AUTONOMOUS BLIMP

Proof of concept for renewable air transportation.

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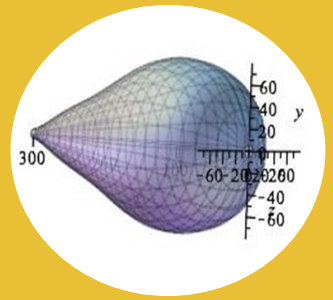
DESIGN AND PURPOSE

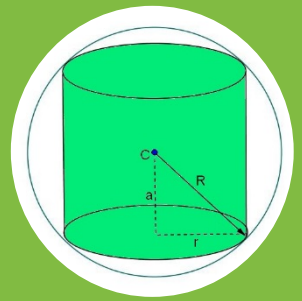
- To promote discussion of Hydrogen as a lifting gas
- To build a rudimentary aircraft that could be used as a platform for more advanced projects
- To gain multidisciplinary engineering experience and team skills
- Explore Non-traditional Applications of Autonomous Aircraft

RESEARCH

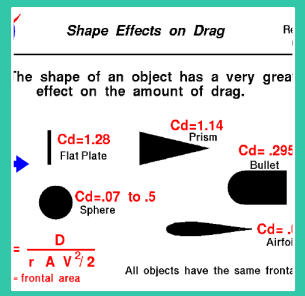
Looked to the past to see what had worked before



Modeled a few concepts with the help of SRJC faculty

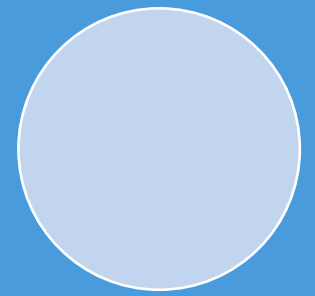


Calculated buoyancy figures and determined experimental lift capability



Determined Drag from the drag equation

$$\vec{D} = \frac{1}{2}\rho C A \vec{V}^2$$



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WHY HYDROGEN?

Cost

- Helium cost is \$70 m^3, Hydrogen would cost \$0.65 m^3 (generated from electrolysis is 3.25KWh at \$.20 KWH).

Renewable

- Helium has the lowest phase change temperature or any element, and is essential to the operation of low temperature physics experiments and research
- Helium is required for these applications: Superconducting magnets in MRI machines and science experiments like CERN , deep water diving, and as an inert welding gas.
- Helium plays an essential role in scientific studies and is a non-renewable resource.

Flammability

- The Hindenburg disaster has painted Hydrogen in a very negative light
- Our blimp contains 89 moles of Hydrogen, with a chemical potential energy of
- $2H_2 + O_2 \rightarrow 2H_20\ \Delta H = -285\frac{KJ}{mol} + \Delta H_{vap}H_2O = \sim\frac{120MJ}{1KG} * .090kg = \frac{10.8MJ}{Blimp}$
- Compared to the Sunday new York times composed of the organic polymer cellulose:
- $\frac{1900g_{NY\ Times}}{\frac{162.1g}{mol}} = 11.1mol * -2805\frac{kj}{mol} + \Delta H_{vap}H_2O = \frac{30.1MJ}{Newspaper}$
- To more fairly compare the relative energies, consider a half a garbage can full of newspaper being lit on fire, and that would approximate the chemical energy present in the blimp, additionally hydrogen's extremely low density would direct the burning mass of gas straight up, and away from anything below it.
- Another comparison of chemical energies 1 blimp = 280 mL of gasoline.
- A full 12 gallon tank of gas in a car contains 162 times this volume of chemical energy safely because it is engineered to do so. I do not think it is unreasonable to assume engineering can significantly increase the safety of hydrogen in much the same way, if properly motivated.

BASIC DESIGN GOALS & PARAMETERS

Payload Capacity

- Est. 1.3kg after mass of airframe
- This is large enough for many small uses (scientific sensors, cartography, reconnaissance, wireless network repeaters, etc.).

