Educating NDSU AIAA Students Aerospace Engineering Practices through CanSat Competitions

NDSU Flying Bison

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Intro to Cansat

- **Competition in Texas**
- **Aerospace System Design and Test**
- **Electromechanical Assemblies**

Mission Summary

- **Design a payload & container for geometry specifications:**
  - Size: 125 mm x 310 mm, Weight: 600 g
- **Container:** Deployed from rocket, descent via parachute
- **Payload:** Deployed from container when stable above 300 m
  - Descent of 10 m/s or less via auto-gyro method
  - Telemetry data will be recorded & sent at 1 Hz
  - Video will be recorded without payload spin
- **Goal:** Safe landing with egg intact
- **Selectable Objective:** Three axis-accelerometer to measure stability & angle of descent.

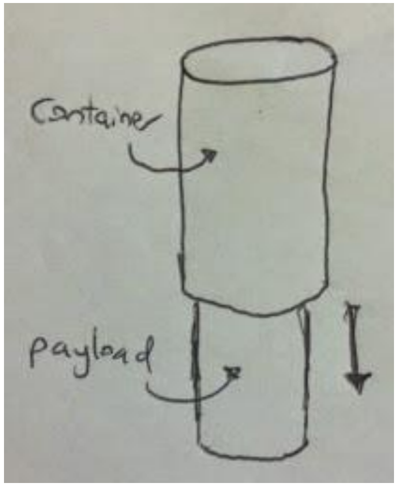
System Requirement Summary

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-1	Total mass of the CanSat shall be 600 grams +/- 10 grams without the egg.	BMR	High	MR-1		X	X	
SR-2	The payload shall be completely contained in the container. No part of the payload may extend beyond the container.	BMR	High	MR-3			X	X
SR-3	Container shall fit in the envelope of 125 mm x 310 mm including the container passive descent control system.	BMR	High	MR-4			X	
SR-4	The container shall use a passive descent control system.	BMR	High	DCR-1	X		X	X
SR-5	The container shall not have any sharp edges to cause it to get stuck in the rocket fairing section.	BMR	High	DCR-2 MR-5		X		
SR-6	The container shall be a florescent color, pink or orange.	BMR	High	MR-6		X		
SR-7	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	BMR	High	DCR-3				X
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
SR-50	Use accelerometer to measure stability & angle of descent.	SO	Medium	SRR-5, 6	X		X	X

System Level CanSat Configuration Trade & Selection

- **Preliminary system-level concepts considered:**
  - General Shape & Integration Selection

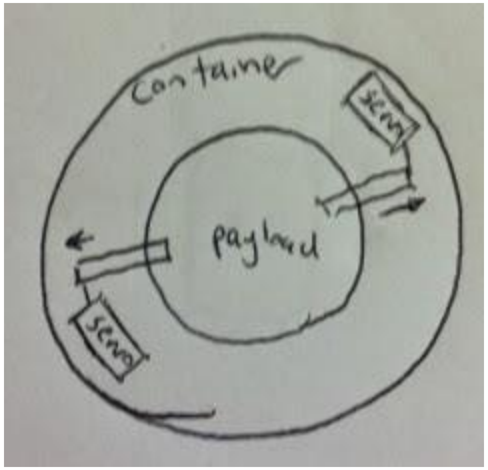
Shape & Integration	Pros	Cons
Cylinder in Cylinder	Easy to Manufacture	Payload may get Stuck
Cylinder in Break-Away Cylinder	Payload Easily Released	More Parts, May Break

