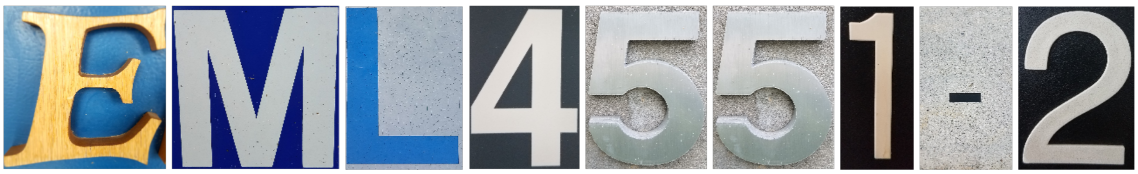
9/9/2022



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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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
CU-ICAR	Clemson University - International Center for 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.

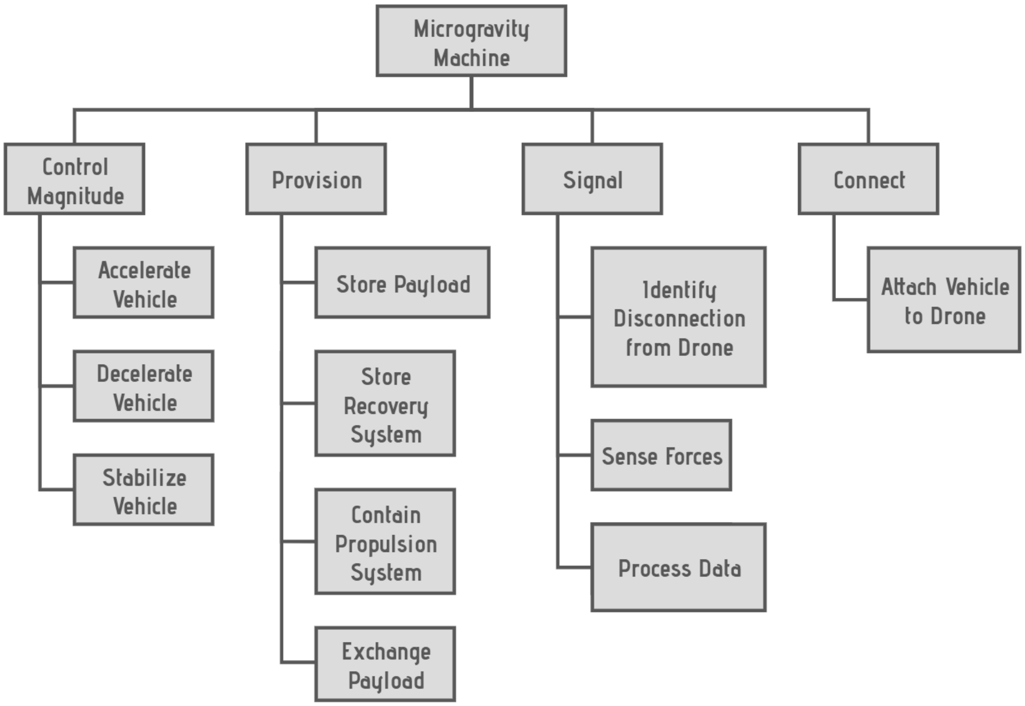

Figure 1: Functional Decomposition Hierarchy Chart

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

Summary of Targets			
Function	**Target**	**Metric**	**Description**
Accelerate Body	9.81 m/s^2	Acceleration	The device must accelerate toward the surface at 9.81 m/s^2
Decelerate Body	0 m/s	Velocity	The velocity will be decreased to less than 5 m/s before touchdown.
Stabilize Vehicle	1	Degrees of Freedom	The degrees of freedom of the device while falling will be limited to one direction.
Store Payload	100x100x300mm	Volume	3U sized payload must fit within the vehicle.
Contain Recovery System	100%	Percent of Volume stored in vehicle	Device must house a system to slow decent of device before touchdown.
Contain Propulsion System	100%	Percent of Volume stored in vehicle	Device must house a propulsion system to counteract the force of drag
Exchange Payload	1 hr.	Time	Must be able to exchange the payload within 1 hr.