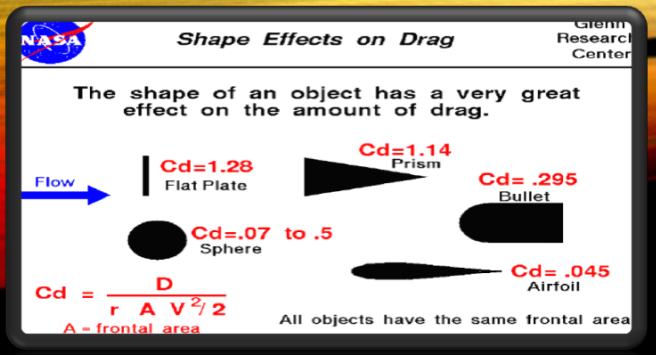
Endurance

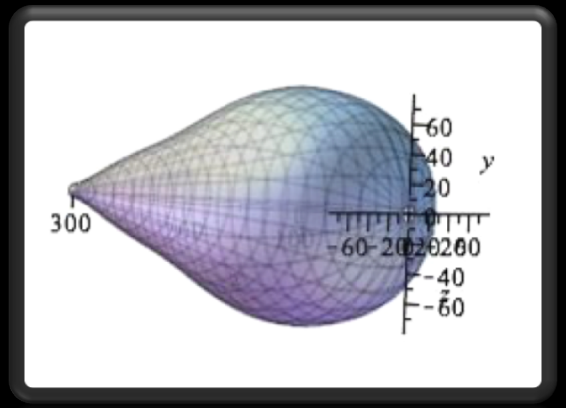
- Based on simple modeling range of 5-10km on a single charge is achievable.
- Adding solar Panels will extend this significantly (3-5X)

