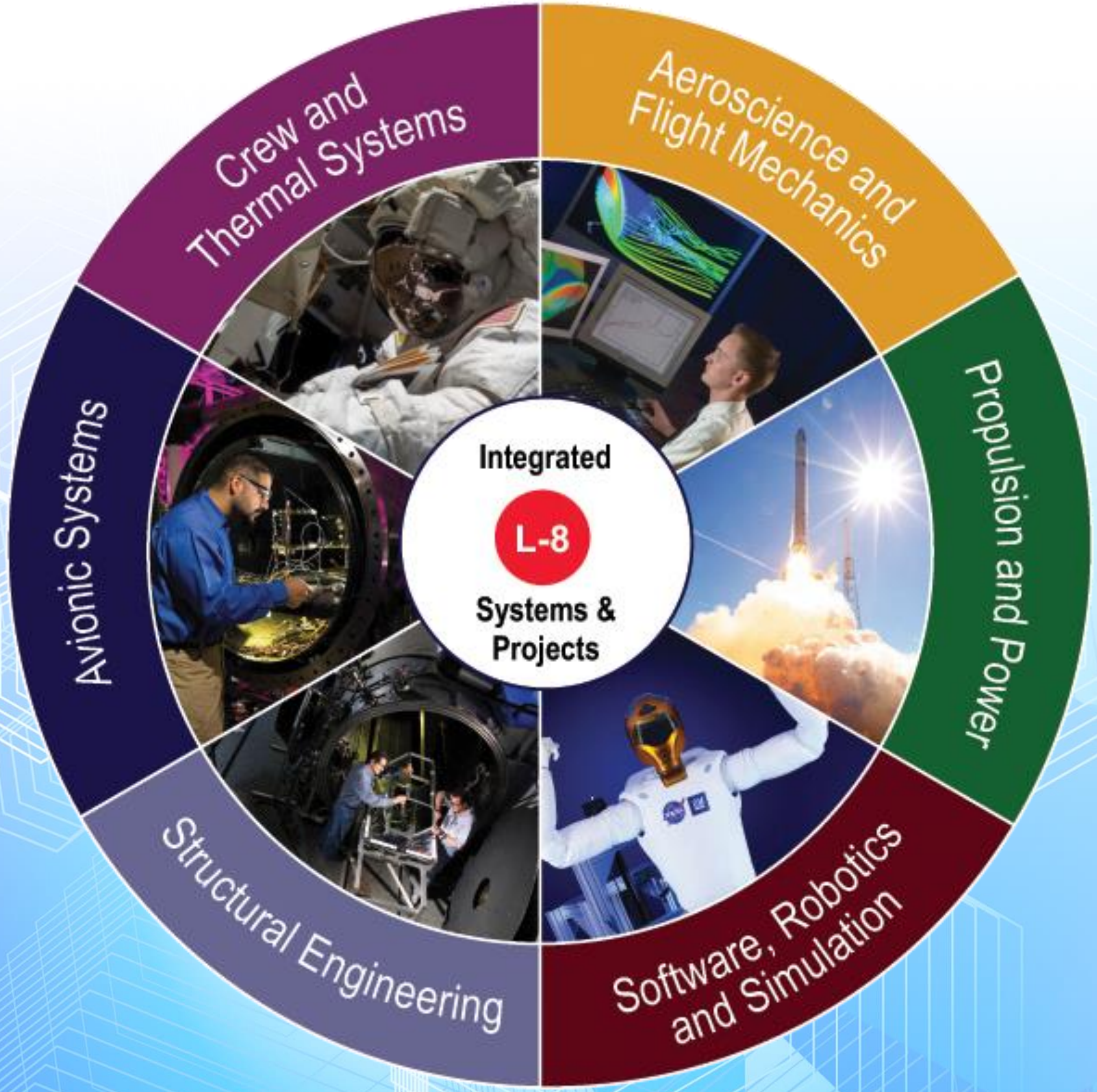
Johnson Space Center Engineering Directorate

