# System for Gathering Oceanographic Data in Littoral Regions

EX485M - Multidisciplinary Engineering Design

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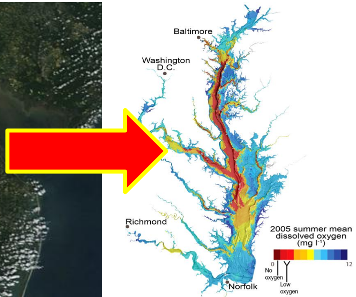
John Stevens

Embodiment Design Review Presentation
October 26, 2015
Academic Year 2016

CAPT J.P. Jones, USN, Team Mentor
Prof. J. Cousteau, Technical Advisor

## What is the Problem?

http://eoimages.gsfc.nasa.gov/images/imagerecords/52000/52169/ChesapeakeBay_tmo_2011256.jpg




http://www.virginiaplaces.org/chesbay/graphics/deadzone.png

## Problem Statement


http://amma-international.org/implementation/sites/ocean/journal/ronbrown.htm

Design and build a system which will allow scientists and researchers to gather oceanographic data rapidly, over a large search area in littoral regions.

## Customers

**CDR Andy Gish, USN, PhD**
USNA NAOE Department

**Prof. Joe Smith, PhD**
USNA Oceanography Dept.

## Current Methods/Benchmarks

http://www.noaanews.noaa.gov/stories2008/images/smartbuoy2.jpg

http://neptune.gsfc.nasa.gov/uploads/images_db/geo-cape2.jpg


http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/61E9A8C492C51D50C12574AB00441781/$file/Remus-100-Brochure.pdf?OpenElement

Joseph Curicio, John Leonard, and Andrew Patrikalakis, *SCOUT - A Low Cost Autonomous Surface Platform for Research in Cooperative Autonomy*, Marine Technology Society (OCEANS) Conference, 2005

Chesapeake BAYWATCH

# Project Motivation

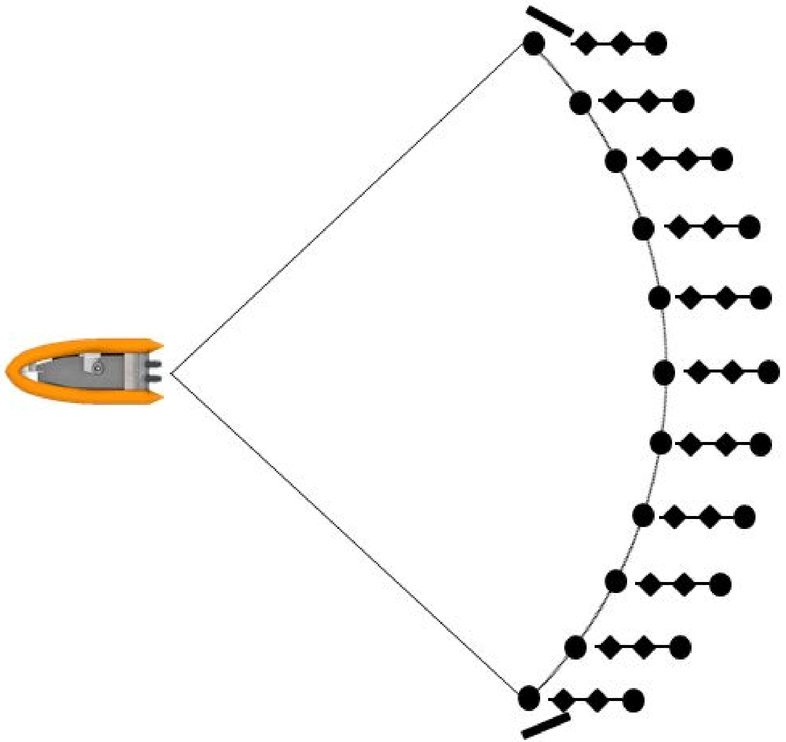
| Customer Requirements | Engineering Characteristics | Units | Direction of Improvement | Rank Order | Target |
|---|---|---|---|---|---|
| Be cheap | cost | $USD | ↓ | 1 | 300 |
| Take measurements and make them available to the user | samples stored/ transmitted | # | ↑ | 2 | 1,000 |
| Cover a specified search area in a reasonable time | search area | $m^2$ | ↑ | 3 | 50 |
| Cover a specified search area in a reasonable time | search rate | $m^2/s$ | ↑ | 3 | 33,000 |
| Cover a specified search area in a reasonable time | area coverage | % | ↑ | 5 | 9 |
| Be man-portable and launchable | mass | kg | ↓ | 6 | 25 |

Chesapeake BAYWATCH

# Revised CRs and ECs (Version 2)

- Conform to all applicable codes and standards
- Reflect positively on the U.S. Naval Academy

