

Ballistic Parachute Recovery System for Unmanned Aerial Vehicles

Auburn REU 2016

Andy Morgan

Research Advisor: Dr. Richard Chapman



AUBURN UNIVERSITY

About Andy

- Youngstown State University
- Computer Digital Electrical Engineering
- Computer Science
- I have always been interested in the “how”
- Hobbies:
 - Sports
 - Outdoors



The Project

- Develop a Ballistic Parachute Recovery System
- Maintain safety when UAVs lose control, fly beyond given airspace, or are low on “fuel”



What is the FAA?

- Federal Aviation Administration
- Maintain safety
- Maintains “powers to regulate all aspects of American civil aviation”
- Traditionally focused on regulations to manned aircraft
 - Shift to new UAVs



FAA Regulations

- New FAA regulations have recently been added concerning Unmanned Systems
- Maintain safety
- Concerns for flight
 - Beyond Line-of-Sight view (LoS)
 - Low on “fuel”
 - Free Fall



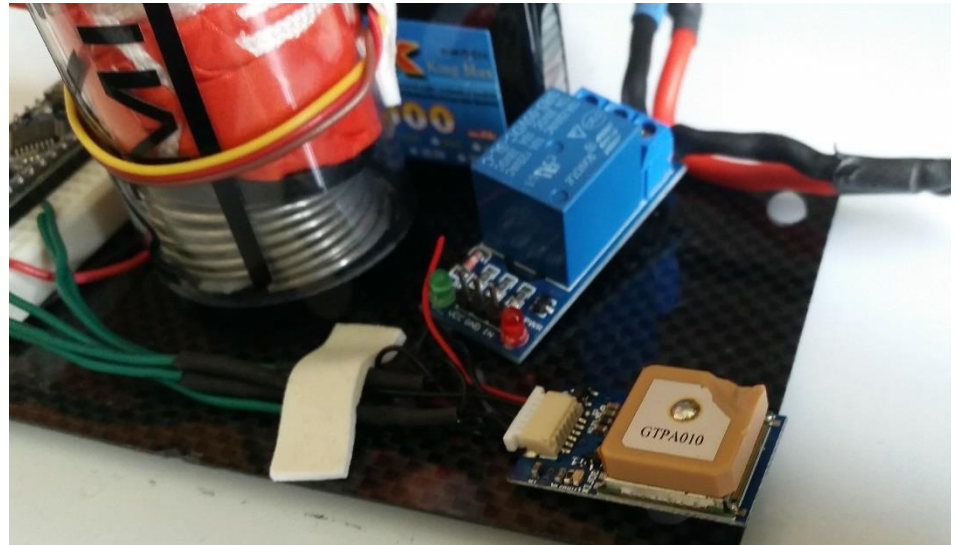
FAA Classifications

- Public Operation
 - Utilized by government own/run organization
- Civil Operation
 - Intended for commercial/business use
- Hobby Operation
 - Intended for hobby/pleasure



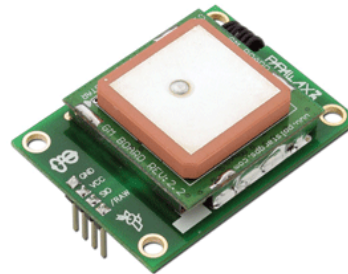
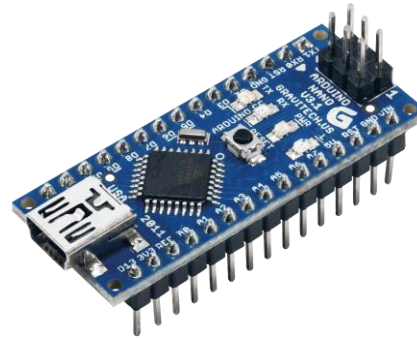
Recovery System

- Scope of Design:
 - **Monitors**
 - Battery Voltage
 - GPS Coordinates
 - Acceleration
 - **Reaction**
 - Deploy Parachute – Servo
 - Cut main power

