# Earth Based Gravity Machines – 2 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 under 100 feet and released. This class of vehicle will be sufficiently aerodynamic such that drag, within the first 2 seconds, will be negligible and produce the desired microgravity environment inside the vehicle.

# 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, 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 2.2, GM 2, a Two Second Passive System Design Competition – one Semester

#### Content

Design and Development will be carried out by University Students as a part of the Senior Design Curriculum at a Florida Engineering school. Envisioned is a single semester Senior Design team competition integrating Feasibility Study Results and Products into an aerodynamically passive vehicle suitable for 1 to 2 second microgravity flights. The GM 2 Second vehicle will be dropped from a local structure (roof, parking garage, tower) and will include a support and release system suitable for safe use, complying with all local regulations. Teams are expected to employ 3D Printing and utilize Open-Source systems to reduce costs. IP will be made available to others for non-commercial use. The test payload will consist of a CubeSat 1U and 2U container. The 1U container will hold an FSI provided accelerometer. The 2U container will be a microgravity demonstrator consisting of 1U open volume for pebbles, TBD cubic centimeters of 5mm to 10mm 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. Mission cycle time should be less than 45 minutes and include a Payload Replacement.

#### Expected Results

An affordable capability providing CubeSat (2U to 3U) size experiments up to 2 seconds or microgravity. The quality of the microgravity is expected to be TBD1 and suitable for middle schools and high school STEM/STEAM education. The Phase 2.2 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 the middle school and high school 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, a simple pin-and-U-bracket will work
* No Explosives – Not even actuators
* Mass Budget, including Payload and required Instrumentation, 10 KG
* Payload Access – Up to team,
* Materials – Inexpensive, 3D Printed or basic materials.
* Autonomy – N/A, is a passive system
* Mission Cycle Time – 45 minutes from drop to drop

##### Judging Criteria

* Fit and Finish
* Flight Data (Accelerometer and Pebble Video)
* Cost to Produce a second version
* Safety
* Release Mechanism
* Final Report and Portal Report

##### Competition

The Feasibility Study demonstrated the suitability of a Large Drone and the Fort Christmas Park Large field for testing. The Fall 2021 event will be held at TBD location Flight Order will be determined by draw. Vehicle recovery will start a 45-minute timer for the next flight opportunity. Subsequent drop(s) will be from the TBD altitude.

##### Scoring

Scoring will be based primarily on the quality of the microgravity environment during the drop. This includes accelerometer data and the subjective 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/> ].