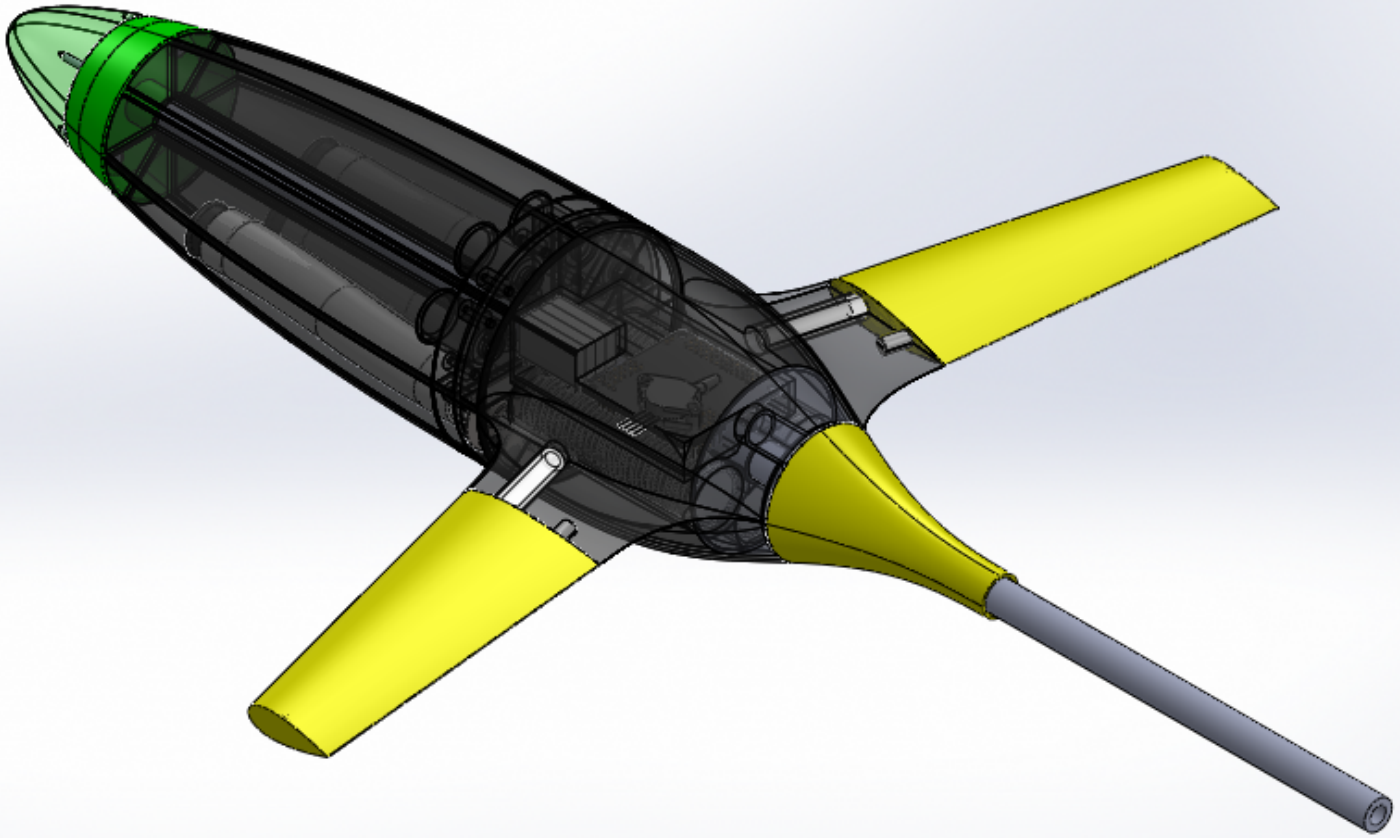


¥10000 Yen Into the Sea

Bio: Flipper

Job Title:Engineering Technician
What: Electric Vehicles

Goal:
Build a low cost underwater glider

“If you want to make an apple pie from scratch, you must first create the universe.” - Carl Sagan

What is an underwater glider?

