Team Inspiration

23 September 2021

Leveraging Competitive Robotics Experience to Spread Marine Education

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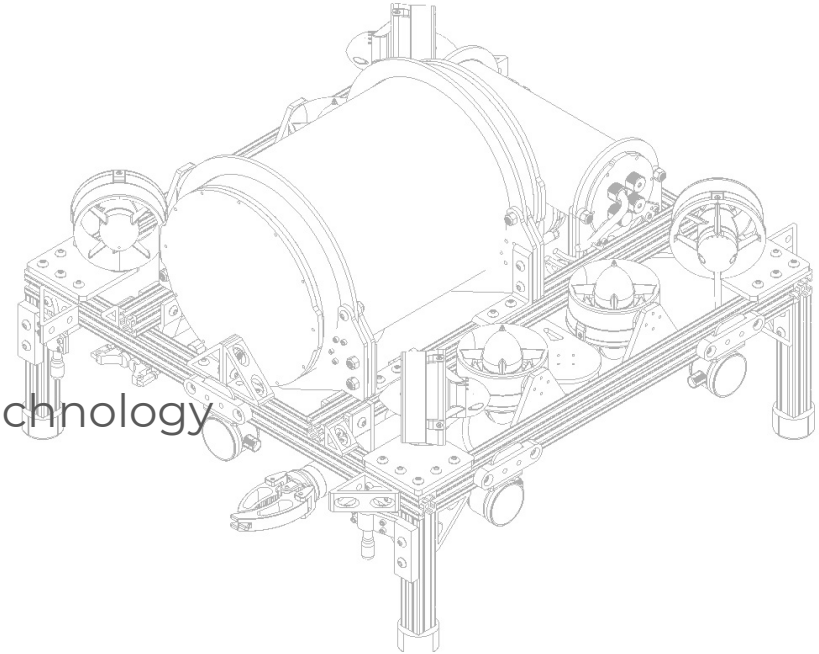
OCEANS
CONFERENCE & EXPOSITION

Team Inspiration

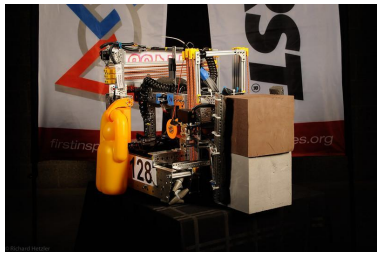
Agenda

- About Team Inspiration
  - Team History
- Our Learning Process
  - RoboSub
  - Surface Vessel (Float Tube)
  - EvKart
  - RobotX
- Applying What We Learned In Marine Technology
- How We Share with Others
- Marine Technology Curriculum
- Acknowledgements
- Questions



Team Inspiration History

2011 - FIRST Lego League (FLL)



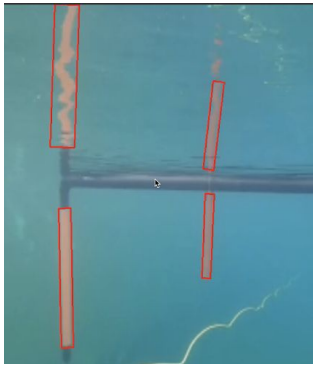
2020 - RoboSub Champion
12 middle/high schoolers

Systems Engineering is the Basis of our Robotics Journey

RoboSub Info and Venue

“RoboSub is an international student competition. Student teams from around the world design and build robotic submarines, otherwise known as Autonomous Underwater Vehicles (AUV). The behaviors demonstrated by these experimental AUVs mimics those of real-world systems, currently deployed around the world for underwater exploration, seafloor mapping, and sonar localization, amongst many others.”

- RoboSub official website



2021 is the 24th annual RoboSub competition

Robosub Competition Results

2019 Results (out of 54 teams)

- Ranked 3rd out of 59 teams in Static Judging
- Ranked 12th out of 59 teams in Overall Performance
- Most Inspirational Team award
- IEEE Innovation award

2020 Results (out of 33 teams)

- Ranked 1st out of 33 teams in Technical Design Report
- Ranked 1st out of 33 teams in Website
- Ranked 2nd out of 33 teams in Video
- Ranked 1st out of 33 teams in Overall Performance

