UNIVERSITY of HOUSTON

COLLEGE of TECHNOLOGY

Modular R.O.V for Sub-Sea Operations

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PROJECT UPDATE 1

10/19/2015

Olly

Safety Moment

Olly

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ROV Presentation Outline

- Project Objectives / Timeline
- 2016 MATE Competition
- MATE Competition Specs
- Design Overview
- First Frame Design
- Second Frame Design
- Stress Analysis – Frame 1
- Stress Analysis – Frame 2
- Control System
- Propulsion System
- Thruster Positioning
- Arm Update
- Updated Project Budget

Olly

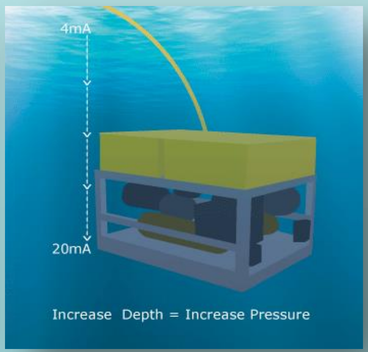
Team Objective

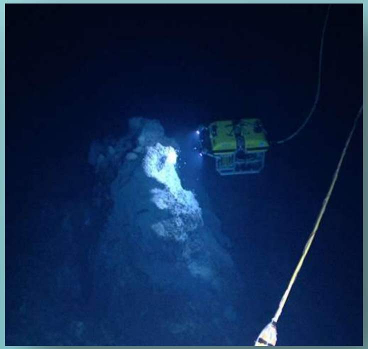
- Team HydroBurst's primary objective is to design, test, and construct an underwater remotely operated vehicle (ROV) to compete in the 2016 National and International MATE Competitions.

MATE

2016 MATE Competition

- Outer Space: Mission Europa
  - Measure thickness of ice
  - Measure total depth
  - Measure temp of thermal vents
  - Retrieve and connect ESP cable





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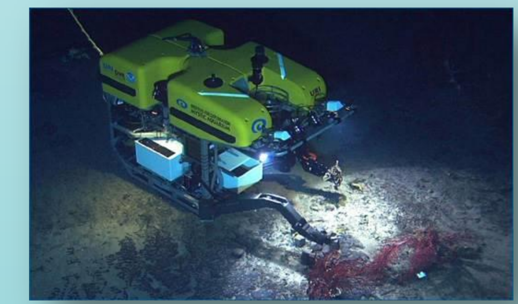
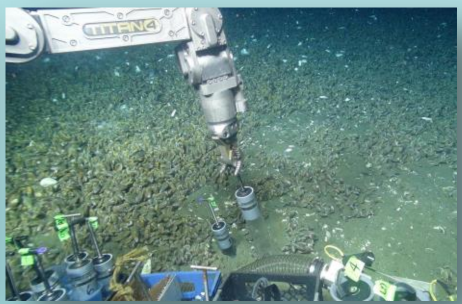
David

MATE

2016 MATE Competition

- Inner Space: Mission-critical equipment recovery
  - Survey the seafloor
  - Collect equipment located on sea floor
- Inner Space: Forensic Fingerprinting
  - Collect oil sample
  - Analyze a gas chromatograph





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2016 MATE Competition

- Inner Space: Deepwater Coral Study
  - Photograph corals and compare with last years images
  - Collect coral samples for analysis
- Inner Space: Rigs to reefs
  - Attach a flange to top of wellhead
  - Secure flange with two bolts
  - Install cap on flange
  - Secure the cap with four bolts

David

MATE

MATE Competition Specs

- Size Constraints (released September 30th):
  - Maximum Diameter of 85cm
    - +5 Points for diameter between 64.1cm and 70cm
    - +10 points for diameter between 58.1cm and 64cm
    - +20 points for diameter less than 58cm
  - Mass
    - +5 Points for mass between 19.01kg and 22kg
    - +10 points for mass between 17.01kg and 19kg
    - +20 points for mass less than 17kg

- Our Design Goals based on Constraints:
  - Diameter less than 58cm (22.8346 inches).
  - Mass less than 17kg (37.4786 lbf)

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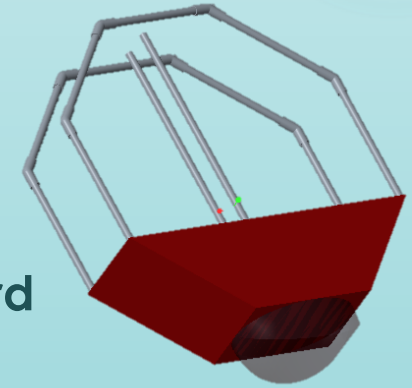
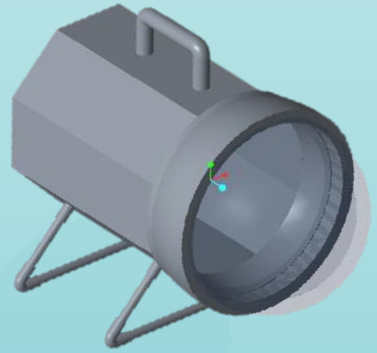
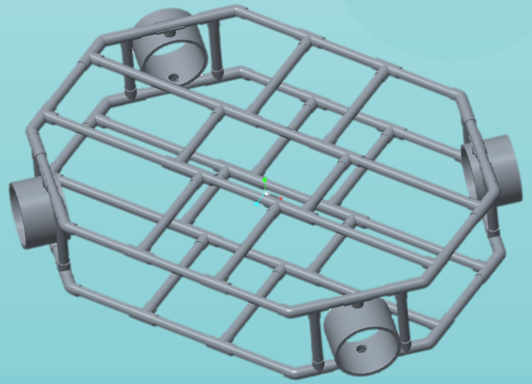
Design Overview

- As covered during the last presentation:
  - we weighed the pros and cons of various standard ROV frame designs.
  - Decided upon the Octagonal model as the most effective model.



