

Autonomous Vehicle for Gathering Oceanographic Data in Littoral Regions

EX485M - Multidisciplinary Engineering Design

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John Stevens

Preliminary Design Review Presentation
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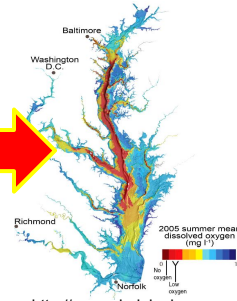
CAPT J.P. Jones, USN, Team Mentor
Prof. J. Cousteau, Technical Advisor



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 an autonomous vehicle for scientists to use in gathering oceanographic data in littoral regions.

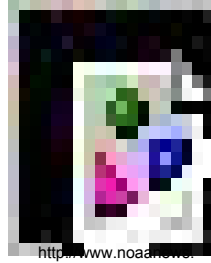
Customers



CDR Andy Gish, USN, PhD
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<http://www.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](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

Current Methods/Benchmarks



Project Motivation



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



Customer Requirements and Engineering Characteristics

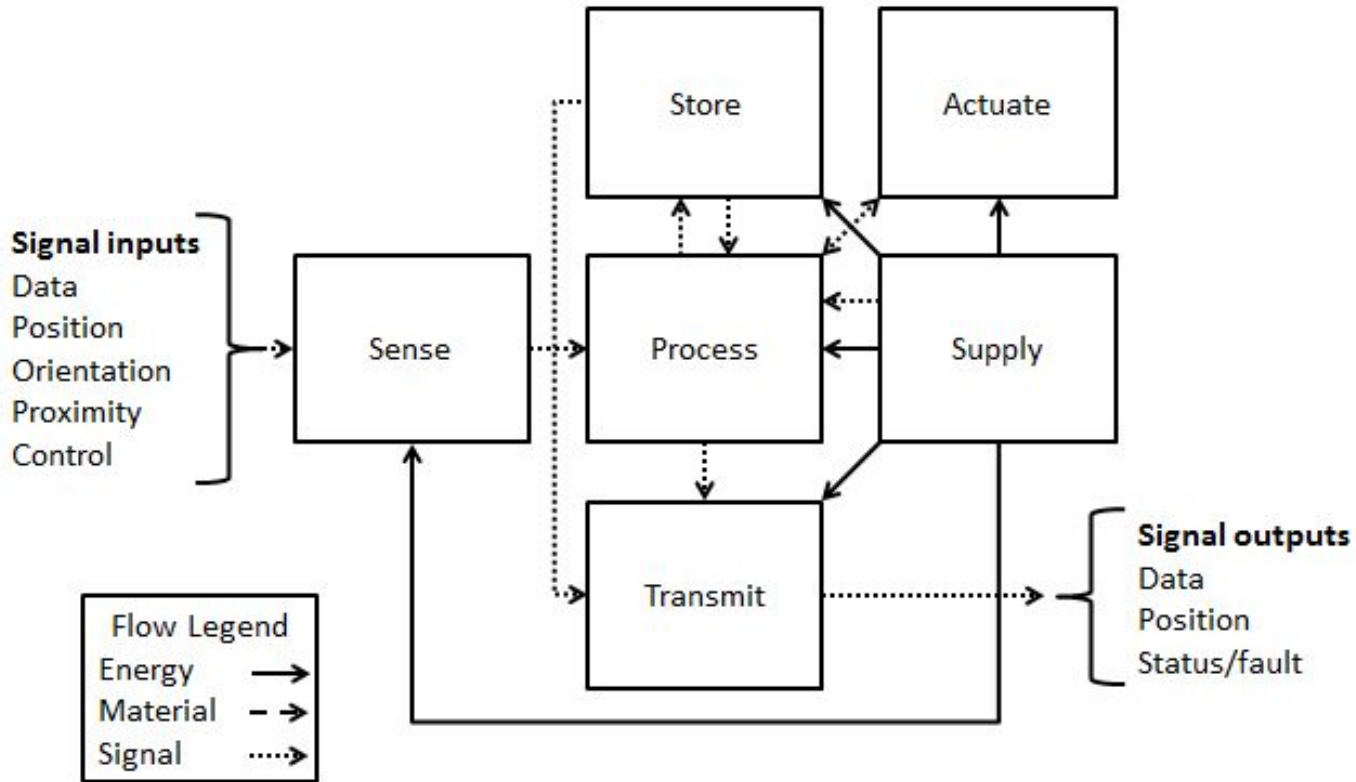


- Operate autonomously
- Conform to all applicable codes and standards
- Does not look like a weapon
- Reflect positively on the U.S. Naval Academy