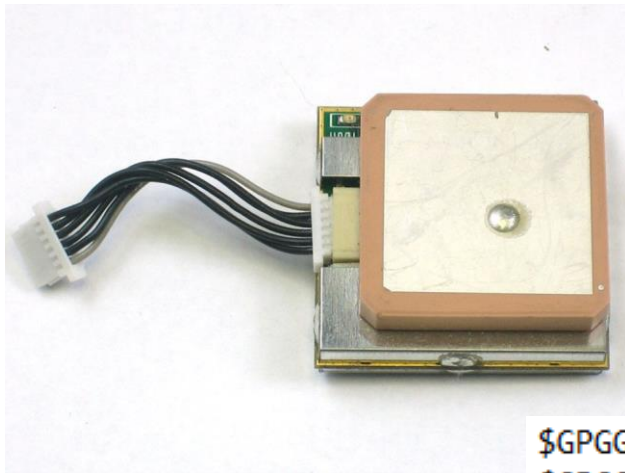


Components

- Arduino Nano
- Voltage Sensor
- Relay
- GPS Module
- Accelerometer
- Servo - Parachute
- 7.4V LiPo Battery



Components - GPS



- Adafruit EM-406A
- Serial Communication
- National Marine Electronics Association (NMEA) Protocol
- Example:

```
$GPGGA,140006.000,3236.3487,N,08529.2584,W,2,8,1.14,201.7,M,-29.4,M  
$GPGGA,140007.000,3236.3487,N,08529.2584,W,2,7,2.07,201.7,M,-29.4,M  
$GPGGA,140009.000,3236.3487,N,08529.2584,W,2,7,2.07,201.7,M,-29.4,M
```



How Does GPS Work?



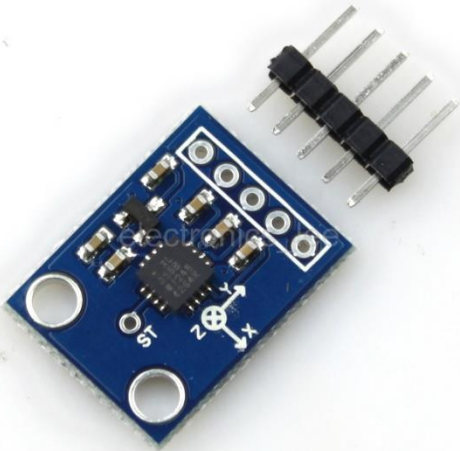
- ~30 Satellite in World
- Transmit Signals
 - Time
 - Location
- Trilateration



Components - GPS



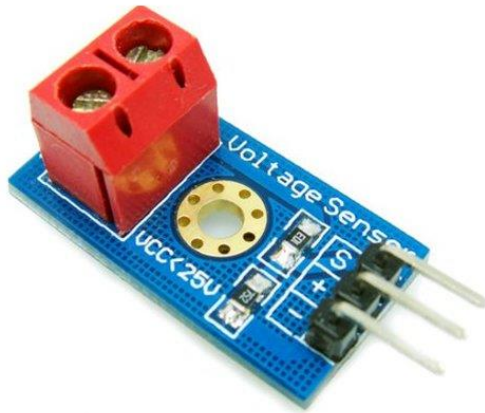
Components - Accelerometer



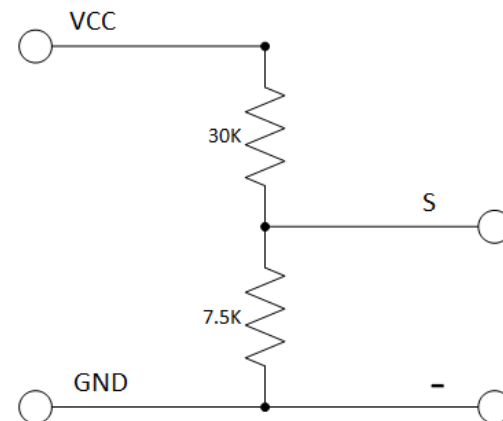
- Produino ADXL335
- X,Y, Z Accerleration (3-axis)
- Analog Values
- Determine if an object is in free fall



Components - Voltage Sensor



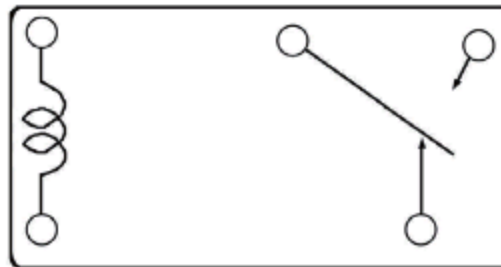
- DC 25V Voltage Sensor Module
- Analog Read Values for Battery Voltage
- Allows input of batteries up to 25V