Underwater Gliders:

-Highly efficient autonomous submarines that can travel long distances on battery power

Background

ARGO Floats

http://www.argo.ucsd.edu/float_design.html
http://www.argo.ucsd.edu/operation_park_profile.jpg
http://www.webbresearch.com/pdf/EurekaMoment.pdf
http://discovermagazine.com/1996/apr/athousanddivingr734

"The Slocum Mission" - Henry Stommel
April 1989 - *Oceanograpy* Magazine

http://auvac.org/uploads/publication_pdf/the_slocum_mission.pdf
http://www.webbresearch.com/slocumglider.aspx

"Scarlet Knight"

- "Scarlet Knight is 93 inches in length. Most of the gliders flown by Rutgers are 84 inches"
- 23.8 kilograms of Batteries
- 59.1 liters displacement
- ~4,500 mile trip
  - source:http://rucool.marine.rutgers.edu/atlantic/about_gliders.html
- Lithium CSC @ 900Wh/kg =21.42kWh
  - source:http://www.electrochemsolutions.com/pdf/Echem%20Corporate%20Case%20Study_Slocum%20Glider.pdf

How do you make an Underwater Glider?

Design Spiral:

1. Define Requirements
2. Research
3. Buoyancy engine
4. Energy Storage
5. Attitude Control System
6. Hull Design
7. Testing

Efficiency crucial elements of an Underwater Glider

-Low Drag Hull Form
-Buoyancy Engine

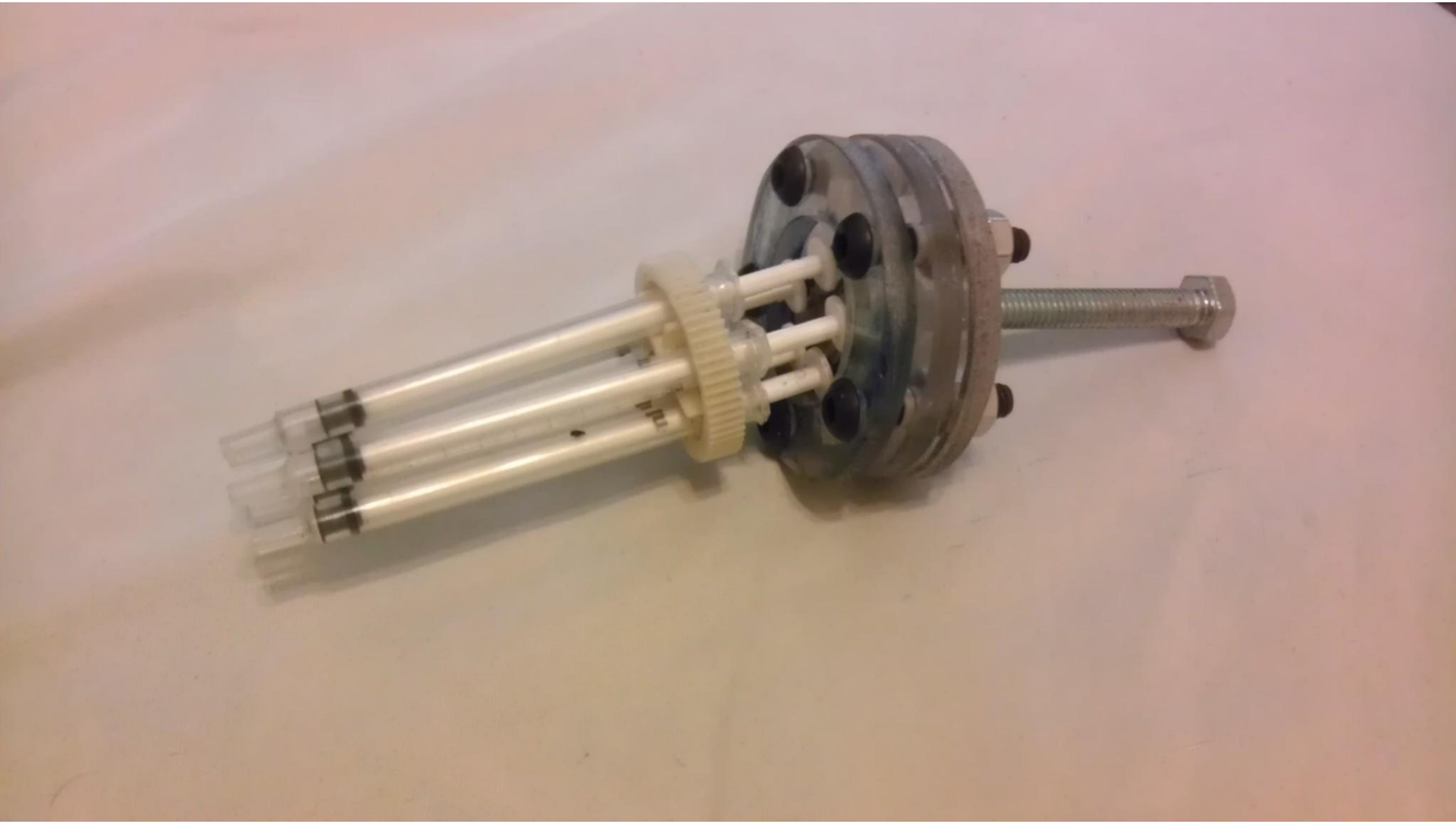
Conservative: Torpedo(Myring 1976)
Bold: Laminar Flow X-35(Carmichael 1966)