L-8: Advanced Concepts for O2 Concentration and Storage

John Graf

November 2016

JSC Engineering: HSF Exploration Systems Development



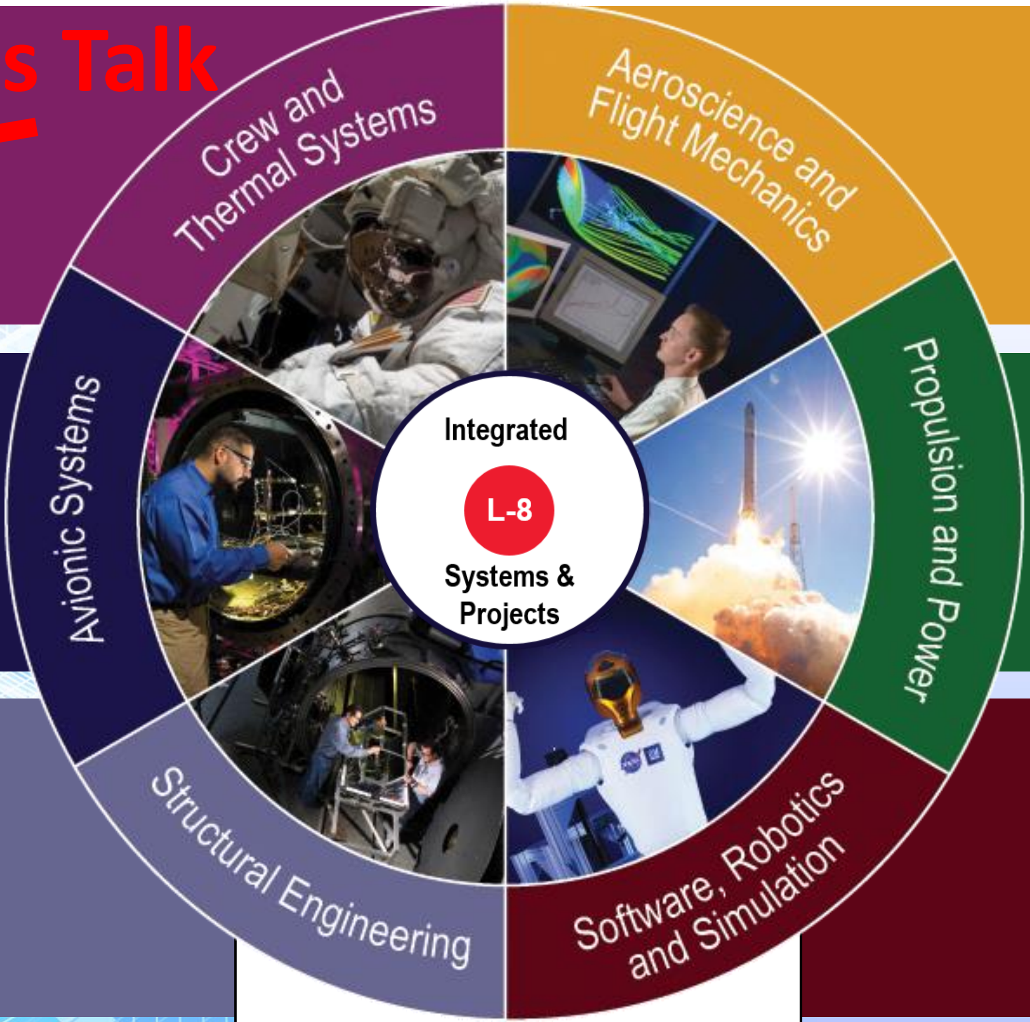
- At the agency level, **NASA** is sharpening the focus on Human Space Flight (HSF) Exploration Beyond Low Earth Orbit
- **NASA** wants to ensure that HSF technologies are ready to take Humans to Mars in the 2030s.
  - NASA uses Mission - Discipline Roadmaps to define and prioritize needed technologies
- **Human Space Flight Goal**: Get within 8 years of launching humans to Mars (L-8) by 2025
  - Develop and Mature the technologies and systems needed
  - Develop and Mature the personnel needed
- **Crew and Thermal Systems:** Enable a way to lsaunch safe, stable, chemically inert water, and convert the water as it is needed into: 1) breathing oxygen, 2) space suit oxygen, 3) emergency medical oxygen
- **This Talk:** Describes one key technology that may provide space suit grade oxygen – and seeks collaborators to help develop this technology

