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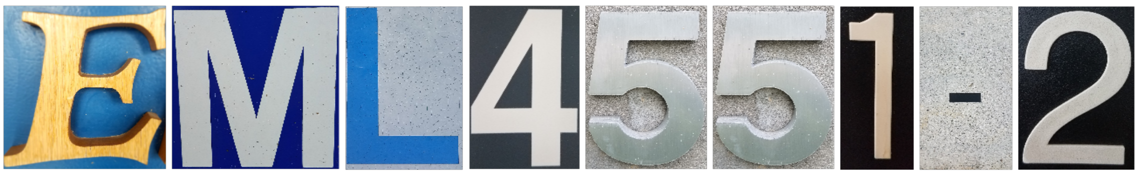

Team 511: Microgravity Machine

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Abstract

The abstract is a concise statement of the significant contents of your project. The abstract should be one paragraph of between 150 and 500 words. The abstract is not indents.

Keywords: list 3 to 5 keywords that describe your project.

Disclaimer

Your sponsor may require a disclaimer on the report. Especially if it is a government sponsored project or confidential project. If a disclaimer is not required delete this section.

Acknowledgement

These remarks thanks those that helped you complete your senior design project. Especially those who have sponsored the project, provided mentorship advice, and materials. 4

- Paragraph 1 thank sponsor!
- Paragraph 2 thank advisors.
- Paragraph 3 thank those that provided you materials and resources.
- Paragraph 4 thank anyone else who helped you.

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List of Tables

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Notation

A17	Steering Column Angle
A27	Pan Angle
A40	Back Angle
A42	Hip Angle
AAA	American Automobile Association
AARP	American Association of Retired Persons
AHP	Accelerator Heel Point
ANOVA	Analysis of Variance
AOTA	American Occupational Therapy Association
ASA	American Society on Aging
BA	Back Angle
BOF	Ball of Foot
BOFRP	Ball of Foot Reference Point
CAD	Computer Aided Design
CDC	Centers for Disease Control and Prevention
	Clemson University - International Center for
CU-ICAR	Automotive Research
DDI	Driver Death per Involvement Ratio
DIT	Driver Involvement per Vehicle Mile Traveled
Difference	

Chapter One: EML 4551C

1.1 Project Scope

Project Description

Design an easily replicable air vehicle that can simulate microgravity conditions for 3-4 seconds when dropped from a drone and be recovered for multiple uses. The device must contain a payload consisting of a CubeSat and GoPro camera to record data.

The objective of our project is to design a replicable system that can be dropped to induce microgravity during decent, and be safely recovered.

Key Goals

The primary end goal of this project is to increase the availability and quality of microgravity sources in the state of Florida.

To achieve this goal, the microgravity machine must be designed to allow the payload to experience zero gravity for up to 4 seconds or longer. The design must accommodate a 3U class CubeSat payload while weighing less than 25 pounds. The design must also accelerate downward at 9.81 m/s^2. The design must be easily reproducible, affordable, and reusable.

These key goals must be implemented to successfully accomplish the needs of the Florida Space Institute (FSI) which include increasing space awareness and science amongst middle school, high school, and college students and furthering research opportunities.

Markets

The primary market for this device is researchers who wish to run experiments in a microgravity environment which fits within the dimensions of a 1U or 3U CubeSat.

The secondary markets for this device include middle and high schoolers who wish to replicate our design and conduct microgravity experiments of their own. Further secondary markets include private companies/organizations that wish to purchase/use our design for testing.

Tertiary markets include individuals seeking hands-on experience with a microgravity environment for recreational purposes.

Assumptions

The assumptions for this project are as follows: the vehicle's freefall path will be clear of obstacles, weather conditions will be calm during testing, air drag will be negligible for the first 0.5 seconds of free fall, device will be lifted and dropped without malfunction of drone, vehicle will be tested in standard earth atmosphere.

