II. Accomplishments:

A. What are the major goals of the project?

The purpose of this work is to better understand the fundamentals of turbulence particle interaction through quantification of turbulence steady state and decay in a microgravity environment, provided by the International Space Station (ISS), using a liquid laden with particles that are both more and less dense than the base fluid.

The experiment consists of two liquid-filled cylinders, one having a concentration of dense sediment and the other having a concentration of gas bubbles. Flow velocities will be measured with Particle Image Velocimetry using a set of miniature high-speed cameras and an LED light sheet for illumination. Turbulence will be created by counter-rotating bladed plates at the ends of the cylinders creating a von Kármán flow. Both steady-state and decaying turbulence flow states will be measured. The experiment will be entirely automated, minimizing effort from space station personnel.

Of particular interest are how the particles impact the turbulence decay rate and how energy is transferred between turbulence scales. Proper statistical convergence requires multiple trials for each case, making the ISS with constant true microgravity an ideal environment for the experiments as compared to parabolic flights. An exact replica of the experiment with trials conducted at the University of Delaware will provide an opportunity to fully test the facility and provide data in a gravity environment to compliment the ISS experiments.

The specific overarching goals of the work include:

1. Build and test a compact dual chamber von Karman flow facility safe and reliable enough for ISS experimentation.
2. Create a software/firmware scheme to automatically run through a series of experiments while remote on the ISS with limited connectivity and communication.
3. Conduct a series of gravity and sans-gravity tests of steady state turbulence and decay using particle image velocimetry.
4. Analyze data and disseminate to scientific communities that include sediment transport, air-sea interactions, and astrophysics.

B. What was accomplished under these goals?

The accomplishments over the past year are largely on the finalizing the design of the test facility and preparation for testing. There were a few flight delays, and a transition of leadership on the Nanoracks side that led to pauses in potential for flight. In that time, we refined the construction and design and prepared for launch.

1. Fluid flow facility: The fluid flow facility has been completely designed, tested, and refined. We have run multiple benchtop tests of the facility to get gravity-based data, tested the data processing capabilities, and run longevity tests with power interruption to ensure the device is robust enough for ISS use.

2. We have worked closely with the team at Voyager (formerly Nanoracks) to ensure our facility can interact with their test rig on the ISS. This included weekly meetings with them and a few iterations of sending the technology back and forth for iteration. Things we updated were

Loctite to the fasteners, removing zinc-based fasteners from the design, moving to solid-state capacitors, among others. Now, the facility is with them for safety panel testing in final preparation for the August launch date.

3. We refined the control system to be overly simplistic to avoid potential for failure while in the ISS. In layman's terms, the microcontrollers and computers do not "speak" to one another with any form of communication, they merely poke each other when ready. This simplifies the controls a tremendous amount as they can both be operated in their native languages. This has been extremely robust in testing, and the simple operation is more than enough to collect the data we need.

C. What opportunities for development has the project provided to the Jurisdiction's Research Infrastructure as a whole?

This project has facilitated two separate senior design teams, one for Mechanical Engineering and the other for Computer Science. These allows over 10 undergraduate students to use NASA EPSCoR as their Capstone project. Additionally, the project has hosted 2 undergraduate students and one graduate student as research assistants. One of the undergraduates has moved on to graduate school at Princeton University and the other is currently interning with NASA.

D. How have the results been disseminated to communities of interest?

We have presented our design and initial results at the American Physical Societies annual conference for the Division of Fluid Dynamics.

E. What do you plan to do during the next reporting period to accomplish the goals?

Complete our safety training, launch to the ISS, monitor progress, complete our data acquisition, and begin data processing.

III. Products:

A. List Journal publications – Please only list papers that have been published. **Please do not remove the table; or alter columns, add additional rows as required.**

Date Published	Published Paper (APA format)
	None to report

B. List Conference Papers – Please only list papers that are included in conference proceeding. **Please do not remove the table; or alter columns, add additional rows as required.**

Conference Date	Conference Paper (APA format)
	None to report

C. List Conference Presentation – Please list conference presentation. **Please do not remove the table; or alter columns, add additional rows as required.**

Conference Date	Presentation Topic (APA format)
Nov 2023	**"Inertial particles in stationary and decaying turbulence: towards microgravity experiments on the ISS", 76th Annual Meeting of the APS Division of Fluid Dynamics.**

D. List Books and/or other Publications – Please include explanations, help us to learn about your accomplishments. **Please do not remove the table; or alter columns, add additional rows as required.**