Constraints





Design Methods: Functional Decomposition

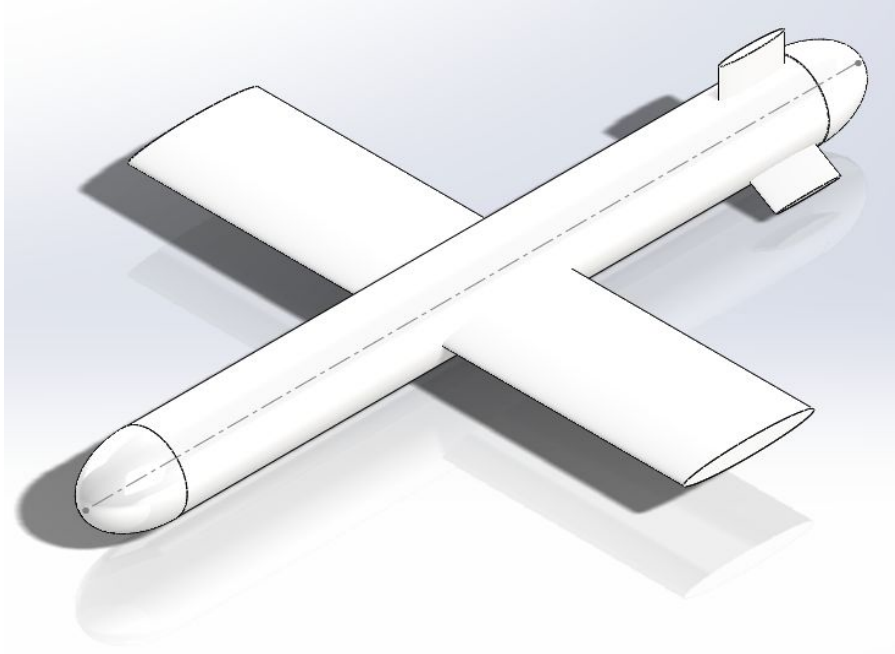


Function	Means					
Sense (measurements)	Digital	Sample collection				
Sense (position)	GPS	INS (partial)	Triangulation	Physical reference to known position		
Sense (proximity)	Light (laser, IR)	Sound (Ultrasonic)	Bumper	Accelerometer	Pressure sensor	
Sense (control)	WiFi receiver	Cellular receiver	Radio receiver			
Process	Arduino	Raspberry Pi	Picaxe	Launchpad		
Store	Micro SD					
Actuate	Propeller	Buoyancy engine	Flapping fins	Water jet	Sail	Currents/drift
Supply	Battery	Solar panel	Directed energy	Fuel tank		
Transmit	WiFi	Cellular	Radio			