Define Requirements:

1. Low Price($100 Target)
2. Difficulty of manufacture(In my boxers)
3. Range/Efficiency(Fingers crossed)

Early Efforts During Learning Phase

-Axial Piston Syringe Pump



Research
(Considered a variety of approaches)

- High Test Peroxide
- Free Piston Diesel
- Hydraulic Pumps
- Electric Motors
- Linear Actuators
- Wave Power/Solar

Buoyancy Engine

-Phase Change Material("PCM")

-Not N-Pentadecane(~10 degree C melting point)

-Canning wax:

http://en.wikipedia.org/wiki/Paraffin_wax

" In chemistry,paraffin is used synonymously with "alkane", indicating hydrocarbons with the general formula C_nH_{2n+2} " --

Expands ~8-12 percent at Phase Change

--Melting Point ~60 degree C(varies with composition)

Energy Storage

- Lithium CSC Chemistry:
  - ~549Wh/kg
  - ~1170Wh/L

source:http://www.batteryspecialties.com/electrochemcsc93dd.aspx

- Manganese Dioxide Lithium Coin Cell:
  - 3V @ ~265mAh CR2330
  - 209Wh/kg

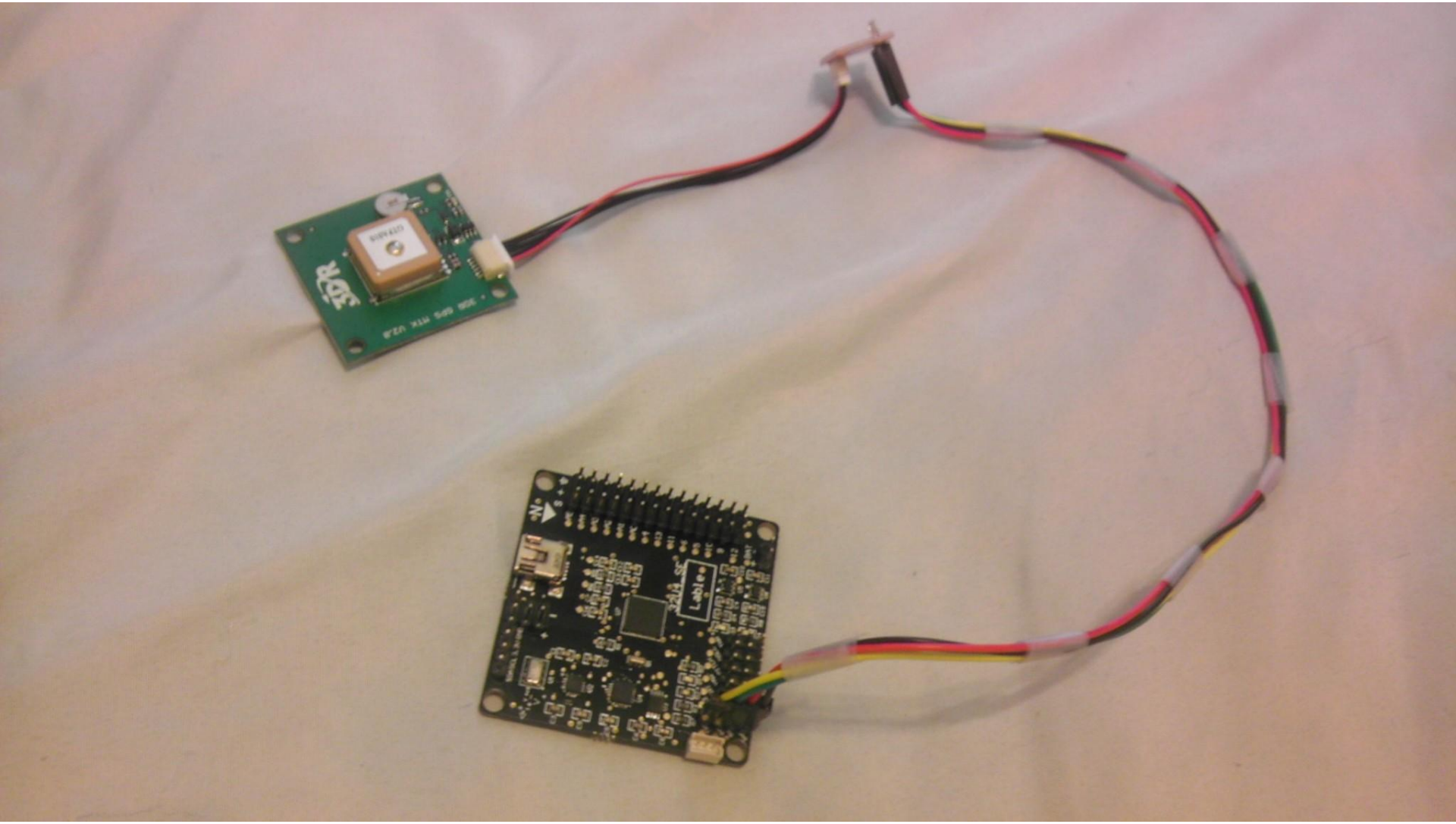
source: http://www.panasonic.com/industrial/includes/pdf/Panasonic_Lithium_CR2032_CR2330.pdf

