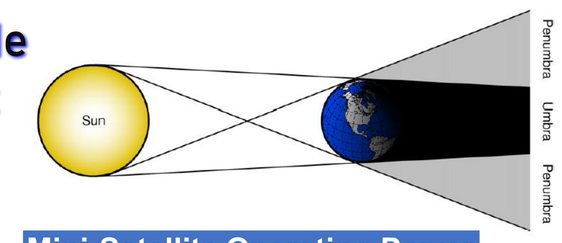
AFRL

Regenerative Solid Oxide Cells (SOFC/SOEC)

2022 Pentagon Energy Expo Exhibit 73

Development of Solid Oxide Cells Coupled with Rocket Bipropellant Storage

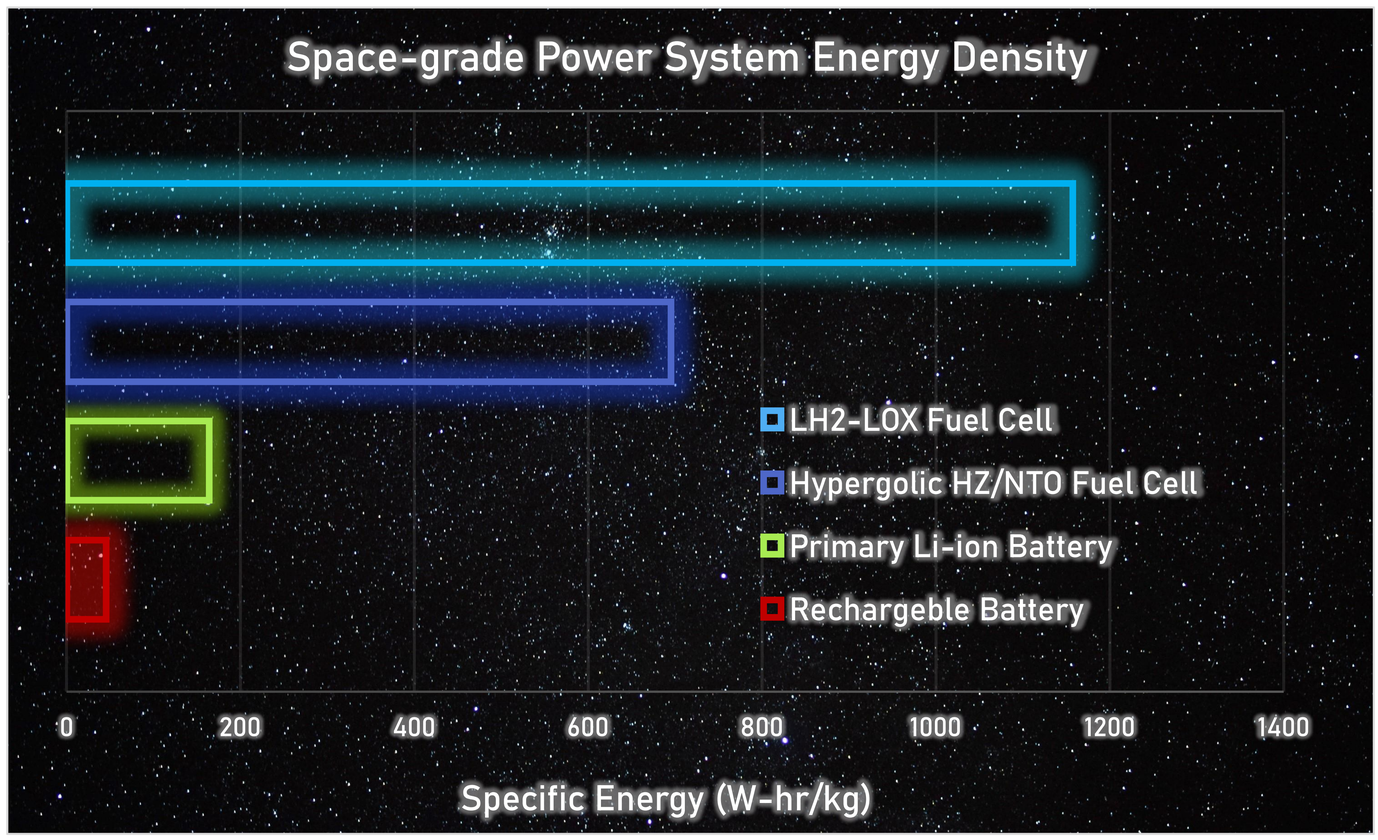
- Possibility of power delivery non-sunlit phase of operation.
- Need for concept validation through system-level simulation.
- Need for materials development for enhanced cell life and power output.