Stakeholders

Stakeholders for our project include our project sponsor Mike Conroy, our senior design professor Dr. Mcconomy, our advising professor Dr. Ali, the colleges Florida Polytechnic University and University of Central Florida for putting on the competition and providing test fields, and the Florida Space Grant Consortium for providing the funding for this project.

1.2 Customer Needs

To obtain the customer needs, the team had a meeting with the sponsor, Mike Conroy and asked him questions about what was expected from the machine. Interpreted needs were derived in terms of engineering language to clarify design goals from the responses to these questions.

Below Table 1 summarizes the most important needs received from our sponsor. The most important needs are what the team identified to have the largest impact on the project objective. For all questions and customer statements, see Table A in Appendix B.

Table 1 – Summary of Interpreted Needs

Questions:	Customer Statements:	Interpreted Needs:
What are the dimensions for the payload to be contained?	100x100x300 mm (standard 3U CubeSat)	Machine must house a 3U CubeSat sized payload of dimensions 100x100x300 mm.
What phase of the project are we in (how long will we have to experience microgravity?	Phase 2.5	Machine must simulate microgravity for 3-4 seconds
Are there weight restrictions for the machine?	It should be light enough for the drone to lift. The drone can lift 25 lb, but shoot for 21-22 lb.	Machine must be less than 22 lb.
Are there any material restrictions?	No explosives, typically it is intended to be recreated by High School level classes, PLA, ABS stinks, Nylon stinks. Recommend 3D printing.	Use low-cost materials that are accessible.

Why haven't previous teams' designs been successful?	None of the teams' parachutes worked. Their tolerances were too high, or their parachute was installed incorrectly.	Design needs to be recoverable.

1.2.1 Contain 3U CubeSat

The first interpreted need that we derived was that the machine must contain a 3U CubeSat of dimensions 100x100x300 mm. This is a standardized structure to which other things can be attached. This is necessary because this device will have the ability to house a variety of experiments which future researchers may wish to perform.

1.2.2 Microgravity Time

The second interpreted need that we derived was that the machine must experience microgravity for 3-4 seconds. Mike Conroy told us that we are in phase 2.5 of a multiyear project where the aim is to increase the amount of microgravity time experienced each year. Last year none of the groups were able to achieve microgravity so the desired time has not changed.

1.2.3 Low Weight

The third interpreted need that we derived was that the machine needs to weigh less than 22 lbs. Although the drone can lift 25 lbs, a GoPro and accelerometer will be added so the device must be designed to weigh less than the maximum weight lifted by the drone.

1.2.4 Low Cost

The fourth interpreted need that we derived was that the machine needs to be constructed using accessible, low-cost materials. Mike Conroy stated that high schools and other colleges will be recreating this experiment. For them to do this, the machine needs to use materials that these institutions can access and afford.

1.2.5 Recoverable

The fifth interpreted need that we derived was that the machine needs to be recoverable to prevent damage at impact. Mike Conroy needs to access the data from the GoPro and accelerometer. This means that these components must be intact to determine if microgravity conditions were met.

1.3 Functional Decomposition

Microgravity machines are complex, and to efficiently approach the problem it needs to be broken down into manageable parts. By using the needs specified by the customer we were able to create a chart describing the required functions for the project. The four main subsystems of our product are control magnitude, provision, signal, and connect. The two largest subsystems are the control magnitude and the provision systems making them the most integral parts of the product.

