# Earth Based Gravity Machines – 4 Second Microgravity Vehicle

Fall 2021

### Mike Conroy – Florida Space Institute with the Center for Microgravity Research Version 2.1 – July, 2021

# Opportunity

Studies indicate a small number of microgravity drop towers exist today. Microgravity duration over 2 seconds is rare and drop towers providing over 3 seconds are limited to a small number of national institutes in the US, China, Japan and Germany; with the longest microgravity duration under 10 seconds. Usage involves travel or remote testing, dramatically limiting educational involvement outside of sub-second experiments in room sized facilities.

# Approach

Create a series of inexpensive, easily reproducible, air vehicles able to provide low-cost access to microgravity for CubeSat class (3U) payloads. These vehicles will be carried to altitudes ranging from 400 to 4,000 feet and released with sufficient propulsion to offset air friction and ensure the desired microgravity environment inside the vehicle. Standard versions are expected to use a closed loop control system to manage thrust. More sophisticated versions would support a yo-yo function, incorporating upward flight to increase the duration of the microgravity event. A benefit of this approach over traditional drop towers is the ability to modify the propulsive forces to simulate more than just microgravity. Such a system could easily reproduce Lunar or Martian gravity or provide programmed variations across the flight.

# Phases

Complex efforts are often best broken into segments that stand alone, provide value at the end of the phase and provide a window (between segments) to enable inclusion of new technologies or lessons learned in future efforts. This project is broken into 4 phases:

Phase 1 – Feasibility Study

**Complete**

A look at the physics, technologies, state of the art and operational concepts.

Test goal is 2-3 seconds of Microgravity

Will determine if project continues to Phase 2

Phase 2 Vehicles

A basic vehicle suitable for STEM/STEAM outreach

Goals are:

**3 to 4 seconds of Microgravity with an active system**

1 to 2 seconds of Microgravity with a passive system

Will include designs for a series of basic student microgravity experiments

Will determine if projects continue to Phase 3

Phase 3 Vehicle

A more advanced vehicle providing, longer duration and higher quality microgravity

Goal is 4 to 8 seconds of microgravity

Will determine if project continues to Phase 4

Phase 4 Vehicle Study

Significantly more advanced vehicle and lift system

Goal is 8 to 12 seconds of microgravity

Study only, no development at this time

# Phase 2.0, 2 Paths

Phase 2 of the Gravity Machine project will cover 2 related but different efforts. Phase 2.1 is very similar to the original Phase 2 with a few minor updates. Phase 2.2 will leverage successes from the Phase 1 Feasibility study to create an inexpensive, unpowered option geared towards low-cost access to up to 2 seconds of free fall.

### Phase 2.1, GM 4, a 4 Second University Completion

#### Content

Design and Development are to be carried out by University Students as a part of the Senior Design Curriculum at Florida Engineering schools. Envisioned is a design competition with participants from 4 Universities. Teams will be encouraged to simplify Phase 1 control systems, employ 3D Printing and utilize Open-Source technologies to reduce costs. The Phase 2.1 vehicle will be dropped from an FSI sourced asset (commercial drone) at an FSI provided location (Florida Poly) and carry 2 FSI specified and team developed payloads. The first will be a CubeSat 1U container with an FSI provided accelerometer. The Second will be a microgravity demonstrator consisting of a CubeSat 2U payload containing a 1U volume for pebbles, TBD cubic centimeters of 5mm diameter pebbles and a window into the second compartment. The second 1U compartment will include a GoPro Camera and lighting to film the pebbles during the drop. This video will help determine the quality of the microgravity. The focus will be on 4 seconds of microgravity with a soft, under 10G landing. Each team will provide a prototype for testing. Test results and system evaluations will be used to select one design for production. This will be considered the GM-4 vehicle and will be used for primary and secondary educational opportunities. Feasibility Study IP will be made available to all teams for non-commercial use.

#### Expected Results

An affordable capability for performing microgravity experiments with smaller CubeSat (2U to 3U) size payloads. The quality of the microgravity is expected to be TBD1 and suitable for middle schools and high school STEM/STEAM education. The Phase 2.1 system should be easily reproducible and will be shared under a suitable open-source license. Collaboration with the Center for Microgravity Research and the Kennedy Space Center are expected to provide experiment topics suitable for High School and Undergrad education.

#### Fall 2021 Student Competition

##### Preparation

Notice to Florida Universities with Senior Design Programs through Florida Space Grant. Interested universities to respond to Mike Conroy [mike.conroy@ucf.edu](mailto:mike.conroy@ucf.edu).

##### Kickoff

The event Kickoff with responding universities to be held virtually in early September; Kickoff will provide a schedule, funding opportunities, a rules package, the scoring rubric, a review of the Feasibility Study data and a review schedule.

##### Cadence

Monthly event tagups will be held between FSGC and at least one member of each team

##### Rules

* Release Interface – Highly Defined, mechanical and electrical
* No Explosives – Not even actuators
* Mass Budget, including Payload and required Instrumentation 15 KG
* Payload Access
* Materials
* Autonomy
* Mission Cycle Time – 1 hour

##### Competition

The Feasibility Study demonstrated the suitability of a Large Drone and the Fort Christmas Park Large field for testing. The Spring 2022 event will be held at Florida Polytechnic. Flight Order will be determined by draw with initial drops from 200 feet for a system test. Vehicle recovery will start a 1-hour timer for the next flight opportunity. Subsequent drop(s) will be from TBD2 altitude, allowing for a 4 second drop and TBD3 feet for deceleration and recovery. These will be driven by safety and Air Traffic Control restrictions.

##### Scoring

Scoring will be based primarily on the quality of the microgravity environment during the drop. This includes accelerometer data and analysis of the experiment video. Also evaluated will be cycle time, payload access, and significant transient events during flight (recovery deployment and landing).

##### Mentors

Mentors are planned from both the Florida Space institute and the Center for Microgravity Research. As this is a design competition, Mentors will work with all teams to ensure a fair outcome.

##### Funding

Financial support is available for teams that meet the criteria identified by sponsors. The Florida Space Grant Consortium criteria is located here [ <https://floridaspacegrant.org/program/senior-design-projects/> ].