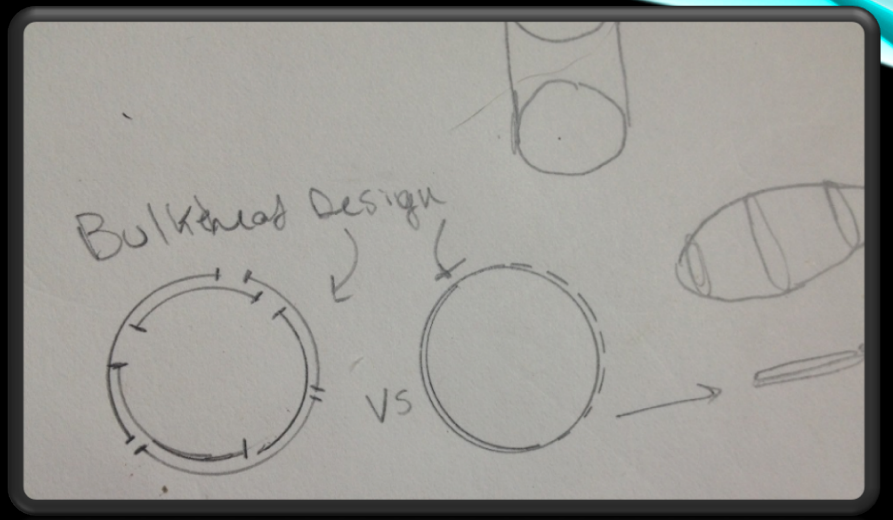
Power

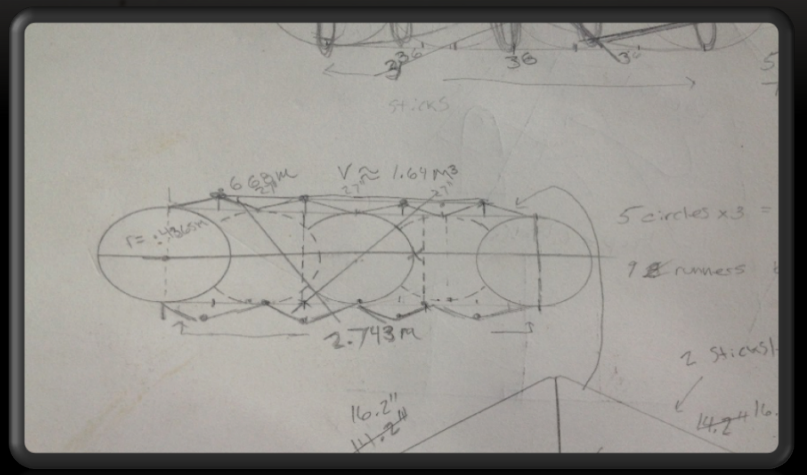
- The Prototype we designed should be capable of traveling into a 7 m/s headwind for 1 hour
- With no headwind the aircraft has a theoretical maximum velocity of 7 m/s
- (~15 mph)

DESIGN









Initial Brainstorm

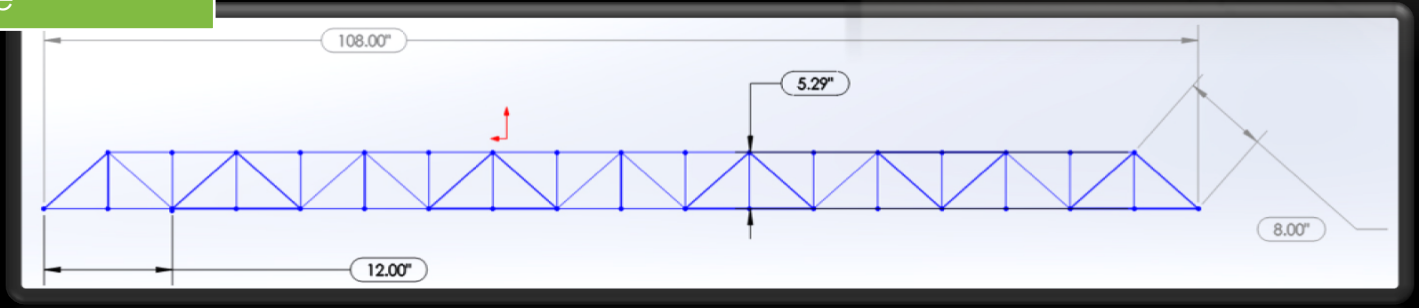
- Rigid or Flexible frame?
- Motor assembly?
- Shape? Aerodynamic for shear forces? Or Aerodynamic for frontal forces?
- Feasability estimate

Narrowing selection of options

- High energy density battery source limited power plant choices (Li-Co Chemistry)
- Weight considerations and ease of construction dictated cylindrical shape.

Finalizing the structural requirements

- Empirical Evaluation of strength of the frame
- Inclusion of engineered balsa truss on top and bottom to increase rigidity over length of airframe