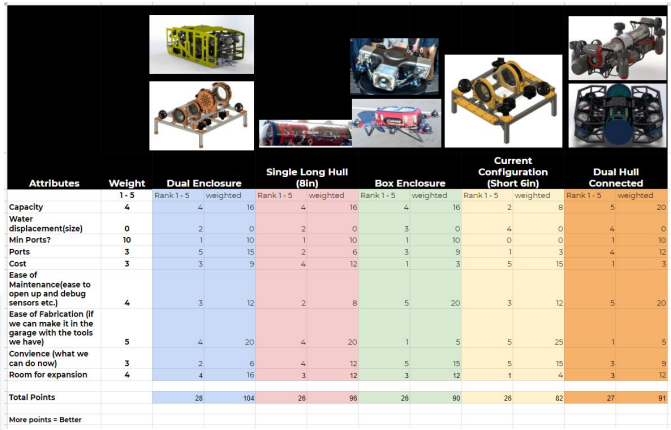
2021 Results (out of 54 teams)

- 4th for the Hull Design Skills Video out of 34 submissions
- 8th for the Sensor Optimization Video out of 26 submissions
- 8th for Website out of 53 submissions
- 13th for the Technical Design Report out of 53 submissions

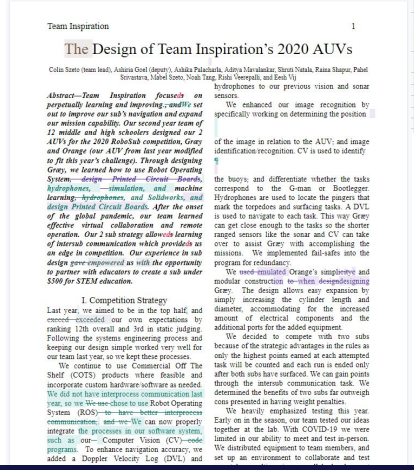
Being requirement-driven enabled us to win

What Made Our Team Excel

- Focus on the competition guidelines
- Competitor analysis and research
- Hard work and dedication
- Communication
- Iteration and parallel prototyping
- Trade studies
- Attention to detail
- Rigor in documentation
- Utilizing mentors and vendors
- Team work
- Availability
- Solution oriented



Attributes	Weight	Dual Enclosure		Single Long Hull (8in)		Box Enclosure		Current Configuration (Short 6in)		Dual Hull Connected	
	1 - 5	Rank 1 - 5	weighted	Rank 1 - 5	weighted	Rank 1 - 5	weighted	Rank 1 - 5	weighted	Rank 1 - 5	weighted
Capacity	4	4	16	4	16	4	16	2	8	5	20
Water displacement(size)	0	2	0	2	0	3	0	4	0	4	0
Min Ports?	10	1	10	1	10	1	10	0	0	1	10
Ports	3	5	15	2	6	3	9	1	3	4	12
Cost	3	3	9	4	12	1	3	5	15	1	3
Ease of Maintenance(ease to open up and debug sensors etc.)	4	3	12	2	8	5	20	3	12	5	20
Ease of Fabrication (If we can make it in the garage with the tools we have)	5	4	20	4	20	1	5	5	25	1	5
Convience (what we can do now)	3	2	6	4	12	5	15	5	15	3	9
Room for expansion	4	4	16	3	12	3	12	1	4	3	12
Total Points		28	104	26	96	26	90	26	82	27	91
More points = Better											



Team Inspiration 1

The Design of Team Inspiration's 2020 AUVs

Colin Szeto (team lead), Ashitia Goel (deputy), Ashika Palacharla, Aditya Mavalankar, Shruti Nittala, Raina Shapur, Pahel Srivastava, Mahel Szeto, Noah Tang, Rishi Veerepalli, and Eesh Vij

Abstract—*Team Inspiration focuses on perpetually learning and improving, and We set out to improve our sub's navigation and expand our mission capability. Our second year team of 12 middle and high schoolers designed our 2 AUVs for the 2020 RoboSub competition, Grey and Orange (our AUV from last year modified to fit this year's challenge). Through designing Grey, we learned how to use Robot Operating System, design Printed Circuit Boards, hydrophones, simulation, and machine learning, hydrophones, and Solidworks, and design Printed Circuit Boards. After the onset of the global pandemic, our team learned effective virtual collaboration and remote operation. Our 2 sub strategy allowed learning of intersub communication which provided us an edge in competition. Our experience in sub design gave empowered us with the opportunity to partner with educators to create a sub under $500 for STEM education.*

I. Competition Strategy

Last year, we aimed to be in the top half, and exceed exceeded our own expectations by ranking 12th overall and 3rd in static judging. Following the systems engineering process and keeping our design simple worked very well for our team last year, so we kept these processes.

We continue to use Commercial Off The Shelf (COTS) products where feasible and incorporate custom hardware/software as needed. We did not have interprocess communication last year, so we We use chose to use Robot Operating System (ROS) to have better interprocess communication, and we We can now properly integrate the processes in our software system, such as our Computer Vision (CV) code programs. To enhance navigation accuracy, we added a Doppler Velocity Log (DVL) and hydrophones to our previous vision and sonar sensors.