EA Domain Implementation Plan Overview

JSC Engineering: HSF Exploration Systems Development

This Talk

- Life Support
- Active Thermal Control
- EVA
- Habitation Systems



AA-2 | iPAS | HESTIA | Morpheus

- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Deep Space GN&C

- Human System Interfaces
- Wireless & Communication Systems
- Command & Data Handling
- Radiation & EEE Parts

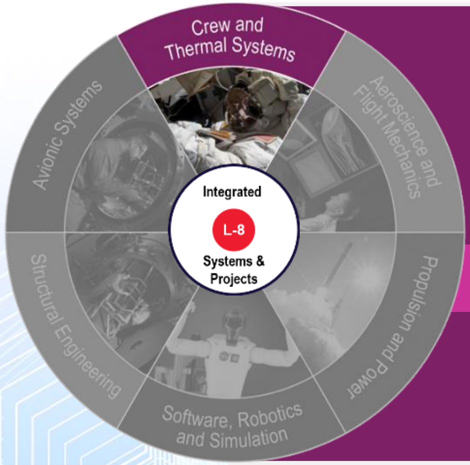
- Reliable Pyrotechnics
- Integrated Propulsion, Power, & ISRU
- Energy Storage & Distribution
- Breakthrough Power & Propulsion

- Lightweight Habitable Spacecraft
- Entry, Descent, & Landing
- Autonomous Rendezvous & Docking
- Vehicle Environments

- Crew Exercise
- Simulation
- Autonomy
- Software
- Robotics

Crew and Thermal Systems Technology Challenge: Oxygen for Human Exploration

JSC Engineering: HSF Exploration Systems Development



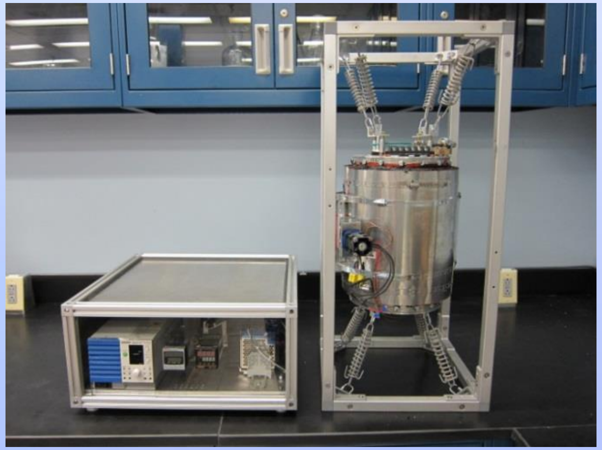
- Active Thermal Control
- Habitation Systems
- Life Support
- EVA

The Problem

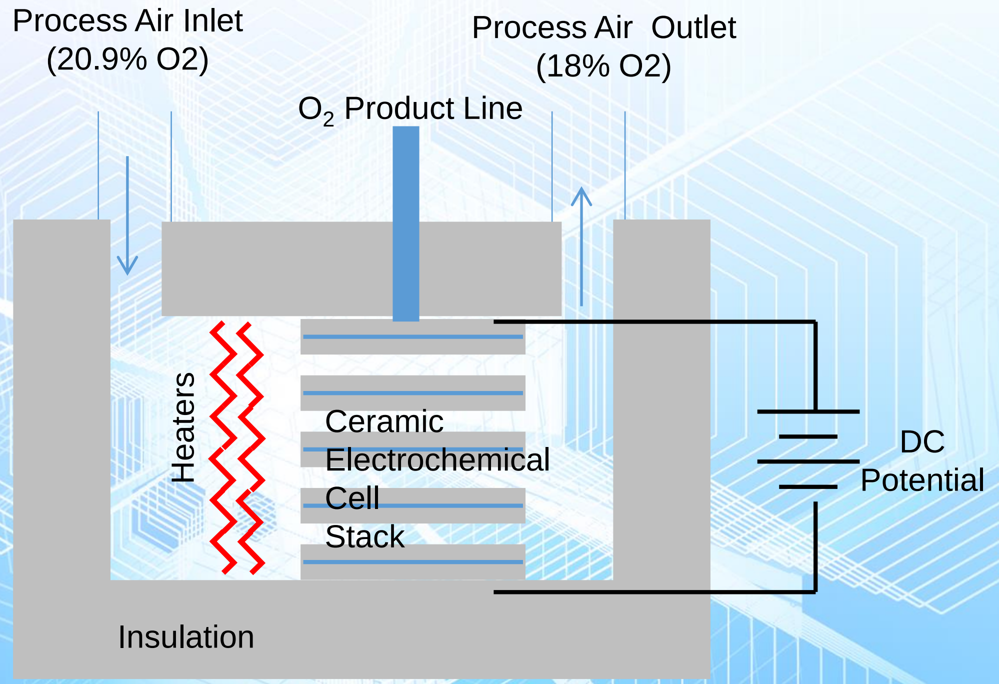
- *We need to safely store tons of oxygen*
  - *(likely in the form of water*
- *We need to safely convert most of the water to oxygen for breathing (low pressure O2 is fine, and it is safer to handle than high pressure O2)*
- *We need to safely convert some of the low pressure oxygen to high pressure (3500 psi), high purity (>99.99%) oxygen for space suits*

