Team Inspiration

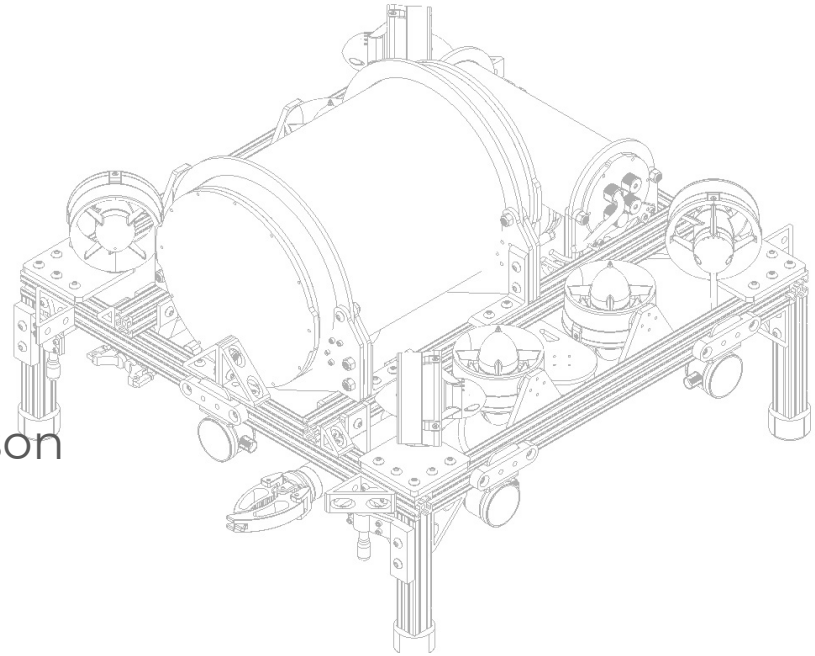
2020 INCOSE SD Mini-Conference

5 December 2020

Competitive Edge of the 2020 RoboSub World Champion Team

Ashiria Goel, Colin Szeto, Mabel Szeto, Rishi Veerepalli

Agenda

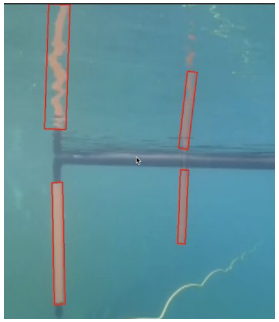


- About RoboSub
- About Team Inspiration
  - Team History
  - Team Inspiration News
- Systems Engineering during 2020 season
  - Virtual Competition
  - Competition Results
  - Our Robot
  - Covid-19 Adaptations
  - Digital Engineering
- Our Learnings
  - What Made Our Team Excel
  - Global Changes In Systems Engineering
  - Attributes of a Successful Systems Engineer
- Questions

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.” - RoboNation

2019 images



2020 is the 23rd annual RoboSub competition

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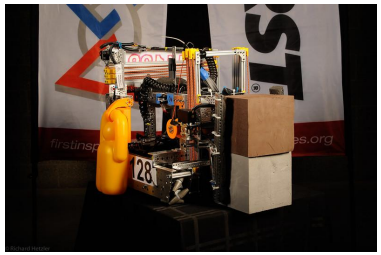
Team Inspiration History

2011 - FIRST Lego League (FLL)