Design Methods: Morphology Design



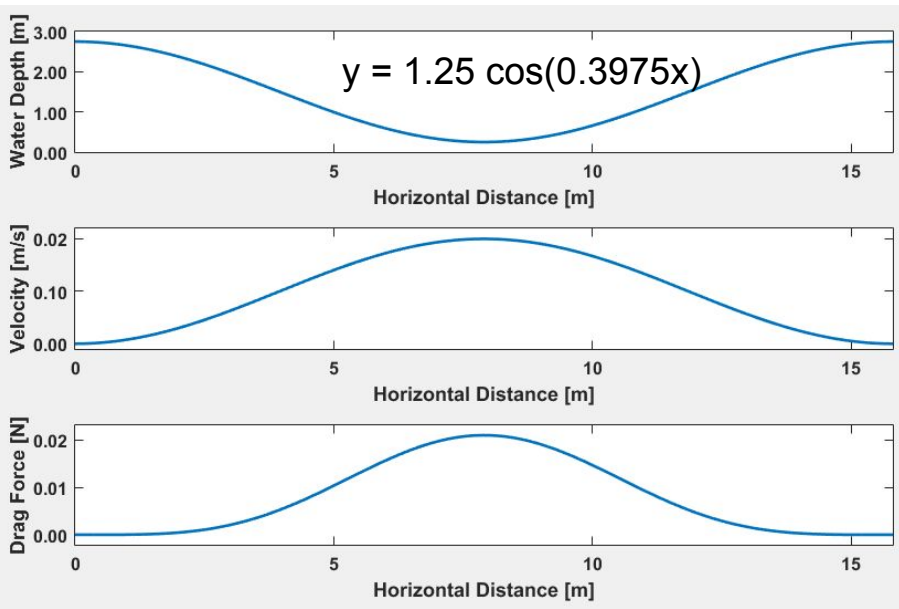


Engineering Characteristics	Units	Target Values	Predicted Performance
<u>cost</u>	\$USD	1,000	1,550
samples stored/ transmitted	#	20,000	6,100
search area	m ²	1,800,000	152,350
search rate	m ² /s	12	0.5
area coverage	%	50	100
<u>mass</u>	kg	25	21

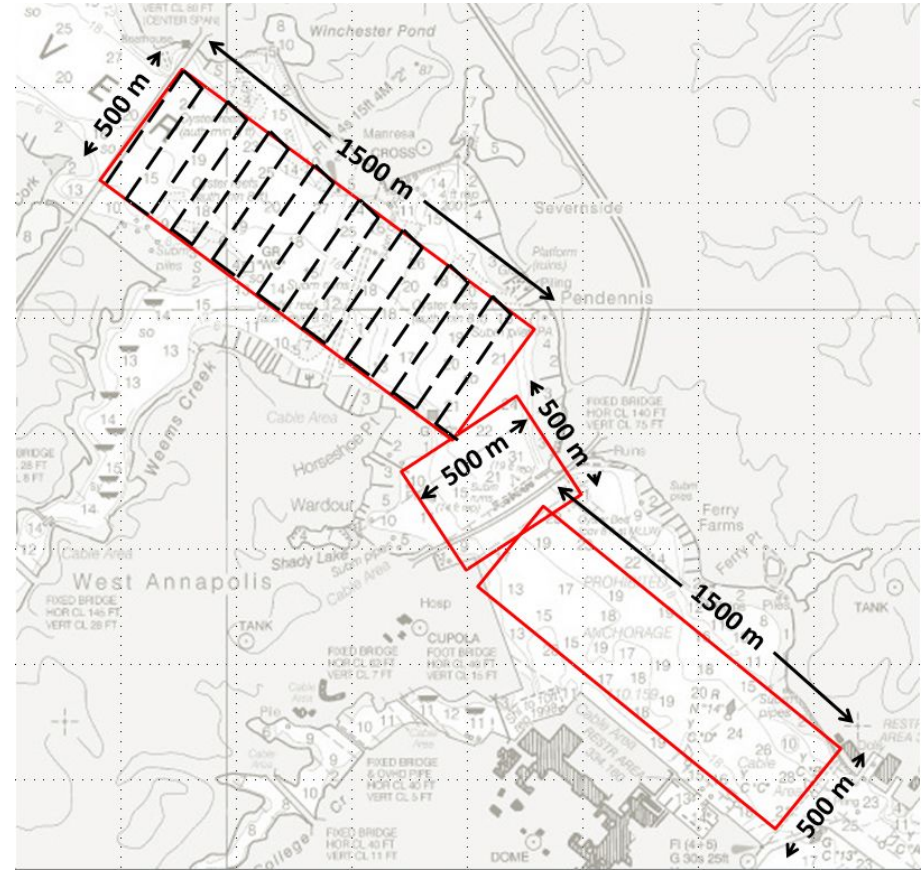


Design Concept 1: "Trapped Beneath the Sea, Part I"