Advanced Concepts for O2 Concentration and Storage

- *Proposed Effort*
- *Ambient pressure water electrolysis*
- *Oxygen extraction / separation from cabin air using solid oxide electrochemical oxygen concentrator*
  - *Possibly mechanical compression*
  - *Possibly solid state compression*



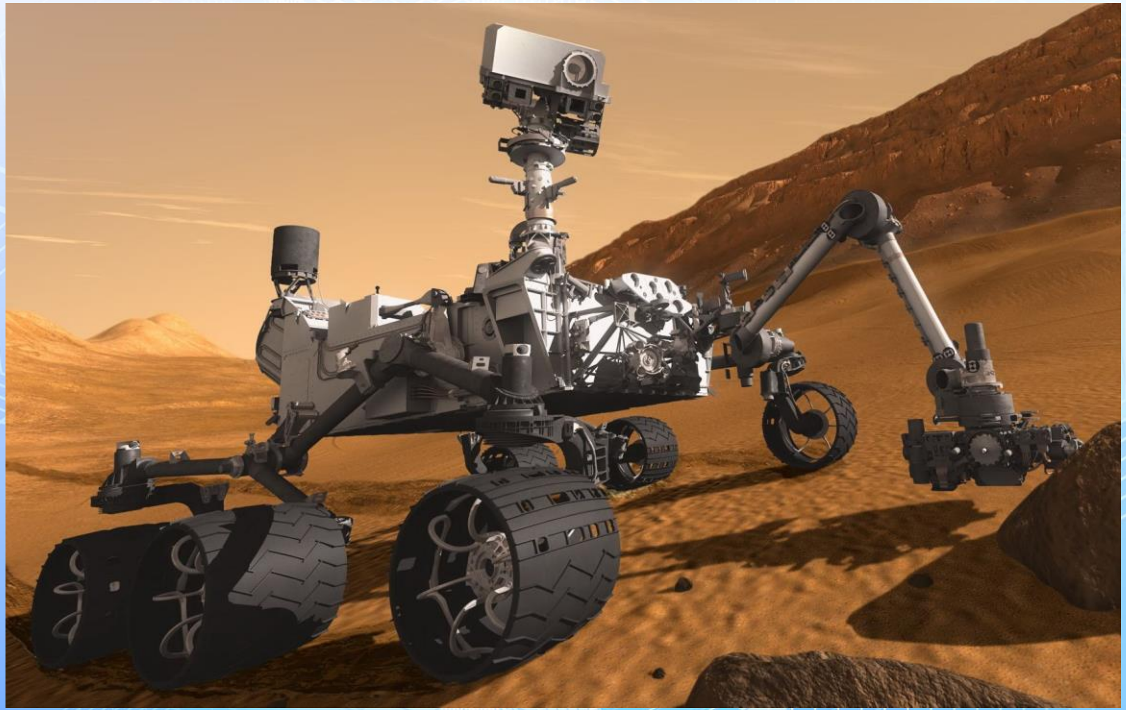
Solid Oxide Electrochemical Oxygen Separation (In a nutshell)