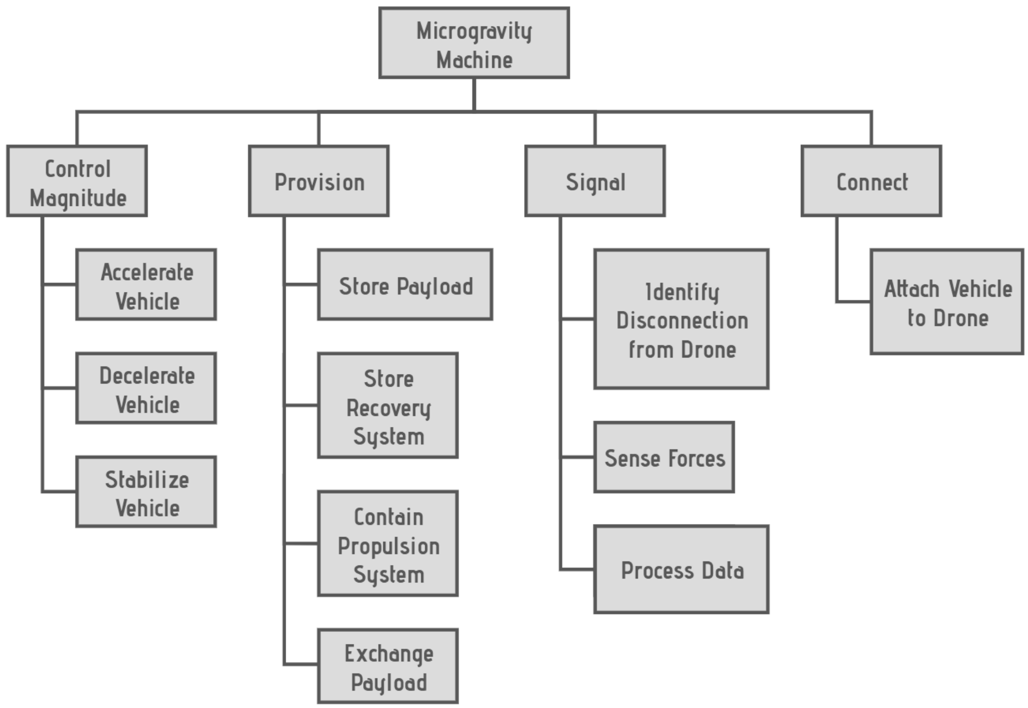

Figure 1: Functional Decomposition Hierarchy Chart

1.3.1 Connection to Systems

The control magnitude subsystem includes four functions: accelerate the vehicle, slow the vehicle, process data, and stabilization of the vehicle during flight. These four functions are the backbone of the product as acceleration to counteract drag allows for microgravity conditions and slowing allows for reusability. Stabilizing the vehicle during flight will aid in minimizing acceleration along the lateral and vertical axes of the vehicle while also minimizing rotation about its longitudinal axis. Control of this subsystem will be handled by an onboard processor.

The provision subsystem stores all the necessary components to the propulsion and deceleration mechanisms as well as the payload housing. The means of acceleration and deceleration have yet to be determined but there will need to be storage devices for any type of propellant or deceleration system that is chosen. The payload housing is what allows the payload to float in the vehicle during the descent. This is what allows for the payload to experience microgravity. The housing is accessible to allow for multiple tests to be performed in succession. These systems will take up most of the space inside the vehicle and will greatly influence the final look of the design.

The signal subsystem's functions detect release from the carrier drone and handle the processing of input/output stream of data between the onboard processor, sensors, and propulsion and deceleration mechanisms.

The connection subsystem's functions manage the attachment of the payload, recovery subsystems, propulsion subsystems, and connection of the carrier drone to the machine.

1.3.2 Smart Integration

By observing each function in Table 2, we can identify the functions which are related to multiple subsystems and are therefore affecting the system in different ways. The acceleration and deceleration components both overlap in the control magnitude and signal subsystems. This relationship exists because in order to accelerate or decelerate the vehicle, we need to detect what forces are influencing the vehicle, so we know how much we need to accelerate/decelerate and when to do this. The connect and provision subsystems have many overlapping functions because while the payload, propulsion, and recovery are all stored in the device, they need to be fastened as well. Since the payload is both stored and connected, the exchange payload function must also be stored and connected. The process data function is integrated in both signal and control magnitude because the signals will be sent to a computer where the signals will be converted/calculated and sent to the other systems, so the systems know how to behave. The function identify disconnection from drone falls under two subsystems: signal and connection.