Components - Relay



- 5V Relay Module
- Turns Power to Aircraft ON and Off
- Two Modes
 - Normally Closed
 - Normally Open



Components - Servo

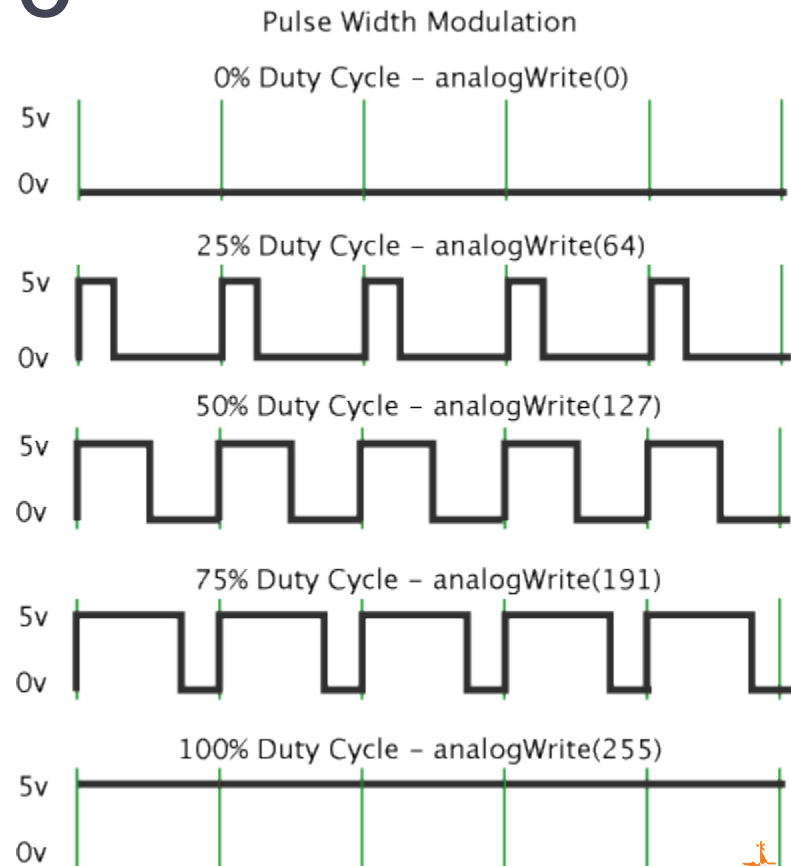


- Standard Servo Motor
 - No Potentiometer for continuous rotation
- Provides 180° of rotation
- Operates door on parachute