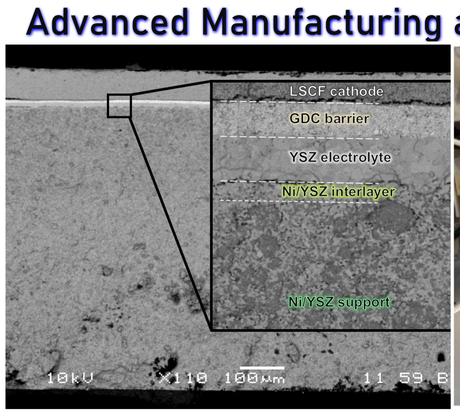
Mini-Satellite Operating Power Requirements

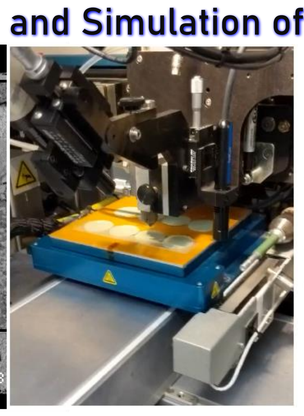
Component	Power (W)
Reaction Wheels (Attitude & Orbit Control System)	12.0
Transmitter (Communications)	25.0
Computer (On-board Data Handling)	22.0
Ion Engine (High Performance Maneuvering)	600.0
Electric Heaters (Thermal Control)	60.0

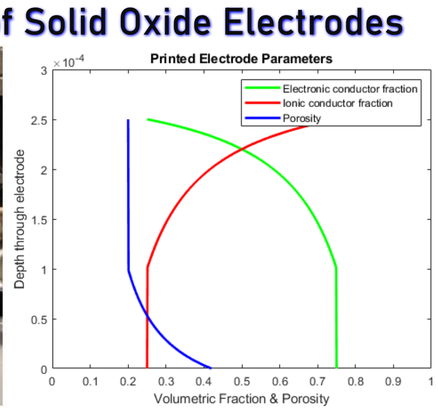
S. Ulrich et al. Acta Astronautica 64(2009) 244 –255