There is opportunity for innovation here because perhaps there can be one component of our design which allows for disconnection and sends a signal.

1.3.3 Action and Outcomes

The actions and outcomes of this project can be obtained from summarizing the functions represented in Figure 1 and comparing these with the customer needs. The machine must provide an alternative solution to create a microgravity environment for experimentation. In order to do this, it must stabilize itself, control its acceleration while falling, and land safely. This requires well timed cooperation between multiple mechanisms. The cooperation will be controlled through an onboard processor. It also needs to have stable and efficient packing to contain all necessary components including, the propulsion system, the recovery system, and the payload. The machine must be able to connect with a drone so it can be lifted to a start position and know when the drone has released the machine so the automated control can be activated.

Table 2 – Cross Reference Table

Functions	Systems			
	Control Magnitude	**Signal**	**Connect**	**Provision**
Accelerate Body	**X**	**X**		
Decelerate Body	**X**	**X**		

Stabilize Vehicle During Flight	**X**			
Store Payload			**X**	**X**
Contain Recovery System			**X**	**X**
Contain Propulsion System			**X**	**X**
Exchange Payload			**X**	**X**
Identify Disconnection from Drone		**X**	**X**	
Sense Forces		**X**		
Process Data	**X**	**X**		
Attach Vehicle to Drone			**X**	

https://online.visual-paradigm.com/diagrams/features/functional-decomposition-diagram-tool/

1.4 Target Summary

1.5 Concept Generation

Concept 1.

Concept 2.

Concept 3.

Concept 4.

Concept n+1.

1.6 Concept Selection

1.8 Spring Project Plan

Chapter Two: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan.

Appendices

Appendix A: Code of Conduct

I. Mission statement

The mission of our team is to design a microgravity machine, test it, and compete against other schools to see who can achieve the most time under microgravity conditions while maintaining structural integrity.

II. Modes of Communication

Microsoft Teams and email. A distribution list was created on OneNote, this should be used for team email communications regarding assignments. Text or phone calls if needed for rapid communication. Email response time should always be as soon as possible.

III. Team Roles

Samuel Duval: Flight dynamics and propulsion. Deals with the flight dynamics and required propulsion aspects of the project design.

Pedro Siman: Recovery engineer. Test the recovery system of the projectile and research the best way to recover it without damaging it, allowing us to reuse the case and lower our total costs.

John Tietsworth: Materials Engineer. In charge of material selection and ensuring durability for the product.

Thomas Lenz: Test and Safety Engineer: Testing of the system and analyzing the data. Ensures all components are safe and meet the requirements.

Collin Gainer: Body design and propulsion. Primarily focused on the design of the dropped body and propulsion systems with contribution to all aspects of the project.

Other Duties: Team members will be asked to volunteer for new duties. This will be discussed at team meetings.

IV. Outside Obligations

Samuel Duval: I will work full time on MW and a couple of hours on Fridays. So, I will work until 4-5pm on MW and be busy with class on TR until Senior Design. I will not be available most Fridays. I will be able to work on Fridays and weekends as needed later in the year. Generally available after 4-5pm M-TR.

Pedro Siman: Monday: free after 5PM, Tuesday free after Senior Design, wednesday free after 5PM, Thursday free after Senior Design, Friday free after 3PM. Also willing to work on the weekends and meeting at the COE to work on Senior Design. Will miss classes Thursday Oct 13th, Tuesday Oct 17th, and Thursday Oct 20th for my sister's wedding, will be available through zoom meetings but not for any after class meetings.

John Tietsworth: Monday: 3:30PM -4:45PM. Tuesday and Thursday: 9:30AM 12:30PM and after 7:45PM. Wednesday 9:00 AM -11 AM and 3:30PM - 4:45PM. Friday before 1:00PM. Saturday 1:30PM – 4:30PM.