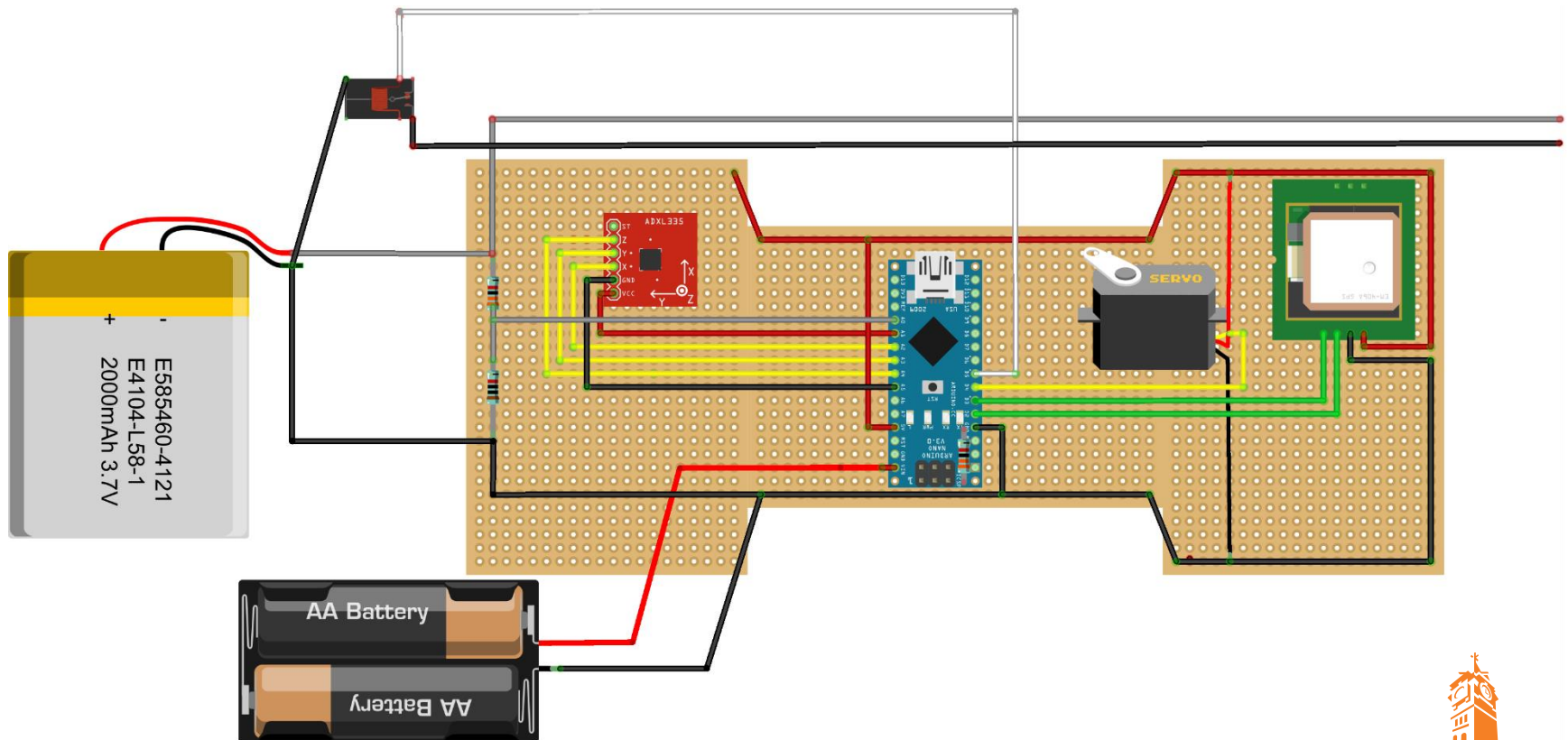


Components -Servo

- Controlled by Pulse with Modulation (PWM)
- Servo Class built into Arduino
- Most Atmel Chips only support on certain pins