- Zinc Air Chemistry:
  - ~367.5 Wh/kg
  - ~1300 Wh/L!
- High Test Peroxide (HTP):
  - ~ 813 Wh/kg
  - ~1187 Wh/L

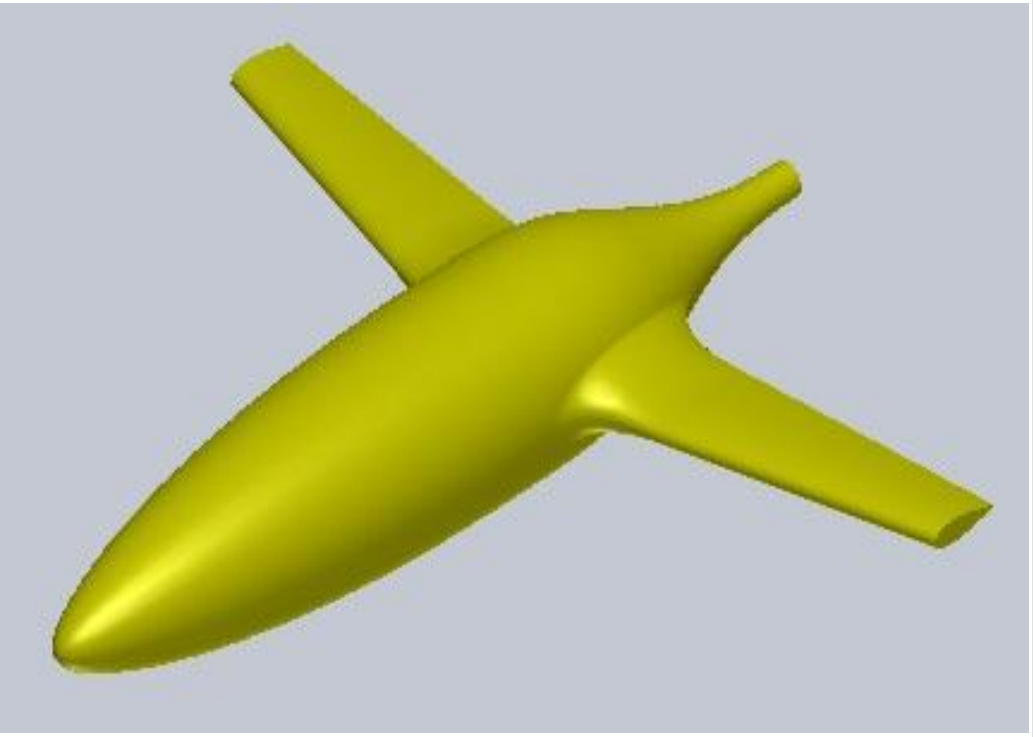
source:http://wiki.xtronics.com/index.php/Energy_density#Energy_Density_sorted_by_Wh.2Fl