Thomas Lenz: Monday: 8:00AM-10:00AM, 3:30-4:45PM. Tuesday and Thursday: 9:30PM-10:45PM, 3:30-7:30PM. Wednesday: 3:30-4:45PM. Friday: 12:30-3:15PM. Available any other time. Out of town November 16th-November 20th

Collin Gainer: Tuesday and Thursday 11:00AM-3:15PM, Friday 3:00-6:15PM

V. Meetings

Weekly meeting times: During class time (TR)

As Needed meeting times: Afternoon MW after 5:00, weekends.

Notify the team at least two days before you need to miss a meeting.

VI. Team Rules

Do assigned tasks or give notification two days before missing a task.

Be professional when representing the group.

Notify the team after submitting an assignment.

VII. Dress Code

Design Reviews: Business Professional; Suit and tie.

Sponsor Meetings: Business Casual; Button down shirt/Polo with slacks/Khakis.

Team Meetings: Casual

VIII. Attendance Policy

Attend every meeting unless you have another commitment at the same time. If you know you will miss a meeting let the other team members know through either email or the team's chat. Before meetings, attendance will be taken and uploaded to team's page for archiving.

IX. Conflict Resolution

1st offence: We will reach out in over predefined methods of communications.

2nd offence: We will reach out in over predefined methods of communications **AND** cc Dr. McConomy.

3rd offence: Dr.McConomy will be contacted directly with an explanation of the issues.

Offences include missing team meetings without an excuse, missing deadlines assigned by group, failing to respond to team members in a timely manner,

For all subsequent offences, Dr. McConomy should subtract 1% from the team member's total grade.

X. Making Amendments

4 people must agree on every amendment.

Amendments should be added at the end of the Code of Conduct

Amendments should include the date they were added

XI. Statement of Understanding

By signing this document below, I affirm that I have read the rules and principles stated above and agree to the terms listed.

Print Name	Signature	Date:
Samuel Duval		09/08/2022
John Tietsworth		09/08/2022
Thomas Lenz		09/08/2022

Collin Gainer | Collin G | 09/08/2022

Pedro Siman | PSiman | 09/08/2022

XII. Personality Test Results

Samuel Duval:

INFP

Introvert(9%) iNtuitive(31%) Feeling(12%) Perceiving(25%)

- You have slight preference of Introversion over Extraversion (9%)
- You have moderate preference of Intuition over Sensing (31%)
- You have slight preference of Feeling over Thinking (12%)
- You have moderate preference of Perceiving over Judging (25%)

Collin Gainer:

INTJ

Introvert(62%) iNtuitive(25%) Thinking(47%) Judging(41%)

- You have distinct preference of Introversion over Extraversion (62%)
- You have moderate preference of Intuition over Sensing (25%)
- You have moderate preference of Thinking over Feeling (47%)
- You have moderate preference of Judging over Perceiving (41%)

John Tietsworth:

ENFJ

Extravert(19%) iNtuitive(53%) Feeling(19%) Judging(50%)

- You have slight preference of Extraversion over Introversion (19%)
- You have moderate preference of Intuition over Sensing (53%)
- You have slight preference of Feeling over Thinking (19%)
- You have moderate preference of Judging over Perceiving (50%)

Thomas E. Lenz:

ESFJ

Extravert(22%) Sensing(34%) Feeling(6%) Judging(9%)

- You have slight preference of Extraversion over Introversion (22%)
- You have moderate preference of Sensing over Intuition (34%)
- You have slight preference of Feeling over Thinking (6%)
- You have slight preference of Judging over Perceiving (9%)

Pedro Siman:

ENFJ

Extravert(1%) iNtuitive(16%) Feeling(25%) Judging(38%)

- You have marginal or no preference of Extraversion over Introversion (1%)
- You have slight preference of Intuition over Sensing (16%)
- You have moderate preference of Feeling over Thinking (25%)
- You have moderate preference of Judging over Perceiving (38%)

