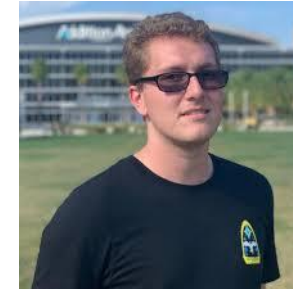


Fluid Flows Beyond Earth: How fluid dynamics research shapes Space Exploration and Colonization

Computational Fluids and Aerodynamics Laboratory (CFAL)

Space-Related Research

- Computational Fluid Dynamics: development to application
 - Algorithms, CPU/GPU/Quantum(?)/ML/AI, etc.
- Aerodynamics / Fluid dynamics: all-Mach
- Multiphase flow systems: Solid/Liquid/Gas mixtures
 - Regolith, sloshing, cavitation, boiling, cryogenics



Brendon Caviano, Ph.D.
Postdoc working on hypersonics and atmospheric simulation



Caroline Anderson, Ph.D.
Postdoc working on re-entry vehicle design



Michael Marques, Ph.D.
Postdoc working on Dust-Kickup relating to Space Exploration



Michael P. Kinzel, Ph.D.
Associate Professor
Aerospace Engineering
michael.kinzel@erau.edu



Jackson Asiatico
(PhD candidate)
Space-Exploration Rotorcraft



Taylor Peterson
(PhD candidate)
Cislunar Fluid Transfer



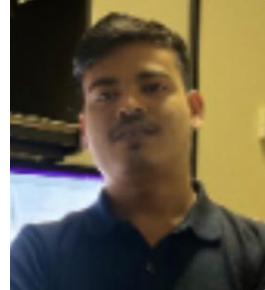
Sweetie Sarkar (PhD student)
Atmospheric Modeling



Andy Torres (MS, PhD student)
Atmosphere in Celestial Bodies



Juan Pablo Roldan (MS, PhD student)
Multiphase processes in Hypersonics



Sagar Gharti (MS, PhD student)
Biofluids in Microgravity

Team of Undergrads: Colby Bolduc, Ethan Bratt, Spencer Rouland, Michael Culbertson, and others

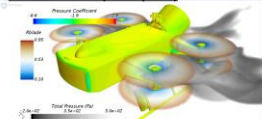
CFAL Contributions to the Dragonfly Mission: Aerodynamics, Stability, and Dust Dynamics

Dragonfly Mission to Titan

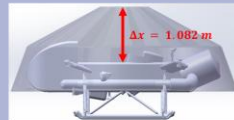
- 1st flight-based lander
 - KSC launch: July 2028
- Contributions:

(2017-2023) Fuselage aerodynamics

2017: First CFD (conceptual)



2018: Phase B (still conceptual)



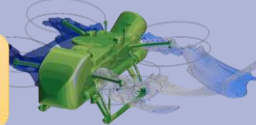
2021: Larger Design (larger Aeroshell)

2023: Refined Body (low drag and stable)

Aerodynamic Design: Many CFAL

Contributions

- Improved flight dynamics
- Lower drag



(2021-2023) EDL control issue and initial correction

(2022) Flight control issue: Yaw Stability and corrected design

(2023-2025) Dust! (video)

- Erosive Damage
- Dust sensor design/calibration
 - Collaboration with Brisset (UCF)



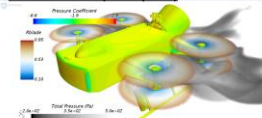
CFAL Contributions to the Dragonfly Mission: Aerodynamics, Stability, and Dust Dynamics

Dragonfly Mission to Titan

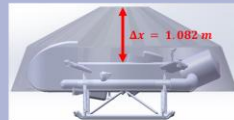
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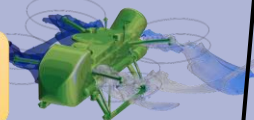
2018: Phase B (still conceptual)



2021: Larger Design (larger Aeroshell)

Aerodynamic Design: Many CFAL Contributions

- Improved flight dynamics
- Lower drag



(2021-2023) EDL control issue and initial correction

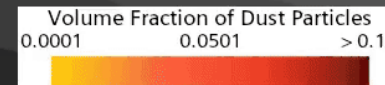
(2022) Flight control issue: Yaw Stability and corrected design

(2023-2025) DUST! (video)

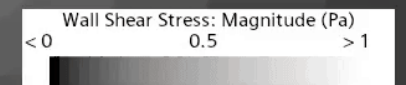
- Erosive Damage
 - Dust sensor design/calibration
- Collaboration with Brisset (UCF)

Current Focus: Dust Operations

Value: High-fidelity computations to support the untestable.