## Constraints (Version 2)



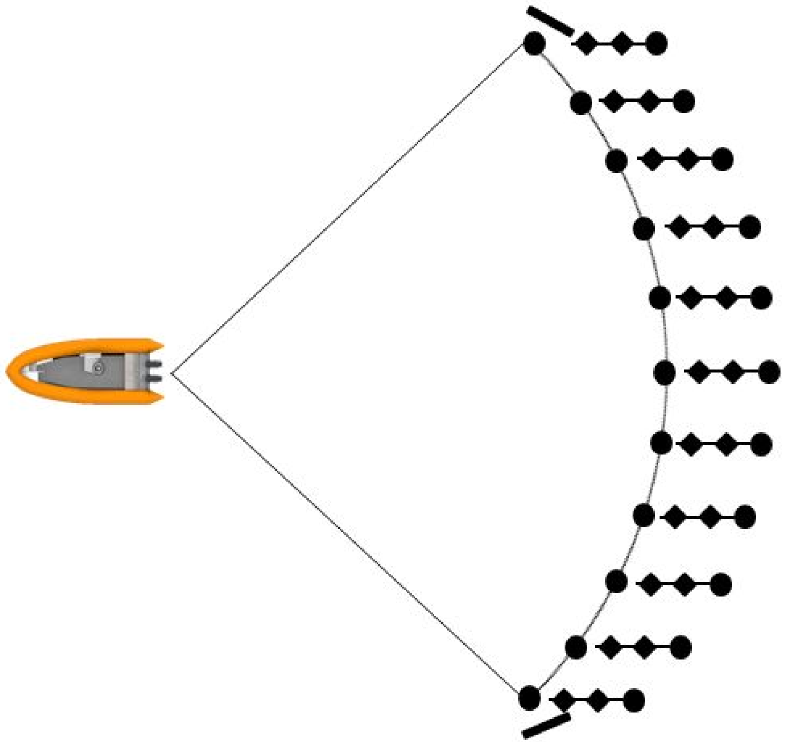
# Selected Design: *Swept Away*

# Embodiment Design

- End goal: scaled, **proof-of-concept model**
- **Calculations** to show full-scale feasibility
- **Plans and Bill of Materials** for full-scale prototype

# Review of Project Scope

1. Storage, transport, and support.
2. Cables and attachment.
3. Planar boards.
4. Sensor array.
5. Sensors suite and power supply.
6. Array control and steering.



# *Swept Away Subsystems*

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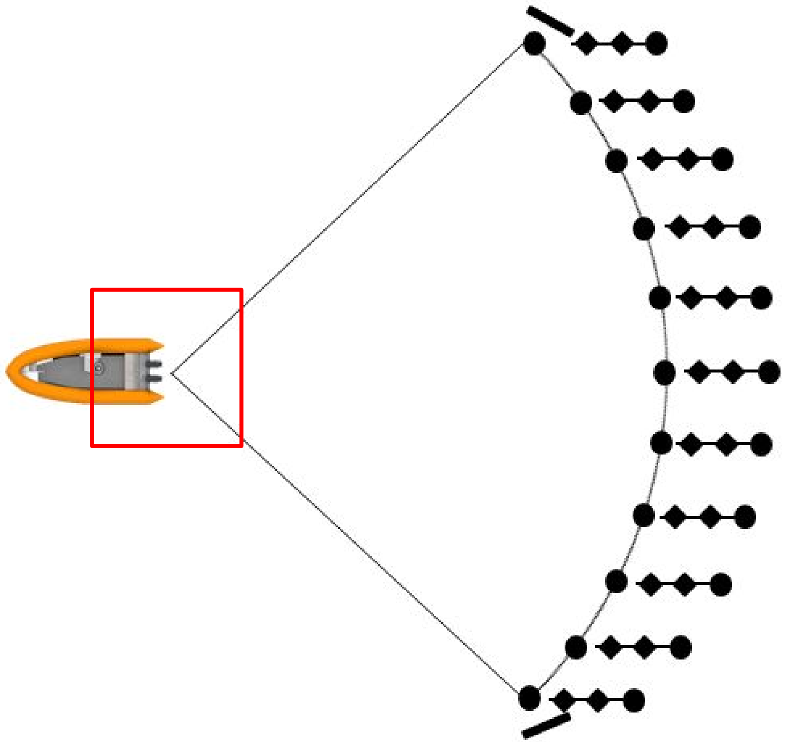

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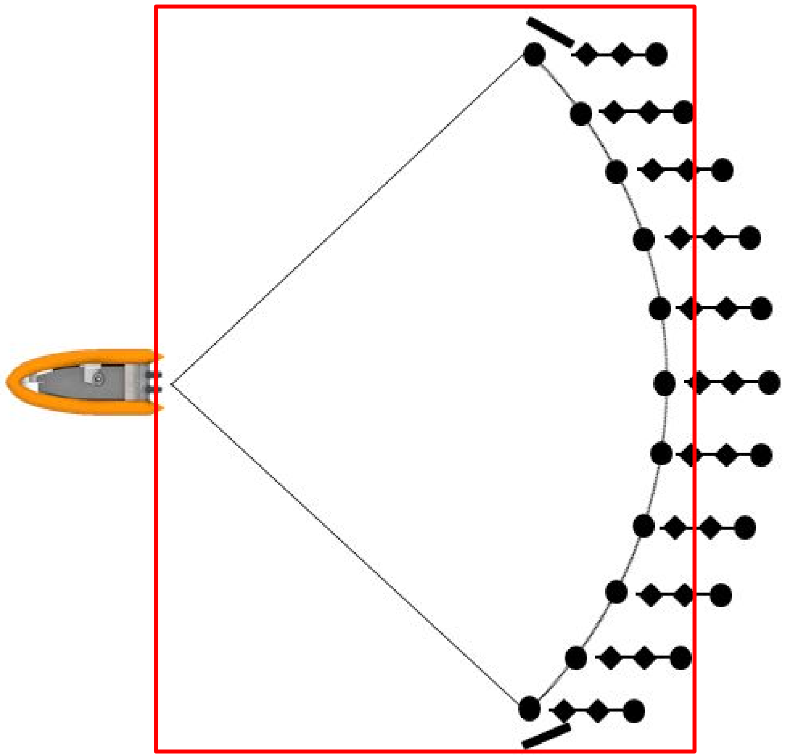