Appendix B: Customer Needs

Table A – Complete List of Customer Needs		
Questions:	Customer Statements:	Interpreted Needs:
What are the dimensions for the payload to be contained?	100x100x300 mm (standard 3U CubeSat	Machine must house a 3U CubeSat of dimensions 100x100x300 mm.
What phase of the project are we in (how long will we have to experience microgravity?	Phase 2.5	Machine must simulate microgravity for 3-4 seconds
Is there a standardized way of loading the payload into the machine?	Whatever you want, last year's group inserted payload through the aft end of the device.	Payload can be removed and added to the device. There are no restrictions on method of payload loading.
What is our budget for this project?	You will need to apply for funding through the Florida Space Grant	Budget is dependent on grants received.
Will we be given any components such as the accelerometer or payload housing?	Payload housing should be 3D printed by the team. Accelerometer and GoPro will be provided	Accelerometer and GoPro will be provided. Payload housing CAD files will be provided, and team must 3D print it.
Are there any size restrictions for the machine?	Must contain the 3U CubeSat payload.	The machine must be large enough to house the 3U CubeSat sized payload.
Are there any weight restrictions for the machine?	It should be light enough for the drone to lift. The drone can lift 25 lb but shoot for 21-22 lb.	Machine must be less than 22 lb.
Do we need to be concerned with attachment of the machine to the drone?	No, the machine will be attached using J hooks and banana jacks	Attachment between microgravity machine and the drone will be J hook and banana jacks.

Will there be any obstacles to avoid during freefall?	No, maybe birds	Machine does not need to control movement in the directions parallel to the earth's surface.
What will be provided to us on launch day?	Power	Some devices can be charged via generator on the competition day.
Are there any other restrictions for this machine?	No explosives	Explosives must not be used for any facet of this project.
Why haven't previous teams' designs been successful?	None of the teams' parachutes worked. Their tolerances were too high, or their parachute was installed incorrectly.	Design needs a suitable recovery mechanism to prevent damage at impact.
Are there any material restrictions?	No explosives, typically it is intended to be recreated by High School level classes, PLA, ABS stinks, Nylon stinks. Recommend 3D printing.	Use low-cost materials that are accessible.
Are we allowed to have a crumple zone in the front of the nose cone?	Sure, but the machine must be reusable for multiple trials.	The Machine must be reusable for multiple trials.

Appendix C: Functional Decomposition

Appendix D: Target Catalog

Appendix A: APA Headings (delete)

Heading 1 is Centered, Boldface, Uppercase and Lowercase Heading

Heading 2 is Flush Left, Boldface, Uppercase and Lowercase Heading

Heading 3 is indented, boldface lowercase paragraph heading ending with a period.

Heading 4 is indented, boldface, italicized, lowercase paragraph heading ending with a period.

Heading 5 is indented, italicized, lowercase paragraph heading ending with a period.

See publication manual of the American Psychological Association page 62

Appendix B Figures and Tables (delete)

The text above the cation always introduces the reference material such as a figure or table. You should never show reference material then present the discussion. You can split the discussion around the reference material, but you should always introduce the reference material in your text first then show the information. If you look at the Figure 1 below the caption has a period after the figure number and is left justified whereas the figure itself is centered.

Figure 1. Flush left, normal font settings, sentence case, and ends with a period.

In addition, table captions are placed above the table and have a return after the table number. The second line of the caption provided the description. Note, there is a difference between a return and enter. A return is accomplished with the shortcut key shift + enter. Last, unlike the caption for a figure, a table caption does not end with a period, nor is there a period after the table number.

Table 1
The Word Table and the Table Number are Normal Font and Flush Left. The Caption is Flush Left, Italicized, Uppercase and Lowercase

Level of heading	Format
1	**Centered, Boldface, Uppercase and Lowercase Heading**
2	**Flush Left, Boldface, Uppercase and Lowercase**
3	***Indented, boldface lowercase paragraph heading ending with a period***
4	***Indented, boldface, italicized, lowercase paragraph heading ending with a period.***
5	*Indented, italicized, lowercase paragraph heading ending with a period.*

References

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