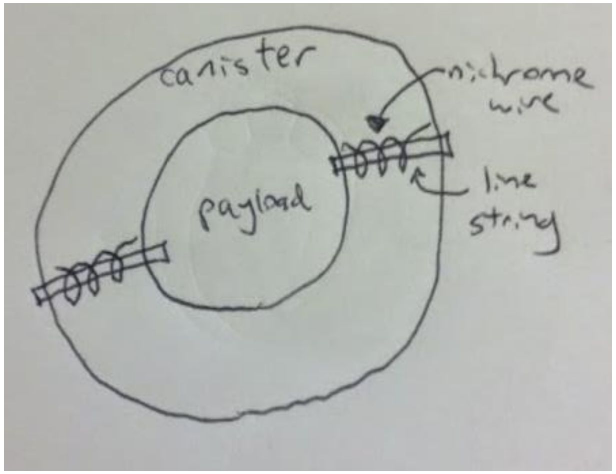


> Selection: Cylinder in Cylinder, Easy to Manufacture & Sturdy

– Detachment Methods

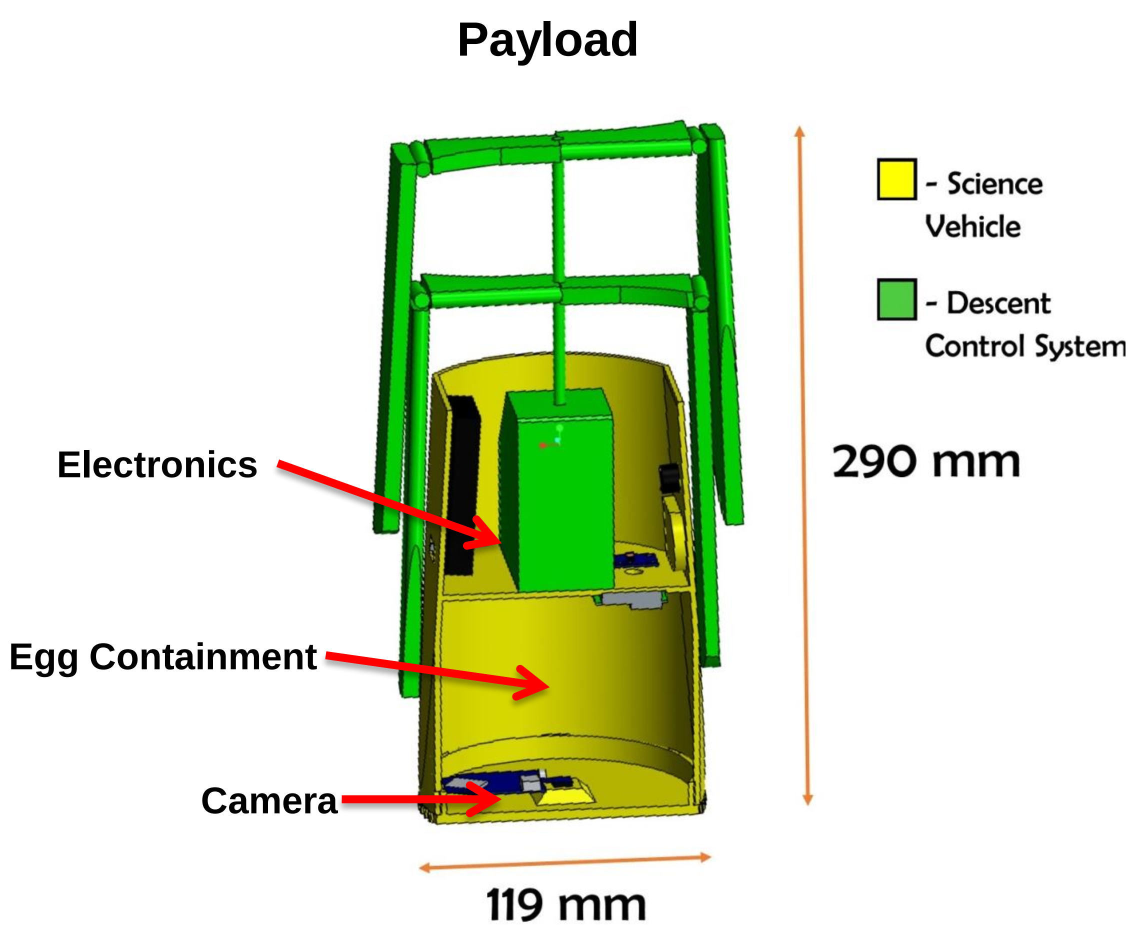
Method	Pros	Cons
Servo Ring	One mounting point	Difficult to Manufacture
Servo Rods	Easy to implement in our design	Two mounting points
Nichrome Wire Cutter	Most Secure	Difficult to Time