We enhanced our image recognition by specifically working on determining the position of the image in relation to the AUV; and image identification/recognition. CV is used to identify the buoys; and differentiate whether the tasks correspond to the G-man or Bootlegger. Hydrophones are used to locate the pingers that mark the torpedoes and surfacing tasks. A DVL is used to navigate to each task. This way Grey can get close enough to the tasks so the shorter ranged sensors like the sonar and CV can take over to assist Grey with accomplishing the missions. We implemented fail-safes into the program for redundancy.

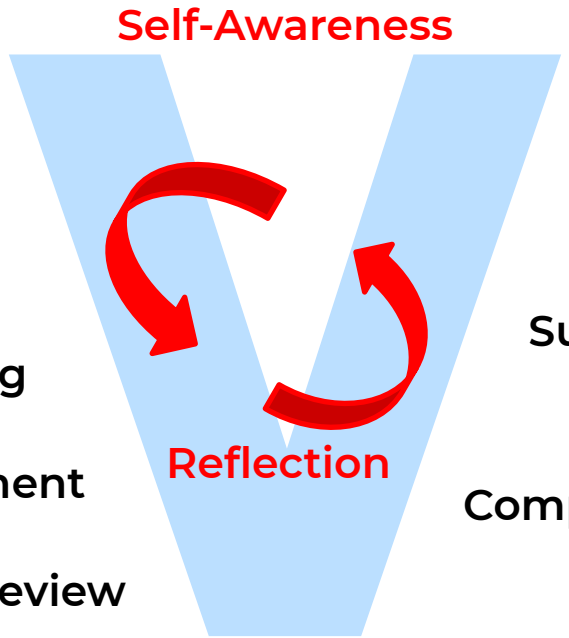
We used emulated Orange's simple drive and modular construction to when designdesigning Grey. The design allows easy expansion by simply increasing the cylinder length and diameter, accommodating for the increased amount of electrical components and the additional ports for the added equipment.

We decided to compete with two subs because of the strategic advantages in the rules as only the highest points earned at each attempted task will be counted and each run is ended only after both subs have surfaced. We can gain points through the intersub communication task. We determined the benefits of two subs far outweigh cons presented in having weight penalties.

We heavily emphasized testing this year. Early on in the season, our team tested our ideas together at the lab. With COVID-19 we were limited in our ability to meet and test in-person. We distributed equipment to team members, and set up an environment to collaborate and test

Because we are solution oriented COVID is not a blocker

Systems Engineering “V” is an Enabler



Competitor Research, Industry Survey

Mission Exploration

Planning

Requirement Development

Design Review

Modular & Parallel Development

System Testing

Subsystem Testing

Component Testing

Best practice with focus on reflection and self-awareness

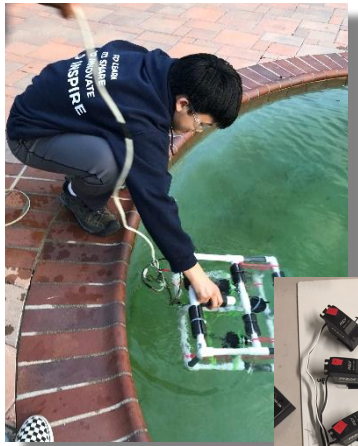
Planning

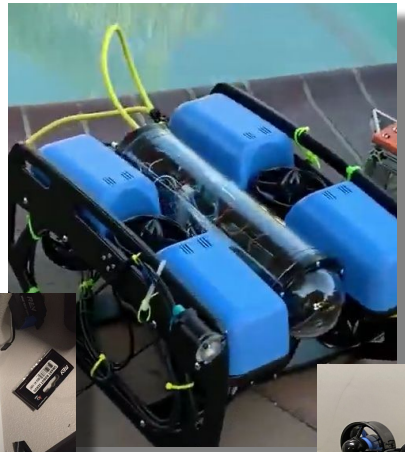
- Draft schedule at Kick-Off – schedule focus
- Develop schedule backward from goal with contingency
- Long lead material procurement – RoboSub components
- Rapid prototype – weekly increments
- Parallel and modular development
- Early testing – start from the beginning
- Multiple decision milestones

