COE CST Tenth Annual Technical Meeting

Task 396: Mapping Life Support System Functions and Technologies to Commercial Spaceflight Applications

PI: David Klaus

Students: Kaitlyn Hauber and Hunter Hatchell

Agenda

- Team Members
- Task Description
- Schedule
- Goals
- Results
- Conclusions and Future Work

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Team Members

- Principal Investigator
  - Professor **David Klaus**
    COE CST Executive Director

- Student Researchers
  - **Kaitlyn Hauber**
  - **Hunter Hatchell**

Task Description

- **Current Effort**
  - **Task 396**: Mapping Life Support Functions and Technologies to Commercial Spaceflight Applications (2/5/20-12/31/21)

- **Prior Related COE CST Projects**
  - **Task 353**: Design and Operational Considerations for Human Space Flight Occupant Safety (6/1/17-5/31/18)
  - **Task 320**: Commercial Spaceflight Risk Assessment and Communication (6/1/15-5/31/17)
  - **Task 184**: Human-Rating of Commercial Spacecraft (6/1/11-12/31/14)

Task Description

- **Current Effort**
  - **Task 396**: Aligned with FAA's *Environmental Control and Life Support Systems for Flight Crew and Space Flight Participants in Suborbital Space Flight* document (Version 1.0, April 2010)
- **Prior Related COE CST Projects**
  - **Task 353**: Aligned with *FAA Recommended Practices for Human Space Flight Occupant Safety* (Version 1.0, August 27, 2014)
  - **Task 320**: Aligned with *14 CFR 460.45, Operator Informing Space Flight Participant of Risk* (2013)
  - **Task 184**: Aligned with *FAA Established Practices for Human Spaceflight Occupant Safety* DRAFT (July 31, 2013)

Task Description

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- **AIM 1: ‘Generic ECLSS Model’** – a map of ECLSS functions will be defined and coupled with existing technologies capable of meeting the needs as representative systems for different flight profiles ranging from suborbital excursions to orbital for short and long durations.

- **AIM 2: ‘ECLSS Tradeoff Models’** – a foundational database will be established to identify a comprehensive listing of current and future ECLSS components and related technologies with detailed performance specifications needed to enable future trade off model analysis.

Task Description

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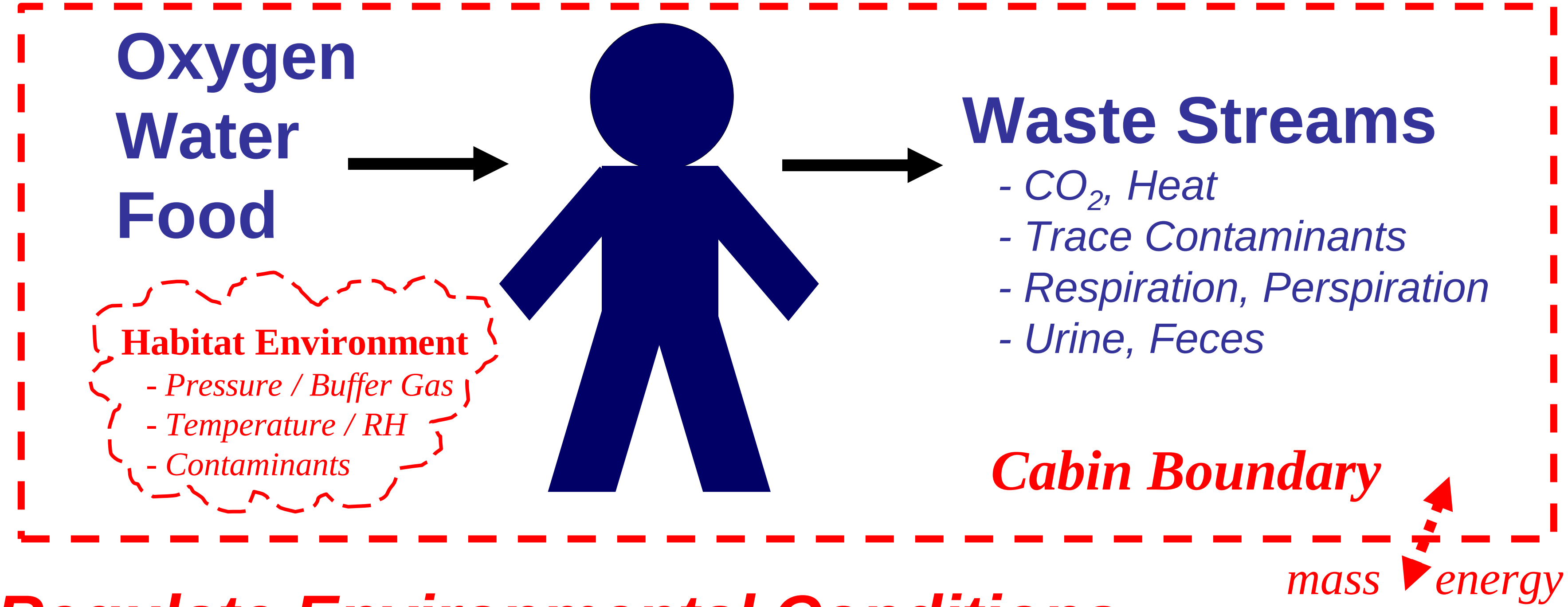
ECLSS Functional Requirements