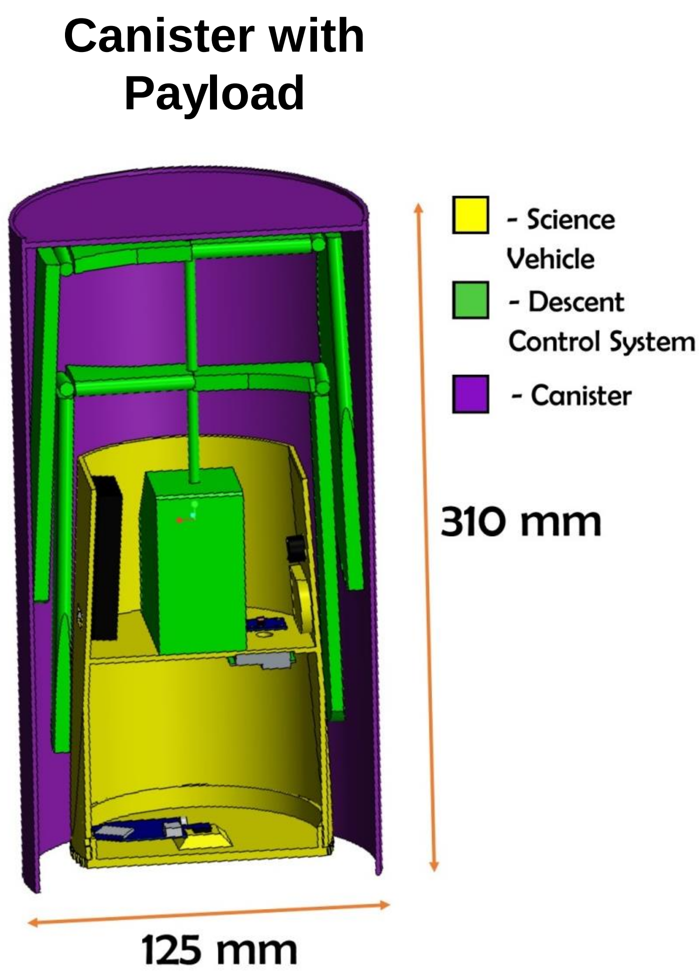




>Selection: Servo Rods, Easiest to Implement

Physical Layout





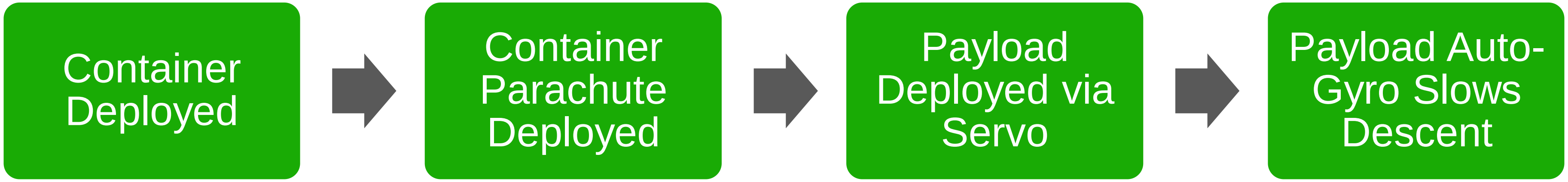
Electronics Selections

Company	ID	Price	Weight (g)	Size (cm)	Resolution (bits)	Sample Rate (Hz)	Voltage (V)	Connection Type
Sparkfun	MMA7361	$11.95	50	1.27 x 2.286	13	-	2.2-3.6	Analog
Sparkfun	ADXL345	$27.96	0.02	0.334 x 0.534	13	6.25-400	2-3.6	I2C
Sparkfun	MMA8452Q	$9.95	4	1.778 x 1.778	12	1.56-800	1.95-3.6	I2C

- **Final Selection: Sparkfun MMA8452Q**
  - Connection Type
  - Cost
  - Voltage Needed

Descent Control Overview

- **Properly sized parachutes for container**
- **Correct material selection with weight and CG calculation**
- **Servo control for release of payload from container**
- **Payload spin reduced for video feed**
- **Ability to withstand shock**