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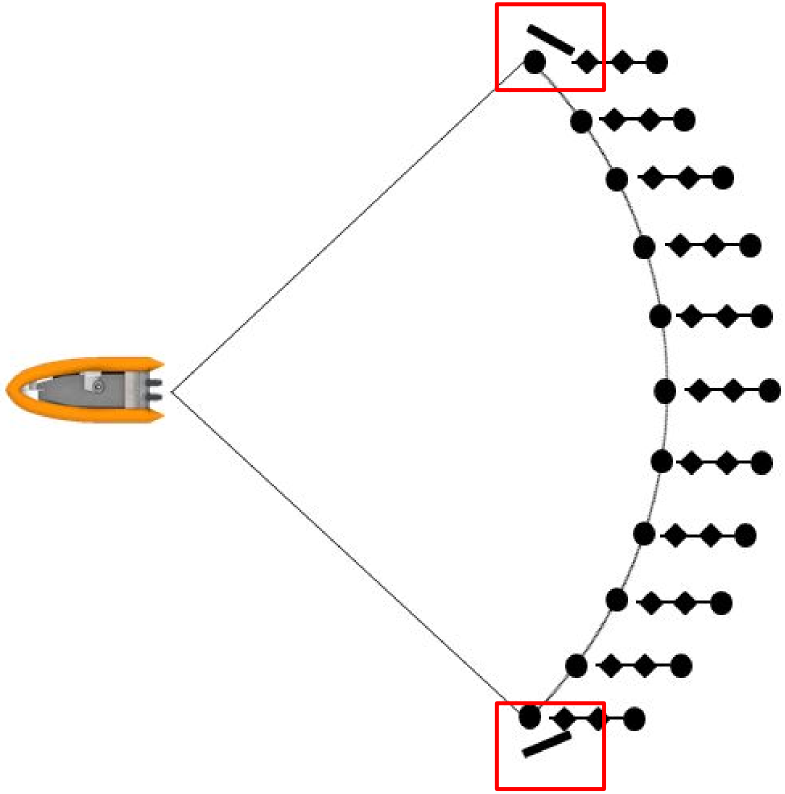

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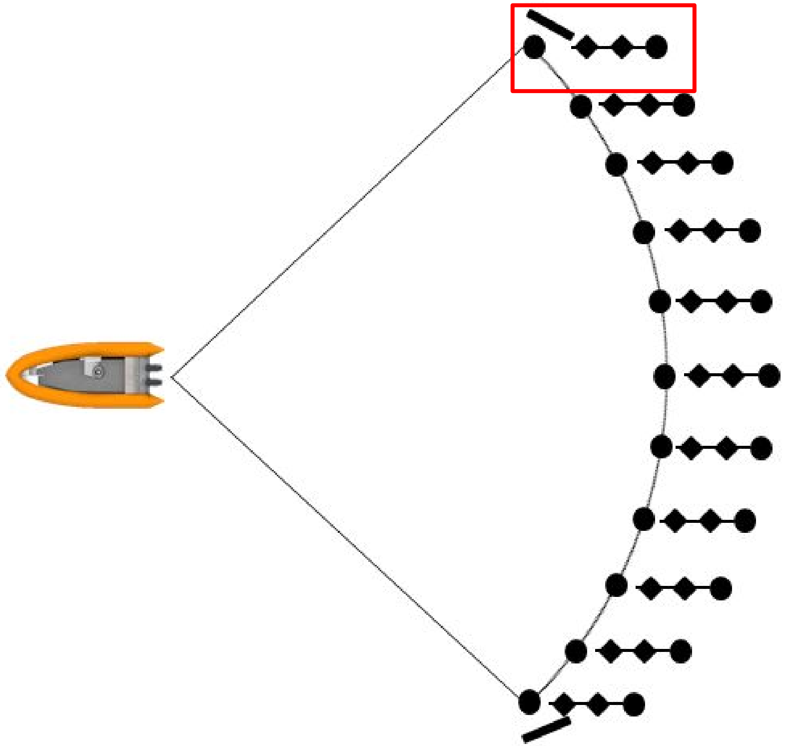

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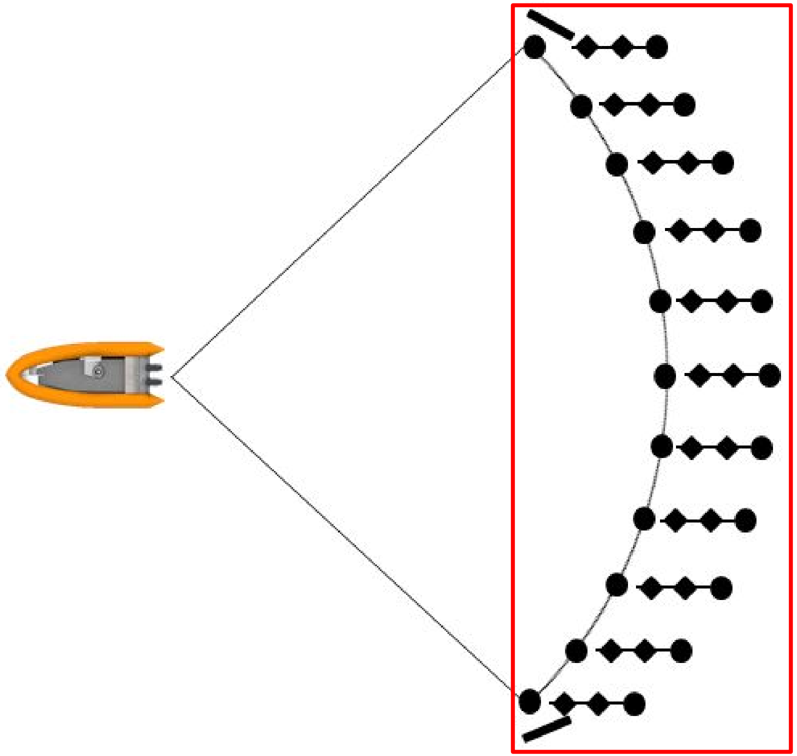