Identify Disconnection from Drone	0.1 s	Time	Vehicle can recognize when the drone has dropped the vehicle within 0.10 seconds.
Achieve Weight Limit	10kg	Weight	Device must weigh less than 10 kg so the drone can lift it.
Achieve Microgravity	4s	Time	The vehicle must experience microgravity for 4 seconds.

1.4.1 Determination of Targets

From the functional decomposition, our team determined the corresponding targets and metrics. We also determined necessary targets for the design that are not contained in the functions. This section aims to explain the reasoning behind the most important targets and metrics.

Accelerate Body

The purpose of accelerating the body is to overcome the force of drag which will allow for microgravity conditions. To achieve microgravity conditions the design must accelerate at a rate of 9.81 m/s^2.

Decelerate Body

The purpose of decelerating the design is to slow the design before it impacts the ground. The design must not sustain damage and all the components inside must function properly after the test. We determined that in order to reduce the damage/ impact force, we want to slow the vehicle to less than 5 m/s at the time of impact. Doing this will allow our design to meet the recoverable requirement.

Stabilize Vehicle

The purpose of stabilizing the design limits the degrees of freedom during descent. This is necessary to minimize acceleration along the lateral and horizontal axes of the vehicle while also minimizing rotation about its longitudinal axis. This will also minimize the drag experience by the design while also allowing it to be constant. If the design isn't stabilized, the drag will vary during the descent, making it harder to measure. There is also the risk of the design flipping or reorienting itself during the descent, resulting in a failed run.

Store Payload

The purpose of including the store payload function as a target is to emphasize the need for the payload to be able to fit inside the design. If it doesn't, then the design will be invalid and not meet the requirements specified by the sponsor. The payload is 100x100x300 cm, so the design must be large enough to house this payload.

Contain Recovery & Propulsion System

The contain recovery system function is included as a target to emphasize the need for internal space inside the design. Although the only requirement from the sponsor is for the payload, accelerometer and GoPro to fit inside the design, we need to ensure there is room for the entire recovery system and propulsion system to fit inside.

Functionless targets

Although not a function, achieving the required weight limit is crucial for the design to be successful. The design must weigh less than 10 kg (22lbs) so the drone can lift the design up to the specified altitude on the day of the competition. Achieving microgravity is one of the most important targets because the entire purpose of the project is to design a way for the payload to achieve microgravity. The goal specified by the sponsor is 3-4 seconds, which is our target. The design must be repeatable in the sense that we must be able to reattach the design to the drone multiple times after multiple drops. Therefore, whatever propellant that is used in the design must have a way for us to refuel after the drop. We have one hour to reset the vehicle for another test.

In order to reduce the amount of drag, the design needs to have an aerodynamic design which is quantified by using the drag coefficient. We've estimated a drag coefficient of 0.8 for model rockets. Once we have a finalized design, we can experimentally measure this in a wind tunnel to ensure we are at or below a drag coefficient of 0.8. We've estimated the required propulsive force to be 25N. This is the required force to overcome the drag and was calculated based upon last year's design to give us a rough estimate.

1.4.2 Critical Targets

The mission critical targets are the Achieve Microgravity target and Contain Recovery System target. The first critical target is to achieve microgravity because the purpose of the project is to make testing microgravity conditions in a simpler, cheaper, and more replicable way. The whole project relies on the system achieving microgravity for at least 4 seconds to be considered a success. The second critical target we have set is that the system must successfully contain and deliver the recovery system. In a similar way to our first critical target, the system won't be of any use if this target isn't achieved. The only way we could tell if the system achieved microgravity is by containing and protecting the payload. The best way to protect the payload is by slowing down the device enough so that it is not destroyed, and it can be recovered for reuse.

1.4.3 Validation of Targets

The major systems will be tested before competition day. Each system will be tested individually. Testing will be conducted in this manner because we will not have access to a drone capable of lifting our device to 900ft to simulate the competition. Furthermore, conducting testing by dropping the fully assembled device will result in damage or destruction of the device should the recovery system fail, potentially preventing us from competing.