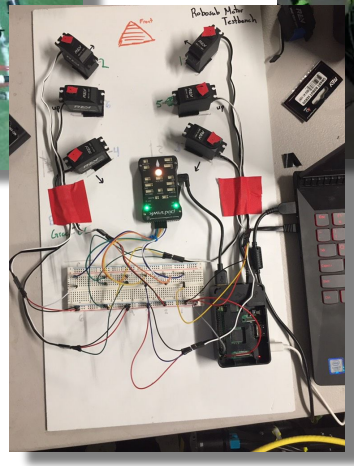
Week	Agenda
16-Mar	Kick off – RoboSub team research
23-Mar	RoboSub team research – refine requirements – assign role
30-Mar	Identify/procure long lead items – Select computer – prioritize requirements
6-Apr	Connect benchtop vehicle – test component
13-Apr	Identify all equipment
20-Apr	program remote control
27-Apr	put together simple underwater vehicle – first prototype
4-May	Experiment first prototype in water
11-May	Program autonomous
18-May	Experiment with IMU and depth sensor
25-May	Experiment with computer vision
1-Jun	Draft technical paper
8-Jun	Review draft – Experiment with second prototype
15-Jun	Final technical paper
22-Jun	Submit technical paper
29-Jun	Experiment sonar
6-Jul	Experiment with final vehicle
13-Jul	Data correlation with vision input Pre-qualification
20-Jul	Refine autonomous programming
27-Jul	Pack robot for competition
Jul 29 - Aug 4	Competition at NIWC PAC TRANSDEC

Plan with flexibility and contingency

RoboSub Progression

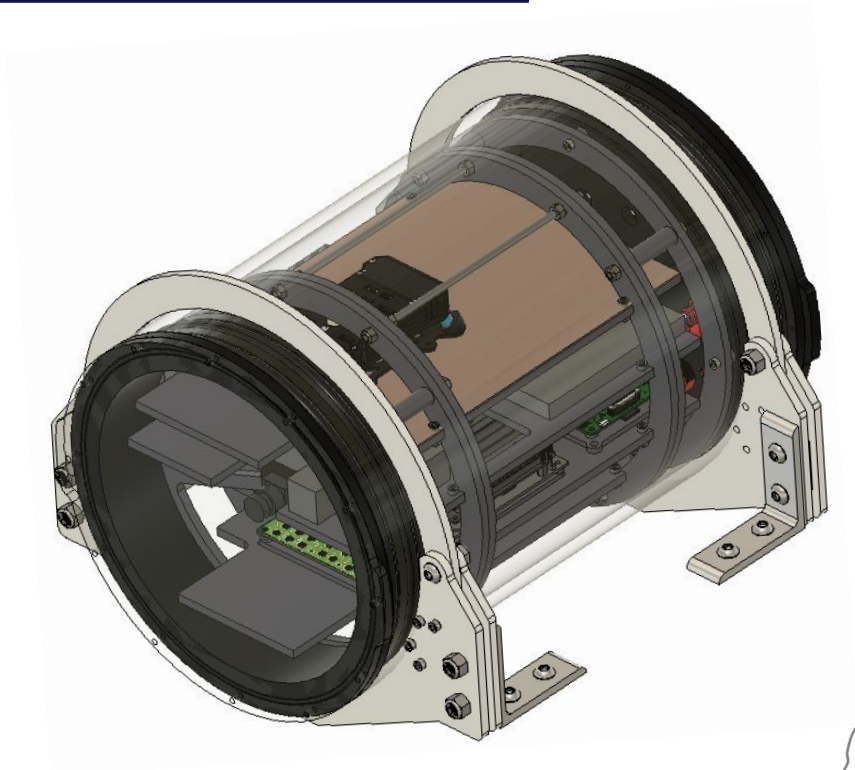






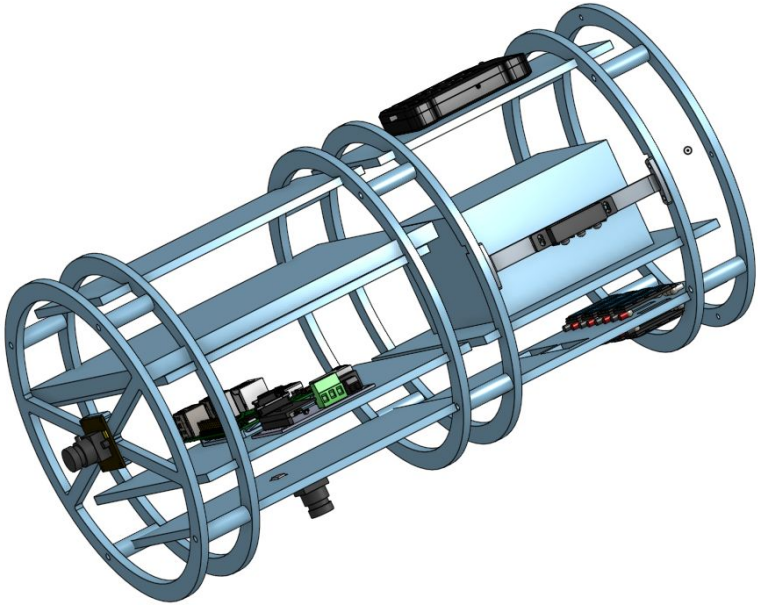
From Sea Perch to BlueROV to Orange, enables