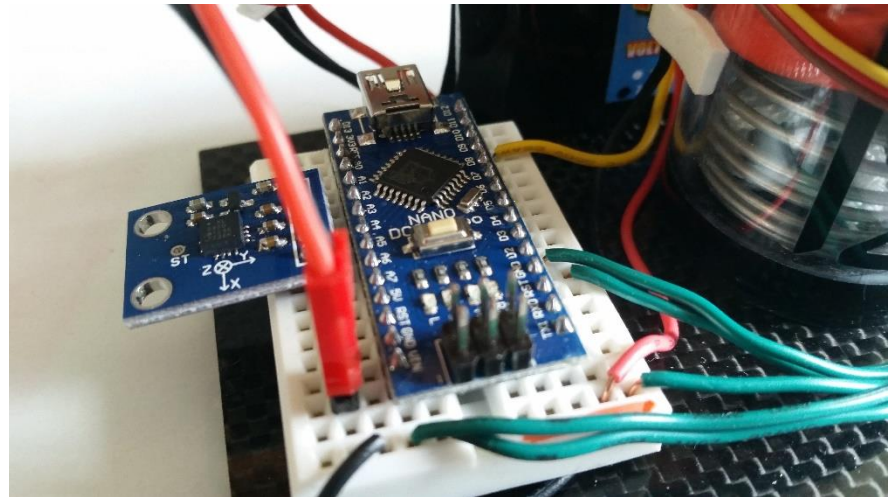


Complete Hardware Design



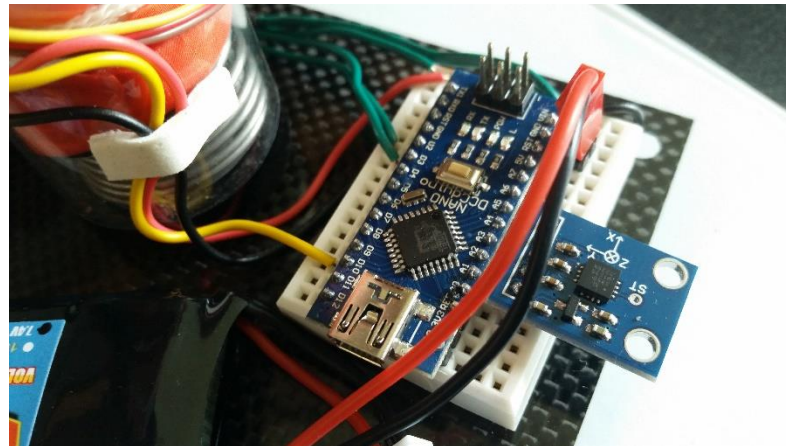
Arduino Software Design

- Arduino will act as the brain to the system
- Nano
 - 2K SRAM
 - 32K Flash
 - 16 Mhz Clock
 - 14 Digital I/O Pins
 - 8 Analog Pins
- Arduino IDE
 - C++