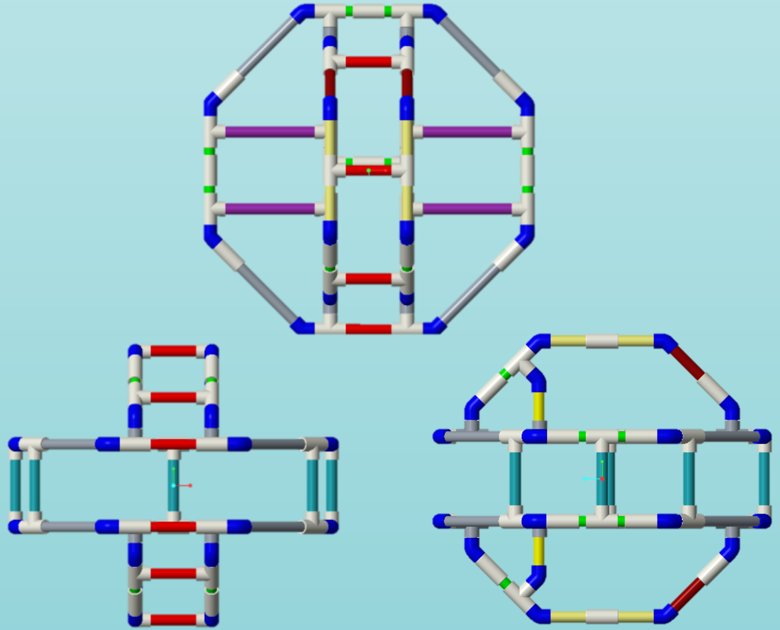


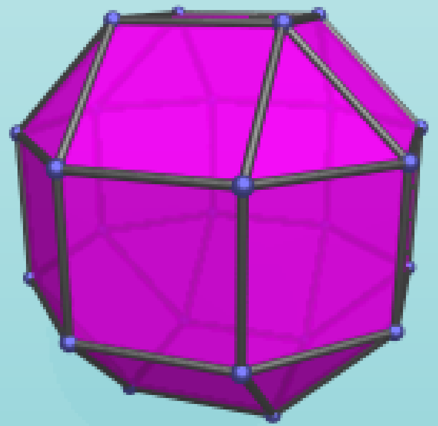


	Maneuverability	Hydro-dynamics	Internal Space Utilization	Modular Optimization	Corrosion Resistance	Totals
Rectangular	1	1	2	3	5	**12**
Cylindrical	3	4	3	1	5	**16**
Octagonal	**4**	**3**	**2**	**3**	**5**	**17**
Flat	2	3	3	2	5	**16**

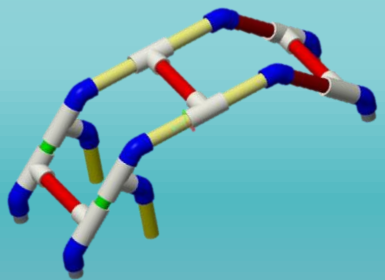
First Frame Design

- Shape: Rhombicuboctahedron
  - To make it as spherical as possible using existing fittings.
- Material: CPVC
  - Light weight, designed for water usage, and can handle high pressures.
- Maximum diameter: 21 inches
  - Minimum of 1.00 inch clearance on all sides.
- Frame weight: 4.5 lbs.





Complete Frame Assembly

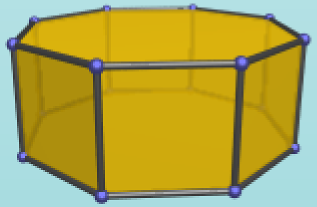


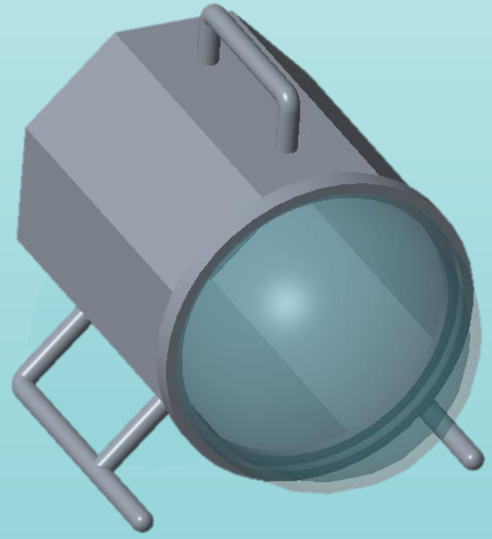
Module (Arms, Sensors, etc…)

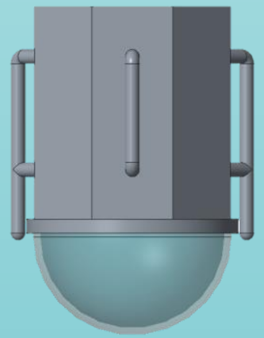
Gustav

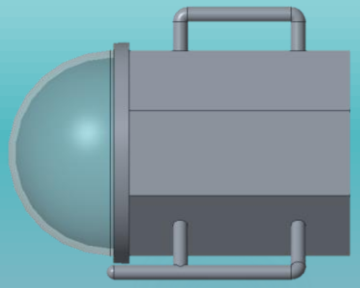
Second Frame Design

- Shape: Octagonal Prism.
  - Solid Frame.
- Material: Plastic or Acrylic.
  - Light weight and strong.
- Maximum diameter: 21 inches.
  - Minimum of 1.00 inch clearance on all sides.
- Clear Dome on the front for access and Camera.