Parallel Prototyping



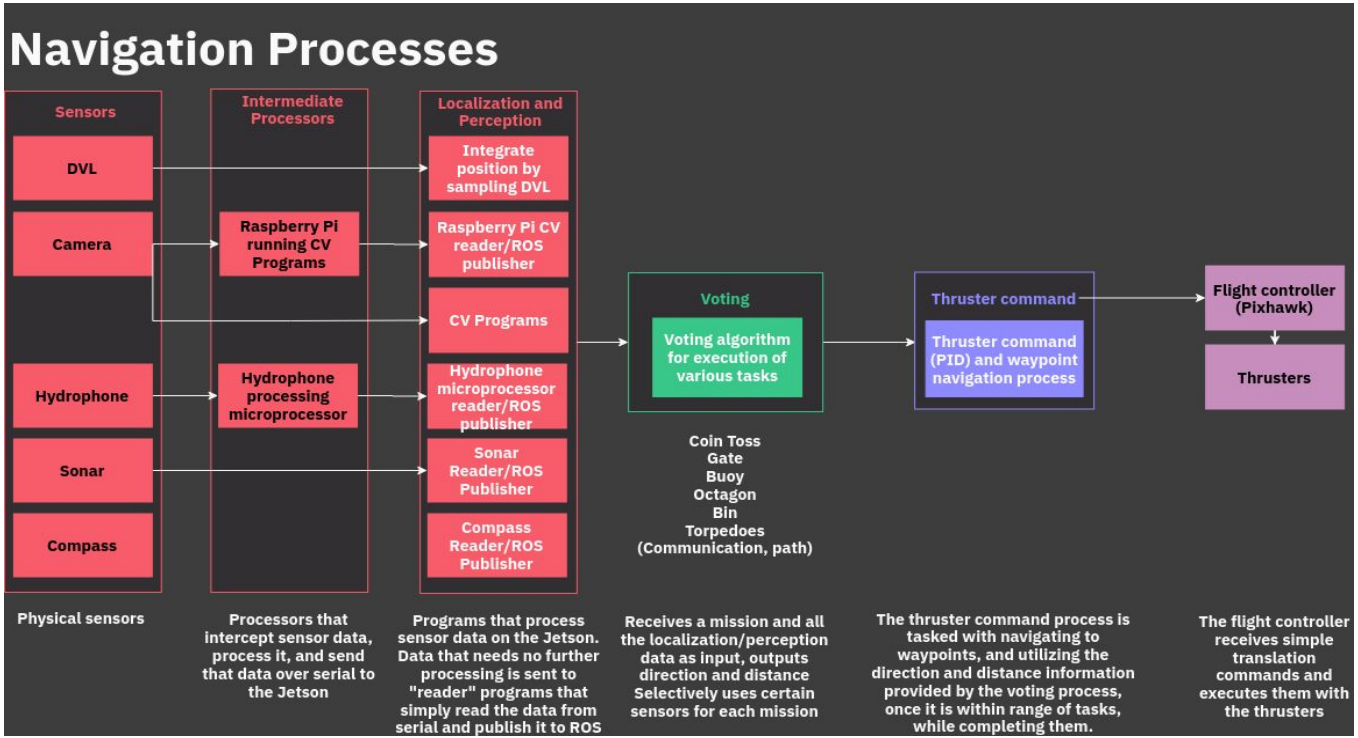
Independent team members' concepts

CAD of Onyx’s enclosure design



Advancing our Electrical Capabilities

Navigation Software Architecture



Localization/perception programs interpret data from hardware, and produce information about env. or location

Sensor fusion program combines localization programs' data to produce estimate of location and env.

