PROJECT UROPA

Underwater Robotic Oxygen Portability Assistant

Capstone Senior Design Project • Fall 2019

PURDUE UNIVERSITY
Mechanical Engineering

Left to right:
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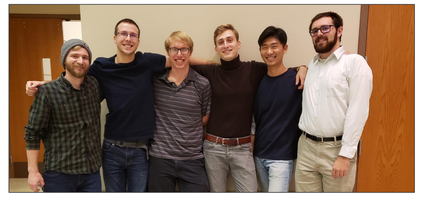


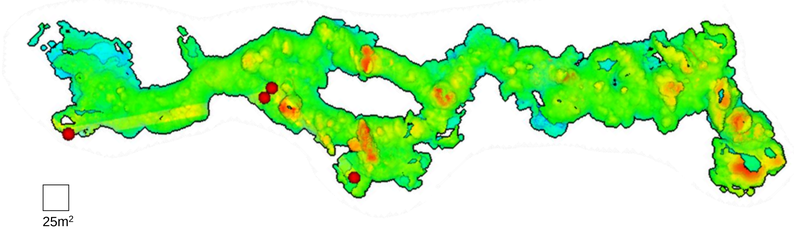
The Problem

- **166 scuba-diving related fatalities** (in 2018), **~8.35%** annual growth since 1999[2]
- **15%** of accidents caused by equipment malfunction[2]
- **84%** of cave-diving accidents due to insufficient breathing gas[3]

SCUBA diving in underwater cave systems is dangerous due to the lack of breathable air. Existing AUV cargo solutions cannot accommodate the buoyancy differences between full and empty SCUBA tanks, and so are unable to efficiently transport the life-saving air divers need.

Our Innovation

We have created an autonomous underwater vehicle (AUV) capable of in-field, rapid buoyancy adjustment to accommodate changes in cargo weight and balance necessary for SCUBA operations.



3D Visualization of Peacock Springs underwater cave system in FL, by Project Sunfish[4]

Benchmarks

UROPA	SeaEye Tiger[7] SAAB	BlueROV2[1] Blue Robotics	RevolutionROV[5] Deep Trekker	SUNFISH[6] Stone Aerospace
				

Customer Requirements	U.R.O.P.A	SeaEye Tiger	BlueROV2	RevolutionROV	SUNFISH
Untethered:	Yes	No	Yes	Yes	Yes
Autonomous Control:	Yes	Yes	No	No	Yes
Buoyancy System:	Dynamic	Static	Static	Static	Static
Payload Capacity:	72 lbs	70 lbs	N/A	N/A	N/A
Navigate Cave Environment:	Yes	No	No	No	Yes

Business & Growth Model

Target Industries: how does our solution create value?

- **Scientific/Research:** Extended mission duration for more efficient use of research funds and time
- **Oil & Gas:** Accelerated aquifer integrity check process for on-shore drilling operations, saves time
- **Military:** Increased range and speed of divers, decreases fatigue, saves time and energy
- **Recreational:** Increased safety for leisure diving with reserve oxygen tanks, decreases risk

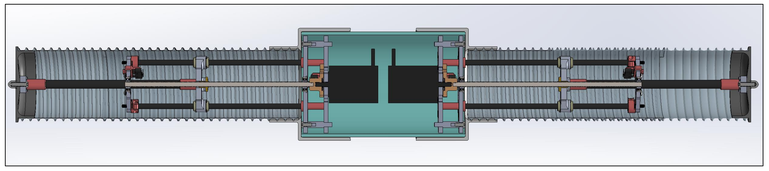
Year	Production Cost	Support & Other Costs	Sale Price	Support Income	Sale Profit Margin	Unit Sales	Total Profit
1	$20,000	$10,000	$40,000	0	25%	5	$50,000
3	$18,000	$15,000	$40,000	$60,000	17.5%	10	$103,000
5	$15,000	$20,000	$40,000	$180,000	12.5%	20	$280,000

Primary Income Model: Charge a $1000/mo support fee per robot.