2020 - RoboSub
12 middle/high schoolers

Systems engineering is the basis of our robotics journey

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Our Team in the News

Video provided by: CBS 8

Getting the message out to the public

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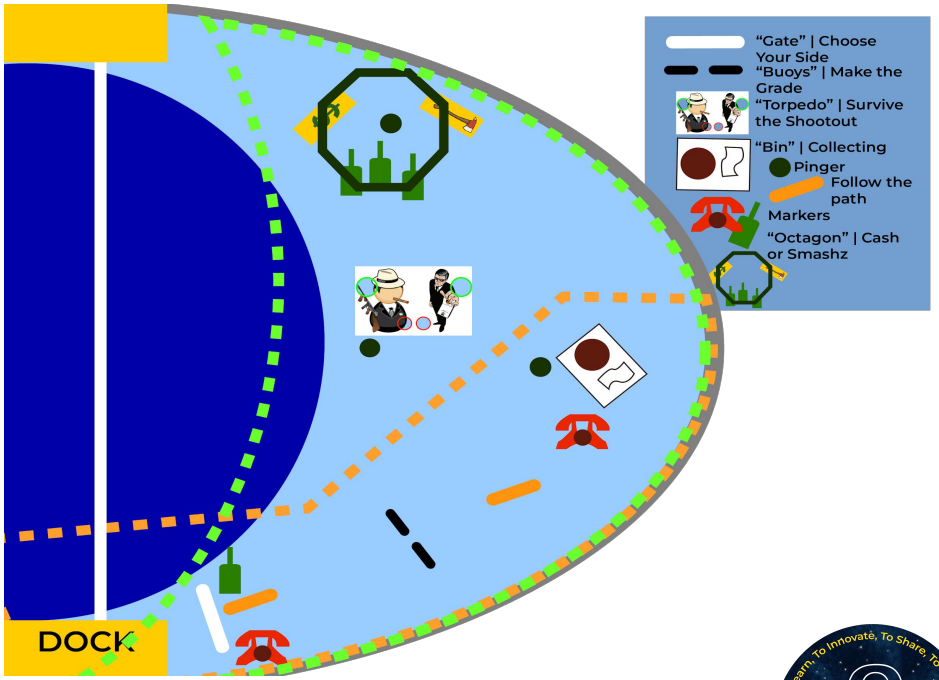
2020 Virtual Competition Criteria

Technical Paper
- Under 5 pages
- Should showcase the maturity of the system and team

Team Video
- Under 15 min
- Replacement for the onsite judging presentation

Team Website
- Should supplement the video and technical paper



Criteria drive our team objectives

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Competition Results

Overall Standings

1st Place: *Team Inspiration*
2nd Place: Si Se Puede Foundation & Arizona State University
3rd Place: Tecnológico de Monterrey
4th Place: San Diego State University
5th Place: Carnegie Mellon University
6th Place: University of Alberta

Video Standings

1st Place: Tecnológico de Monterrey
2nd Place: *Team Inspiration*
3rd Place: Indian Institute of Technology Bombay
4th Place: Si Se Puede Foundation & Arizona State University
5th Place: San Diego State University

Technical Design Report Standings

1st Place: *Team Inspiration*
2nd Place: California Institute of Technology
3rd Place: Si Se Puede Foundation & Arizona State University
4th Place: Duke University
5th Place: The Ohio State University

Website Standings

1st Place: *Team Inspiration*
2nd Place: Si Se Puede Foundation & Arizona State University
3rd Place: Amador Valley High School
4th Place: Tecnológico de Monterrey
5th Place: École de Technologie Supérieure

33 TEAMS

- Ain Shams University
- Amador Valley High School
- Arizona State University
- Beaver Country Day School
- California Institute of Technology
- California State University, Los Angeles
- Carnegie Mellon University
- Duke University
- École de Technologie Supérieure
- Federal University of Rio de Janeiro
- Georgia Institute of Technology
- Gonzaga University
- Indian Institute of Technology Bombay
- Kasetsart University
- Kennesaw State University
- National University of Singapore
- North Carolina State University
- Oregon Institute of Technology
- Robotics Association at Embry-Riddle
- San Diego City College
- San Diego State University
- Si Se Puede Foundation & Arizona State University
- Team Inspiration
- Tecnológico de Monterrey
- Texas A&M University
- The Ohio State University
- University of Alberta
- University of California at Riverside
- University of California, San Diego
- University of Colorado at Boulder
- University of Colorado at Boulder
- Vortex NTNU
- Wrocław University of Science and Technology