Height from Skids: 6.10 (m)
Solution Time: 0.075 (s)



Pitch Angle: 0.0 (deg)
Roll Angle: 0.0 (deg)

Hypersonic Cooling

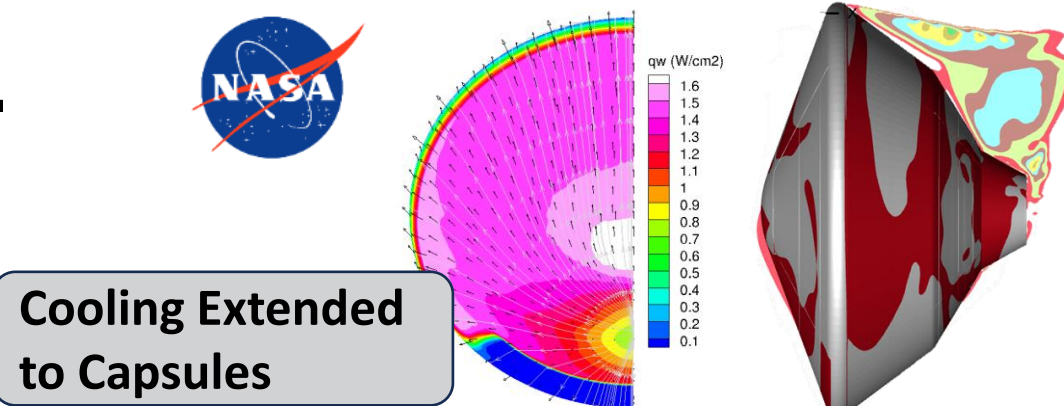
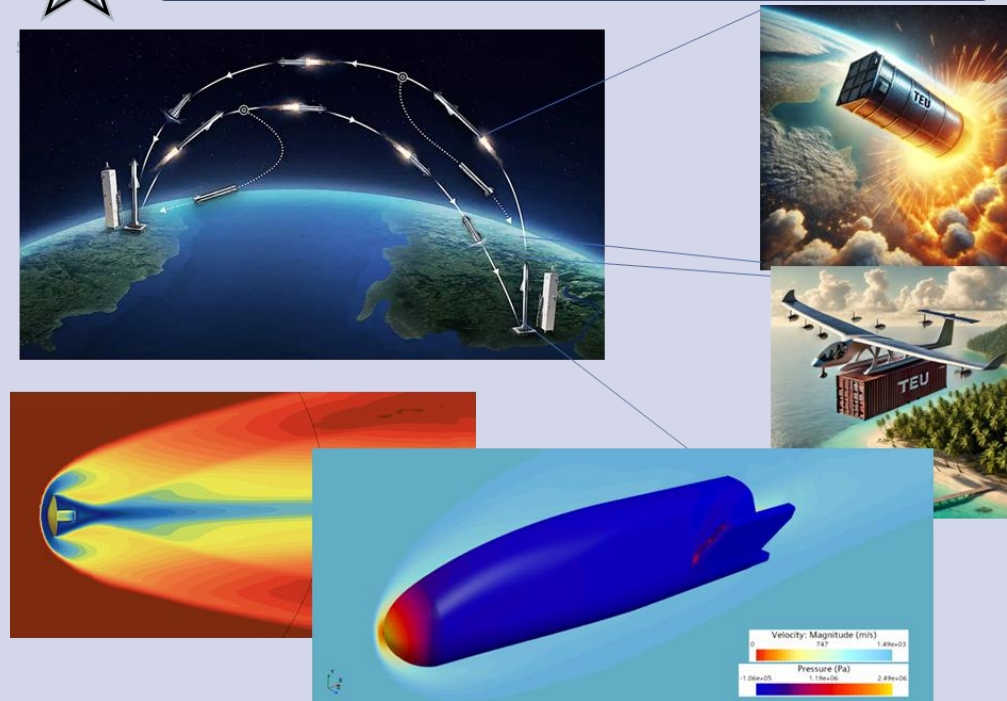
Up/Down-massing Space

Goal: Low cost access to space!

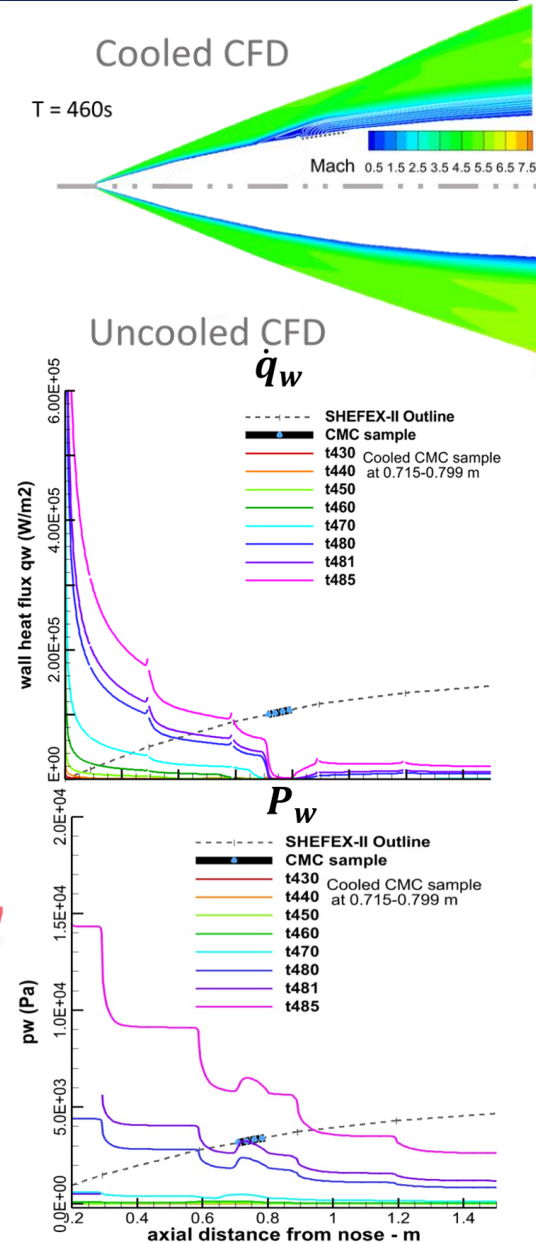
Approach: From launch processes, to returning things from space.