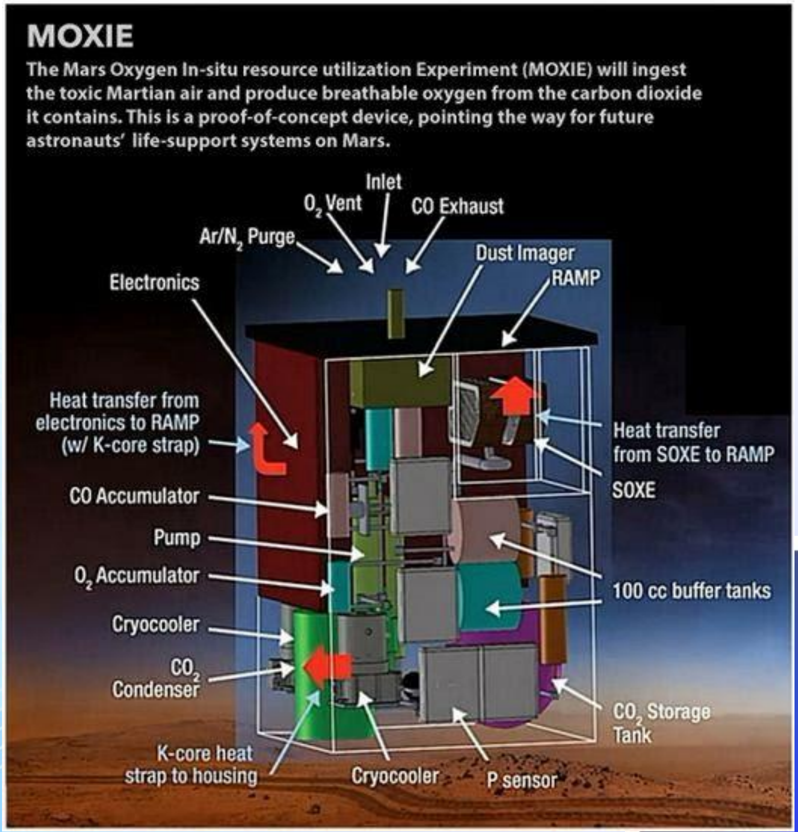


Attributes:

- O_2 production rate: 2 lpm
- O_2 delivery pressure: 200 psig
- O_2 purity: >99.99%
- Power use: 470 Watts
  - Heater Power: 200 Watts
  - DC power to cell: 250 Watts
  - Balance of plant: 20 Watts
- Operating Temp: 700 C
- Number of moving parts: 1
  - Process air fan

