NASA Student Launch 2017

Critical Design Review Presentation

UNIVERSITY OF SOUTH FLORIDA

SOCIETY OF AERONAUTICS AND ROCKETRY

January 18th, 2017

Final Launch Vehicle Dimensions

Property	Quantity
Diameter (in)	6
Length (in)	145
Projected unloaded weight (lb)	40.06
Projected loaded weight (lb)	49.81

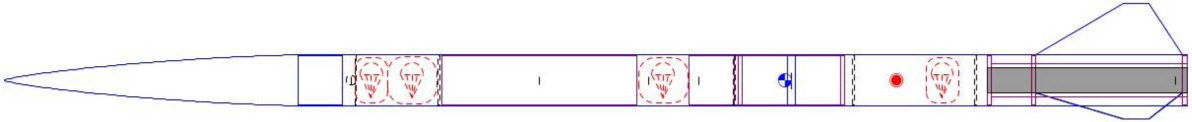


Figure 1: Overview drawing of launch vehicle assembly

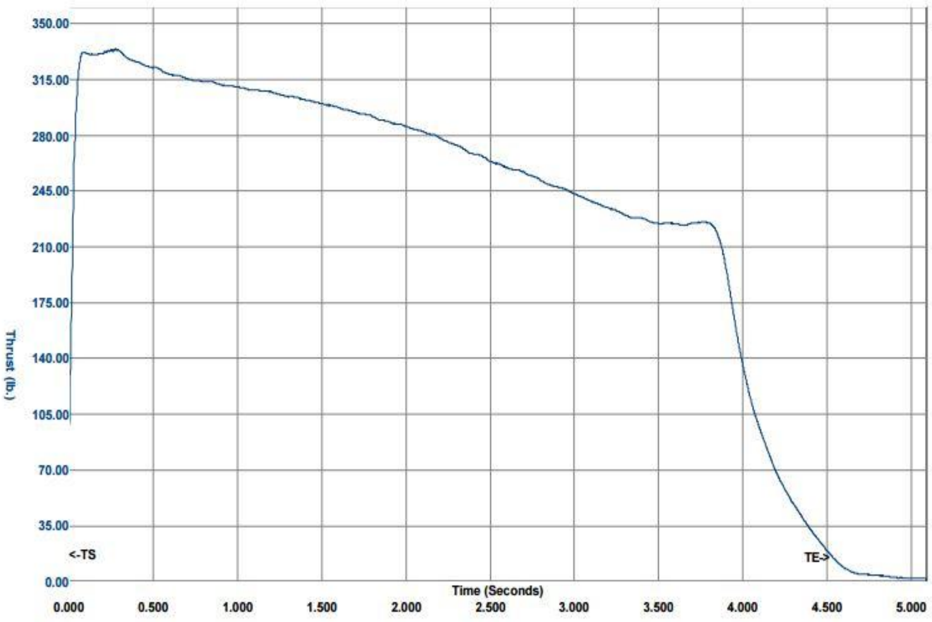
Key Design Features

- Cesaroni L1115 motor
- Four sections
  - Three foot nose cone, five foot body tube, altimeter bay, four foot drogue section
- Recovery
  - One parachute for nose cone, one parachute and one drogue for booster and main body together, one parachute for landing module
- Piston System
  - A piston system is used just below the main parachute to prevent gases from going around the parachutes and improve the probability of successful ejection.
- Landing Module
  - Spring-loaded bi-prop system will steer the landing module under the guidance of a GPS, and a landing gear system consisting of self-closing spring hinges, extension springs and wheels will absorb the force of landing
- Vision System
  - A Raspberry Pi 3b computer module with a VideoCore IV 300Mhz GPU, paired with one of two possible cameras will identify the targets

Final Motor Selection

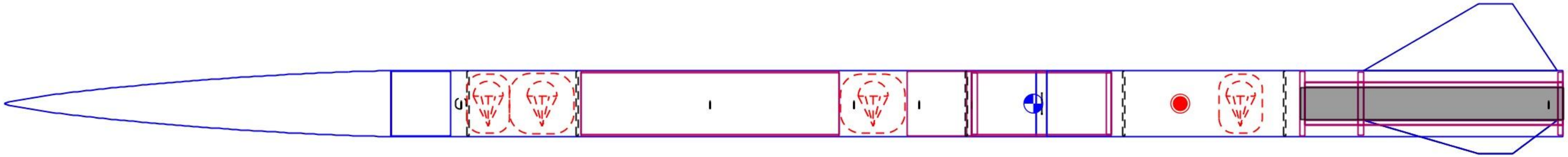
L1115

- Total Impulse:5015 Ns
- Burn Time: 4.5 s
- Diameter 75 mm
- Length: 621 mm
- Propellant Weight: 2394 g



USF SOCIETY OF AERONAUTICS AND ROCKETRY
THE SKY IS NOT THE LIMIT.