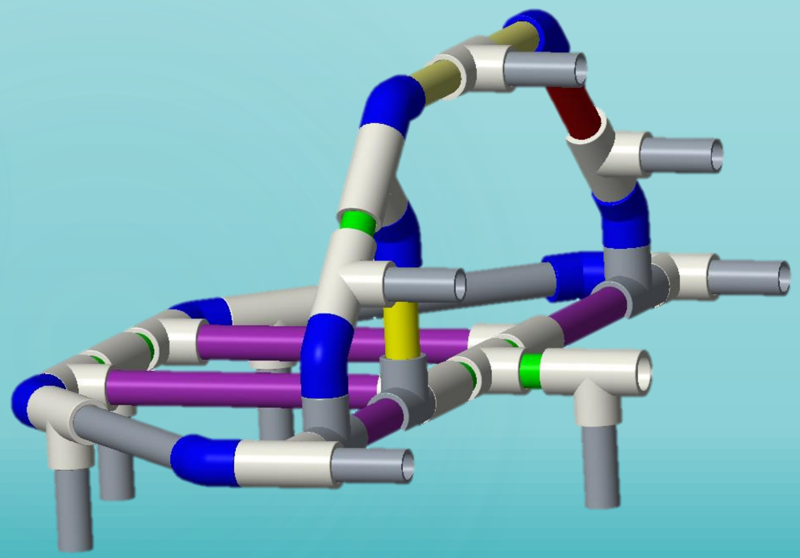




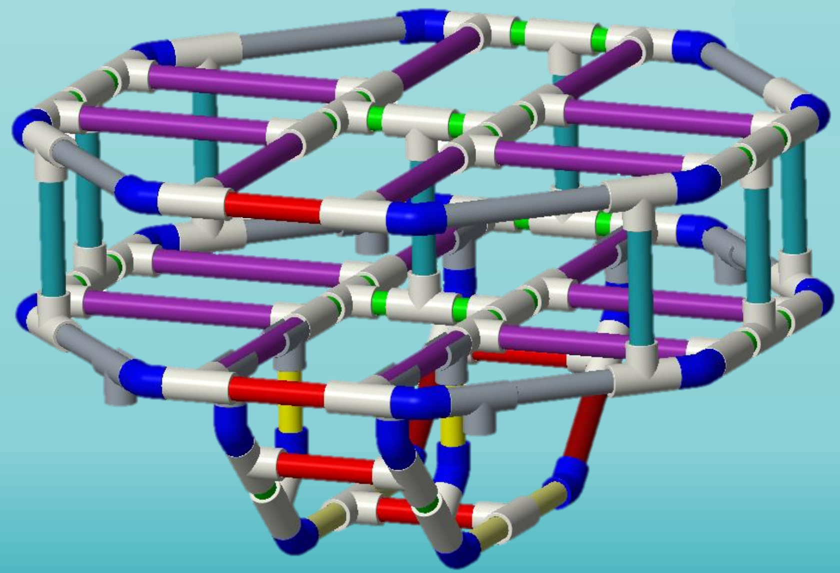


Stress Analysis – Frame 1

Quarter Frame

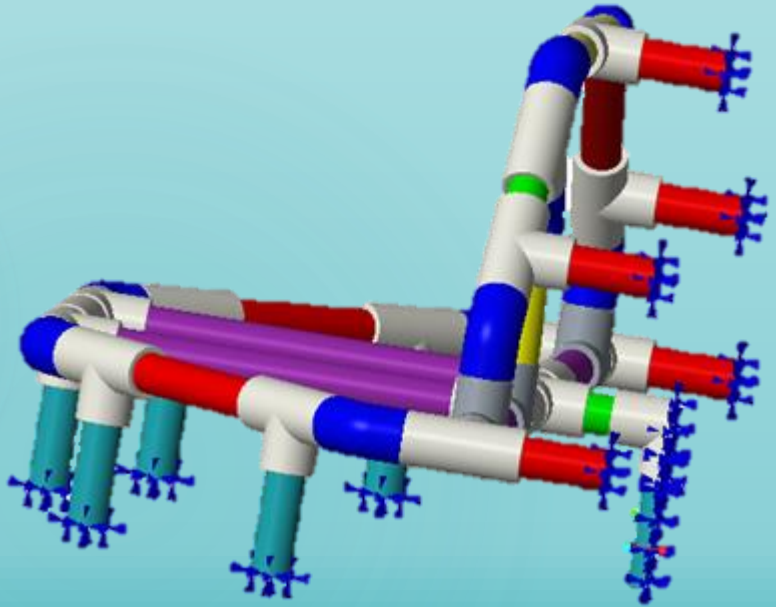


Full Frame



Stress Analysis – Frame 1

Constraints



CPVC Material Definition

Density	0.0559973	lbm/in^3

Structural | Thermal | Miscellaneous | Appearance | User Defined

Symmetry	Isotropic	
Stress-Strain Response	Linear	
Poisson's Ratio	0.3	
Young's Modulus	370000	psi
Coeff. of Thermal Expansion	3.9e-05	/K
Mechanisms Damping		sec/in

Material Limits

Tensile Yield Stress	7600	psi
Tensile Ultimate Stress	12500	psi
Compressive Ultimate Stress		lbm/(in sec^2)

Structural | Thermal | Miscellaneous | Appearance | User Defined

Symmetry	Isotropic	

Properties

Specific Heat Capacity	775002	in^2/(sec^2 F)
Thermal Conductivity	7.71521	in lbm/(sec^3 F)

Juan

Stress Analysis – Frame 1

Pressure

Pressure calculations

$P = \rho \cdot g \cdot h$

P = Pressure
ρ = Density
g = Gravity
h = Underwater distance

$\rho_w := 62.418 \ \frac{lb}{ft^3}$

$g := 32.2 \ \frac{ft}{s^2}$

1. 40 feet underwater

$h := 40 \ ft$

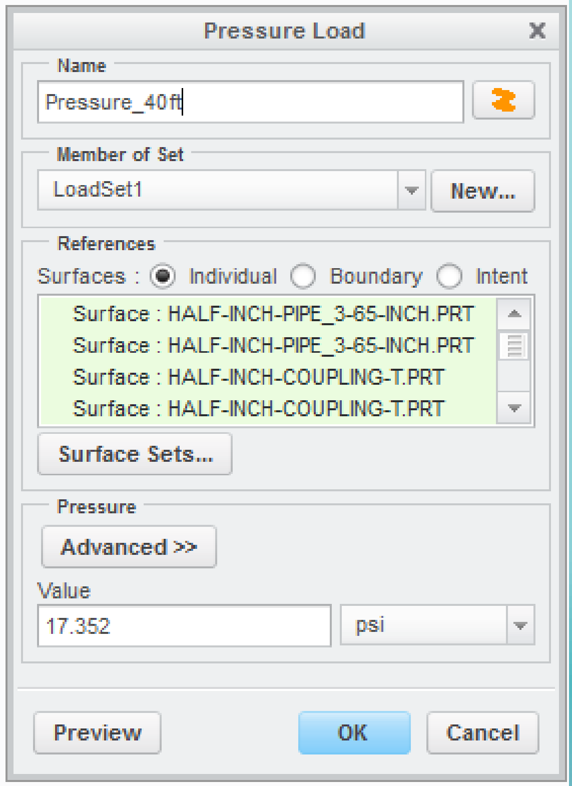
$P := \rho_w \cdot g \cdot h = 17.352 \ psi$

2. 100 feet underwater

$h_2 := 100 \ ft$

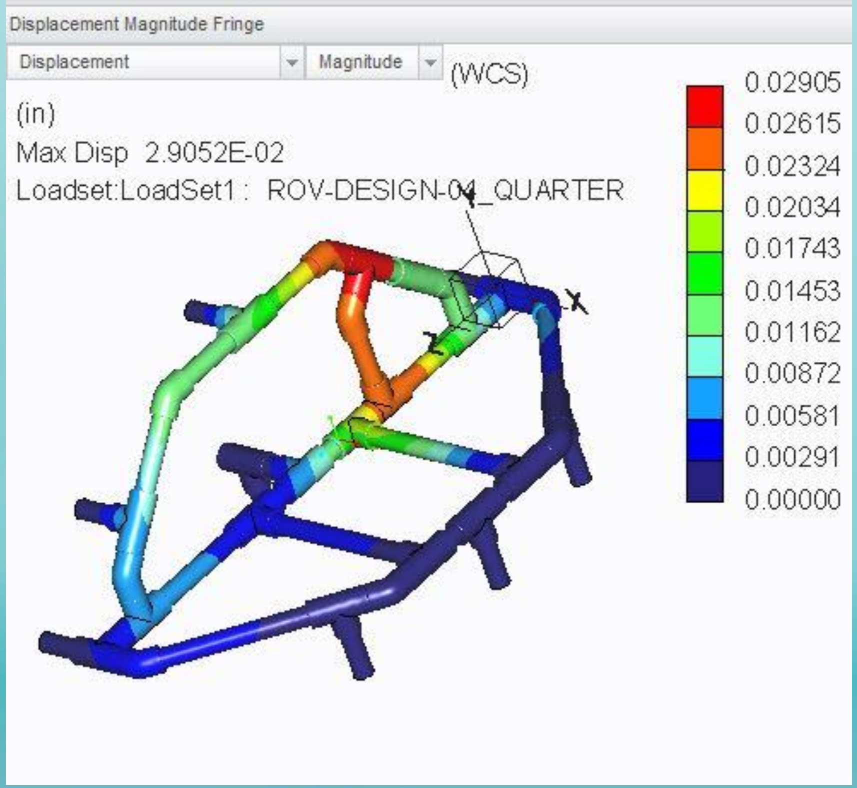
$P_2 := \rho_w \cdot g \cdot h_2 = 43.381 \ psi$