Advanced Manufacturing and Simulation of Solid Oxide Electrodes

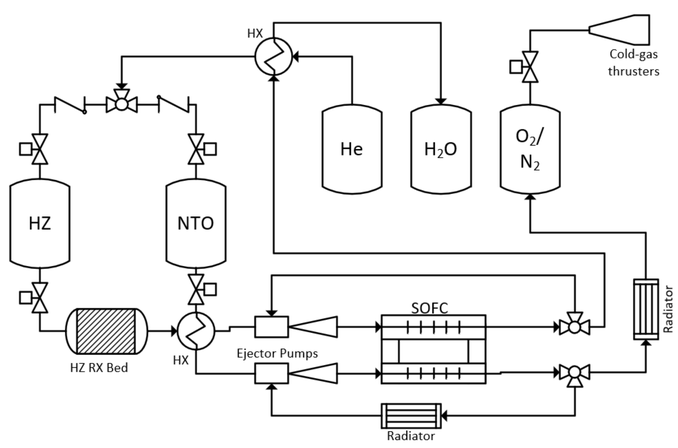




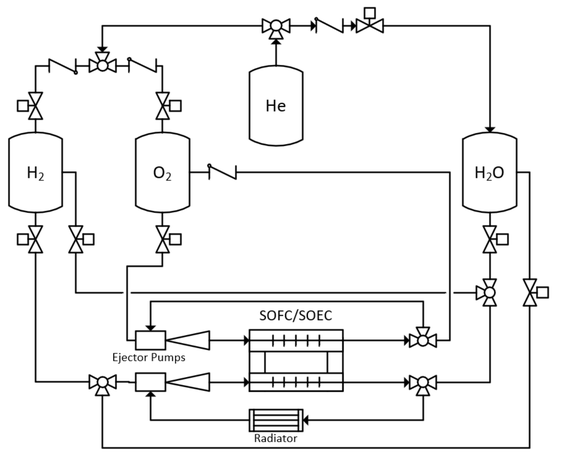


- Optimize electrode composition and porosity locally through aerosol jet additive manufacturing.
- Minimize electrochemical losses due to gas transport and ion conduction.
- Minimize thermal stresses between electrodes and electrolyte.
- Enhance stability against degradation with tuned material inputs.
- Development of modified equations for gas diffusion and ionic conduction in anisotropic electrodes.