The provision system will be tested by assembling the device in competition ready configuration (propellant and batteries loaded, Arduino and sensors powered on, parachute loaded, 3U payload stored). Doing so will ensure that all the systems fit within the device and will be ready to go on competition day. Should one of the subsystems not fit correctly, modifications will be made until they do. Moreover, the provision subsystem that holds the payload should be designed to allow the payload to move freely within the device body. This will be tested by measuring the alignment of this subsystem which should allow the payload to move.

The deceleration system is most important to guarantee the reusability of the vehicle. The release and actuation mechanisms will be tested by commanding the systems to deploy while on the ground.

The propulsion system will be tested by first measuring the maximum output thrust of the system on the ground. The device and propulsion system can be placed into a testing setup to measure the max thrust by commanding the system to supply maximum thrust while the device is positioned onto a scale. This will allow us to measure if the system can supply enough thrust for the duration of free fall. If not, adjustments will be made. The critical target of achieve microgravity for 4 seconds can be tested in the following way. A file of sample accelerometer data will be inputted into the code and the force provided by the thrusters will be measured using a scale. The device will be placed on the scale with the thrusters pointed away from the scale. The scale will be zeroed before the thrusters are turned on. We will measure if the force from the thrusters respond properly to the simulated force from the accelerometer data to achieve a net zero force on the payload.

Disconnection from the drone will be tested by plugging the banana jacks into the Arduino and then rapidly pulling them out to test the timing response of the control system.

1.4.4 Derivation of Targets/Metrics

The targets and metrics were determined by analyzing the functional decomposition and customer needs. The team translated the results of these processes into quantifiable variables which will be used as benchmarks for designing the vehicle. For each of the functions, the team considered what measurement would be best for verifying the function and did research to determine the value to shoot for. Even though the function decelerate body describes an acceleration, the actual value of acceleration is not very important. The most important result of the deceleration is that it lands at a slow velocity, so velocity was chosen as a measurement.

Some of the customer needs were given in quantifiable forms such as the weight restraint of 10 kg and the required stored payload volume of 100x100x300 mm. Therefore, these targets were given directly by the sponsor and are highly important.

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

Name	Signature	Date
Collin Gainer		09/08/2022
Pedro Siman		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

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	

Appendix D: Target Catalog

Function	Target	Metric	Description
Accelerate Body	9.81 m/s^2	Acceleration	The device must accelerate toward the surface at 9.81 m/s^2
Decelerate Body	0 m/s	Velocity	The velocity will be decreased to less than 5 m/s before touchdown.
Stabilize Vehicle	1	Degrees of Freedom	The degrees of freedom of the device while falling will be limited to one direction.
Store Payload	100x100x300mm	Volume	3U sized payload must fit within the vehicle.
Contain Recovery System	100%	Percent of Volume stored in vehicle	Device must house a system to slow decent of device before touchdown.
Contain Propulsion System	100%	Percent of Volume stored in vehicle	Device must house a propulsion system to counteract the force of drag
Exchange Payload	1 hr.	Time	Must be able to exchange the payload within 1 hr.

Identify Disconnection from Drone	0.1 s	Time	Vehicle can recognize when the drone has dropped the vehicle within 0.10 seconds.

Functionless targets			
Goal	**Target**	**Metric**	**Description**
Testing Frequency	2	Successful tests	On the day of competition, the vehicle will survive 2 tests
Propellant Leakage	0 mL	Volume	The propulsion system will leak 0 mL of fluid.
Achieve Weight Limit	10 kg	Weight	Device must weigh less than 10 kg so the drone can lift it.
Achieve Microgravity	4 s	Time	The vehicle must experience microgravity for 4 seconds.
Refuel propellant	1 hr.	Time	Should be able to recharge batteries, or replenish propellants
Power	9 V	Voltage	Voltage supplied to the Arduino should be 9 V
Aerodynamic Design	0.8	Coefficient of Drag	We want a low coefficient of drag so minimize the drag and reduce the propulsive force required
Propulsive Force	25N	Force	Propulsive Force necessary to overcome drag and achieve net zero acceleration

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

There are no sources in the current document.