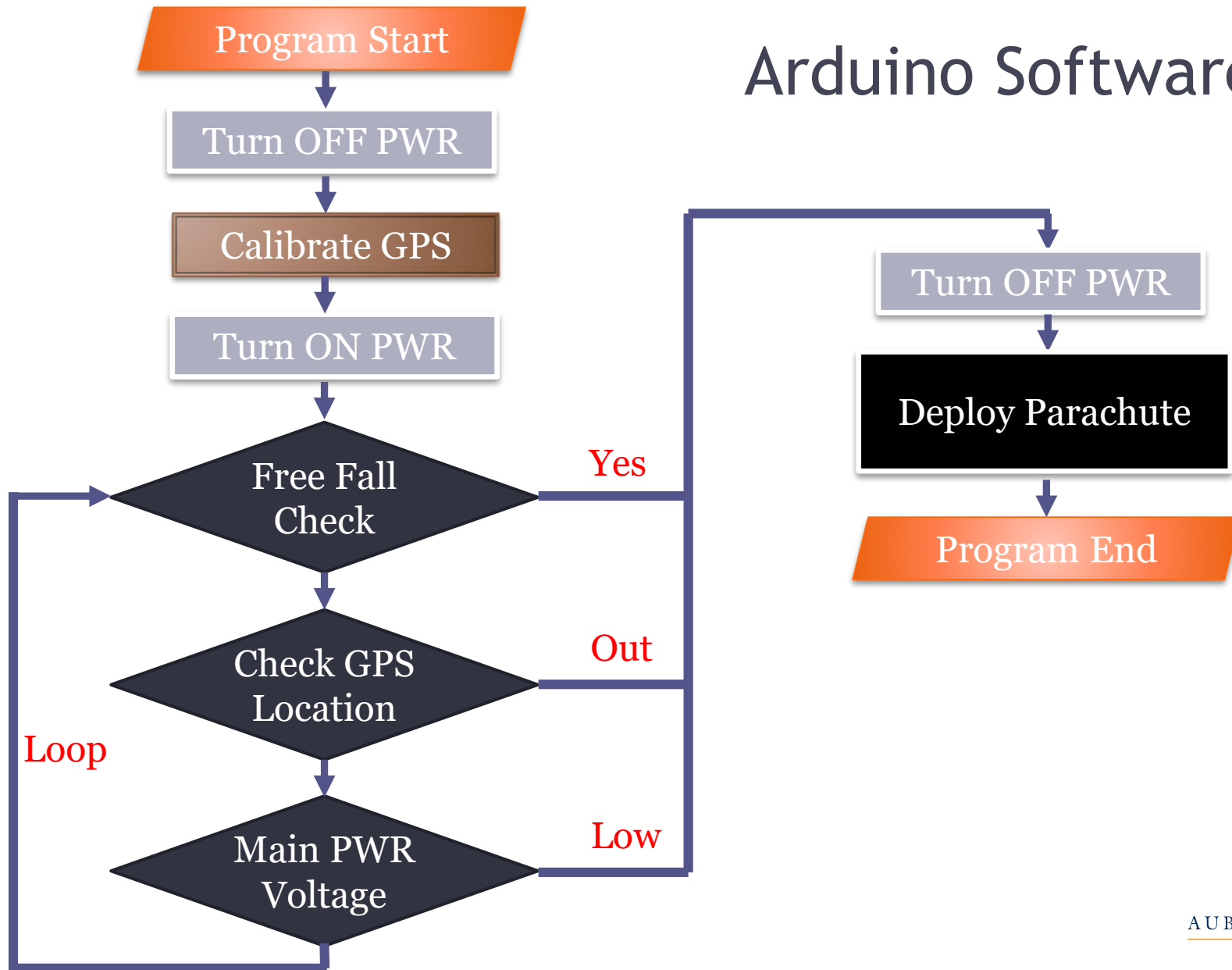


Arduino Software Design

- Powered independently of UAV
 - Ensures proper functionality with low “fuel”
- Monitor all components of the recovery system
- Deploys parachute if a set of conditions are met