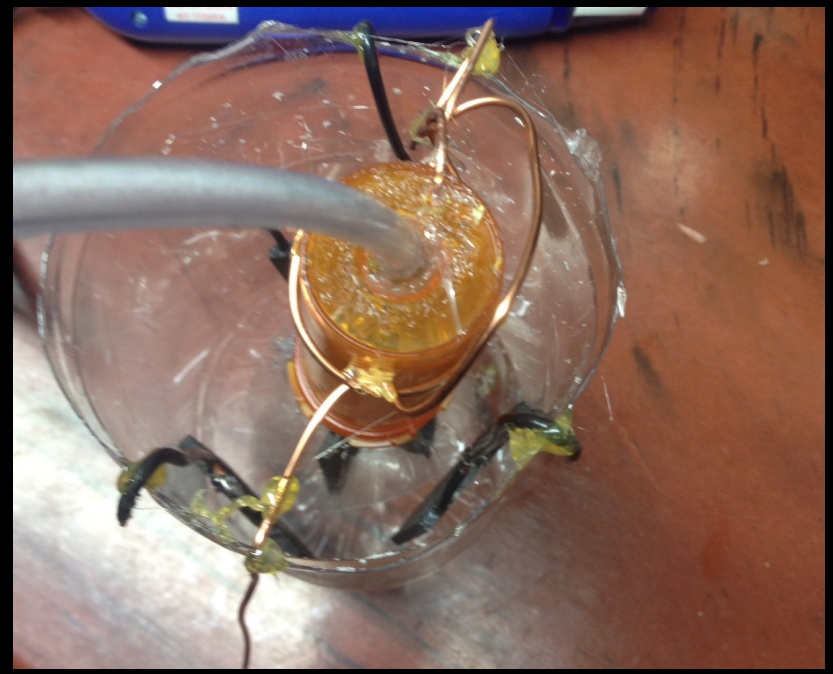


ELECTROLYSER DESIGN

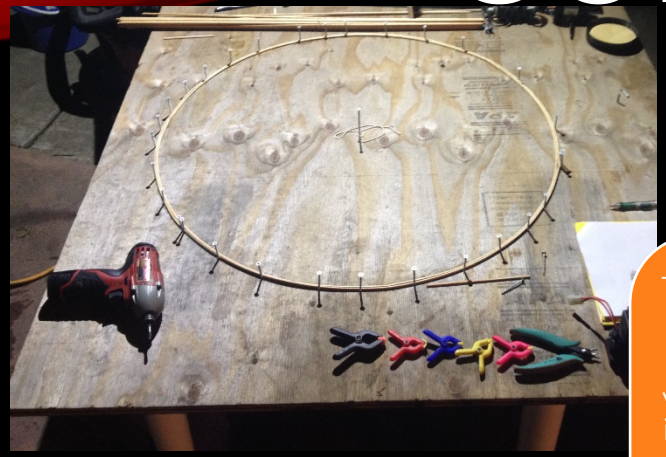
Electrolyser design was based primarily off of the lack of money we had to dedicate to it.

It was assembled with 5 graphite plates purchased from eBay, battery acid, irrigation valves, a hacked apart Xbox power supply, and 2 water bottles, a 1 liter fit inside of a 1.5L.

Results – at 12v, 10A of current flowed corresponding to approximately 70ml of hydrogen produced per minute. At this rate it would take 500 hours (21 days) to produce 2100L of hydrogen.



CONSTRUCTION METHODS 1

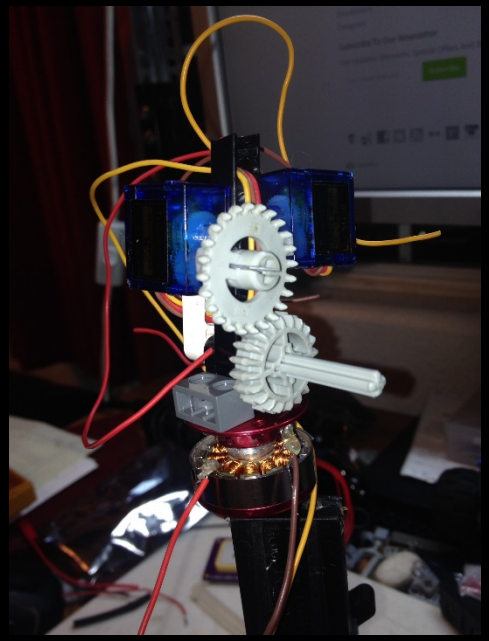


The frame was built from $\frac{1}{8}" * \frac{1}{8}"$ balsa wood. The frame as it stands now weights ~268 grams and is 3 meters in length with a .42meter diameter, yielding a cylindrical volume of 2.0 $m^3$and a lifting capability if fully inflated of ~2kg.