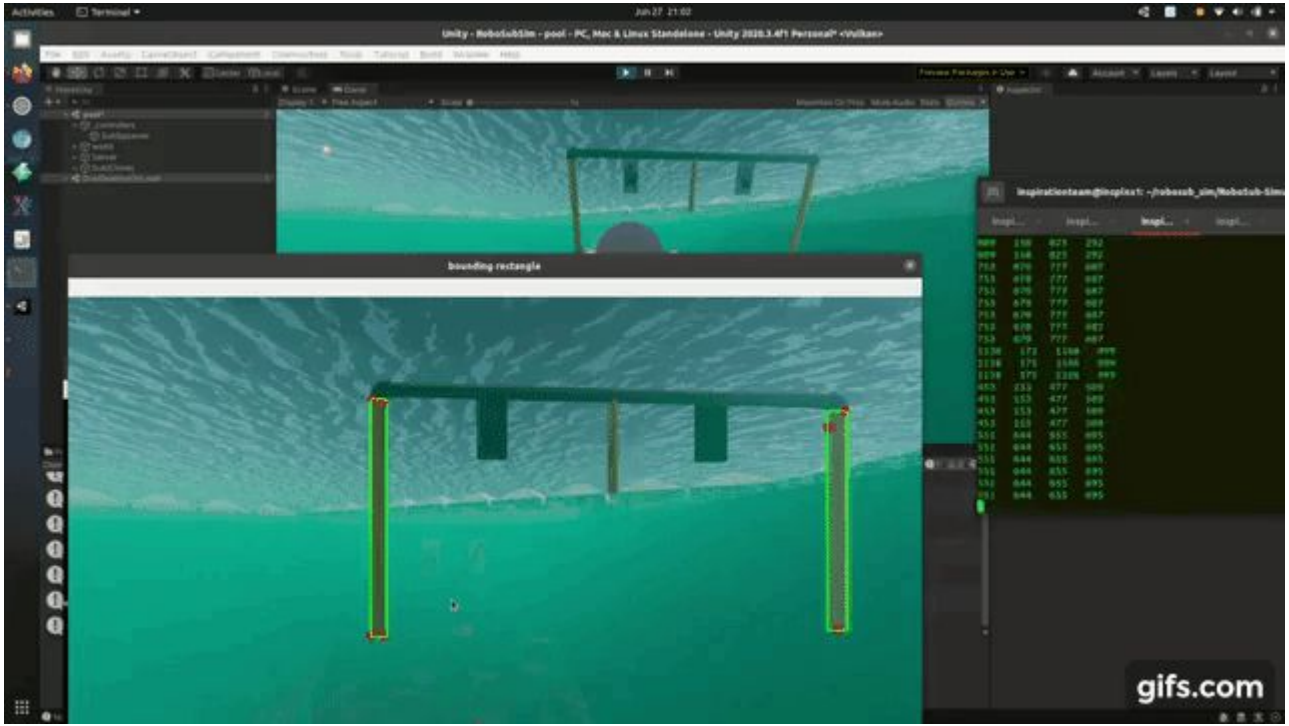
Sent to thruster cmd process which controls motors based on information provided by the sensor fusion program

Clear Architecture and Flow Diagrams

Sim to Real

The Goal of the Season

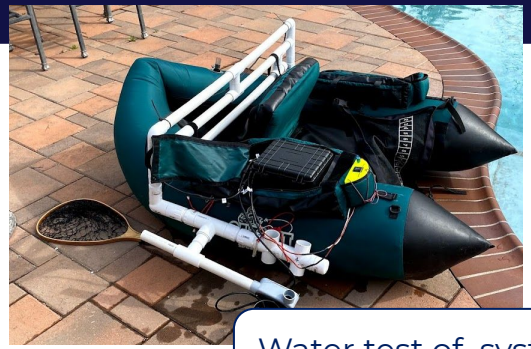
Computer Vision on Simulator



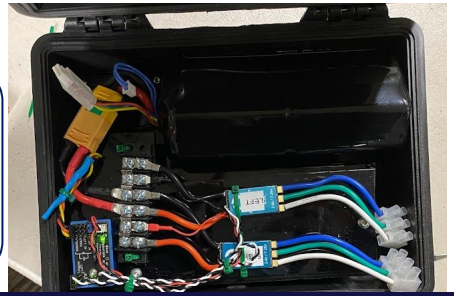
Testing CV on the Simulator before access to Sub

Float Tube

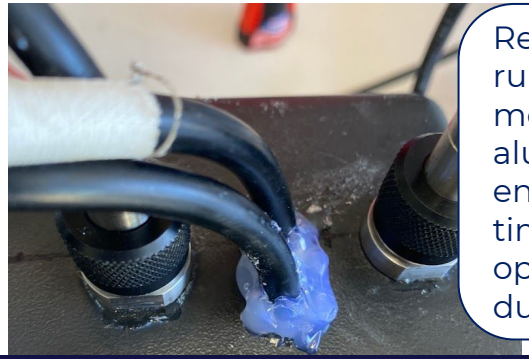
- Continuing communication with customer
- Getting feedback on the performance of the system and ideating with the customer improvements