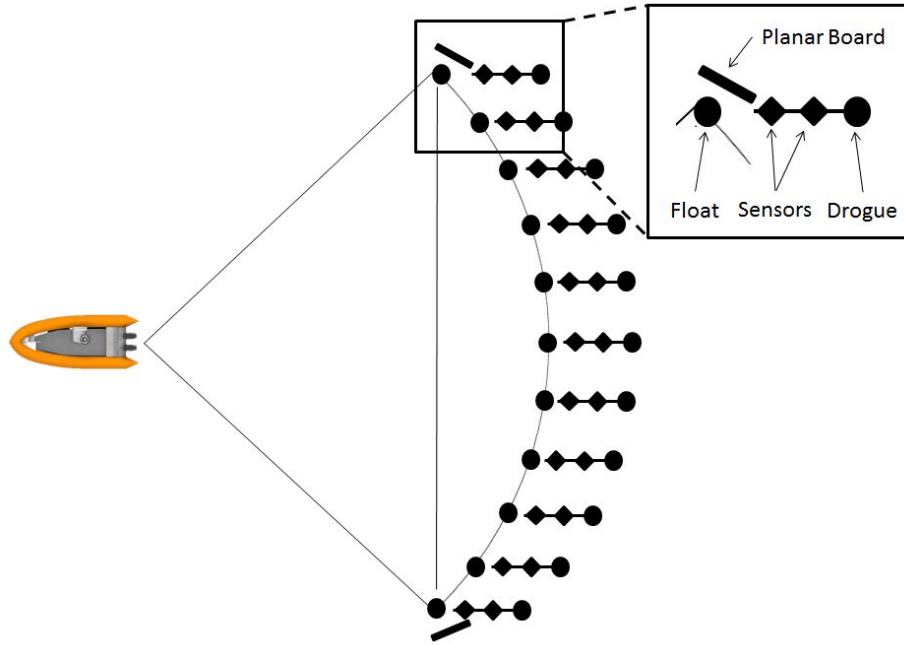


Avg. horizontal speed: 0.1 m/s (Simonetti 1991)
 Battery capacity: 50 Ah
 Operational time: 85 hrs.
 Track length: 30.5 km
 Turn radius: < 5 m (Simonetti 1991)



Design Concept 1: "Trapped Beneath the Sea, Part I"



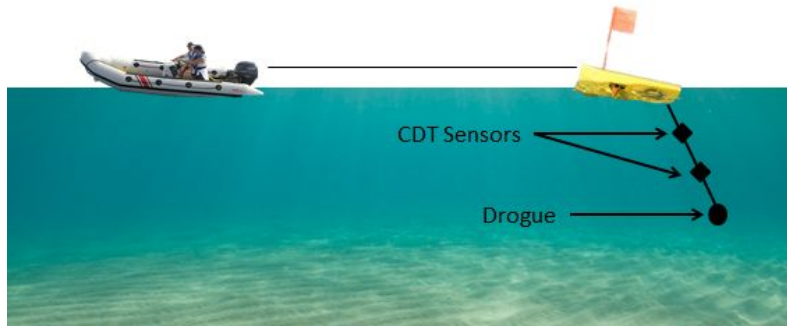
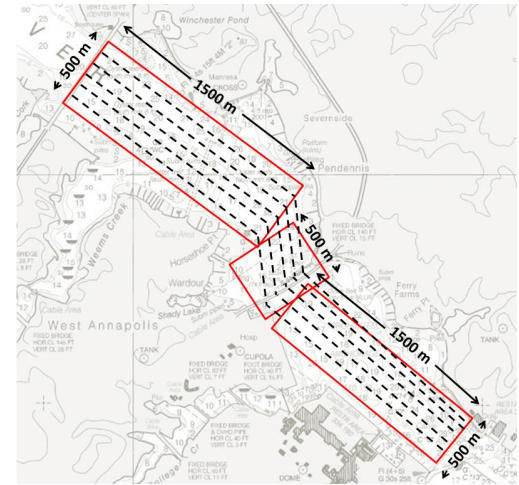
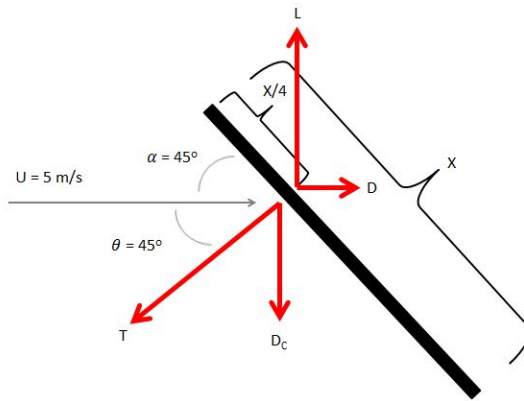
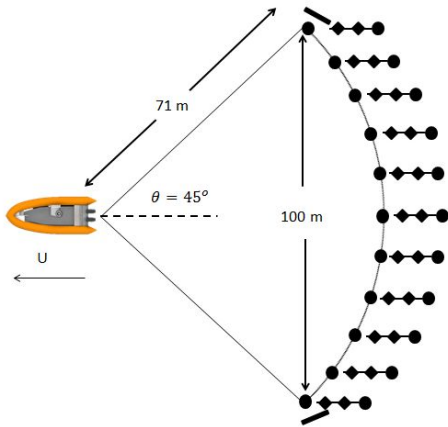