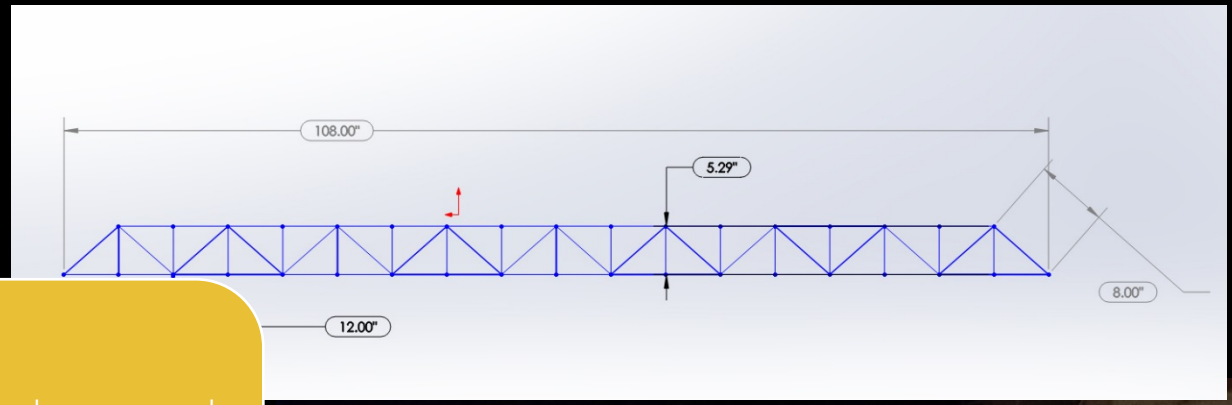
The blimp was made from a series of cylindrical bulkheads to which the outer structural members were then adhered to, these bulk heads were formed in a custom jig made of plastic floor trim.

Triangular elements were added wherever possible to increase strength.

The motor assembly was created with modified Lego components that were superglued and stress relieved with hot glue.



CONSTRUCTION METHODS 2



Truss elements were added for vertical stability were the bulk of the forces were to be experienced

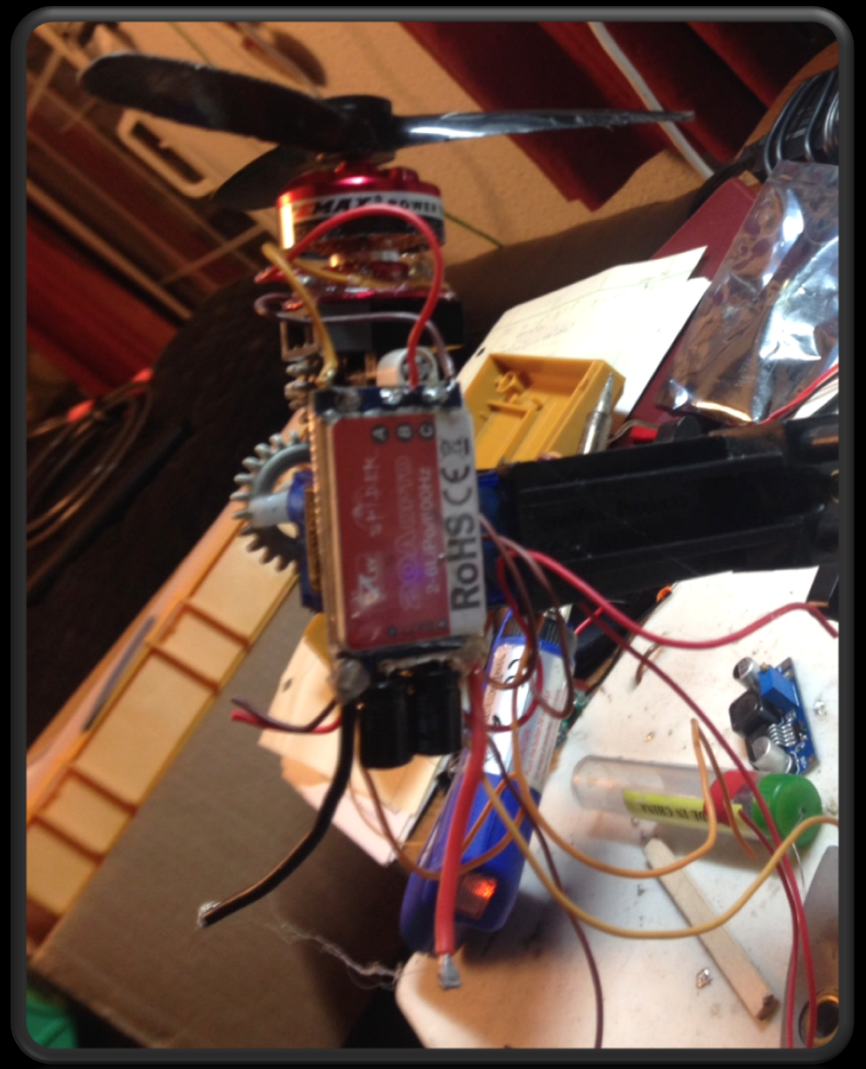
Solidworks was used to properly dimension the truss elements and ensure they were uniform.