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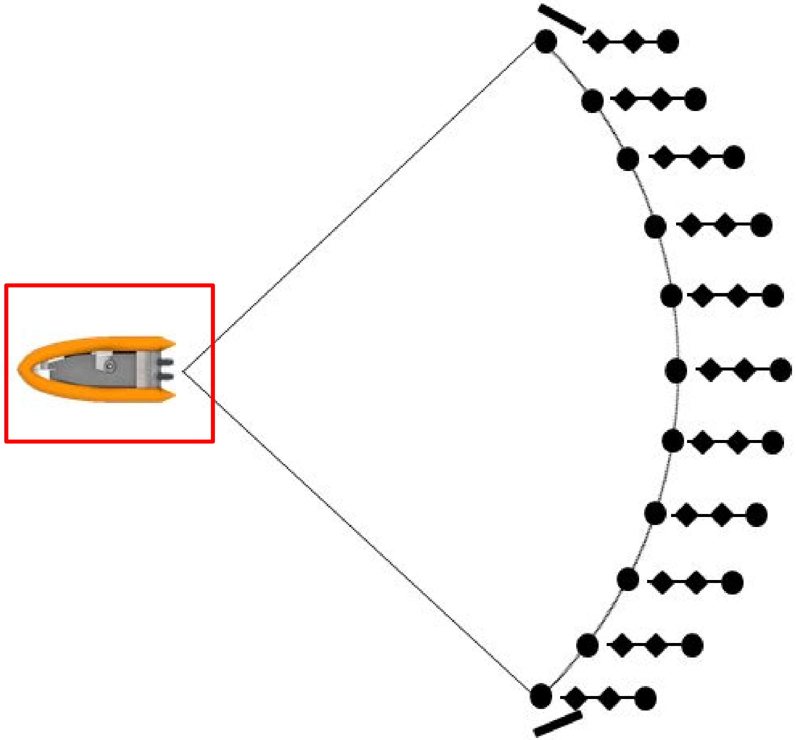
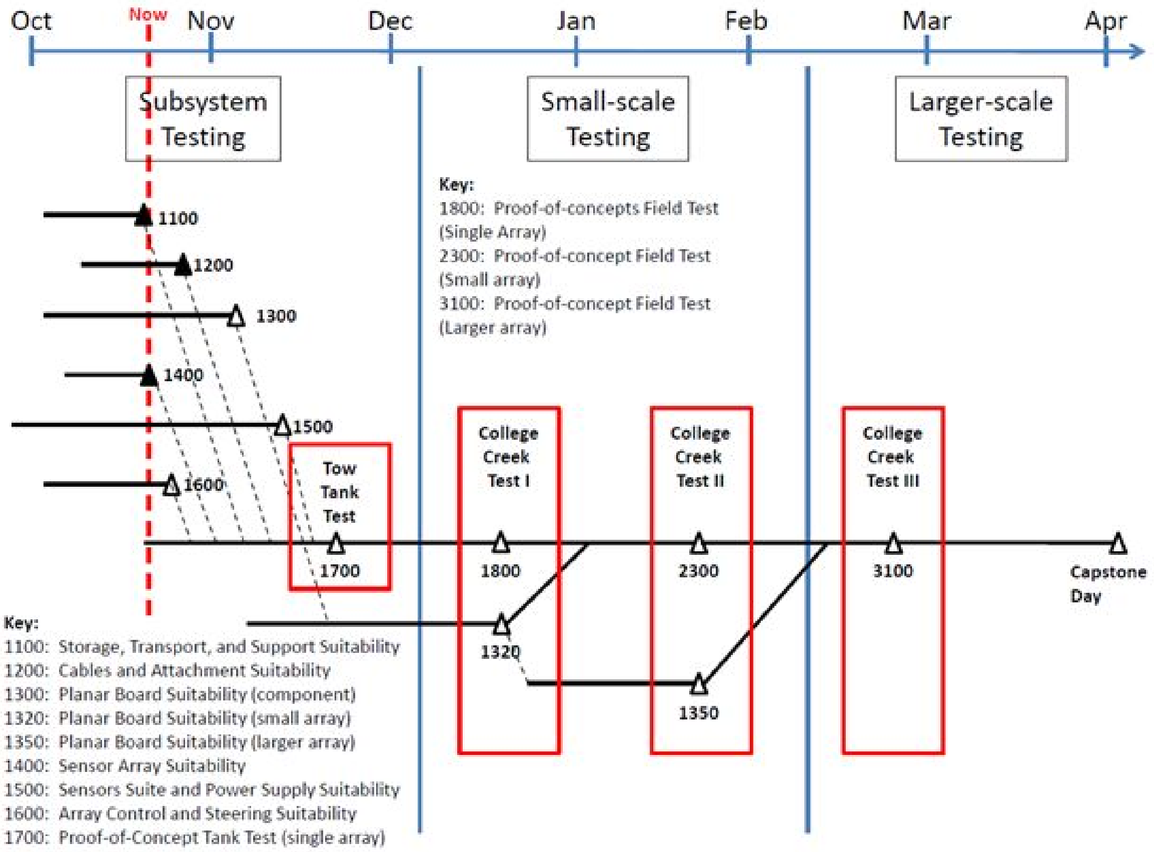


# Swept Away Subsystems

| | 1000 Series Test | 2000 Series Test | 3000 Series Test |
|---|---|---|---|
| | **Subsystem** | **Small-scale Prototype** | **Larger-scale Prototype** |
| **Benchtop/ Tow Tank** | 1100: Planar Board Suitability | | |
| | 1200: Storage, Transport, and Support Suitability | | |
| | 1300: Cables and Attachment Suitability | | |
| | 1400: Sensor Array Suitability - Single Array | | |
| | 1500: Sensors Suite and Power Supply | | |
| | 1600: Array Control and Steering | | |
| | 1700: Proof-of-Concept Tank Test (Integrated Single Array) | | |
| **Field Test (College Creek)** | 1800: Proof-of-Concept Field Test (Integrated Single Array) | | |
| | 1120: Planar Board Suitability - Small Array | 2300: Proof-of-Concept Field Test (Integrated Small Array) | |
| | 1150: Planar Board Suitability - Larger Array | | 3100: Proof-of-Concept Field Test (Integrated Larger Array) |