Engineering Characteristics	Units	Target Values	Predicted Performance
<u>cost</u>	\$USD	1,000	4,780
samples stored/ transmitted	#	20,000	77,000
search area	m ²	1,800,000	1,800,000
search rate	m ² /s	12	500
area coverage	%	50	100
<u>mass</u>	kg	25	90



Design Concept 2: "Swept Away"





- Boat speed: 5 m/s
- Cable drag: 1,000 lbf.
- Planar board area: 0.0448 m² (6 in. x 12 in.)
- Track distance: 17.5 km
- Total Time: 1 hr.
- Total fuel: 2.5 gal.



Design Concept 2: "Swept Away"



Rank Order	Engineering Characteristic	Units	Target Values	Trapped Beneath the Sea: Part I (AUV - glider)	Swept Away (towed array)
1	cost	\$USD	1,000	1,550	4,780
2	samples stored/ transmitted	#	20,000	6,100	77,000
3	search area	m ²	33,000	152,350	1,800,000
3	search rate	m ² /s	12	0.5	500
5	area coverage	%	50	100	100
6	mass	kg	25	21	90



Design Concepts Performance Summary



Constraint	Trapped Beneath the Sea: Part I (AUV - glider)	Swept Away (towed array)
Operate autonomously	Yes	No, but approved by customer
Conform to all applicable codes, standards, and regulations	Yes	Yes
Does not look like a weapon	Yes	Yes
Reflect positively on the U.S. Naval Academy	Yes	Yes