Being requirement-driven enabled us to win

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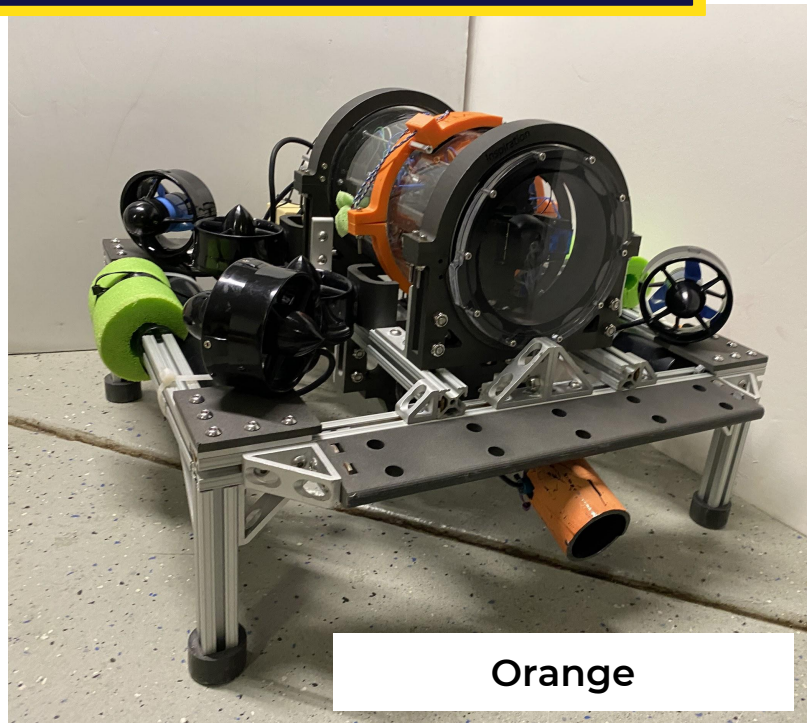
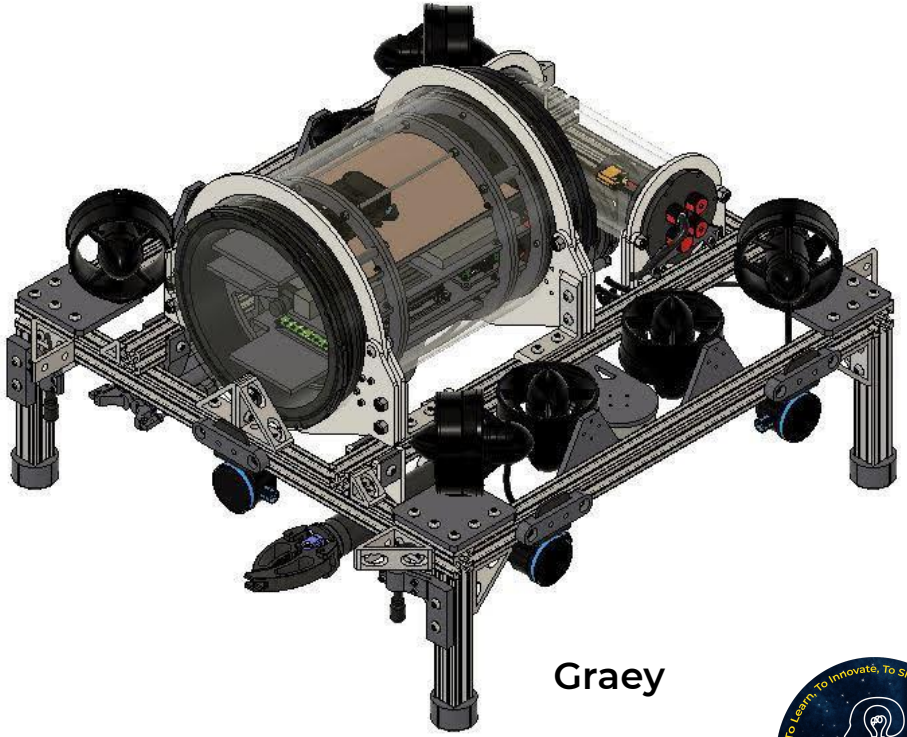
Our 2020 Robots