- Space Logistics Systems Design
 - Gound operations
 - Ravelo and Mollaghasemi (UCF)
 - Reentry
 - Elgohary (UCF)
 - Coastal Resilience
 - Medeiros (ERAU)
 - Reentry
- Reusable heat Shields
 - Transpiration Cooling
 - Brune (NASA Langley)
- Cislunar fuel transport
 - Boiling/Processing/Sensing
 - Hartwig (NASA Glenn)

Downmassing heavy payloads



Cooling Extended to Capsules



Fluids in Space: From Bioflow Physics to Thruster Interactions

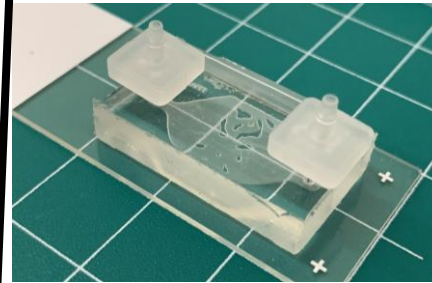
Fluids in Space Environment

Goal: Solve issues in space.

Approach: Apply range of CFD methods to solve challenges.

- Biofluids (Coathup & Seal, UCF)
 - TRL advancement
 - Microgravity effects on flows within bone pores
 - 2 Suborbital Flights:
 - NS23 and 24
- In-Space Manufacturing (Raghavan, ERAU)
 - Curing physics in micro/lunar-gravity
 - μG Flight planning
- Thruster-Plume interactions
 - Thruster-Satellite Damage (Pitt, Aegis)
 - Thruster-regolith interaction

Micro-fluidic Experiment Representing Bone Flows

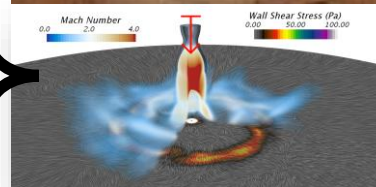


imec USA Lens-Free Imaging (LFI) ↑ TRL for Space

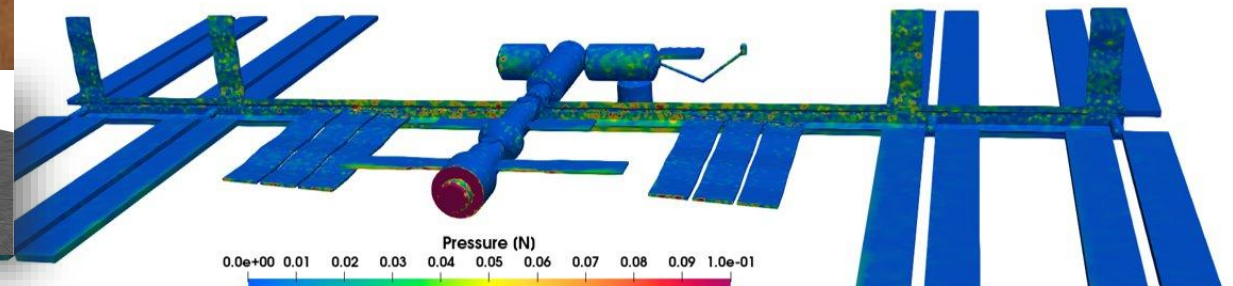
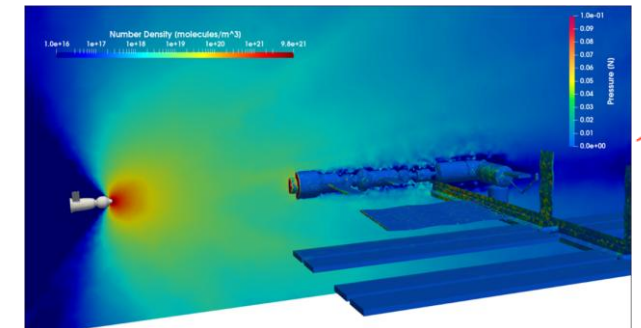


Thruster Plumes: Ground/Satellite

Rarefied Plume Simulation



RCS Thruster Plumes (Collaborating with Pitt, Aegis)



- **Advancing fluids research to enable space exploration and human settlement.**
- **Merging CFD, AI, and experimental methods for rapid TRL advancement.**
- **Thrilled to collaborate across missions, labs, and universities—this is a shared frontier.**
- **Contact: kinzelm@erau.edu**

Florida Space Research: Where scientists, engineers, and medicine converge—turning problems into collective progress.