Water test of system with customer in pool



Initial layout of electronics, layout customized to waterproof container



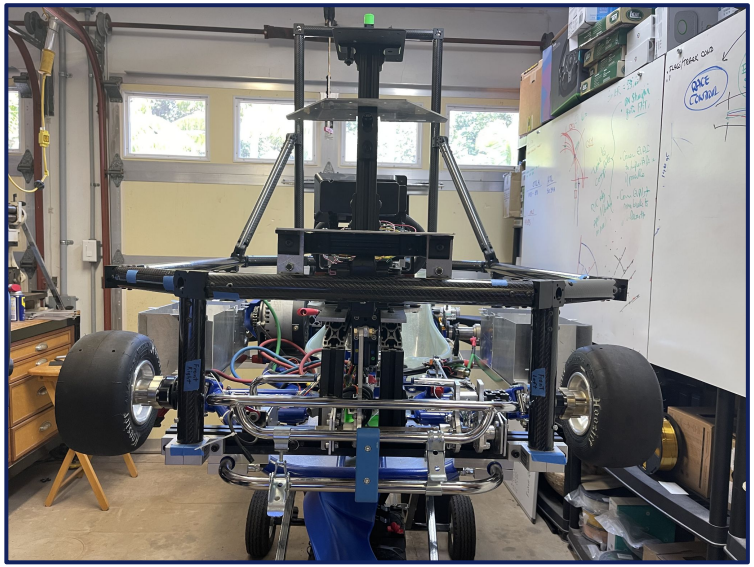
Replaced the cheap rubber connectors with more expensive aluminum connectors, enabled longer run time, easier user operation, increase durability

Developing System as Iterations in Collaboration with Customer

Autonomous EvKart

Self Racing Cars – joint UCSD participation

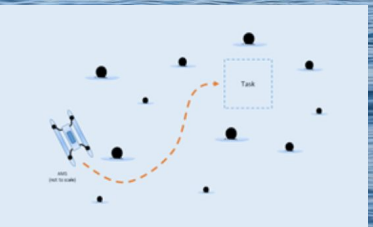
- Autonomous car development

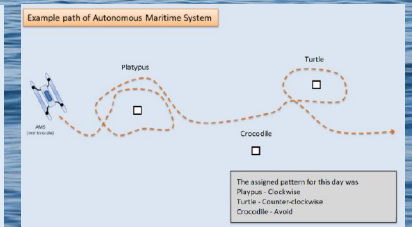


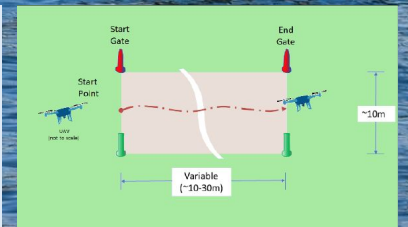
Testing Payloads and Programs on Land Platforms before Integrating on Ocean Platforms

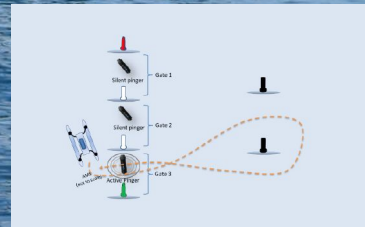
Source: https://robotx.org/programs/robotx-challenge-2022/