CPVC Material Assignment

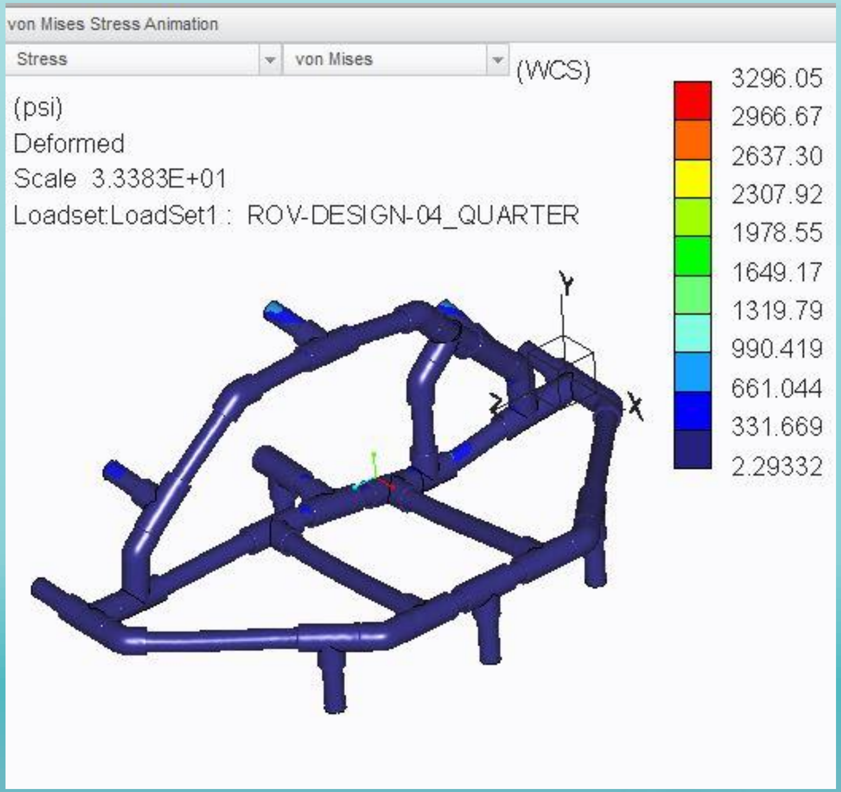


Stress Analysis – Frame 1 40 ft. below water

Displacement (in)



Von Mises Stress (psi)



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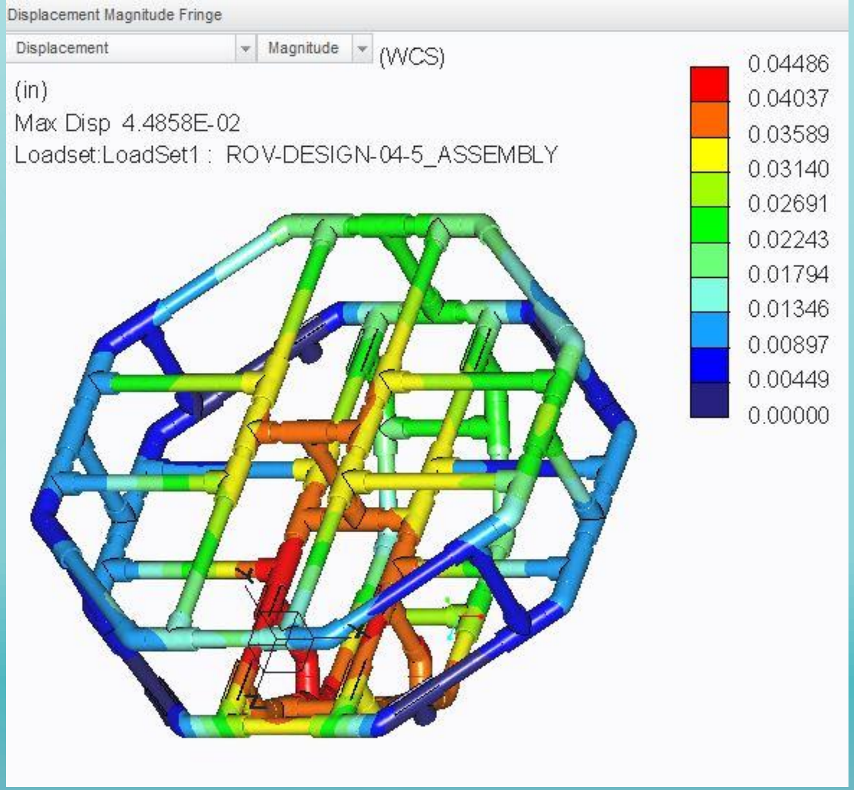
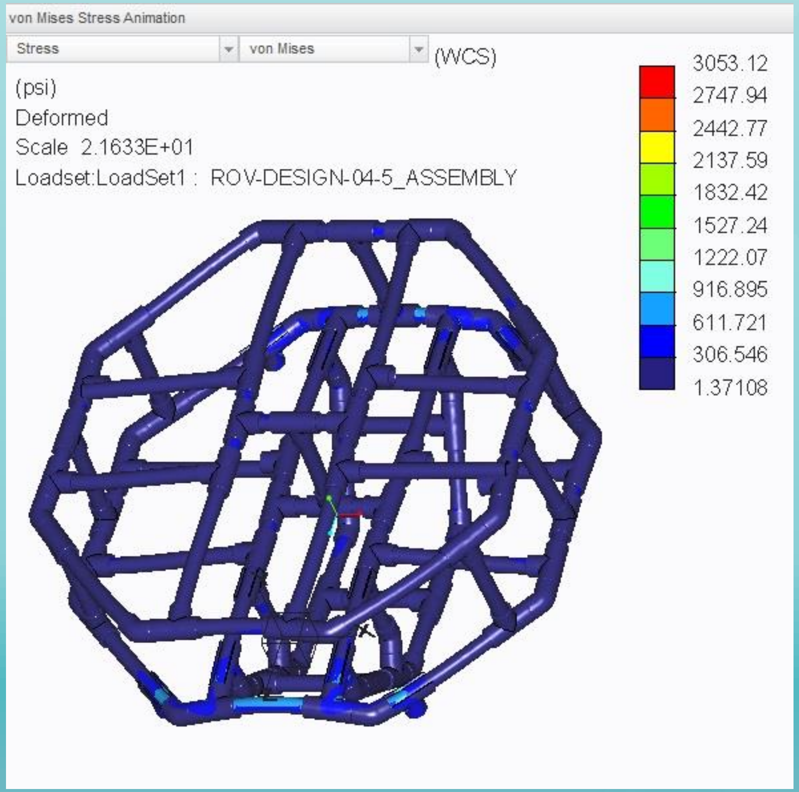
Stress Analysis – Frame 1 40 ft. below water