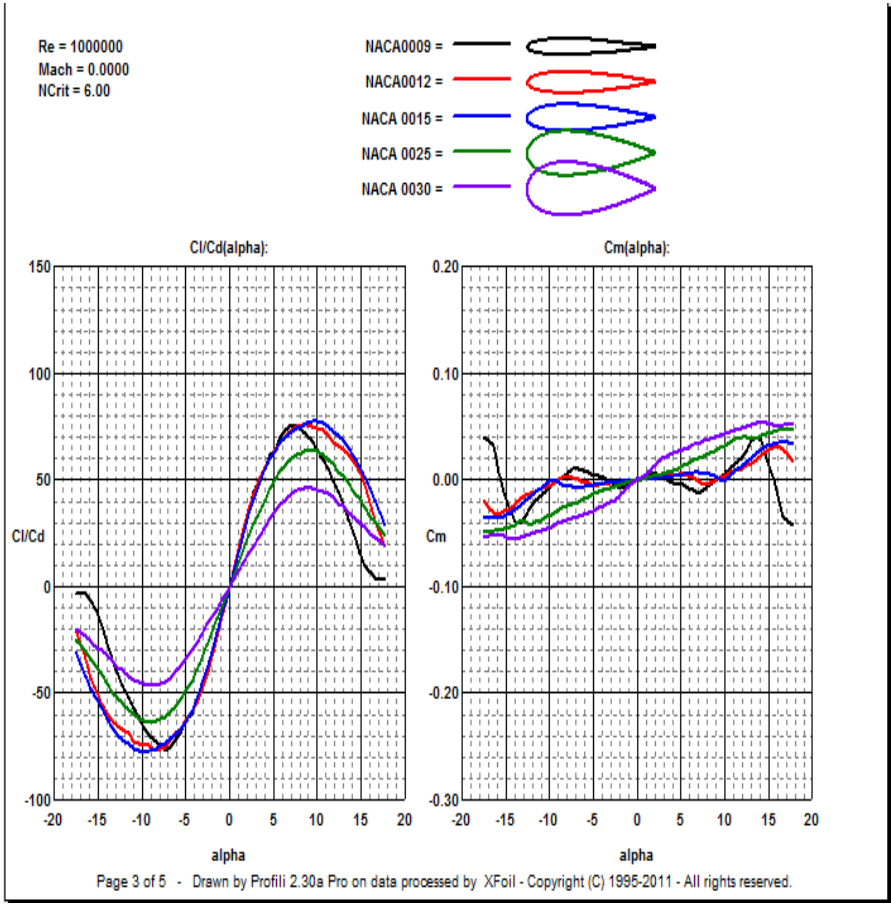
Attitude Control System (AHRS+GPS)

Source Code: http://freeimu.varesano.net/node/779



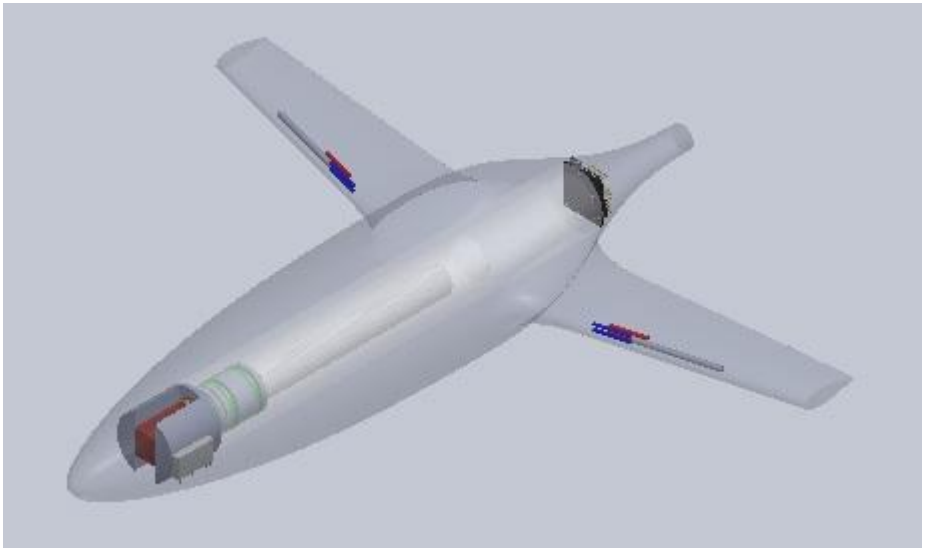
Hull Design (NACA 0020 & X-35)