Satisfaction of Constraints

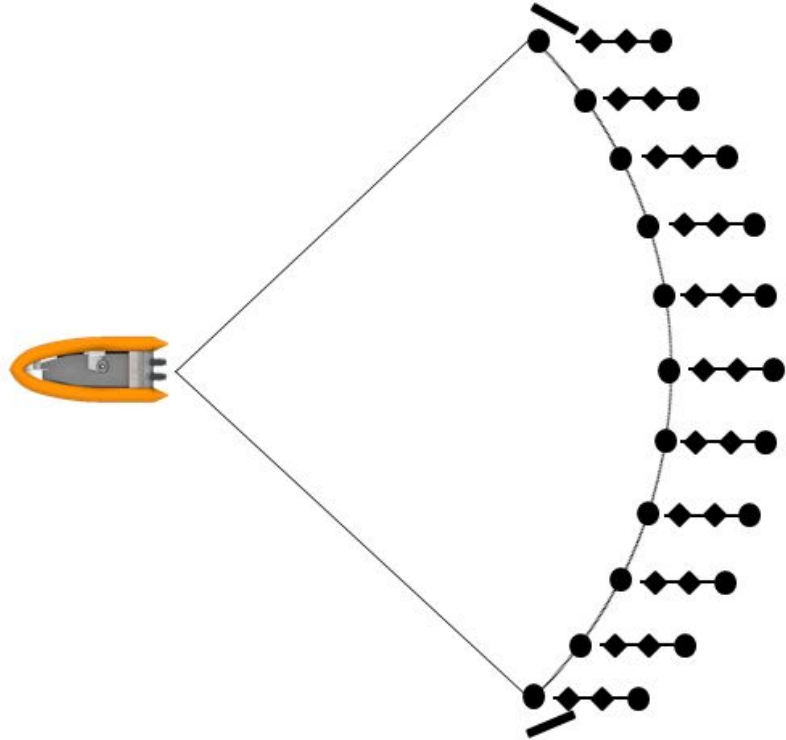


			<i>Trapped Beneath the Sea: Part I Autonomous Glider</i>			<i>Swept Away Towed Array</i>		
Engineering Characteristic	Units	Weight Factor	Magnitude	Rating	Subtotal	Magnitude	Rating	Subtotal
cost	\$USD	0.1952	1,550	3	0.59	4,780	1	0.20
samples stored/ transmitted	#	0.1712	6,100	2	0.34	77,000	4	0.68
search area	m ²	0.1678	152,350	2	0.34	1,800,000	4	0.67
search rate	m ² /s	0.1678	0.5	1	0.17	500	4	0.67
area coverage	%	0.1575	100	4	0.63	100	4	0.63
mass	kg	0.1404	21	4	0.56	90	1	0.14
Total					2.62			2.99



Weighted Decision Matrix





Selected Design: *Swept Away*



Gantt Chart



Project Management



Requested budget: **\$5,000**



Budget



Questions?



Chesapeake Baywatch

“‘Baywatch’ has enriched and in many cases helped save lives.” - David Hasselhoff



Component	Description	Unit cost (\$)	Units	Subtotal (\$)	Component weight (lb.)
Hull ¹	4.5 in. OD Sch. 40 PVC pipe	30 per 5 ft. length	1	30	5.4 ⁴
Nose and tail cones ¹	6 in. PVC rod	100 per ft.	1	100	2.6 ⁴
	O-rings, 4.5 in. OD multipurpose	3 per 10	1	3	0.1 ⁵
Wings ¹	1" x 4" PVC bar	20 per ft.	4	80	8.9 ⁴
Ballast tanks ¹	syringes 140 ml	13	8	104	1.0 ⁵
Motors ²	60 RPM DC servo motors	40	4	160	2.0
Motor controller ²	Arduino Mega	45	1	45	0.1

Component	Description	Unit cost (\$)	Units	Subtotal (\$)	Component weight (lb.)
Batteries ³	NiMH Battery 12 V 20 Ah	240	1	240	7.3
CPU ²	Arduino Uno	25	1	25	0.1
Information storage ²	MicroSD card with shield and adapter	30	1	30	0.1
Temperature sensor ²	Waterproof temp sensors	10	1	10	0.1
Pressure sensor ²	Waterproof pressure sensor	60	1	60	0.1
Conductivity sensor ²	EZO Conductivity circuit	200	1	200	0.1
GPS antenna ²	GPS Antenna	60	1	60	0.1
INS ²	Triple axis accelerometer	50	1	50	0.2
Total				1197	28.2 lb (12.8 kg) (return)

Component	Description	Unit cost (\$)	Units	Subtotal (\$)	Component weight (lb.)
Tow line ¹	3/16 OD polyester yacht braid	\$0.70 per ft.	300 m (985 ft.)	700	20 ²
Planar boards ³	Fiberglass covered foam board (30"x80")	\$50 per sheet	1	40	40
Tether floats ¹	Mast buoy	\$50	11	550	1 ²
Tethers (rods) ⁴	Fiberglass rod ¼" dia. 10 ft. length	10	5	50	1 ²
Weights ¹	Trolling weight 6 lbs.	\$30	11	330	66

Component	Description	Unit cost (\$)	Units	Subtotal (\$)	Component weight (lb.)
Temperature sensor ⁵	Waterproof temp sensors	10	1	10	0.1
Sensor cable ⁶	3 conductor shielded	\$30 per 20 ft.	5	150	12
Inclinometer ⁵	3 axis accelerometer	\$14	11	155	1 ²
Conductivity sensor ⁵	EZO Conductivity circuit	200	11	2200	10 ¹
GPS antenna ⁵	GPS Antenna	60	1	60	0.1
Camera module ⁵	Camera module	35	1	35	0.1
Pelican Case	Case with wheels and protective foam	500	1	500	45
Total				\$4780	200 lb. (90.7 kg) (return)



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