Date	Explanations (APA format -Book, Newspaper Op-Ed, …)
	None to report

E. List talk/presentation/event/outreach activity – Please include explanations, help us to learn about your accomplishments. **Please do not remove the table; or alter columns, add additional rows as required.**

Date	List talk/presentation/event/outreach activity (APA format if applicable)
June 2023	**Outreach: STEM rocket activity with the NASA team featured in UDaily: https://www.udel.edu/udaily/2023/june/nasa-international-space-station-early-learning-center-engineering-outreach-tyler-van-buren/**

F. List of new or updated Website(s) or other Internet site(s). **Please do not remove the table; or alter columns, add additional rows as required.**

URL	Short description of purpose of site
None to report	

G. Technology/Technique – **Please do not remove the table; or alter columns, add additional rows as required.**

Technology/Technique	Short description of technologies or techniques
None to report	

H. List patent – Please include Patent Number/Patent Title/ Patent Abstract (or link to it). **Please do not remove the table; or alter columns, add additional rows as required.**

Date Patent Issued	Patent Number/Patent Title/ Patent Abstract (or link to it)
	None to report

I. List Inventions – Please include Invention Title, List of Inventor(s) and Description. **Please do not remove the table; or alter columns, add additional rows as required.**

Invention Title	List Inventor(s)	Invention Description
None to report		

J. List Licenses – Please include license issued, Invention Title, List of Inventor(s) and Description. **Please do not remove the table; or alter columns, add additional rows as required.**

Date License Issued	License Assignees	License Title
	None to report	

K. List New/Revised Courses – Please include new/revised courses. **Please do not remove the table; or alter columns, add additional rows as required.**

Course Number	Course Name/Title	Offering Institution
	None to report	

L. Others: List Databases, Physical collections, Audio or video products, Software or NetWare, Models, Instruments or equipment, Data & Research Material (e.g., cell lines, DNA probes, animal models) related to your EPSCoR research. **Please do not remove the table; or alter columns, add additional rows as required.**

Accomplishments title	Short Description of accomplishments
	None to report

IV. Participants & Other Collaborating Organizations:

A. University Research Team Members (do not include names of minors). **Please do not remove the table; or alter columns, add additional rows as required.**

Name	Project Role	Nearest person month worked	Contribution to Project	Funding Support
Tyler Van Buren	Lead PI and researcher	3	Project lead, lead researcher	1 summer month
Ajay Prasad	Co-PI and advisor	0.1	Advising	n/a
Jack Puleo	Co-PI and advisor	0.1	Advising	n/a
Fabrice Veron	Co-PI and advisor	0.1	Advising	n/a
Bennett Maruca	Co-PI and advisor	0.1	Advising	n/a
William Matthaeus	Co-PI and advisor	0.1	Advising	n/a

B. NASA Collaborators. **Please do not remove the table; or alter columns, add additional rows as required.**

Name	Title	NASA Center	Nature of the Collaboration
None to report			

C. Industry Collaborators. **Please do not remove the table; or alter columns, add additional rows as required.**

Name	Title	Industry/Company Name	Nature of the Collaboration
None to report			

D. New non-EPSCoR grants. **Please do not remove the table; or alter columns, add additional rows as required.**

Funding Entity	Award Name	Value of New Grant
None to report		

E. Other Organizations Involved as Partners. **Please do not remove the table; or alter the columns, add additional rows as required.**

Organization	Nature of the Collaboration	Benefit of Collaboration	Additional Information
None to report			

V. Changes/Problems

A. Changes in approach and reasons for change.

There were delays from Nanoracks during their change in being purchased by Voyager. This led to a launch delay that extended the launch past the project timeline.

B. Actual or anticipated problems or delays and actions or plans to resolve them.

We anticipate pushing for a 1 year no cost extension to accommodate the launch delay.

C. Changes that have a significant impact on expenditures.

None.

D. Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards.

None.

E. Change of primary performance site location from that originally proposed.

None.

VI. Impact:

Impact: Stimuli article, attach a high-resolution photo and a one line caption. Obtain permission to publish photo from any recognizable person. ***Do not*** *include photos of minors.*

A UDaily article associated with the project has good photo material and captions to choose from for displaying the work. Link: https://www.udel.edu/udaily/2022/september/engineering-student-project-iss-nasa-international-space-station-cubesat/

A UDaily article associated with the project that has good outreach content approved for release. Link: https://www.udel.edu/udaily/2023/june/nasa-international-space-station-early-learning-center-engineering-outreach-tyler-van-buren/