Descent Rate Estimates

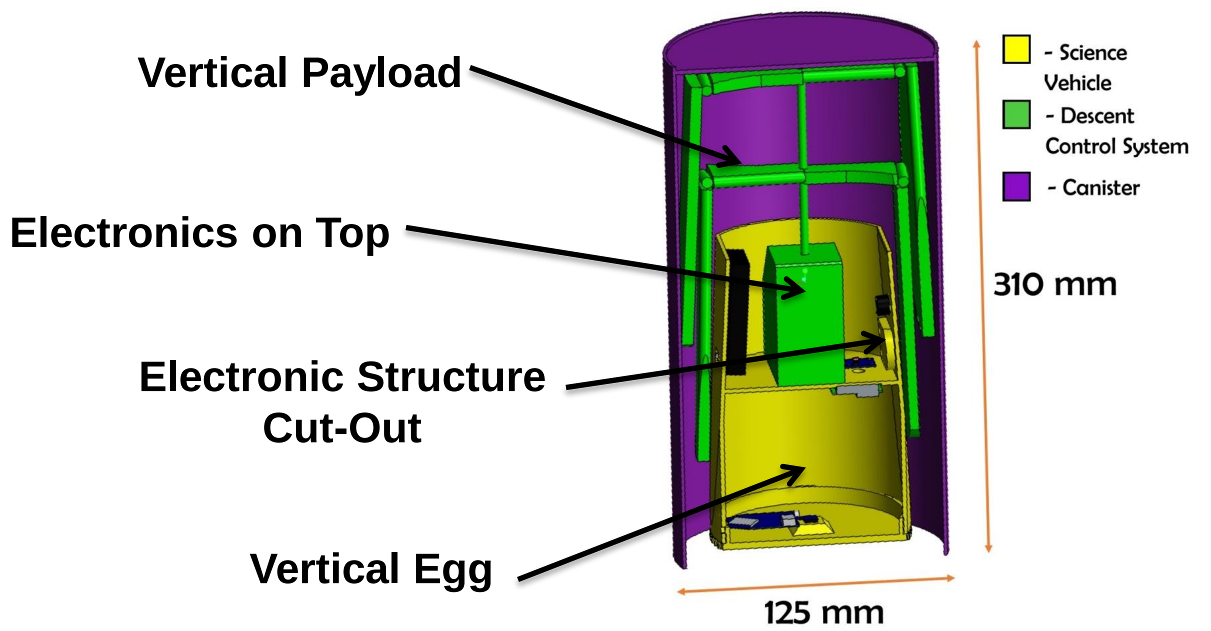
- **Equation relating surface area of parachute for container & payload to descent velocity:**

$$V=\text{sqrt}(2W/(\rho*Cd*S))$$

  - S = surface area, S=π*r^2
  - W = weight
  - P = air density,
    - At 30 C is 1.1644 kg/m^3
  - Cd = coefficient of drag
    - 0.3 for parachute
    - 1.15 for payload

