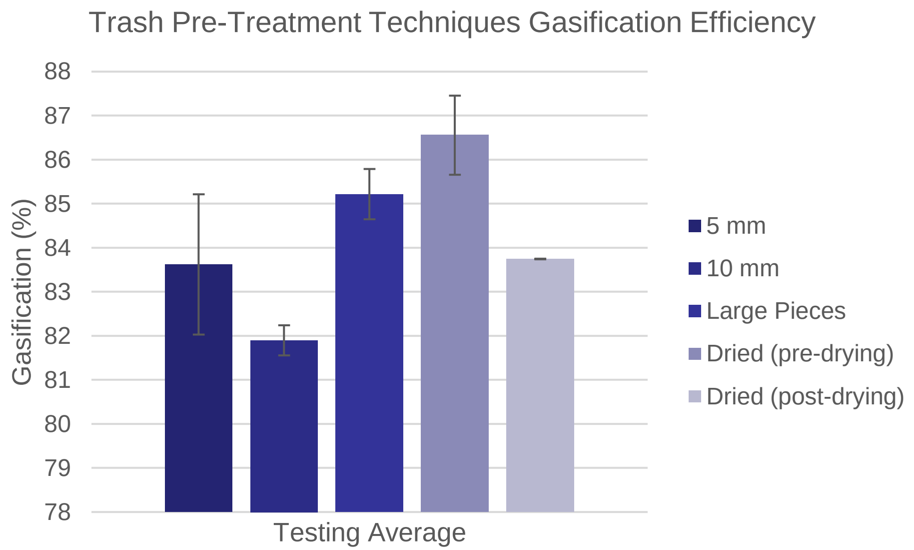
- Trash size comparison: 5 mm vs. 10 mm vs. Large Pieces
- Pre-drying: 60 mins @ 100
- Gasification percentage across all pre-treatment methods was consistent: 82-88%

Literature review

- Treatment: Mixing, shredding, compressing, drying, stabilizing, solidifying, cryogenic grinding, digestion/fermentation
- Feeding: Mechanical ram/pusher



Personal photographs



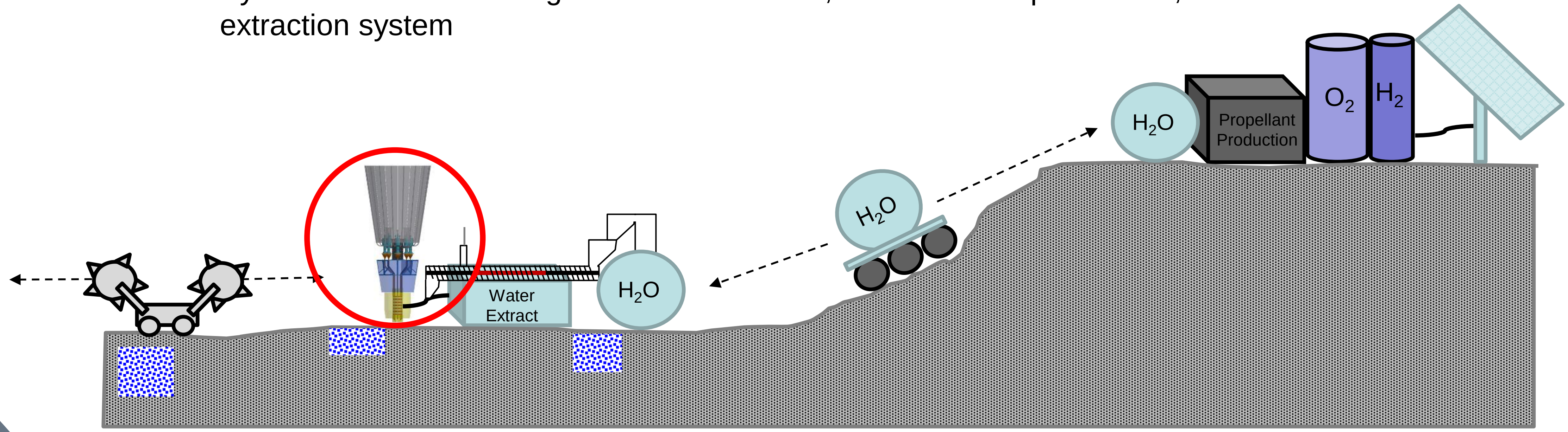
LADI Overview

Project synopsis

- JSC **L**unar **A**uger **D**ryer **I**SRU (LADI)
- Develop auger dryer tech to continuously process icy lunar regolith in Permanently Shadowed Region (PSR)

Our focus

- Lunar Regolith Size-Sorter-Hopper
- System to move lunar regolith from excavator, sort out incompatible bits, feed to water extraction system



Jason Schuler, NASA KSC

Size-Sorter Hopper Work

Assumptions & ground rules

- What is the PSR?

Researched techniques

- Loading from RASSOR
- Removing regolith pieces > 5 mm

Next steps

- Continued literature review
- Trade matrix completion

Concluding Remarks

Lessons learned

- Hands-on / real-life experience with a small-scale combustion reactor system
- Annotated bibliographies, trade studies/matrices
- Experimental design and effective execution
- Data and research presentation/communication
- Don’t be afraid to ask questions
- Organization and safety are key
- Lots of opportunities for inter-group/project collaboration & exploration at KSC

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- Ray Pitts
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- David Rinderknecht