Displacement (in)



Von Mises Stress (psi)



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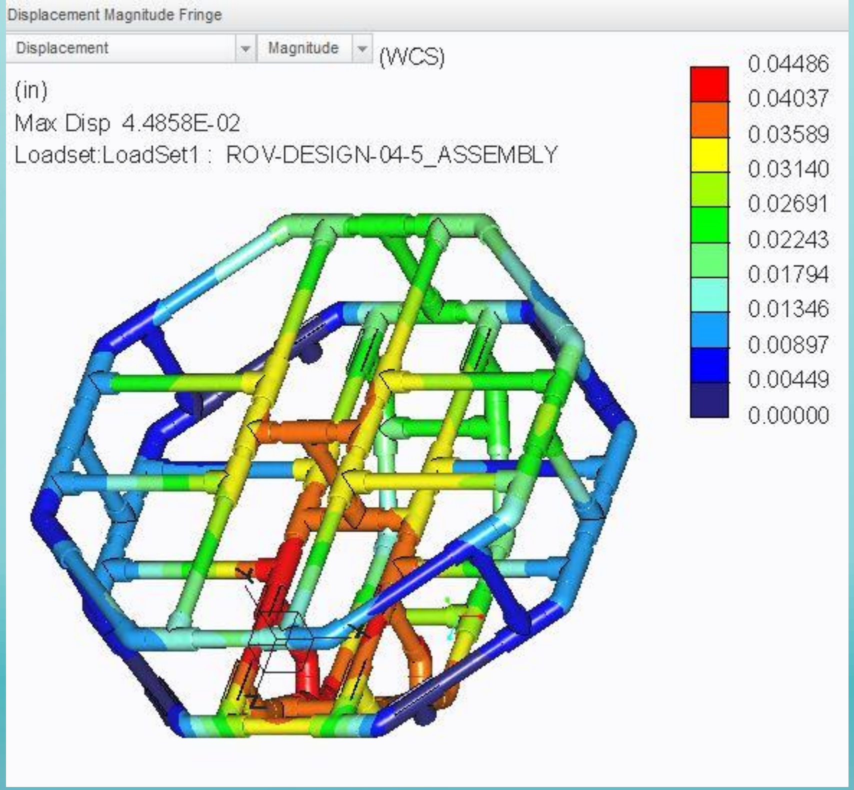
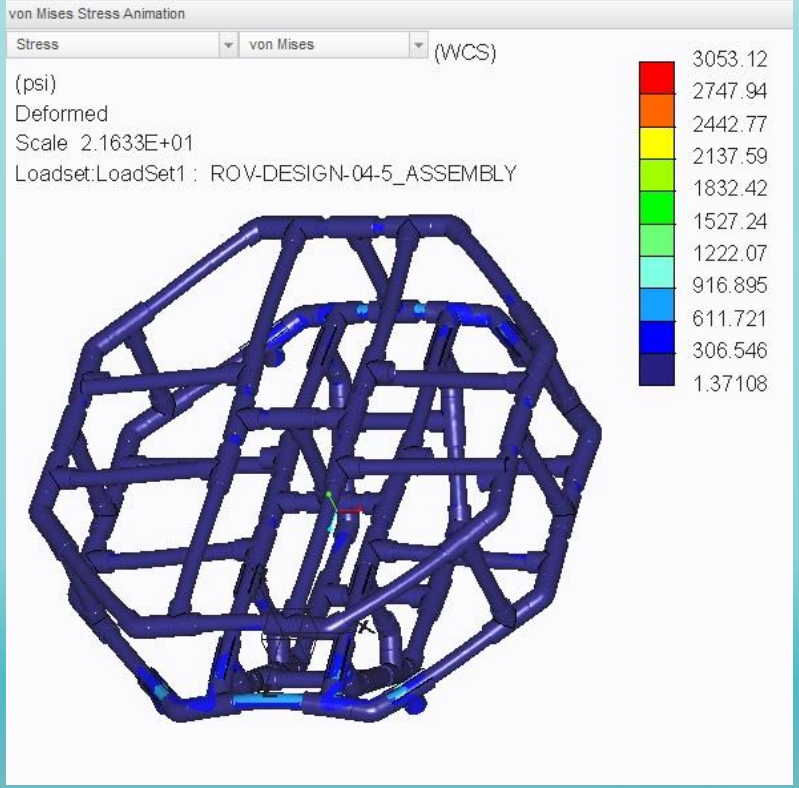
Stress Analysis – Frame 1 100 ft. below water

Displacement (in)



Von Mises Stress (psi)



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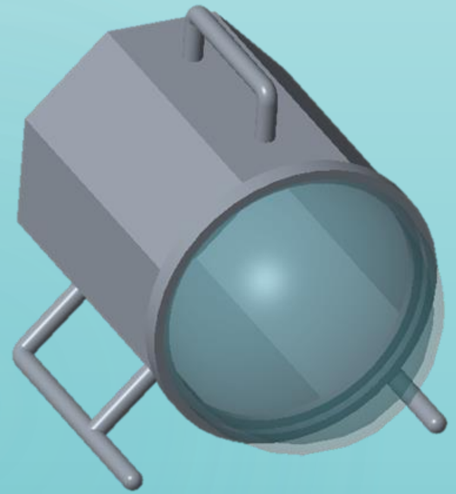
Stress Analysis – Frame 1

Model	Max. Von Mises Stress		Max. Displacement	
	40 ft. depth	100 ft. depth	40 ft. depth	100 ft. depth
Quarter Frame	3296 psi	9914 psi	0.029 inches	0.0734 inches
Full Frame	3053 psi	7633 psi	0.045 inches	0.112 inches

- CPVC Material Properties:
  - Tensile Strength (Yield Strength) 7,600 psi
  - Allowable Stress = ⅔ σy 5066.67 psi

Stress Analysis – Frame 2

ROV Frame



Acrylic Material Definition

Density: 0.68 g/cm^3

Structural | Thermal | Miscellaneous | Appearance | User Defined

Symmetry: Isotropic

Stress-Strain Response: Linear

Poisson's Ratio	0.3	
Young's Modulus	425000	psi
Coeff. of Thermal Expansion	3.9e-05	/F
Mechanisms Damping		sec/in