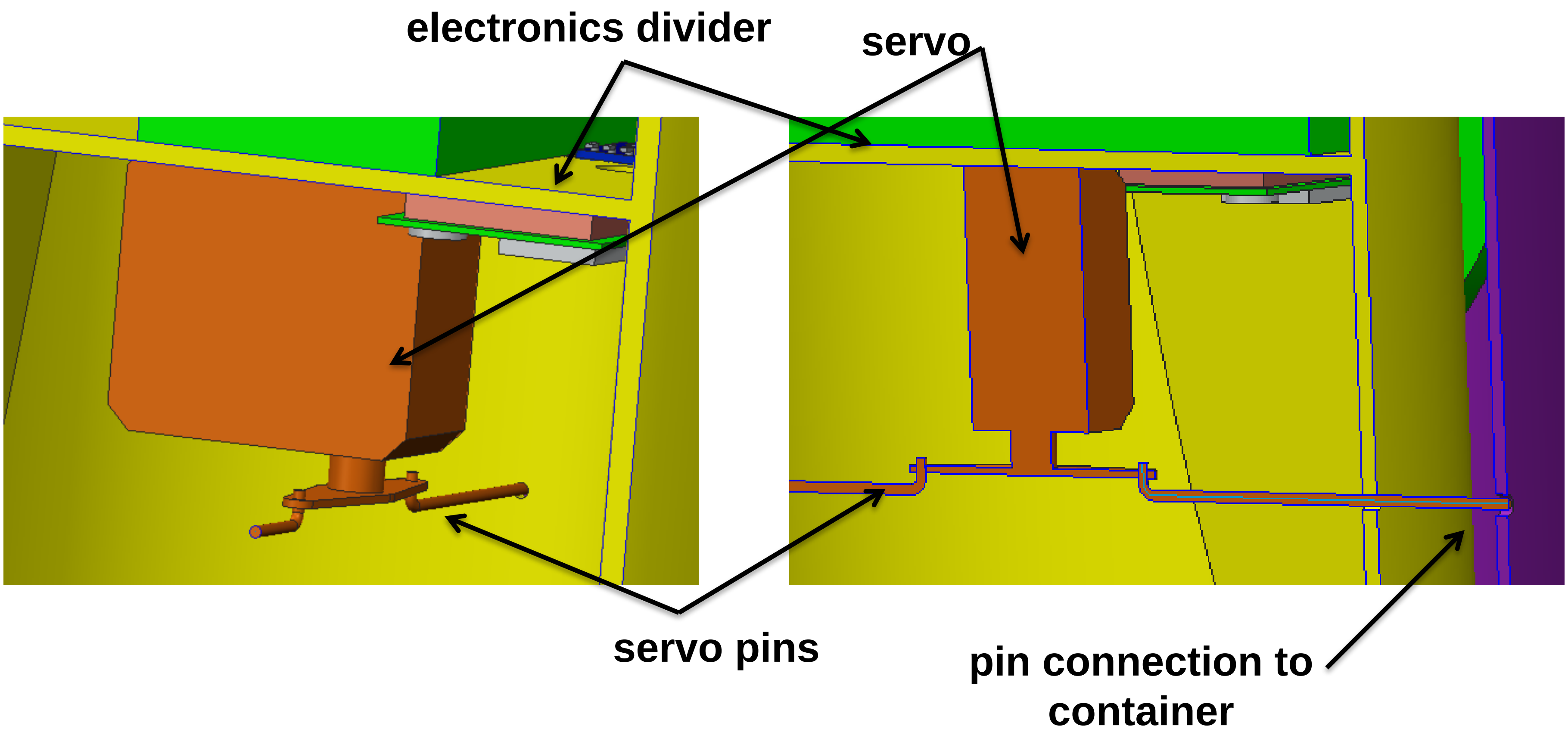
Mechanical Layout of Components Trade & Selection

Mechanical Layout	Pros	Cons
Electronics Housed in Top	Closer to Propeller Assembly	Wires Must be Ran to Camera
Electronic Cut-Outs in Payload Structure	More Secure	Wires Must be Cut Precisely
Egg Vertical	Payload can be Less Wide	Less Room for Electronics
Payload Vertical	Starts Right-Side Up	Propellers More Apt to get Caught



Container - Payload Interface

- **Servo Connections**



Mass Budget

Container		
Component	Mass (g)	Source
Frame	110	Estimate
Parachute	18	Dealer Specs