# Prototype Development Approach




Chesapeake Baywatch

# Test Plan Master Schedule

1. Storage, transport, and support.
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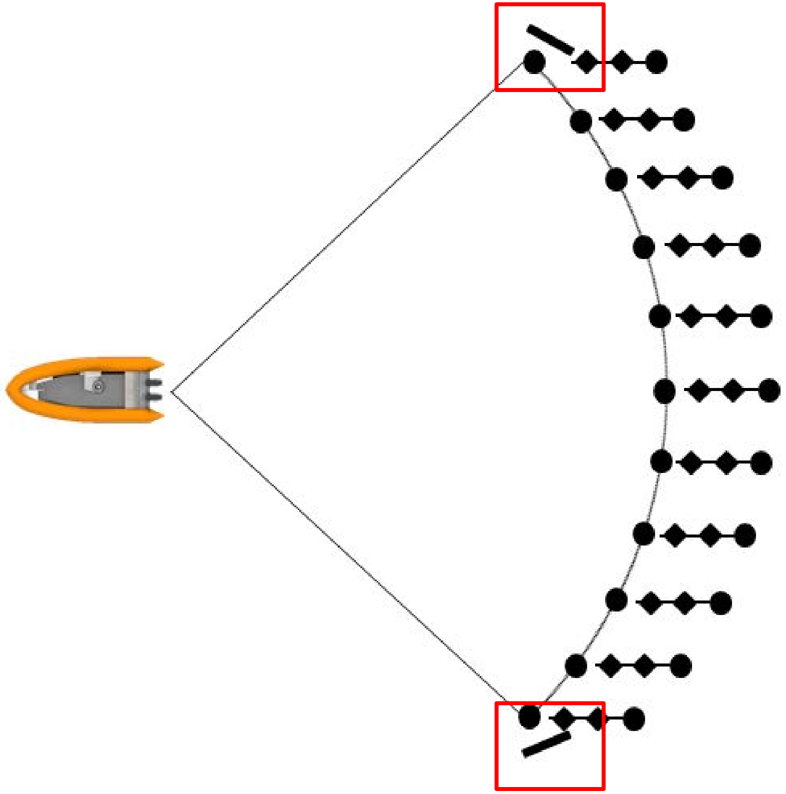


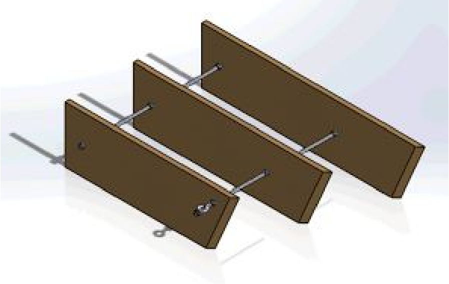
# Test 1100: Planar Board Suitability

# Test 1100: Objectives

- How should the planar boards be deployed?  Do they maintain directional **stability and orientation** without forward boat speed?
- How much **lift force** do they create?  How does the measured value compare to the predicted value?
- How much **drag force** do they create?  How does the measured value compare to the predicted value?
- What is the **spread angle** between the planar boards as a function of the boat (carriage) speed?
- What is a safe and **effective speed envelope** for the system under test?