Satisfy human physiological needs

Provide Metabolic Inputs & Collect Byproducts



Regulate Environmental Conditions

Task Description

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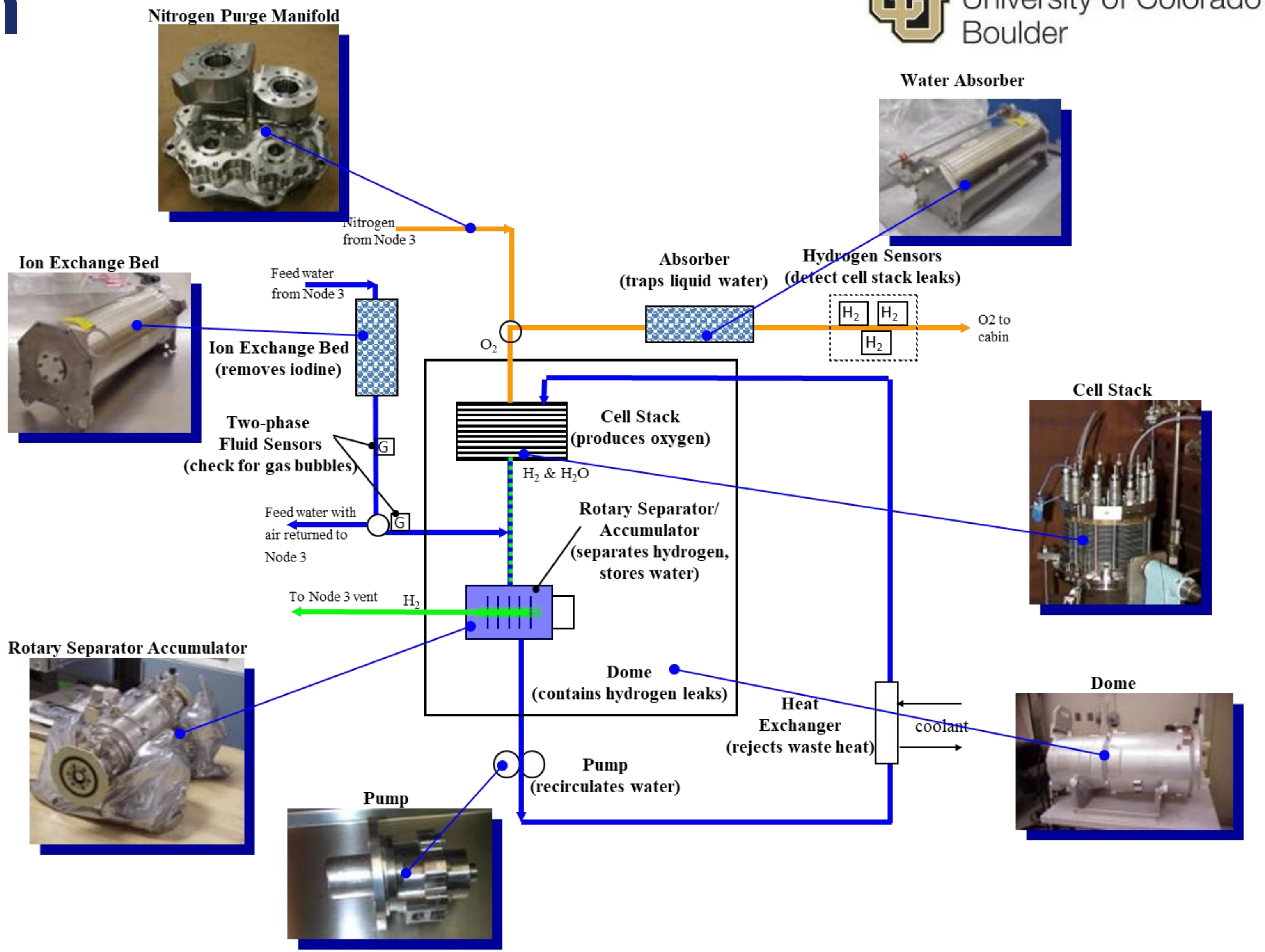
Function: *Provide Oxygen*