Superglue was the primary adhesive and was reinforced with cotton string at joints to increase shock resistance

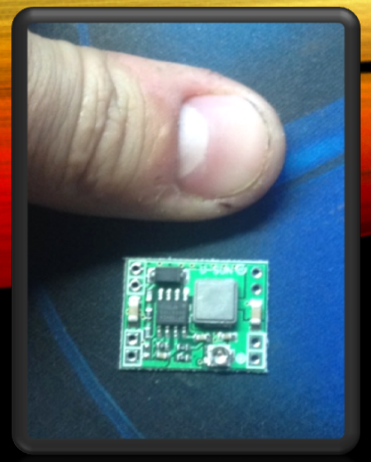
The Balloon gas bags were constructed of heat seal metalized Mylar, and a custom heat sealer made of a power resistor with precision heat control via DC lab power supply.

PROPULSION

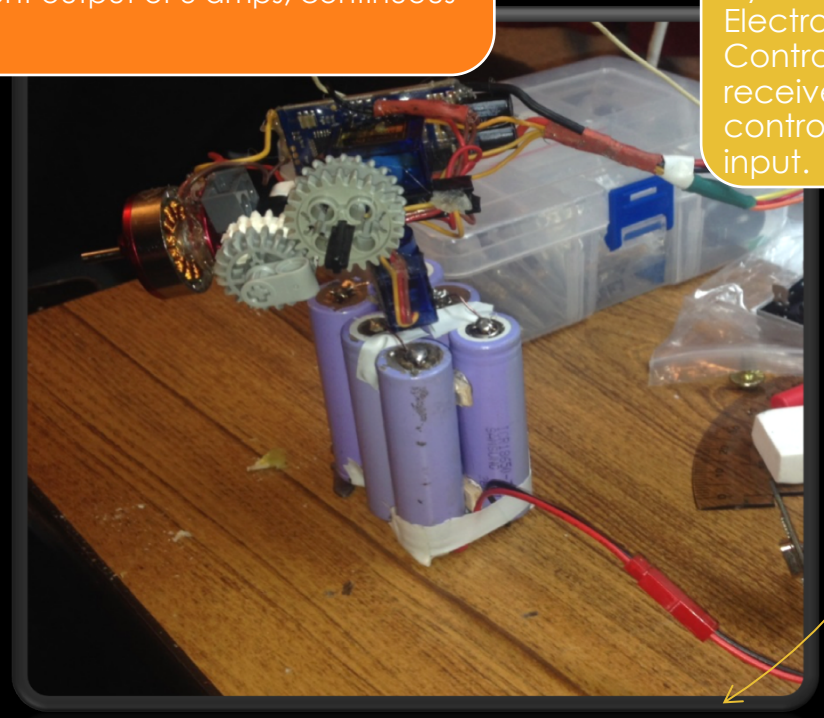
Propulsion was provided by a lightweight high-power brushless motor that was re-wound by hand for the application to increase its efficiency, and decrease its current draw. The end result was a motor that could generate more torque at a lower RPM to turn a large more efficient propeller more slowly.