# Bill of Materials (2 Sets of Planar Boards)

http://www.downtimecharters.com/Ideas/Planer_boards/boards.htm

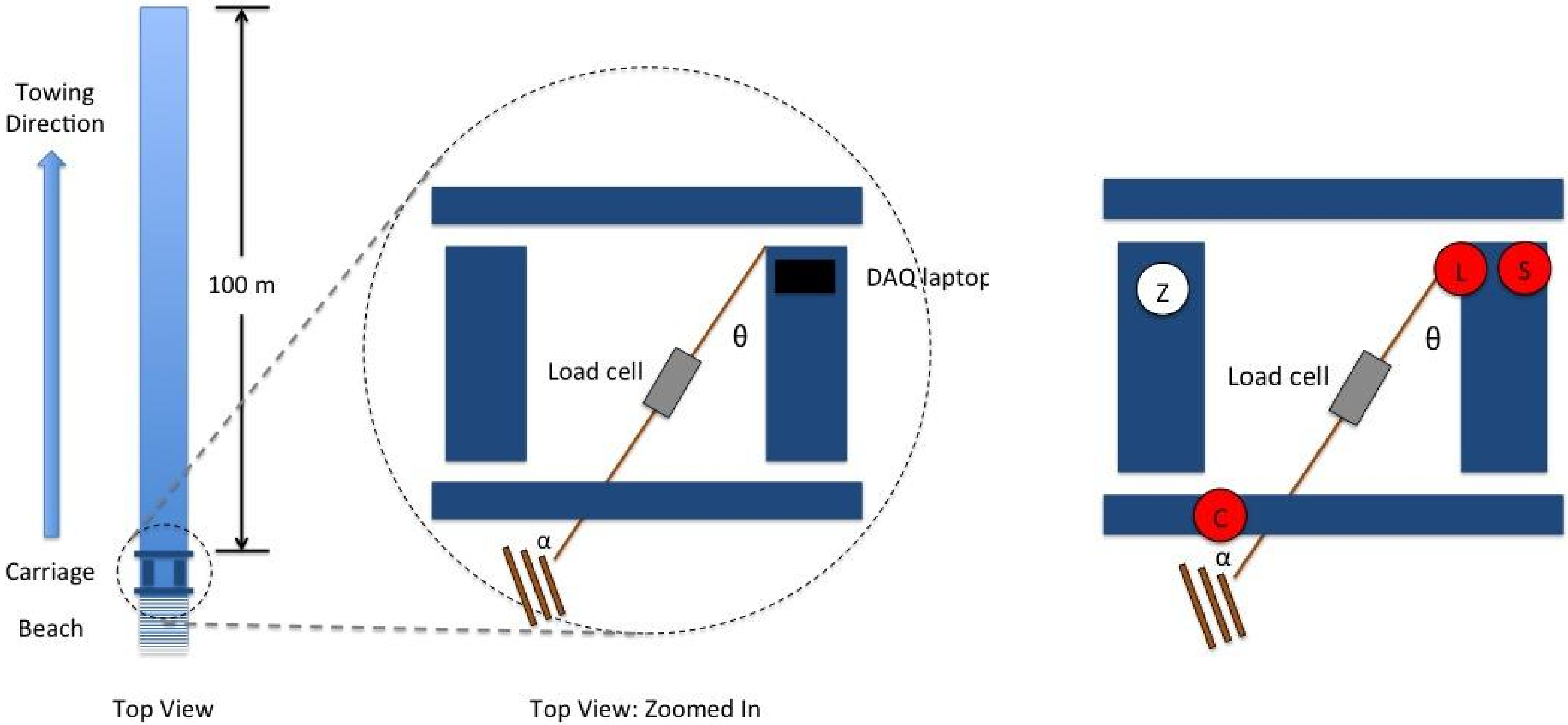


| Description | Number |
|---|---|
| 8’ x 10” x 1” pine board | 2 |
| ⅜”-16 stainless steel nuts | 30 |
| ⅜” x 1” stainless steel fender washers | 28 |
| ⅜”-16 x 6’ stainless steel all thread rod | 2 |
| ⅜”-16 x 3” stainless steel eye bolt | 2 |
| ½” polyester yacht braid - 25’ (9,100 lbf. limit) | 1 |

| | |
|---|---|
| Freeboard | 5 in. |
| Angle of Attack | 20° |
| Spread Angle | 45° |
| Lift Force (@ 5 kts and 20° AOA) | 500 lbf. |
| Drag Force (@ 5 kts and 20° AOA) | 90 lbf. |

Calculations

# Test 1100: Predicted Performance




# Test 1100: Experimental Setup

| Hazard | Probability | Consequence | Assessment | Controls |
| --- | --- | --- | --- | --- |
| Falling off the carriage, into the water | Unlikely | Negligible | Low | • Safety observer<br>• All participants can swim |
| Line parting | Unlikely | Marginal | Low | • Hydrolab staff double-check rigging<br>• Oversized shackle<br>• Increment speed over several runs |
| Injury due to abrupt carriage stop | Possible | Marginal | Moderate | • “All ready” call to start (bells also)<br>• All riders seated or holding on at all times |
| Planar boards impacting tank wall | Possible | Marginal | Moderate | • Use minimum line length<br>• Increment speed over several runs |

# Test 1100: ORM Assessment

| Description | Units | Cost Per Unit ($USD) | Subtotal ($USD) | Remaining Balance ($2,000 provided) |
| --- | --- | --- | --- | --- |
| 8’ x 10” x 1” pine board | 2 | 52.00 | 104.00 | 1896.00 |
| ⅜”-16 stainless steel nuts | 30 | 1.18 | 35.40 | 1860.60 |
| ⅜” x 1” stainless steel fender washers | 28 | 0.69 | 19.32 | 1841.28 |
| ⅜”-16 x 6’ stainless steel all thread rod | 2 | 28.91 | 57.82 | 1783.46 |
| ⅜”-16 x 3” stainless steel eye bolt | 2 | 3.28 | 6.56 | 1776.90 |
| ½” polyester yacht braid (cost per foot) | 100 | 2.08 | 208.00 | 1568.90 |

# Budget: Current Balance

# Questions?

```
%% Test 1100 - Planar Board Suitability Calculations
clear; close all; clc

% physical description

%# constants
g_c = 32.2; %gravitational constant, ft/s^2
g = 32.2; %acceleration due to gravity at the earth's surface, ft/s^2

%# density/mass properties
SG_pine = 0.45; %specific gravity of pine (est.) from www.engineeringtoolbox.com
rho_water = 62.4; %density of fresh water, lbm/ft^3
rho_pine = SG_pine * rho_water; %density of pine wood

%# dimensions
tl1 = 36; %top length of the largest of the three boards, in.
bl1 = 32; %bottom length of the largest of the three boards, in.

tl2 = 32; %top length of the middle of the three boards, in.
bl2 = 28; %bottom length of the middle of the three boards, in.

tl3 = 28; %top length of the smallest of the three boards, in.
bl3 = 24; %bottom length of the smallest of the three boards, in.
t = 1; %board thickness
h = 10; %height of the boards, in.
d = 10.5; %the distance between the boards, in.

% define a function to calculate the planform area of the planar boards
area = @(tl,bl,h) bl*h + 0.5*(tl-bl)*h;
a = [area(tl1,bl1,h),area(tl2,bl2,h),area(tl3,bl3,h)] ; %the planform area of the board (from largest to smallest), in.^2
v = a.*t.*(1/12)^3; %the volume of the boards (from largest to smallest), ft.^3
v_boards = sum(v);

% calculate the maximum angle of attack for which there is no anticipated interference of one board with the ones behind it
alpha_max = atand(d/tl3); %maximum angle of attack, in deg.

% calculate how deep the planar boards are expected to sit in the water
% (assume hardware weight is small compared to the weight of the boards)

% first, calculate the expected weight of the planar boards
m_boards = rho_pine .* v; %the mass of the boards (largest to smallest), lbm
w_boards = sum(m_boards) * g/g_c + 1; %weight of the boards, lbf.

% calculate the mitre on the planar boards
mitre_angle = atand((tl1-bl1)/h);

% calculate the submerged volume required
v_water = w_boards * g_c /(rho_water*g);

% calculate the associated depth
A = 3/2*t*tand(mitre_angle);
B = t*(bl1 + bl2 + bl3);
C = -v_water*(12^3);
p = [A, B, C];

z = real(roots(p)); %the submerged depth of the planar boards, in.
freeboard = h-z;
```