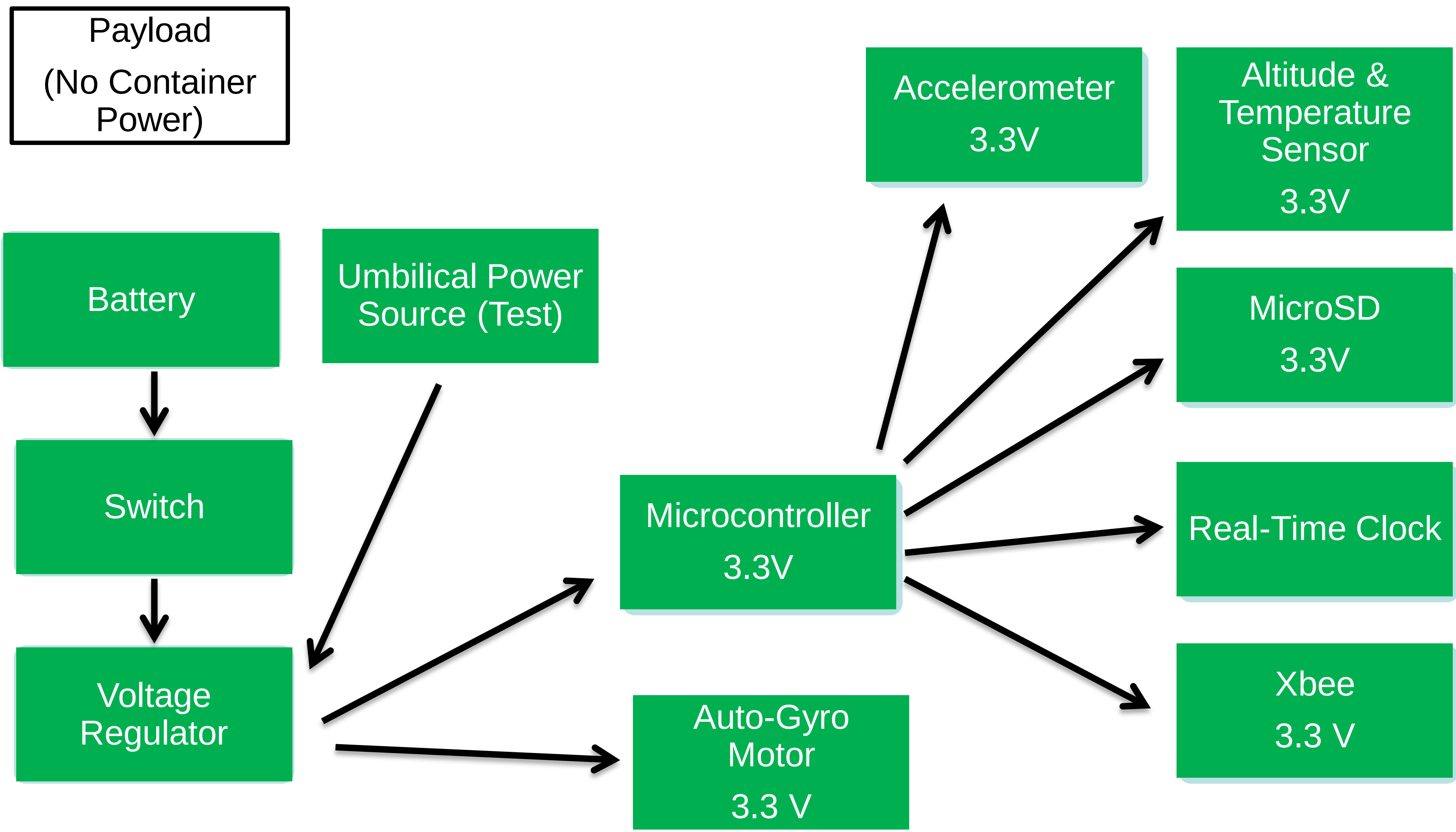
Payload		
Component	Mass (g)	Source
Frame	280	Estimate
Arduino Pro	8	Dealer Specs
Altitude / Pressure / Temperature Sensor	1	Dealer Specs
Accelerometer	4	Specs
XBEE Module	5	Dealer Specs
Separation Servo	9.5	Specs
XBEE Explorer	6.2	Dealer Specs
Auto-Gyro Assembly	50	Estimate
Egg Protection	30	Estimate
MIrcoSD Board	3.4	Dealer Specs
Battery	23	Specs
Camera	40	Estimate
Wiring & Connectors	10	Estimate

Container Total: 128 grams
Payload Total: 470.1 grams

Total: 598.1 grams

- Corrections can be made at launch be reducing frame material & wiring connection components