Apollo Cryogenic Oxygen Storage Tank used to provide oxygen to the fuel cells for electrical power generation, as well as for the crew to breathe

Task Description

Function: *Provide Oxygen*

Oxygen Generator Assembly (OGA) on the ISS used to convert water (recovered from urine and condensate) to breathable O2



Schedule

- **AIM 1:** ‘Generic ECLSS Model’ (Tasks 1-4) June-March 2020
- **AIM 2:** ‘ECLSS Tradeoff Models’ (Tasks 5-7) April-December 2021

<u>Tasks</u>

1. Define and categorize an initial set of ‘generic’ ECLSS functional requirements
2. Identify baseline ECLSS components and related human needs across different flight profiles
3. Document and characterize detailed performance data for current ECLSS technologies
4. Summarize model ECLSS package examples for different representative flight profile categories
5. Extend analysis beyond current ECLSS components to identify optional trade space for new technologies and additional functions (e.g., crew accommodations, IV/EVA suits, exercise countermeasures, food/nutrition, human factors, ergonomics, medical outfitting, etc.)
6. Assess failure modes and identify risk mitigation strategies (e.g., redundancy, sensors, consumable margin, reliability, maintainability, ‘robustness’, etc.)
7. Status long term ECLSS research directions for future technology pipeline insight as a function of TRL (to be included in the database established in task 3).

Goals

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- Task 396 is intended to augment the FAA's *Environmental Control and Life Support Systems for Flight Crew and Space Flight Participants in Suborbital Space Flight* document (Version 1.0, April 2010)
- ECLSS information compiled to inform a compliance matrix for requirements and further serve as a guide for designers to help ensure an optimal, habitable environment is provided and the overall needs of the occupants are met
- Task 396 builds on prior COE CST Tasks addressing human-rating (184), risk analysis (320) and occupant safety (353)

Results

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- **Select Publications from Prior Work to Date**
  - Klaus, D.M. (2018) **The Pursuit of Occupant Safety in Commercial Human Spaceflight**. *New Space* 6(1): 48-52
  - Ocampo, R.P. and Klaus, D.M. (2018) **Applying Regression Analysis to Model the Risk of Space Flight and Terrestrial Activities**. *The Journal of Space Safety Engineering* 5(3-4): 135-139
  - Ocampo, R. and Klaus, D. (2016) **A Quantitative Framework for Defining "How Safe is Safe Enough?" in Crewed Spacecraft**. *New Space*, 4(2): 75-82
  - Neis, S.M. and Klaus, D.M. (2014) **Considerations toward Defining Medical 'Levels of Care' for Commercial Spaceflight**. *New Space,* December 2014, 2(4): 165-177
  - Klaus, D.M., Ocampo, R.P. and Fanchiang, C. (2014) **Spacecraft Human-Rating: Historical Overview and Implementation Considerations**. *IEEE Aerospace Proceedings* (978-1-4799-1622-1/14, no. 2272)
  - Ocampo, R.P. and Klaus, D.M. (2013) **A Review of Spacecraft Safety: from Vostok to the International Space Station**. *New Space* 1(2): 73-80
  - Klaus, D.M., Fanchiang, C. and Ocampo, R.P. (2012) **Perspectives on Spacecraft Human-Rating**. *AIAA-2012-3419*

Publications, Presentations, Awards, & Recognitions

PUBLICATIONS

None from task 396 yet

PRESENTATIONS

None from task 396 yet

AWARDS

Professor Klaus received the International Conference on Environmental Systems Award for Technical Excellence at the 49th annual ICES meeting, held in Boston in July 2019

RECOGNITIONS

Professor Klaus was recognized as an AIAA Fellow in 2020

Conclusions and Future Work

- Per AIM 1, functional requirements for ECLSS will be defined and characterized by representative model systems
- Per AIM 2, a foundation will be laid for future ECLSS trade off studies by providing a detailed set of operational parameters needed to evaluate the use and integration of technologies
  - Feedback will be provided to the FAA AST office with suggestions to ECLSS guidelines and requirements compliance matrix data
  - Input from industry and government will also be solicited
- Task 396 has been impacted due to funding delays and COVID circumstances, currently planned to finish by Dec. 2021