Return

```
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clear; close all; clc

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v = a.*t.*(1/12)^3; %the volume of the boards (from largest to smallest), ft.^3
v_boards = sum(v);

% calculate the maximum angle of attack for which there is no anticipated interference of one board with the ones behind it
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p = [A, B, C];

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freeboard = h-z;
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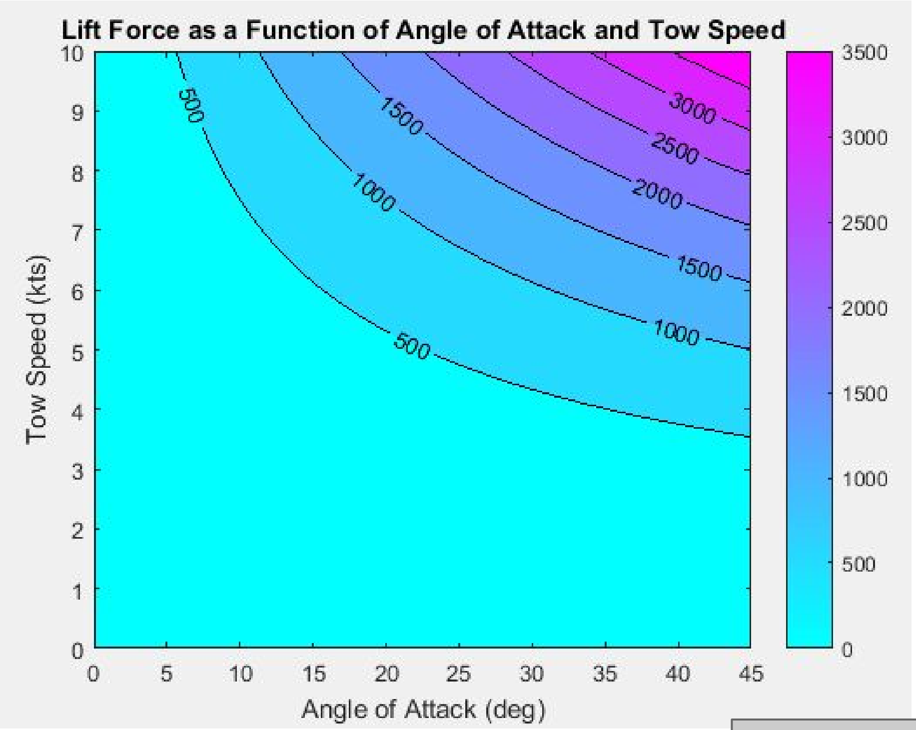
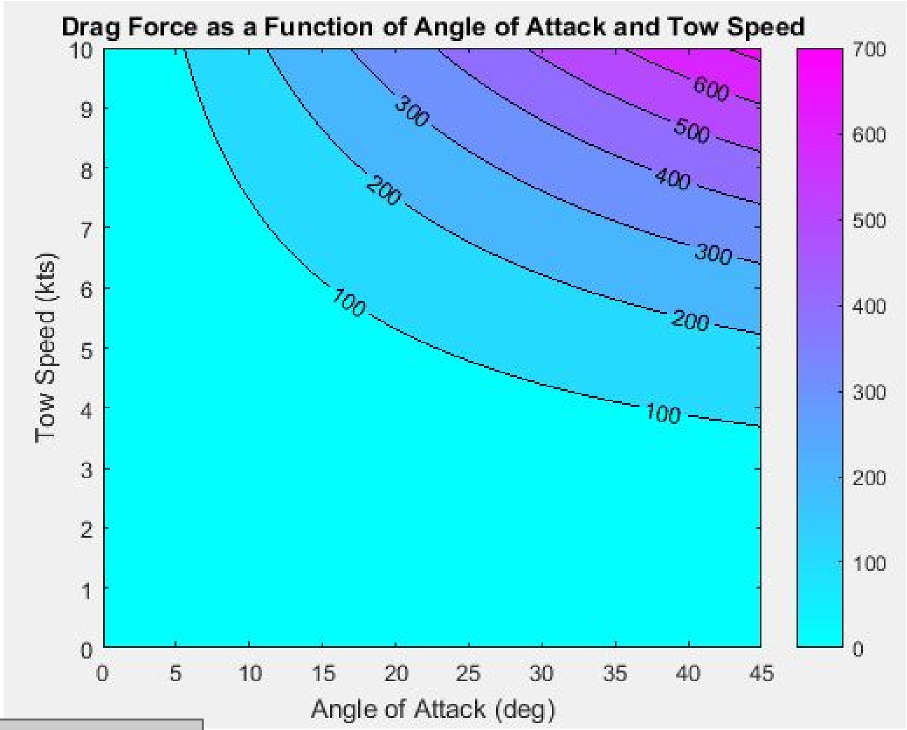
Return