Operational Validation of Various Solid Oxide Power Systems

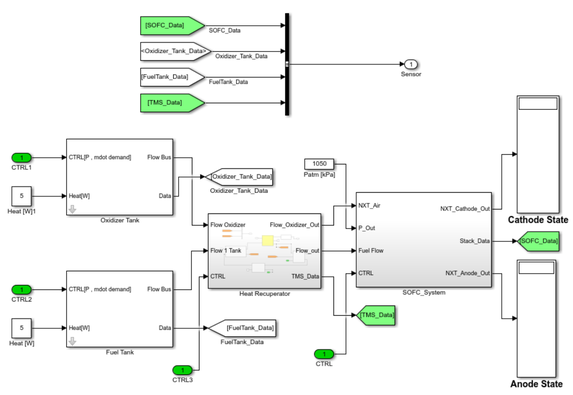


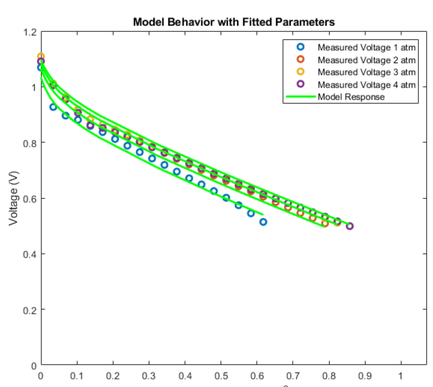
Hypergolic HZ/NTO SOFC System



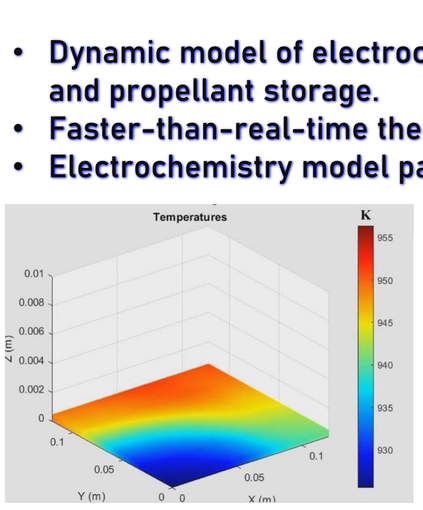
LOX/LH_2 SOEC/SOFC System

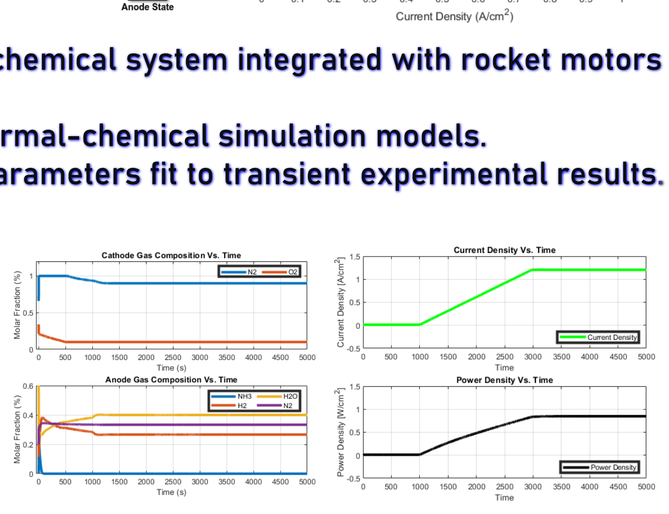
System Simulation Capabilities



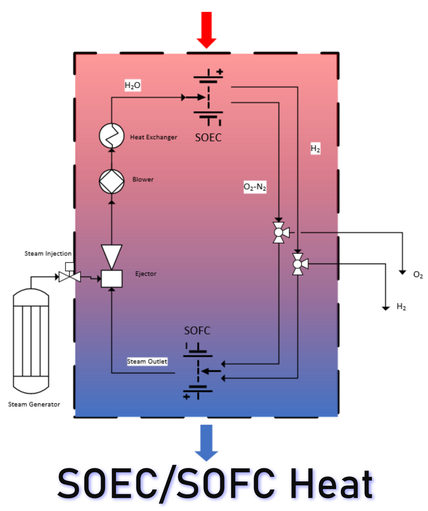


- Dynamic model of electrochemical system integrated with rocket motors and propellant storage.
- Faster-than-real-time thermal-chemical simulation models.
- Electrochemistry model parameters fit to transient experimental results.

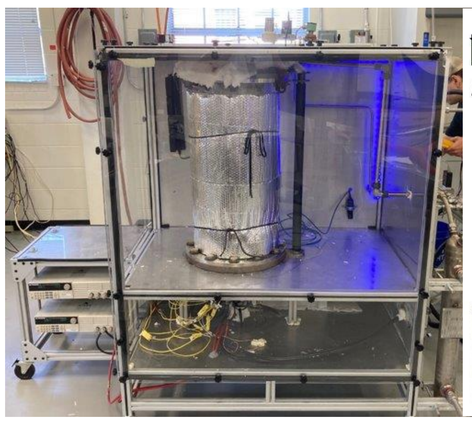


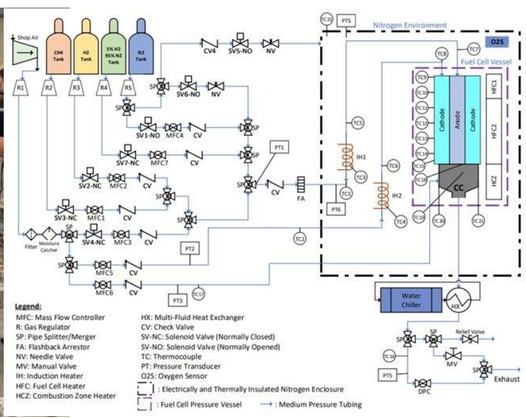


Dynamic Optimization of Controls for Start-up and Shut-down (minimize fuel loss and thermal stresses)

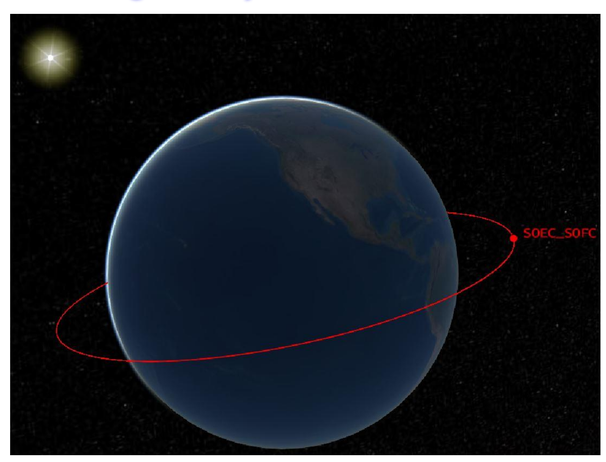


SOEC/SOFC Heat Engine System





Tennessee Tech Solid Oxide High Temp/High Pressure Testing Capabilities



SOFC and SOEC Control within orbital propagation and eclipsed periods.

Research Team

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