Material Limits

Tensile Yield Stress	7500	psi
Tensile Ultimate Stress	12100	psi
Compressive Ultimate Stress		lbm/(in sec^2)

Structural | Thermal | Miscellaneous | Appearance | User Defined

Symmetry: Isotropic

Properties

Specific Heat Capacity	1779.39	joule/(kg K)
Thermal Conductivity	0.202	W/(m K)

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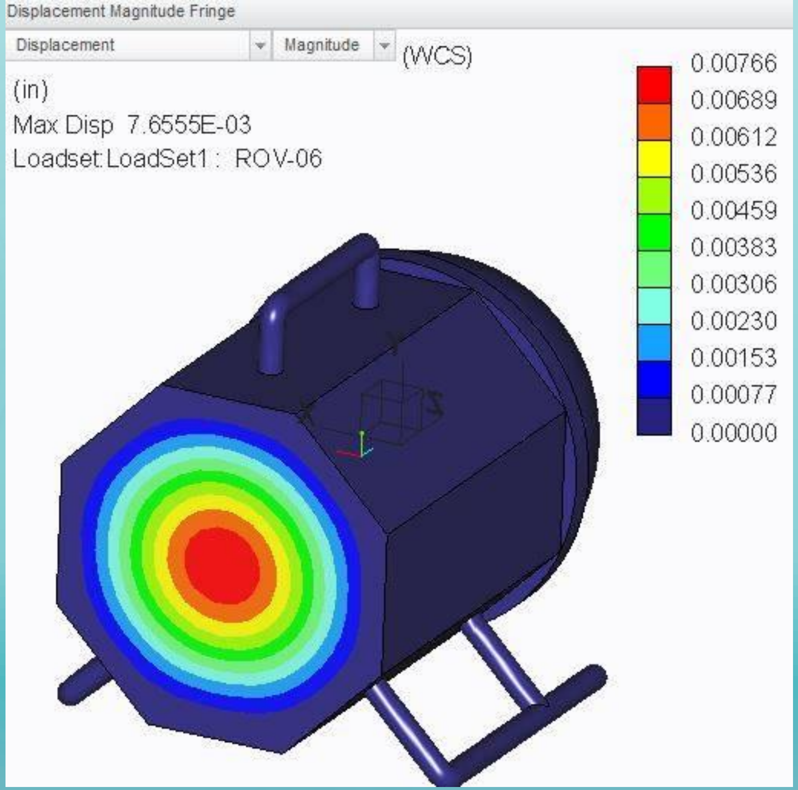
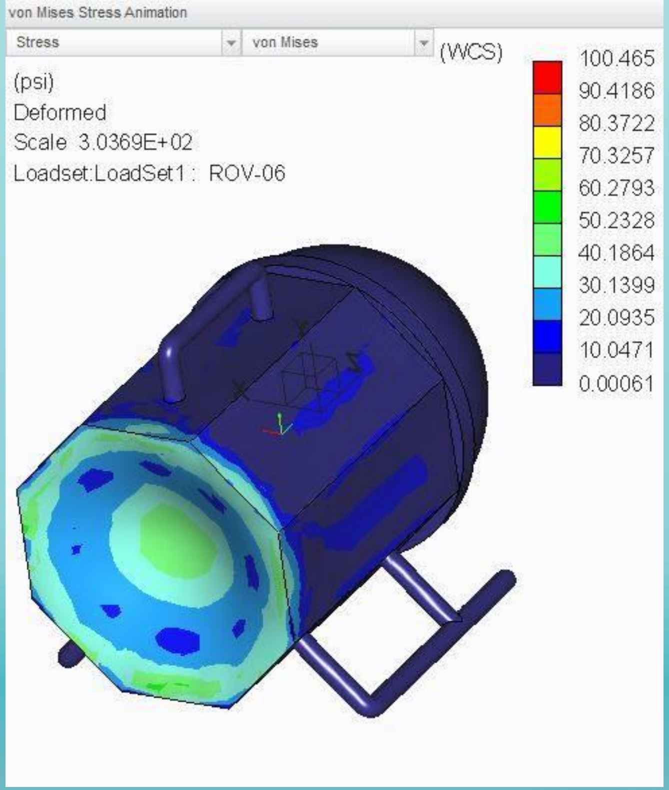
Stress Analysis – Frame 2

Displacement (in)



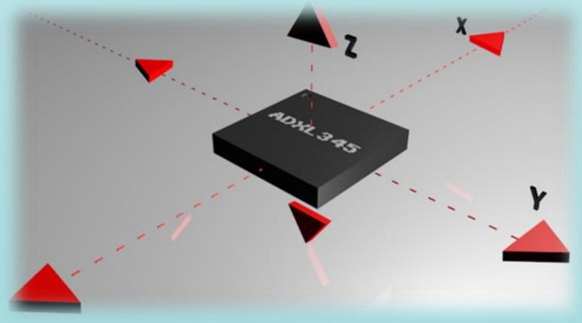
Von Mises Stress (psi)



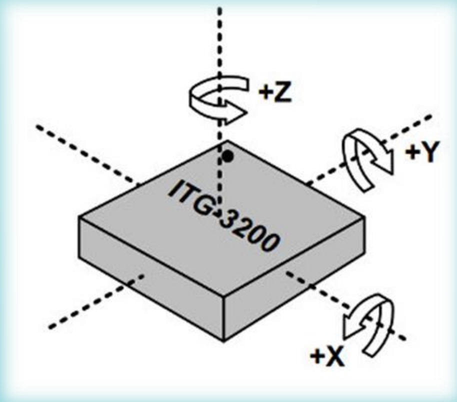
Juan

Control System

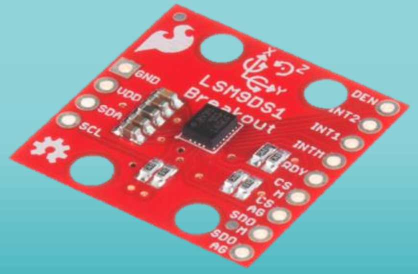
- Feedback Sensors:
  - Accelerometer.



  - Gyroscope.