Rocket Flight Stability



Section	Value
Center of Gravity	95.72 in
Center of Pressure	109 in
Stability	2.24 calipers

Thrust-to-Weight Ratio and Rail Exit Velocity

Section	Value
Thrust-to-weight Ratio	5.04
Rail Exit Velocity	56.9 ft/s

Mass Statement and Mass Margin

Section	**Weight (lbs)**
Nose Cone	2.14
Landing module	9.38
Main Airframe	15.00
Booster	12.69

Recovery Overview

Parachute Name	Parachute Size
Nose Cone parachute	SkyAngle Drogue
Landing Module parachute	SkyAngle Large
Main Body parachute	SkyAngle Large
Drogue parachute	SkyAngle Drogue

The Drogue parachute: Attached to shockcord that is then attached to a U-Bolt.
The Nose Cone parachute: Directly attached to the nosecone.
The Landing Module parachutes: Directly attached to U-bolt on the landing module.

Kinetic Energy Analysis (at key phases of the mission, especially landing)

- Parachutes were chosen to have appropriate descent velocity and kinetic energy on landing

Section	Descent Velocity with L Cert-3 (ft/s)	Kinetic Energy with L Cert-3 (ft-lbf)
Nosecone	16.09	12.06
Upper Section with Lander	16.09	66.33
Altimeter Bay	16.09	24.12
Booster Section	16.09	58.29

Drift Analysis

- Time to apogee - 19.7 seconds

Wind Speed (MPH)	Drift (ft)
0	0
5	575.41
10	1,150.81
15	1,726.22
20	2301.63

Testing Plan

Type of Test	Reason
Ground Test	To ensure that there was enough black powder to successfully eject the components out of the main airframe.
Sub Scale Launch	To ensure that the rocket could successfully reach the wanted point of apogee and also successfully eject the landing module and land it safely.
Future Test: Full Scale Launch	To ensure that the rocket could reach an apogee of 5,280 feet and successfully eject the landing module and allow it to determine the designated tarp while landing upright, safely.

Subscale Test Flight Review

Predicted Flight Data	
Max Altitude: 2,180 ft	Max Velocity: 356 ft/sec
Velocity off the Rod: 43 ft/sec	

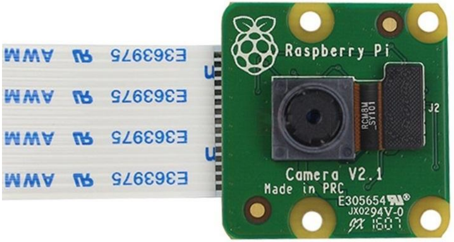
Actual Flight Summary			
Max Altitude: 1,899 ft	Max Velocity: 321 ft/sec	Ascent time: 11.15 sec	Descent Time: 46.75 sec
Drogue Rate: 71 ft/sec		Main Rate: 30 ft/sec	

Recovery System Performance

Component	Status	Solution
Piston	Contained gasses and was able to successfully eject components in the main airframe.	N/A
Main Parachute	Successfully ejected and opened fully.	N/A
Nose Cone with Parachute	Successfully ejected but the parachute got intertwined with the parachute of the landing module	Nomex protector in between the nose cone parachute and the landing module parachute
Landing Module with Parachute	Successfully ejected but the parachute got intertwined with the parachute of the nose cone	Nomex protector in between the nose cone parachute and the landing module parachute

Final Payload Design Overview

- Implements Three Separate Systems
  - Steering: bi-prop design
  - Landing Gear: cylindrical spring loaded legs
  - Electronics Bay: Raspberry Pi 3b based Vision System and Arduino based microcontroller Steering Control System



Steering System

- Utilizes a bi-prop design
    - Compact and light design
    - Generates lateral thrust and counterspin
    - Spring loaded system with a magnetic catch

Figure X: Steering System Isolated

Landing Gear

- Design Criteria
  - Compact
  - Simple
  - Strong
- Objectives
  - Land vertically
  - Prevent tipping
  - Handle high stresses associated with landing
- Final Design
  - Spring loaded cylindrical legs
  - Wheels
  - Extension Springs

Figure 5: Landing Gear System Bottom View

Final Landing Module Dimensions

Dimension	Value
Length (inches)	24.3
Diameter (inches)	Outside: 6.00 Inside: 5.75
Weight (lbs)	8.40

Payload Integration

- Landing Module Deployment
  - Prior to deployment, the landing module sits inside the rocket, which maintains dimensional constraints on the spring loaded systems. Upon deployment, the landing module will be forced out of the rocket due to explosive charges, allowing the motor arms and landing gear to deploy.