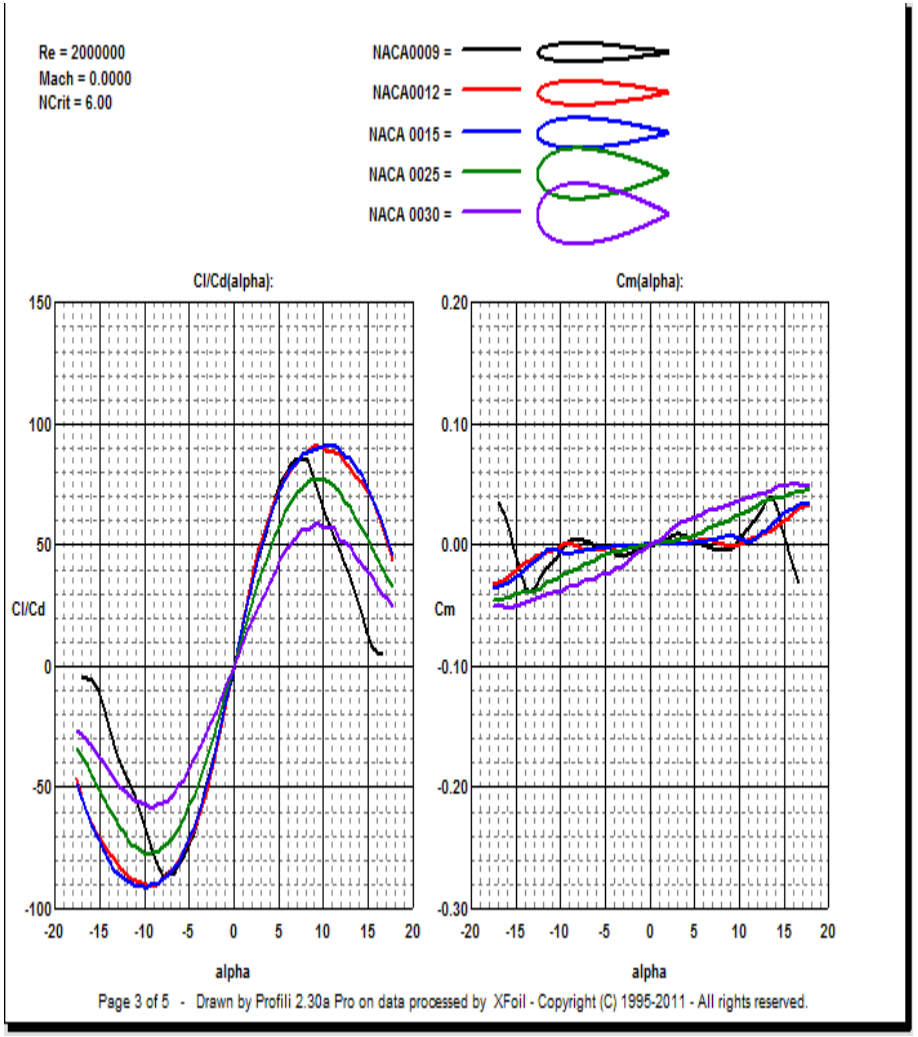


-"Finess Ratio"
-"Aspect Ratio"

ROUND 1



-"Finess Ratio"
-"Aspect Ratio"



Uh Oh...