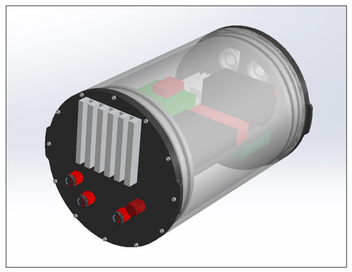
Prototype

Subsystem Design

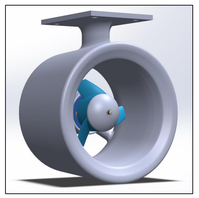
Dynamic Volume Buoyancy Control (Cut-View)



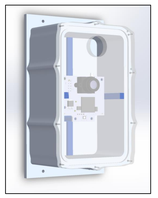
Tube Electronics Enclosure & HMI



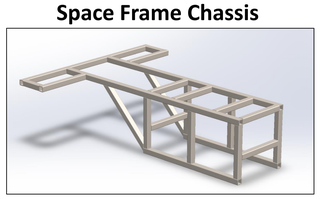
Propulsion



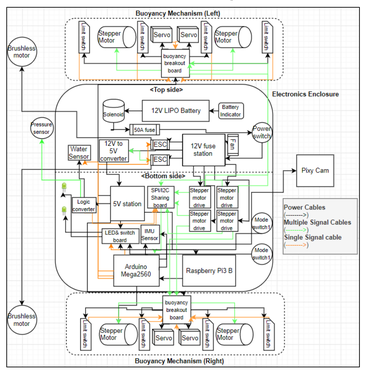
Camera Enclosure



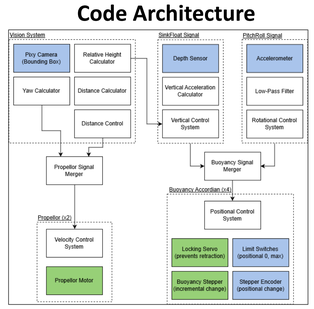
Space Frame Chassis



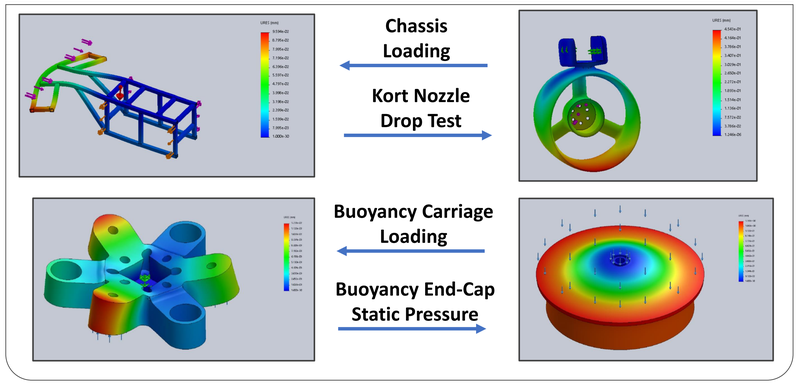
Electronics Layout



Code Architecture



Analysis & Simulation



Testing & Validation

Each subsystem was tested individually before final prototype integration. Shown above is the validation procedure and results for the distance prediction model. We were able to estimate target distance within a 5% error margin.

Future Improvements

Incorporate 3D sonar for enhanced navigation

$2,000 - $20,000

Increase payload capacity to 150lbs+ and transport other dive equipment

$10,000 - $30,000

Hydrodynamic frame design

$5,000 - $10,000

References

[1] "BlueROV2 - Affordable and Capable Underwater ROV." *Bluerobotics.com*, Blue Robotics Inc, https://bluerobotics.com/store/rov/bluerov2/.
[2] Buzzacott, Peter. "American Cave Diving Fatalities 1969-2007." *CDAA*, 21 Nov. 2015, http://www.cavedivers.com.au/article/american-cave-diving-fatalities-1969-2007.
[3] Buzzacott, Peter, and PJ Denoble. "DAN Annual Diving Report 2018 Edition: A Report on 2016 Diving Fatalities, Injuries, and Incidents." *National Center for Biotechnology Information*, Divers Alert Network, 2018, https://www.ncbi.nlm.nih.gov/books/NBK540496/.
[4] "Peacock Springs Sunfish 3D Visualisation." *Stone Aerospace*, Stone Aerospace, http://explore.stoneaerospace.com/interfaces/PeacockMeshDev/PeacockMeshDev.html.
[5] "REVOLUTION ROV." *Deep Trekker*, Deep Trekker Inc, https://www.deeptrekker.com/products/underwater-rov/deep-trekker-revolution.
[6] "SUNFISH® AUV – Pushing the Boundaries of Exploration & Technology." *SUNFISH AUV*, Stone Aerospace Inc, https://sunfishinc.com/.
[7] "Tiger." *SAAB SEAEYE*, SAAB, https://www.saabseaeye.com/solutions/underwater-vehicles/tiger.

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