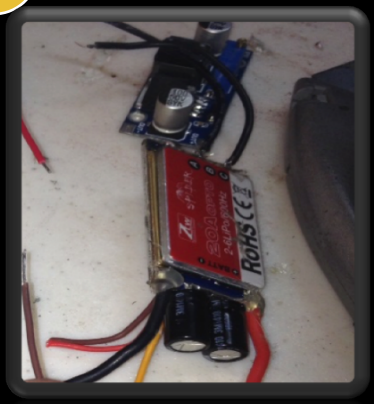
HARDWARE



The battery cell is composed of 6 x Panasonic ICR30A 18650 4.35v Lithium Cobalt Battery cells wired in series $V_{max} = 26.1V$ with a max pulsed current output of 3 amps, continuous 1.5.



The motor is powered by a consumer Electronic Speed Controller which receives a servo control pulse as it's input.



Power is provided to the board and servos through a small Synchronous buck converter which switches the battery voltage ~26v down to the required 5v needed for the Processor's logic circuits.

The blimp is controlled by a ATMEGA328P micro processing unit installed on a proprietary Arduino UNO board.

The Motor is mounted to a system of two servos for 180* control in 2 axes

SOFTWARE

The Motor Control Program was written in a variant of C used by the Arduino IDE

```
/*-----( Import needed libraries )-----*/
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
/*-----( Declare Constants and Pin Numbers )-----*/
#define CE_PIN   9
#define CSN_PIN 53
int throttle;
int yaw;
int pitch;



// NOTE: the "LL" at the end of the constant is "LongLong" t
const uint64_t pipe = 0xE8E8F0F0E1LL; // Define the transmit


/*-----( Declare objects )-----*/
RF24 radio(CE_PIN, CSN_PIN); // Create a Radio
/*-----( Declare Variables )-----*/
int joystick[3];  // 2 element array holding Joystick readings

void setup()   /****** SETUP: RUNS ONCE ******/
{
  Serial.begin(9600);
  radio.begin();
  radio.openWritingPipe(pipe);
}//--(end setup )---


void loop()   /****** LOOP: RUNS CONSTANTLY ******/
{
  int pitchval;
  int throttleval;
  int yawval;
  int throttle = analogRead(A0);
  int yaw = analogRead(A1);
  int pitch = analogRead(A2);

  throttleval = map(throttle,578,775,0,179);
  yawval = map(yaw,544,773,0,179);
  pitchval =  map(pitch,494,754,0,179);



  joystick[0] = throttleval;
  joystick[1] = yawval;
  joystick[2] = pitchval;
  /*Serial.println(joystick[0]);
  Serial.println(joystick[1]);
  Serial.println(joystick[2]);*/

```

It utilizes a Nordic semiconductor NRF24l01 2.4GHz wireless transceiver to transmit mapped sensor values from the handheld transmitter to a sister chip on the blimp

Features such as sensors are still possible, but time constraints have curtailed their inclusion to a later date.

The sister chip on the blimp then uses a C library to generate a series of pulses, the length of which corresponds to a servo position or a throttle output.

SO FAR...

CREDITS

- The Peluso Family for letting us weak havoc numerous times in their backyard
- Professor Ferguson of the math department for his time in generating our first "aerodynamic" prototype
- https://arduino-info.wikispaces.com/Nrf24L01-2.4GHz-HowTo
- Without the above web site, I never would have got the program to work!
- Feline programming assistant and expert balloon popper Sheldon->