- Composite Layup:1
- Flipper: 0

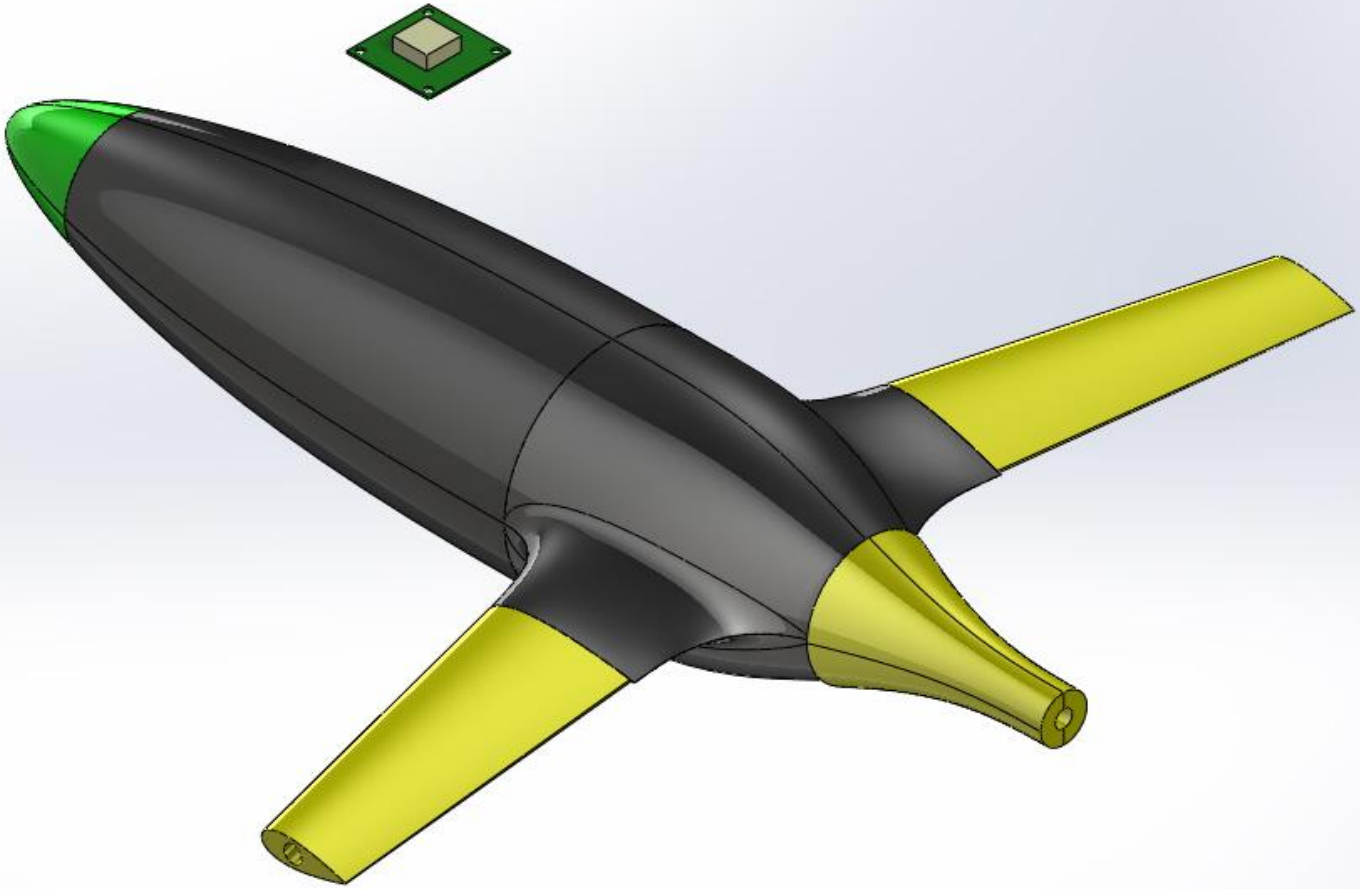
Fiberglass was not as easy as it looked on Youtube!