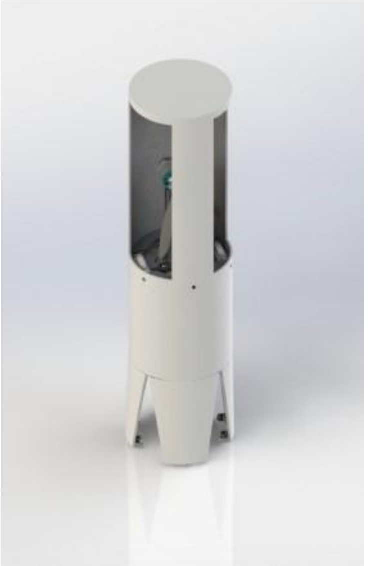


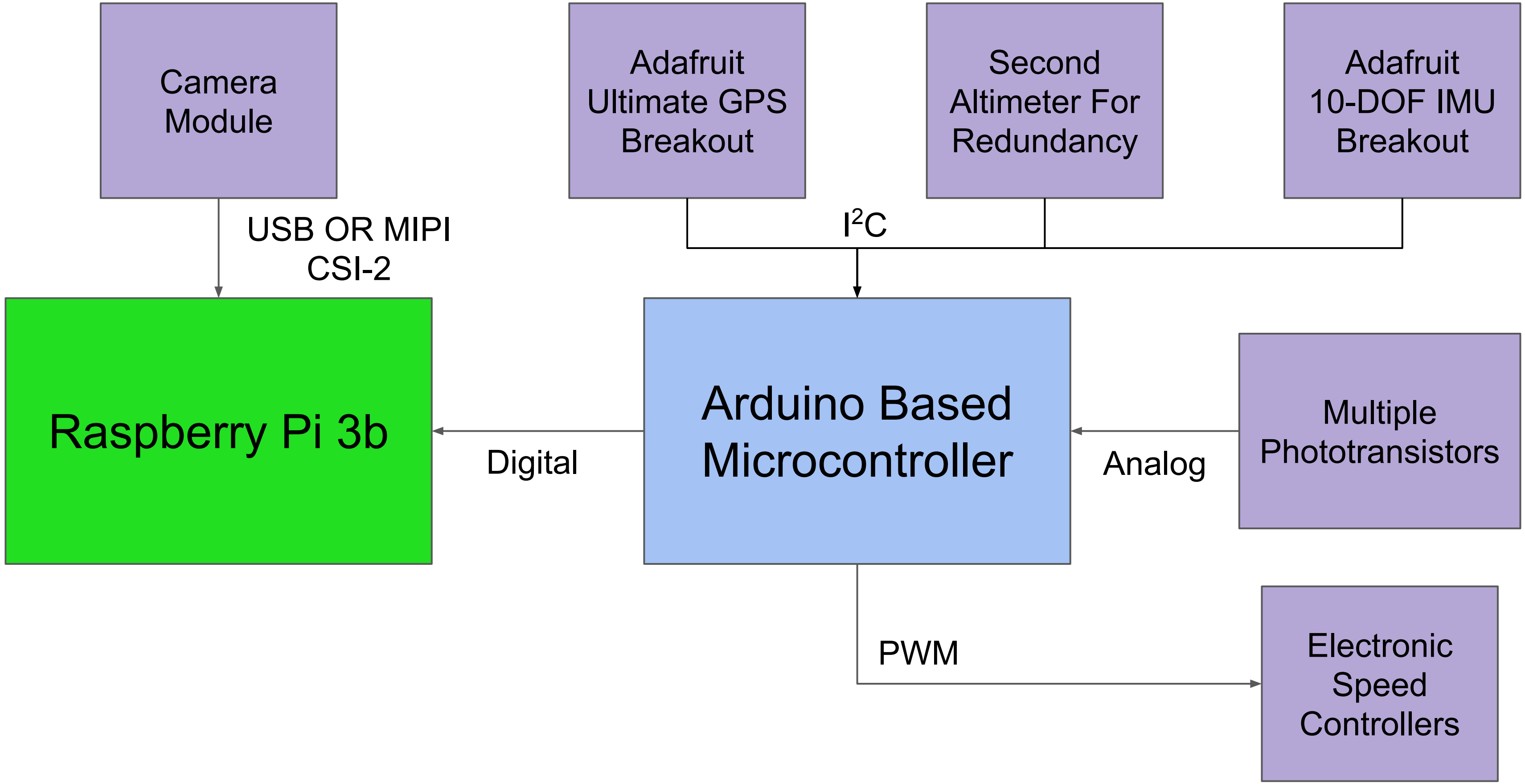
Figure X: Pre-deployment

Figure X: Post-deployment

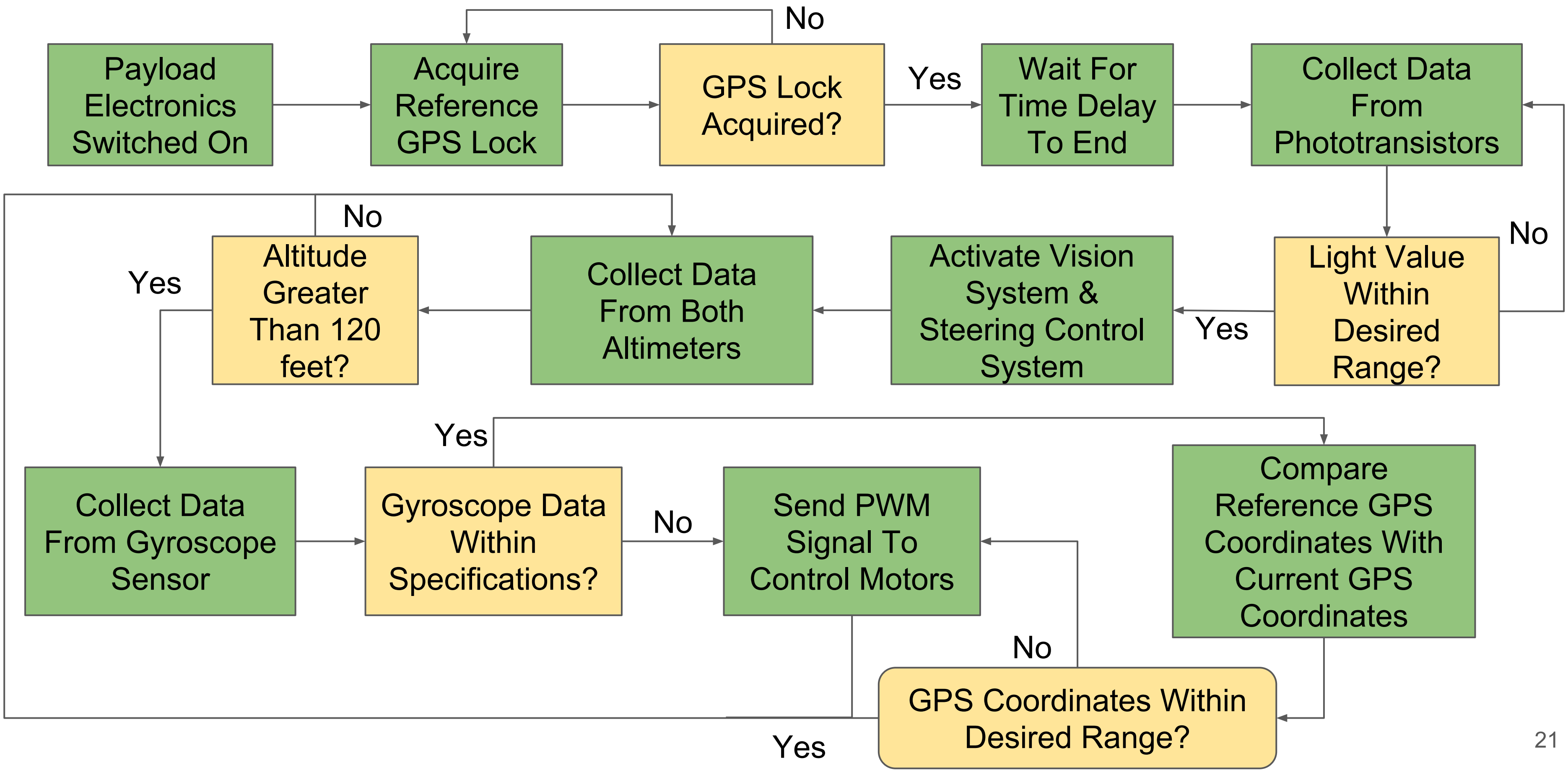
Payload Interfaces

- Loading of the Landing Module
  - The landing module is tucked inside the second stage directly under the nose cone. Dimensional constraints inhibit the motors and landing gear from deploying until the module is removed from the rocket itself.
- Interaction During Flight
  - Deployment of the landing module does not occur until an altitude of 1000 feet on descent. At this point, a detonation will force it out of the rocket at which point all systems will deploy to meet flight objectives. Prior to this, the rocket will simply be inactive in its respective stage.