RobotX Nov 2022 – Sydney, Australia









Applying What We Learned

NORTHROP GRUMMAN

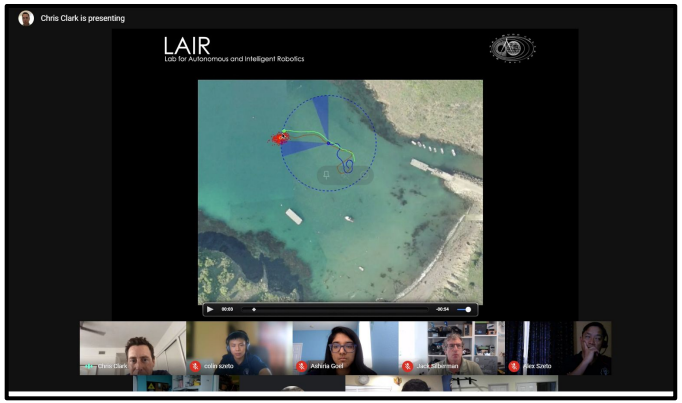
tinyvision.ai

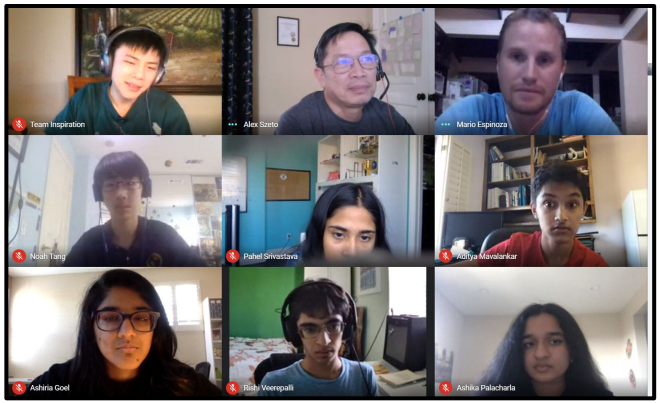
BIOSERO

Applying Systems Engineering, Teamwork, and Collaboration skills to the Workplace

WE STEM - SWENext

Speaker series - professors, industry professionals, and researchers in various STEM fields sharing their expertise with the community





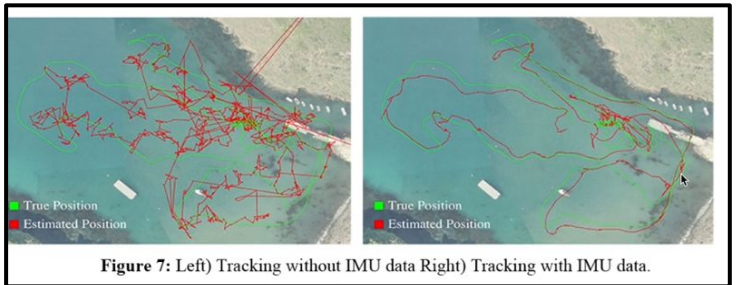
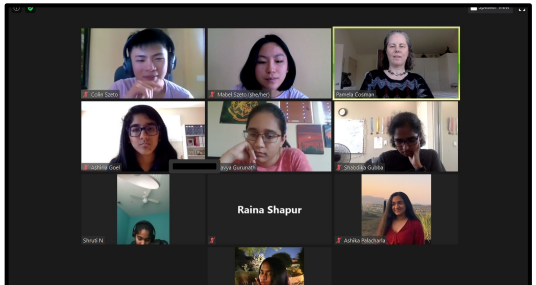


Figure 7: Left) Tracking without IMU data Right) Tracking with IMU data.

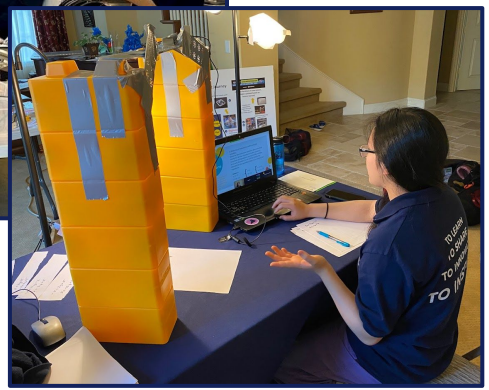


WE STEM - SWENext

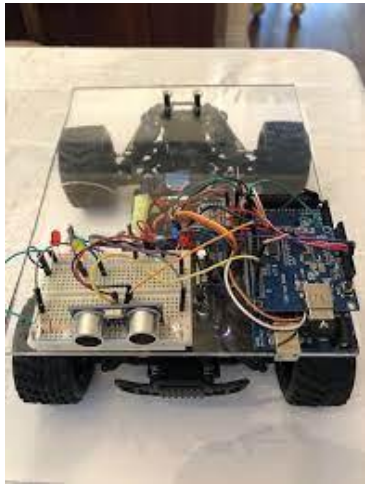
Connecting with small businesses

Using Experience to Teach Others

Learning hydrodynamics with PVC robots → Learning about buoyancy by researching vehicle materials and structures → Programming low level movement commands → Learn about communication between processor and sensors → Create basic autonomous movement program → Learn about new types of sensors → Create basic autonomous programs using data from new sensors



Porpoise Robotics



Working with local Maritime STEM companies

Acknowledgement

- Team Inspiration Members
- Lead coaches
  - Alex Szeto, Jack Silberman
- Mentors
  - Amit Goel, Brian Liu, Dave Warner, Eric Lo, Eugene Kim, Kenzo Tomitaka, Kris Chopper, Kunal Srivastava, Pamela Cosman, Pat McLaughlin, Phil Yao, Michael Arnstein, Valibabu Saladi, and Venkat Rangan
- Sponsors/supporters

Teamwork Enables Success

Questions?

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