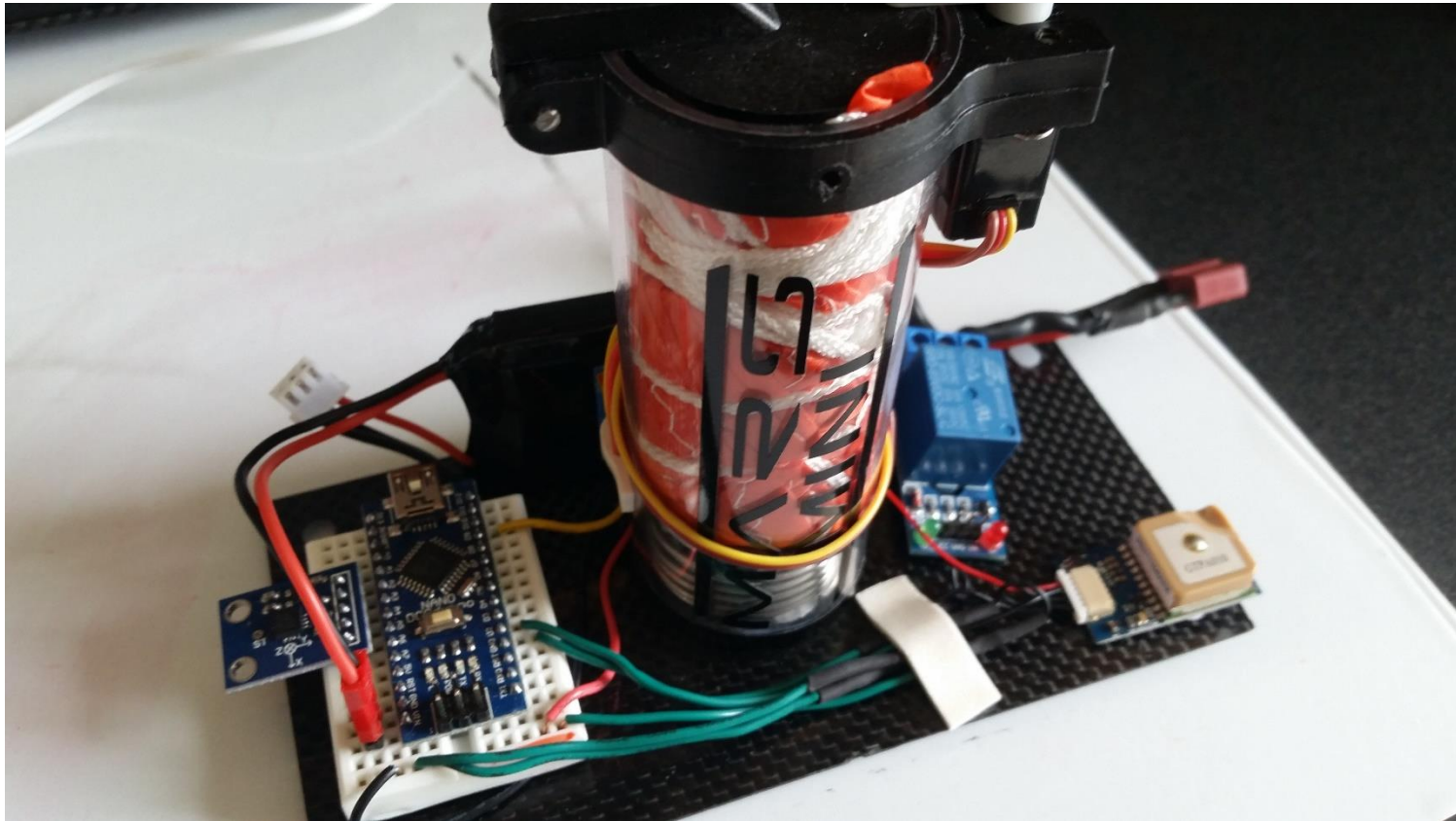
Arduino Software Flow



Arduino Software Design

```
106
107 void loop()
108 {
109
110     getGPSData();
111     getAccelValues();
112
113
114     //Determine if parachute needs to be deployed
115     if((xval<FREE_FALL_HIGH_THRESH &&xval >FREE_FALL_LOW_THRESH) && (yval<FREE_FALL_HIGH_THRESH &&yval >FREE_FALL_LOW
116         Serial.println("We are in freefall...");
117         deployParachute();
118 }
119 if((NLatitude > StartingNLatitude+LatitudeThreshold || NLatitude < StartingNLatitude-LatitudeThreshold) || (WLongi
120     Serial.println("We are outside our airspace...");
121     deployParachute();
122 }
123
124 if( getBatteryVoltage() < MOTOR_CUTOFF_VOLTAGE ){
125     Serial.println("Battery low...");
126     deployParachute();
127 }
128
129
130 }
131
```

Independent System

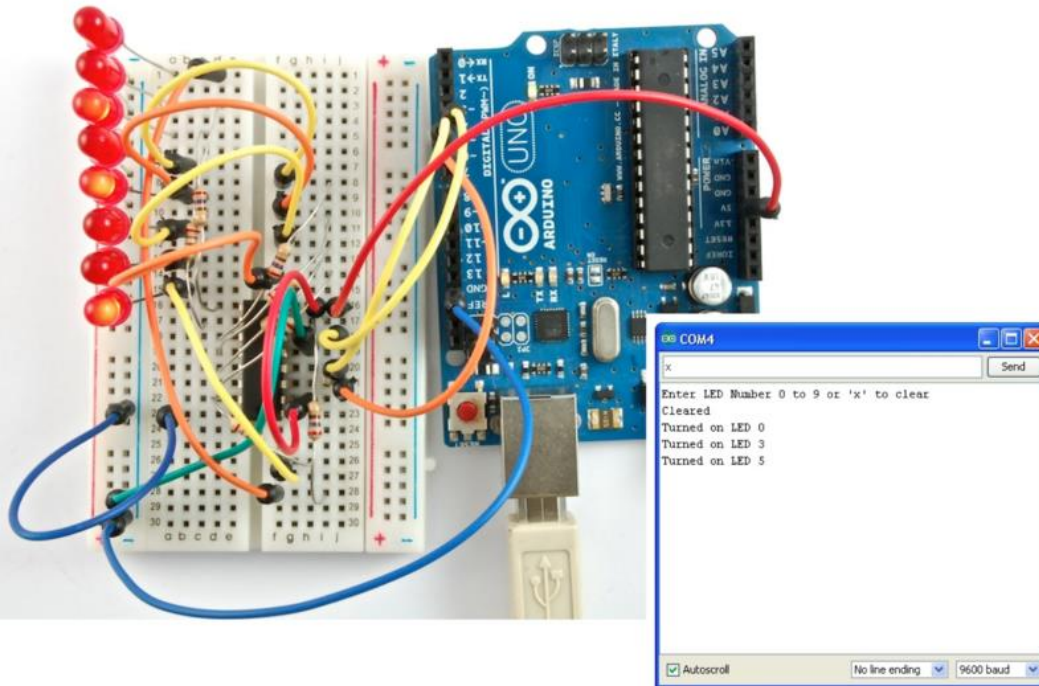


Future Work

- 3D Print Capsule
- Attach to UAV like structure
 - Determine opening distance
 - Determine ground speed
- Write manual for operation instructions



Final Thoughts



- Try Arduino!
 - Growing fast
 - Useful tool for Software to Hardware implementation



Questions