Community of Collaborators: (1)
Solid Oxide Conversion of CO_2 to Oxygen on Mars

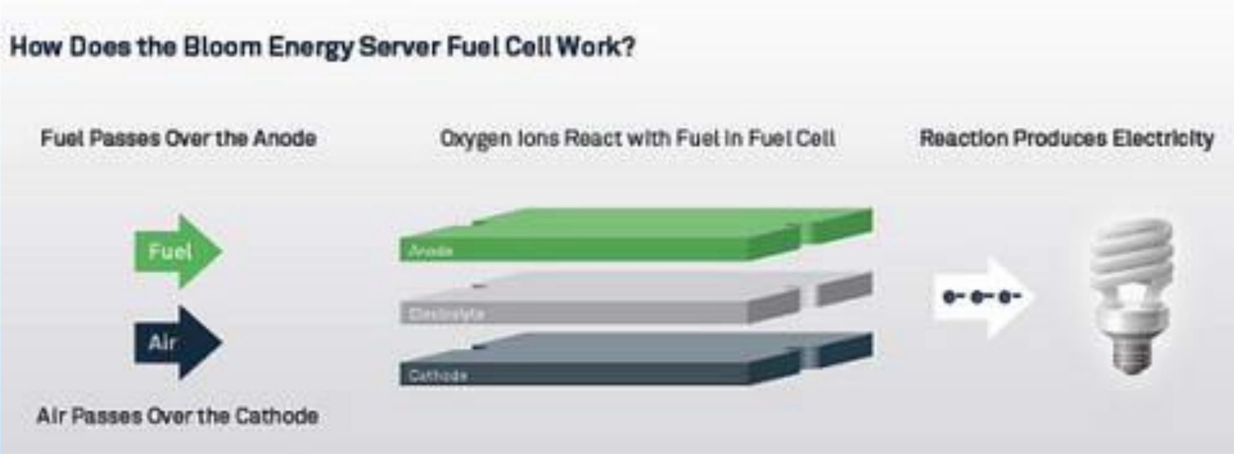


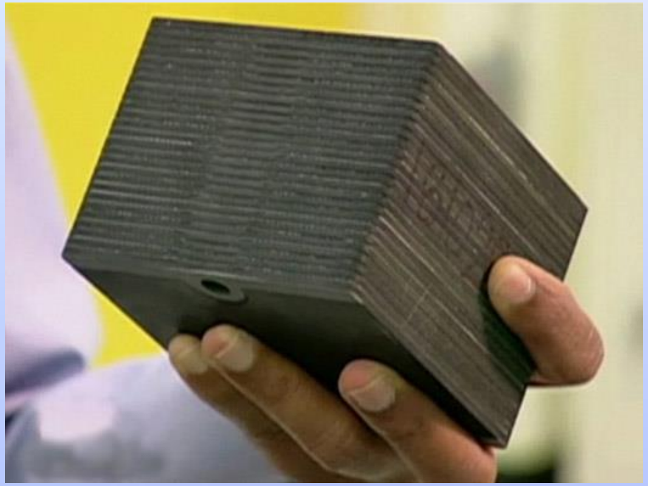


3D-printed model of the preliminary MOXIE payload. Image credit: NASA's Jet Propulsion Laboratory.

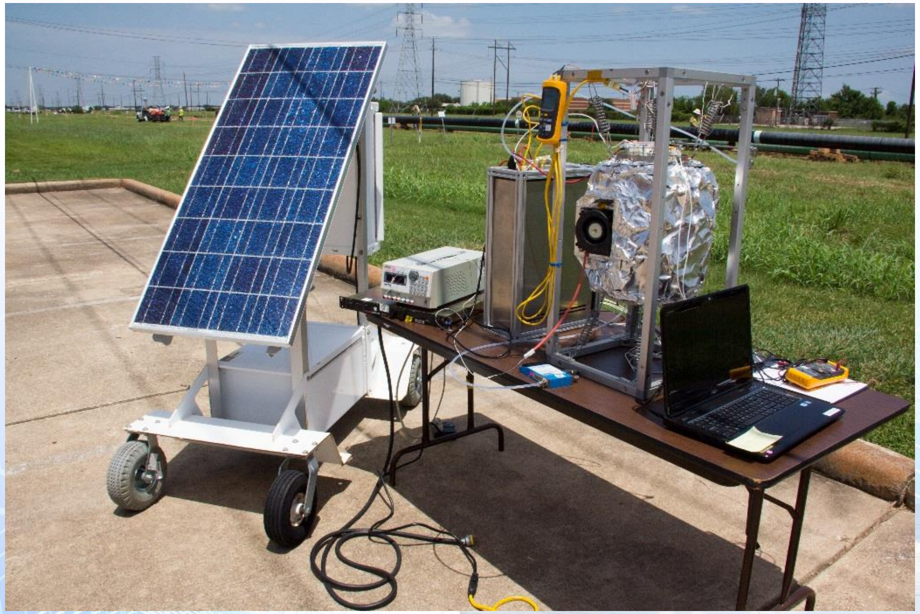
Community of Collaborators: (2)
Solid Oxide Fuel Cells – clean energy for home/business