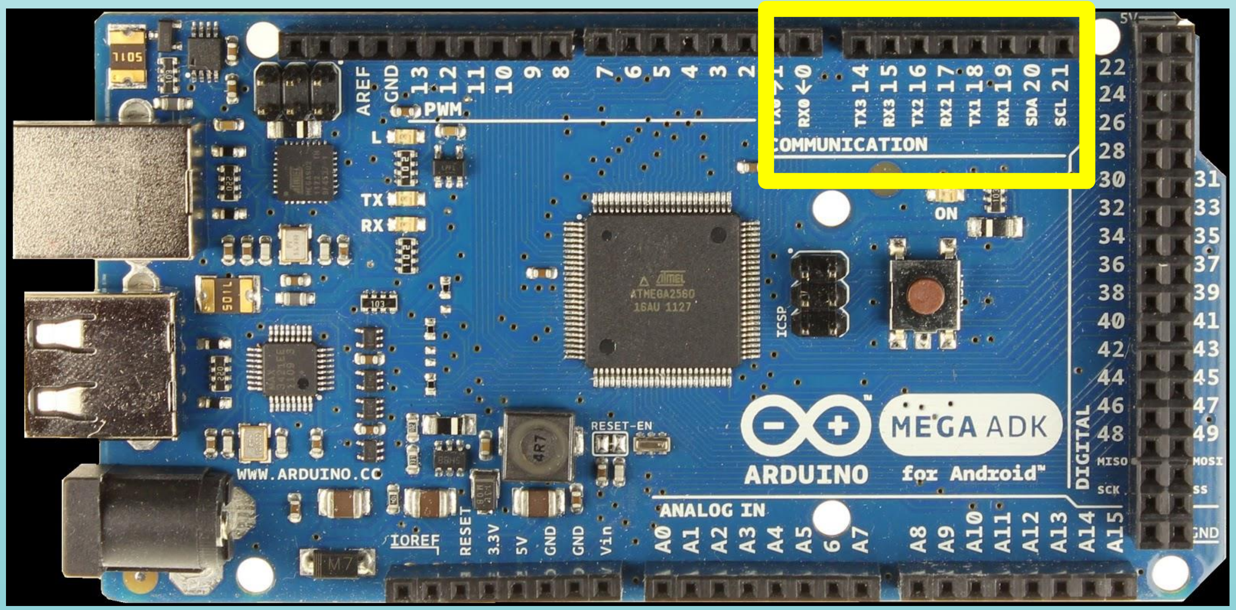


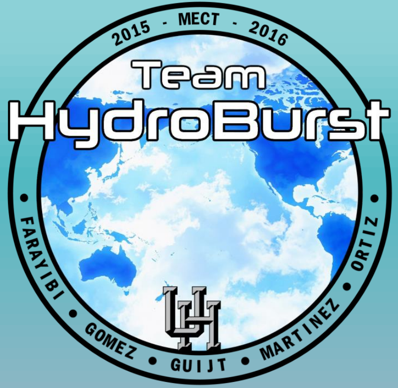
  - 3-in-1 Sensor: 9 Degrees of Freedom IMU (S24.95)
    - 3-axis accelerometer
    - 3-axis gyroscope
    - 3-acis magnetometer



Control System

- Communications:
  - UART.
  - I2C
  - USB Hub





Propulsion System

- Blue Robotics T100 Thruster
  - Price- $134.00 ea.
  - Motor Type- High efficiency brushless
  - Weight in air- 0.93 lb.
  - Max Power- 130W
  - Operating Voltage- 12 volts
  - Max Thrust 5.2:4 Forward (5.2 lbf) Reverse (4 lbf)
  - Min Thrust (0.03 lbf)

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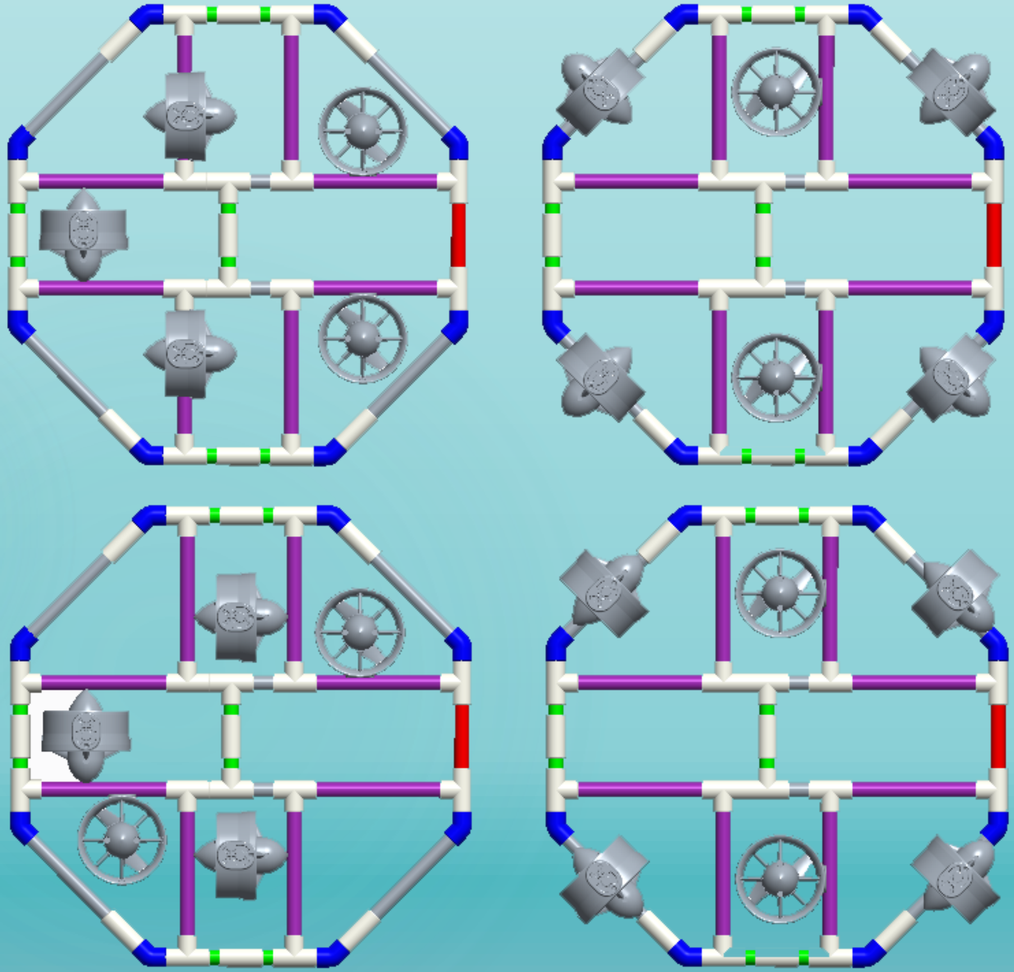
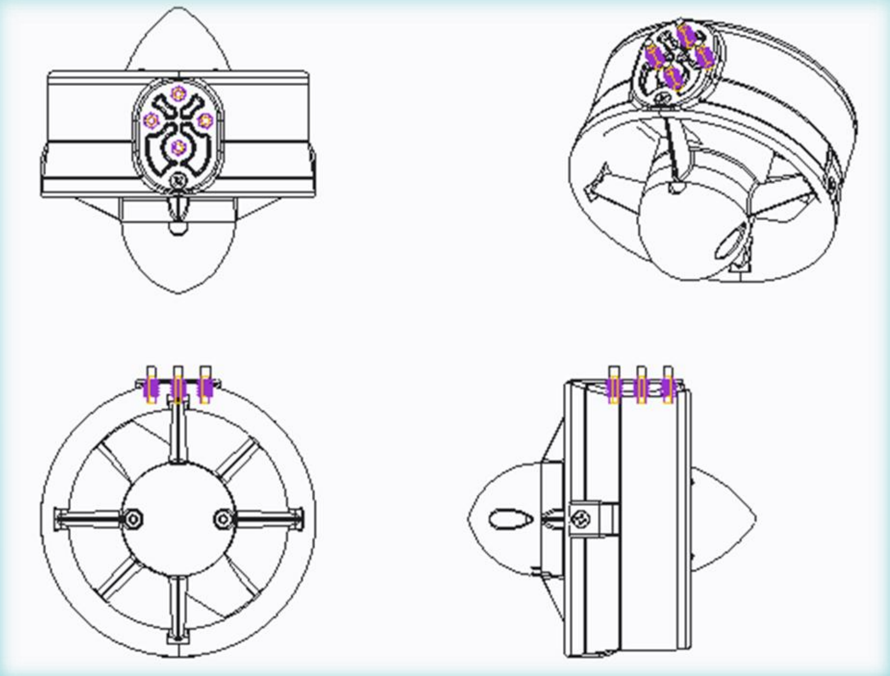
Thruster Positioning