# Test 1100: Prototype Detail Design (Backup)

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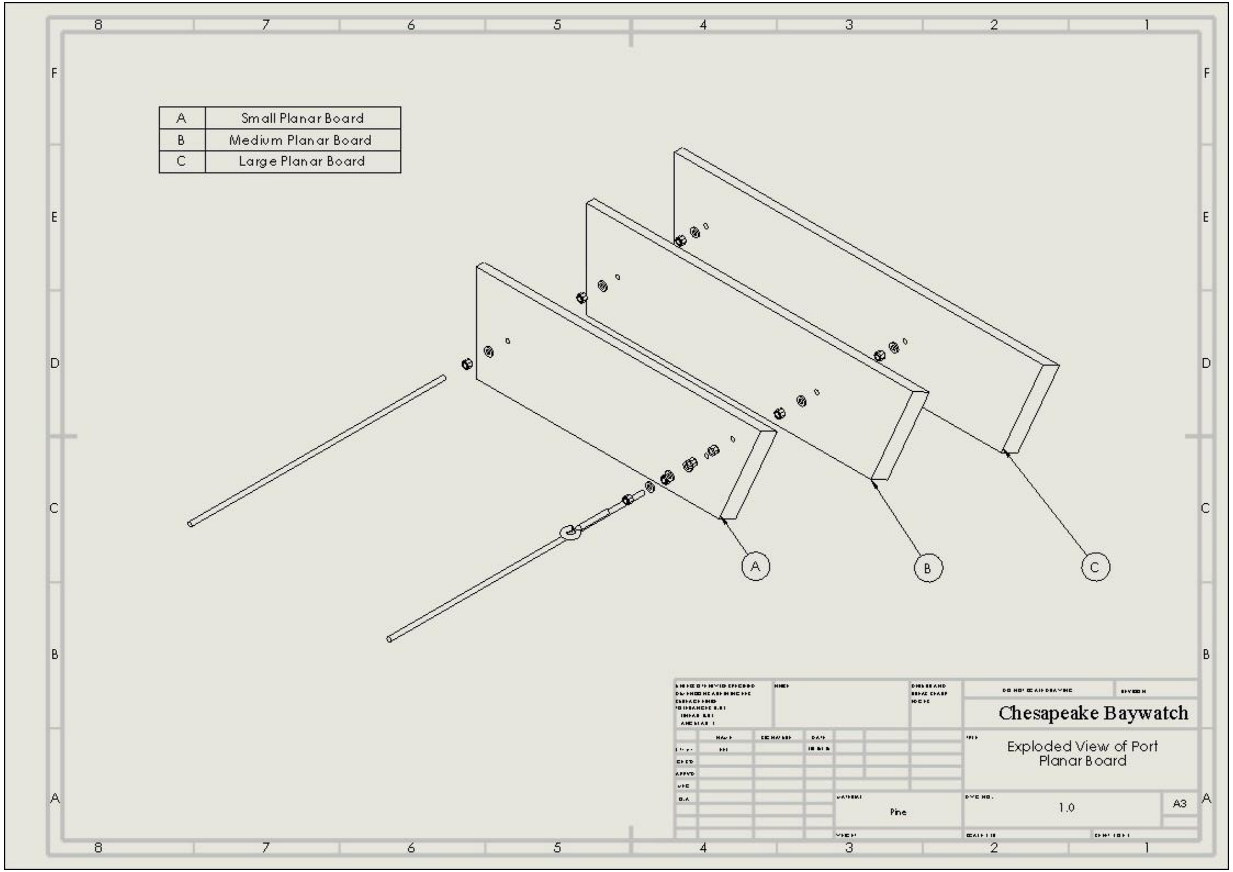


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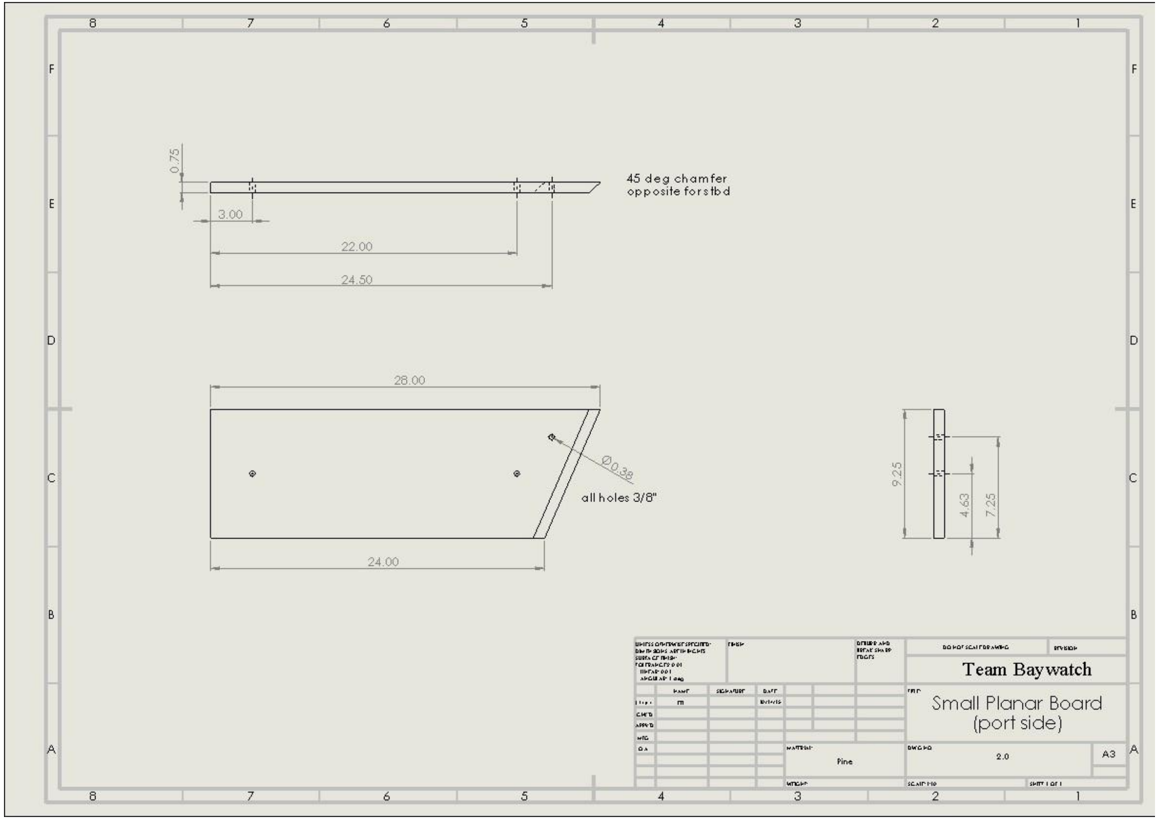


# Test 1100: Prototype Detail Design (Backup)

- Detail design now called embodiment design
- Design, build, test, repeat!
- Design must include modeling and analysis!
- Missing from <u>this</u> presentation:
  - Results, analysis, and discussion
  - Conclusions
- Professional narrative of prototyping process from EDR to Final Report
- Tailor discussion to project progress
- End with Detail Design in May
- New format for the Executive Summary - direct input to website

# Slide Title