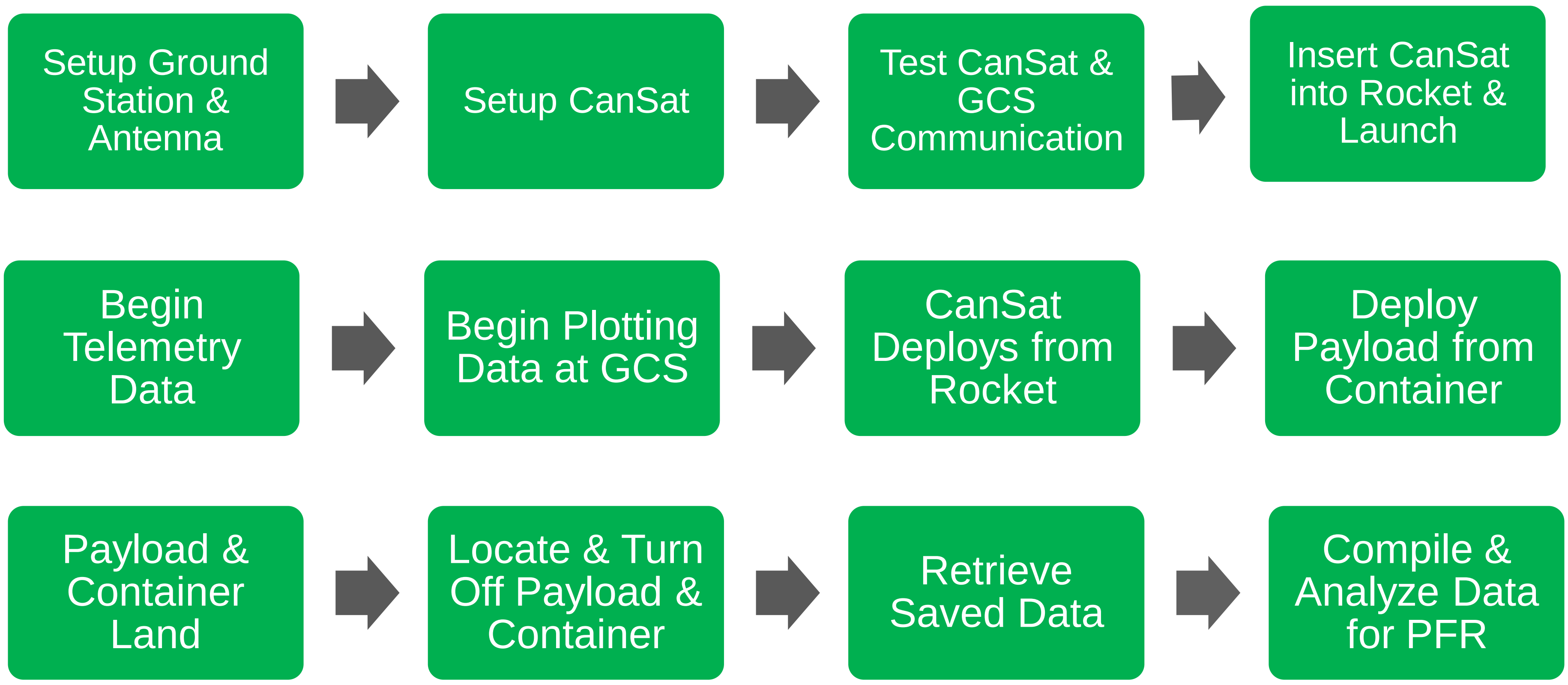
Electrical Block Diagram



FSW Overview

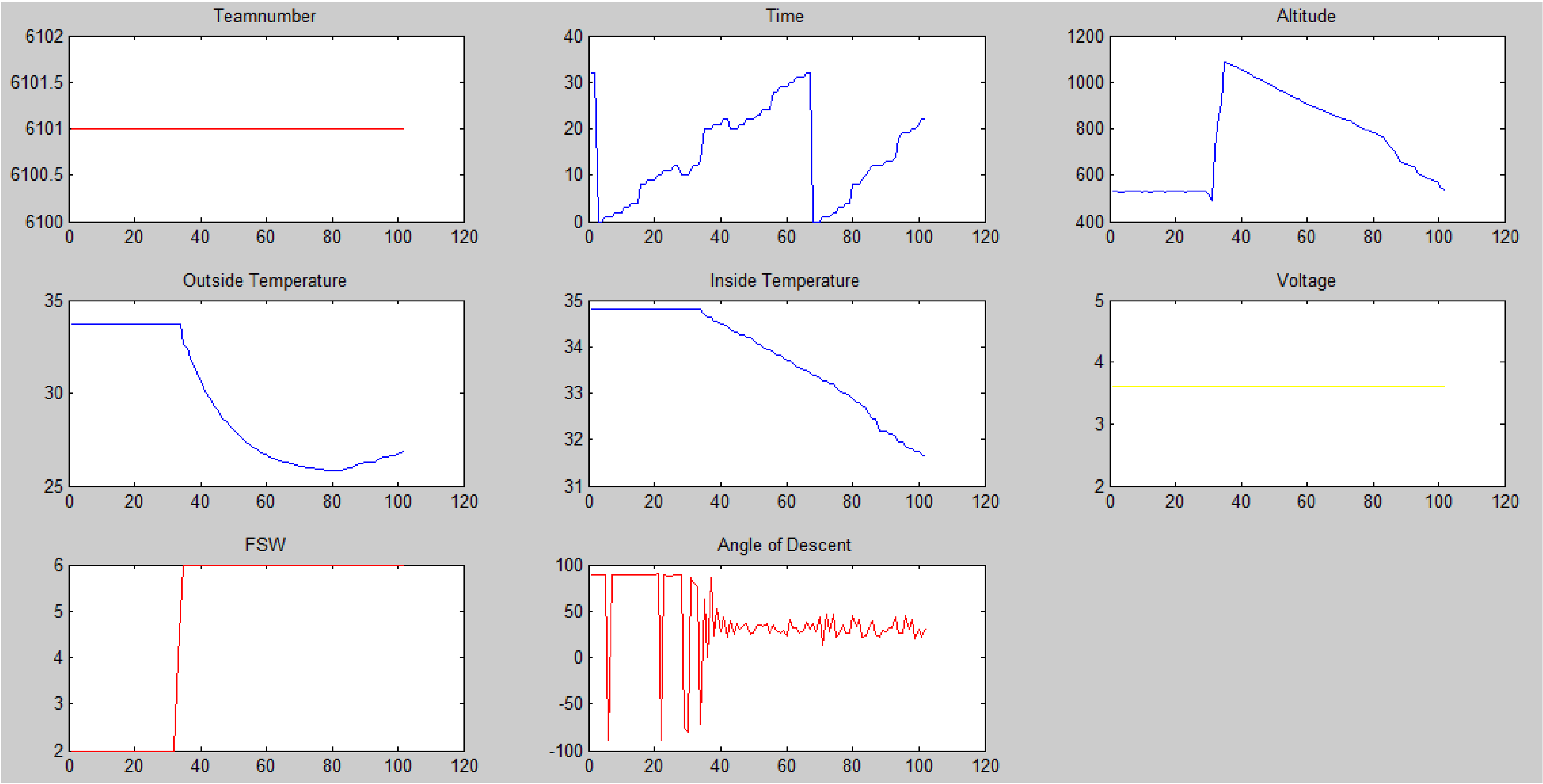
- **Basic FSW architecture**
- **Programming Language**
  - Arduino → C++
- **Development environments**
  - Arduino IDE
- **Brief summary FSW tasks**
  - Read sensors
  - Compile data
  - Send data & save data to memory
  - Deploy payload
  - Aware when container & payload have landed

Overview of Mission Sequence of Events



- **Team members will all work together on all tasks**

Payload Telemetry & Selectable Objective



Failure Analysis

Payload Separation from Canister

- **Initial Servo Failure from super glue**
  - Required Larger Servo
- **Foam interference**
  - Did not allow full range of motion
- **Caused descent Rate requirements Failure**
  - Canister parachute size determined for canister weight not combined weight

Failure Analysis

Camera Recording Objective

- **Battery Failed to fully Charge**
  - Voltage Dropped during Travel
    - 3.8V to 0V
- **Camera Detachment upon Impact**
  - Payload did not separate from canister
    - Decent rate was faster than engineered

How Does Cansat Help Students?

- **Educates with Hands On Experience in**
  - Product Development
  - Programming
  - CAD Design
  - System Integration
  - System Testing
  - Subsystem Communications
  - Failure Analysis

QUESTIONS???

Questions?