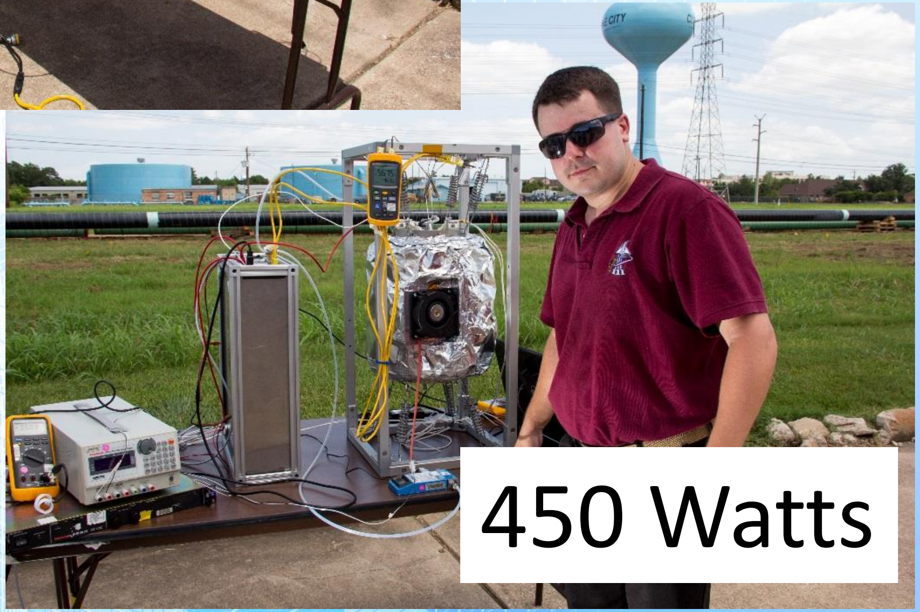
JSC Engineering: HSF Exploration Systems Development

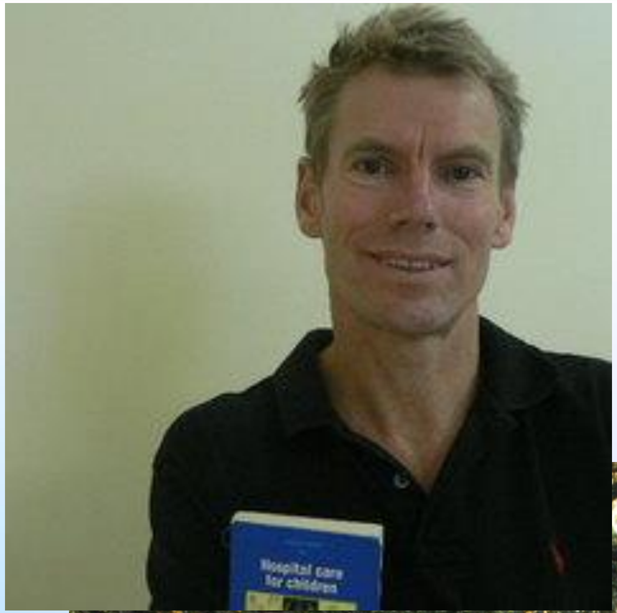




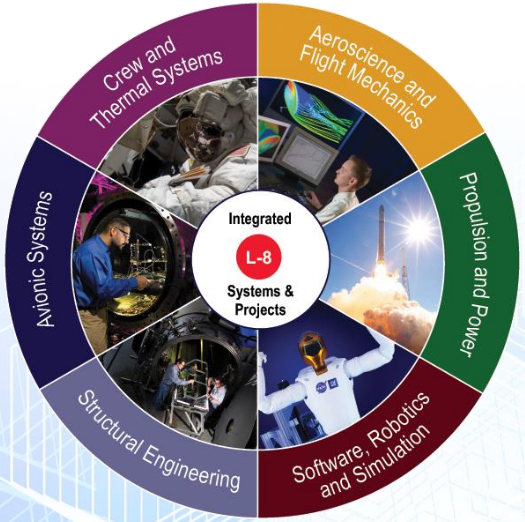
Community of Collaborators: (3) Oxygen Concentrators for Global Health







We are searching for collaborators



Our group at NASA-JSC is actively searching for collaborators to help NASA build the technology for Human Exploration, and to help collaborators adopt this technology for clean energy and global health applications

If you have skills/interest in:

Ceramics

High Temperature Ovens

Thermal Modelling

Insulation

Solar Energy Systems

Global Health Initiatives

Electrochemistry

We would like to collaborate

John Graf, P.E., Ph.D. NASA Johnson Space Center
john.c.graf@nasa.gov