Arms Update

Servo Motors vs. Stepper Motors

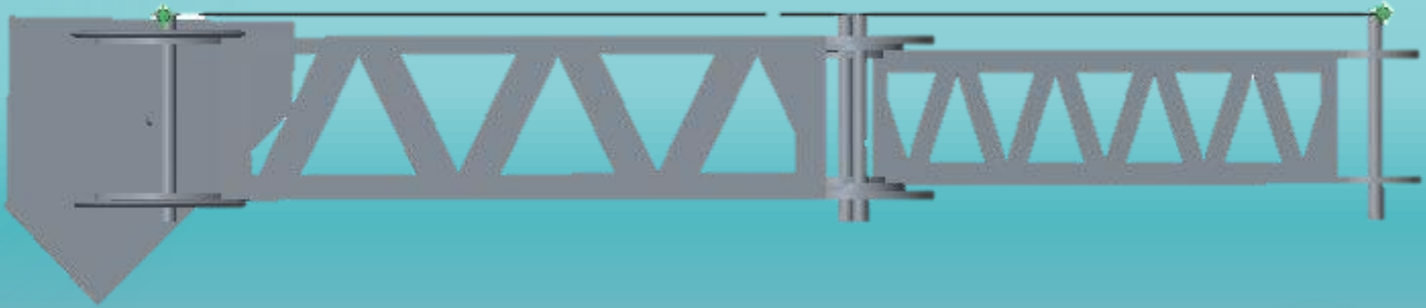
Servo Motor

- Fast
- High Torque
- Accurate Rotation With Limited Angle (≈180°)
- More complicated setup with PWM turning

Stepper Motor

- Slow
- Precise Rotation
- Requires External Control Circuit or Microcontroller
- Easy Set-Up & Control

Arms Update



Victor

Updated Project Budget

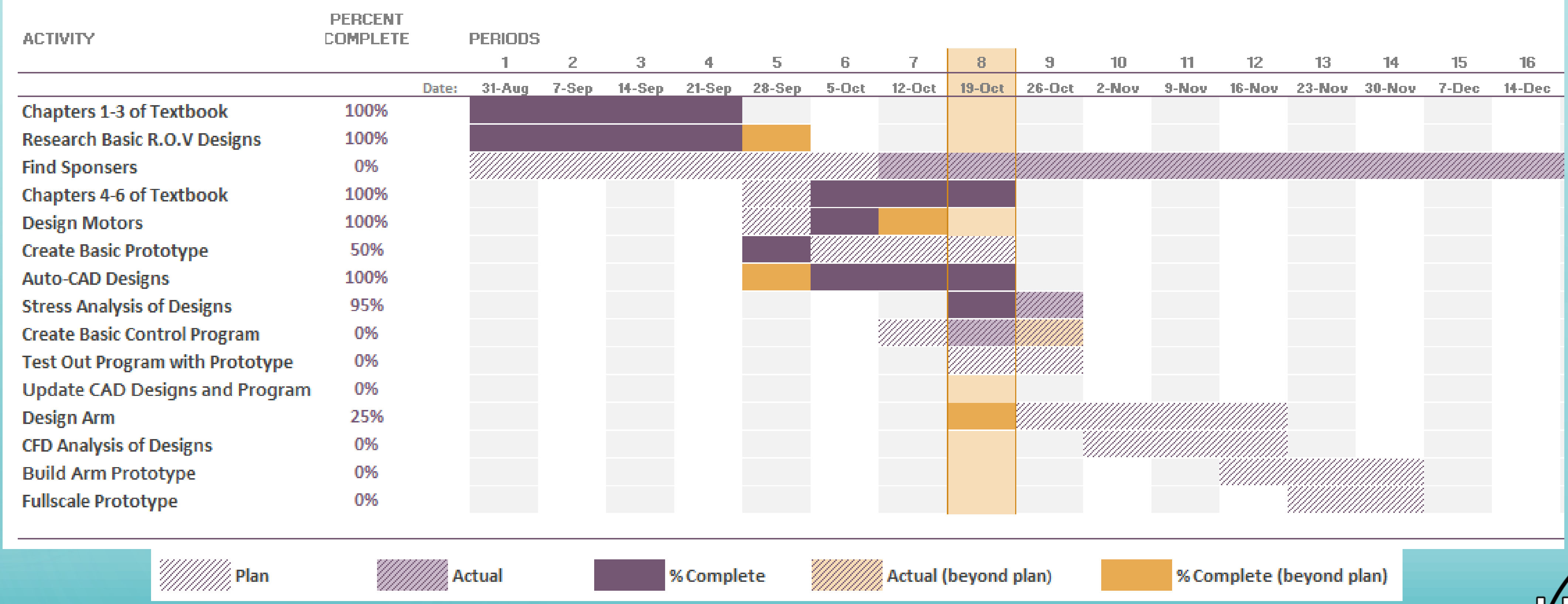
- Current Cash Flow:
  - Expenditures:
    - CPVC components ($86.35)
  - Income:
    - No Sponsors as of 10/19

- Planned Expenditures:
  - Final Frame - $100
  - Propulsion System - $800
  - Control System - $200
  - Arm Module - $700
  - Tether System - $200

  - Total - $2,000

Victor

Updated Gantt Chart



Gustav

Thank You for Listening!

Any Questions, Comments, or Concerns?