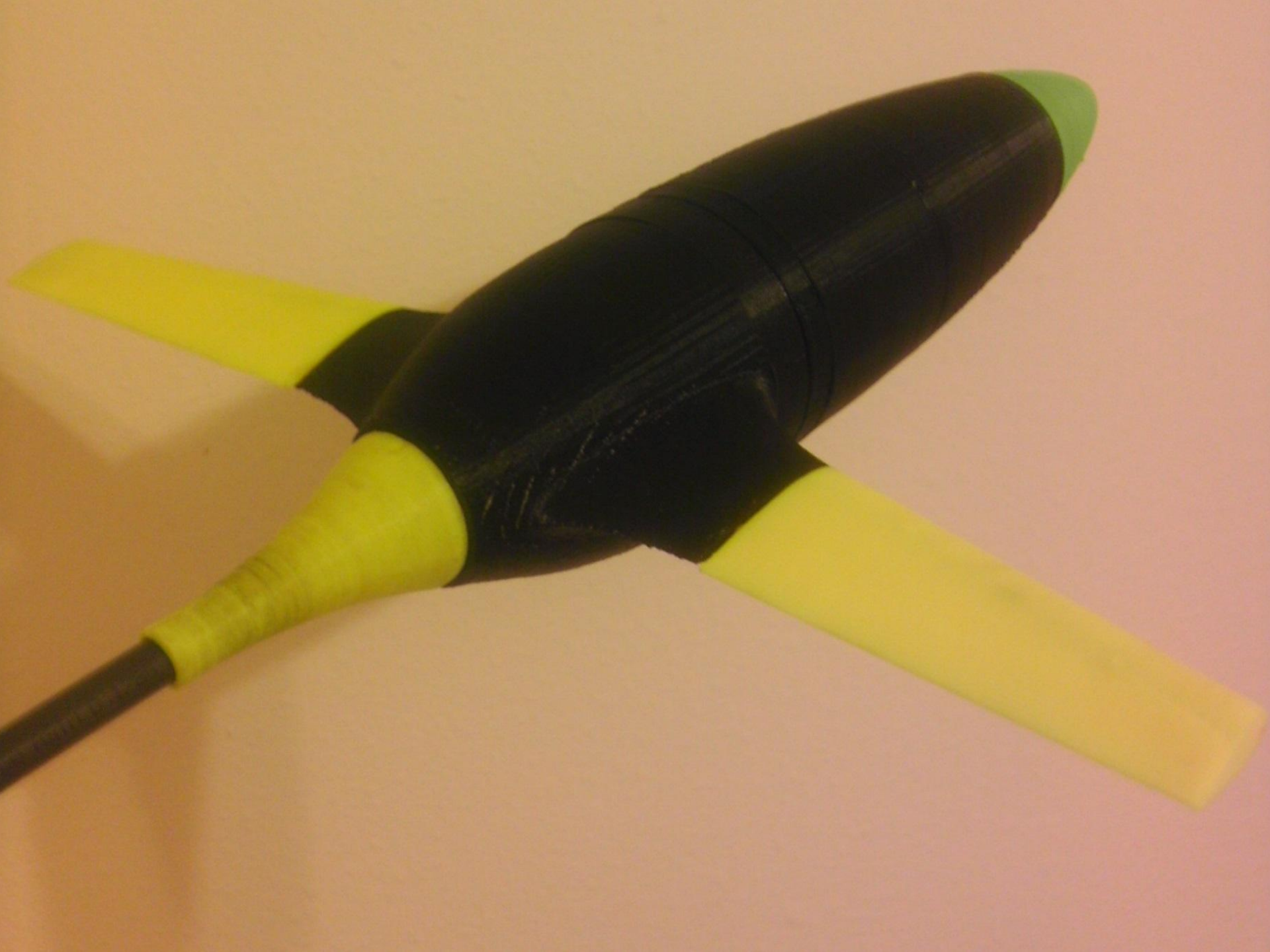
Time to Launch at that rate
=
Too Long

Needed a Plan B

Needed a Plan B

ROUND 2





Bill of Materials Summary:

Total Printed ABS(grams)	**683**
Total Cost Printed Parts: (at $31.00/kg)	**$21.17**
Total BoM	**$277.30**

Benefits of 3D printing

-Reduced engineering burden to purchase and evaluate CoTs components

-With commercial services on the market, the criteria for low barriers to entry are met

-Design rules similar to Plastic Injection Molding

Obstacles:

-With no simulation, test data was expensive to generate

-With no firm targets or test data, it was difficult to quantify design improvements or identify a finished product

Influence of "Out of pocket" on R&D:

Pros:

-no reporting requirements, outside influences on project direction, or accountability.

Cons

-Very small funding agency

-Dubious appropriation of retirement savings

-Free labor(opportunity cost) vs. buying CoTs solutions

What's Next?

-Test Max Depth & Velocity

-Trim Vehicle

    Buoyancy = 3M Microballoons

    Ballast = Salt

-Solid Models, BoM, & Source Code on DVD

-OpenGlider.com = latest revision of source files

Biblio

http://www.boatdesign.net/forums/sailboats/frontal-area-resisantance-vs-wetted-surface-21502.html#post188208

(Carmichael 1966)

Carmichael, Bruce H "Underwater Vehicle Drag Reduction through choice of Shape". AIAA 2nd Propulsion Joint Specialist Conference, Colorado Springs, USA, June 1966, Paper No. 66-657.

(Myring 1976)

Myring,D.F. (1976) A theoretical study of body drag in sub-critical axisymmetric flow. Aeronautical Quarterly, 27(3), pp. 186-194.

http://www.boatdesign.net/forums/boat-design/myring-submersible-shape-24939.html

(Chang 2009)

Chang, Patrick, Aditya Shah, and Mukul Singhee. "Parameterization of the Geometry of a Blended-Wing-Body Morphing Wing."

http://srl.gatech.edu/Members/ashah/ME%206104%20project%20report.pdf

(Parsons 1974)

Parsons, Jerome S., Raymond E. Goodson, and Fabio R. Goldschmied. "Shaping of axisymmetric bodies for minimum drag in incompressible flow."*Journal of Hydronautics* 8.3 (1974): 100-107.

http://www.cafefoundation.org/v2/pdf_tech/Drag.Reduction/5.AIAA-48131-445.pdf

Further Reading:

Robosub.org

Naval Engineering Support Team

Navy Vehicle Primer

http://auvac.com/

Questions?

nickflipper@gmail.com