Payload Electronics Wiring Block Diagram



Steering Control System Flowchart



Status of Requirements Verification

Requirement	Method of Meeting Requirement	Verification
Data from the camera system shall be analyzed in real time by a custom designed onboard software package that shall identify and differentiate between the three targets.	An onboard computer *(Raspberry Pi 3b)* housed in the electronics bay of the landing module will process the captured images in real time. The computer will run a custom python program utilizing the OpenCV computer vision library to differentiate between the three targets.	For verification, review data captured and analyzed by system once recovered after launch.
The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour.	Power consumption calculations will be assessed and an appropriately rated battery will be selected to ensure the electronics system remains in nominal condition. Onboard sensors will keep the main processing computer in a low power mode until specific task are requested.	Computer System with onboard real time clock will log elapsed time of events from the moment it's turned on until the end of the flight.

Status of Requirements Verification

Requirement	Method of Meeting Requirement	Verification
Section housing the cameras shall land upright and provide proof of a successful controlled landing.	An upright landing of the landing module will be made possible by using a landing gear system that will absorb the impact force of the overall system on touchdown and land on any terrain.	Angle of rocket upon landing will be captured and stored within onboard software for later verification.
The launch vehicle shall be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.	The launch vehicle will be designed to separate into 4 separate sections. Each section with its own recovery parachute to ensure the rocket body stays intact. The motor can be replaced within 1-2 hours after the casing has cooled. The landing module can be reset quickly by changing out or charging the battery, and relocking the motor arms in their upright positions.	Proper launch procedures and proper handling of the launch vehicles and its components will be followed. All vehicle preparations and launches will be overseen by a certified TRA member.

Safety

- Highest Risks
  - Environmental
    - Post RAC Level: 2E
    - Risk: Improper disposal of batteries or chemicals causes harmful substances to permeating the ground or water.
    - Mitigation: Batteries and other chemicals will be disposed of properly in accordance with the MSDS sheets.
  - Facility/Equipment
    - Post RAC Level: 1E
    - Risk: Motor fails to ignite initially resulting in rocket failing to launch or firing at an unexpected time.
    - Mitigation: Checklists and appropriate supervision will be used when assembling. NAR safety code will be followed and personnel will wait a minimum of 60 seconds before approaching rocket.

Safety

- Highest Risks
  - Personnel Safety
    - Post RAC Level: 1E
    - Risk: Unleveled launch platform causing rocket trajectory to be unpredictable.
    - Mitigation: Inspect launch pad prior to launch to confirm level. Confirm that all personnel are at a distance allowed by the Minimum Distance Table as established by NAR.
  - Project Plan
    - Post RAC Level: 2E
    - Risk: Parts fail or break resulting in project delay or damage to launch vehicle.
    - Mitigation: Maintain suitable replacement parts on hand. Use checklist when assembling launch vehicle. Ensure technical lead supervision in handling and installation of parts.

Project Plan - Current Budget

Budget Item	Projected Cost	Amount Spent	Remaining Budget
Rocket	$3,000	$263.90	$2,736.10
Payload	$2,000	$1,074.29	$925.71
Travel	$2,857.08	N/A	N/A

Project Plan - Timeline

Main tasks completed between PDR and CDR presentations:

- Prototyping
- Testing of the prototyped system
- Completion of subscale fabrication
- Subscale launch
- Finalization of the full-scale design
- Second subscale launch
- Finalization of CAD models
- Initialization of landing system and full-scale fabrication

Project Plan - Timeline

Tasks to complete before the Final Review Report:

- Full-scale fabrication
- Landing system fabrication
- Launch of the completed full-scale and landing system
- Review of the launch data and consider any changes to motor selection and landing system design
- Adjustments to the landing system if needed
- Participation in education engagement and community outreach activity
- Second full-scale launch with revised landing system
- Review of the launch data

Questions?