Orange



Graey

Dual robot strategies maximized our game potential

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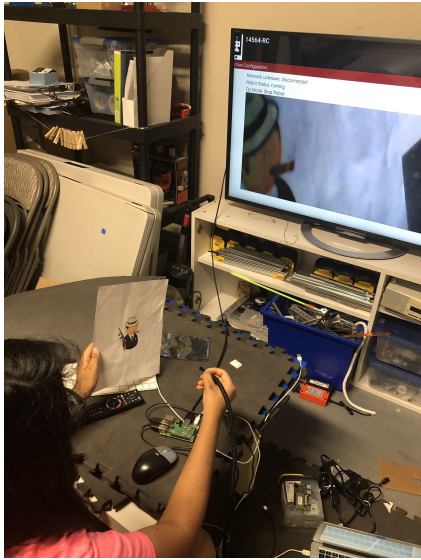
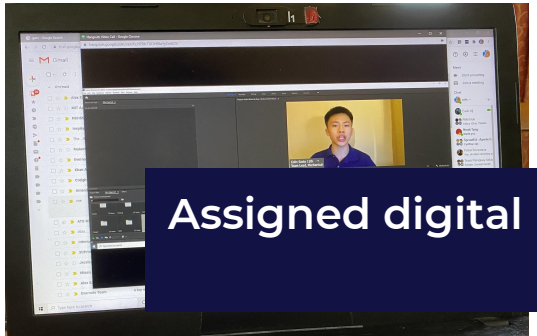
COVID-19 Adaptations





Assigned digital nomad jobs, distributed resources for development

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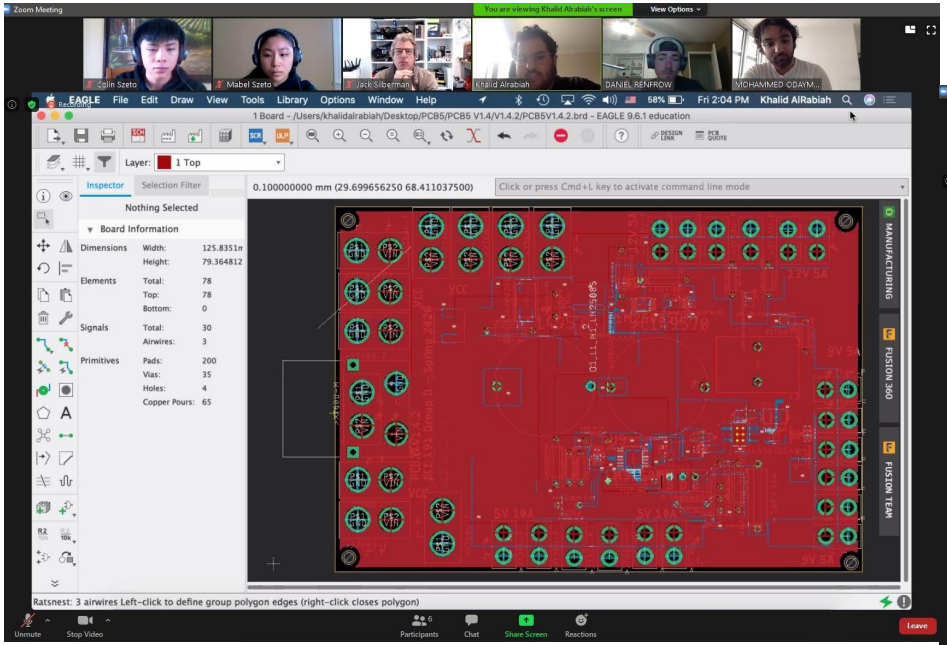
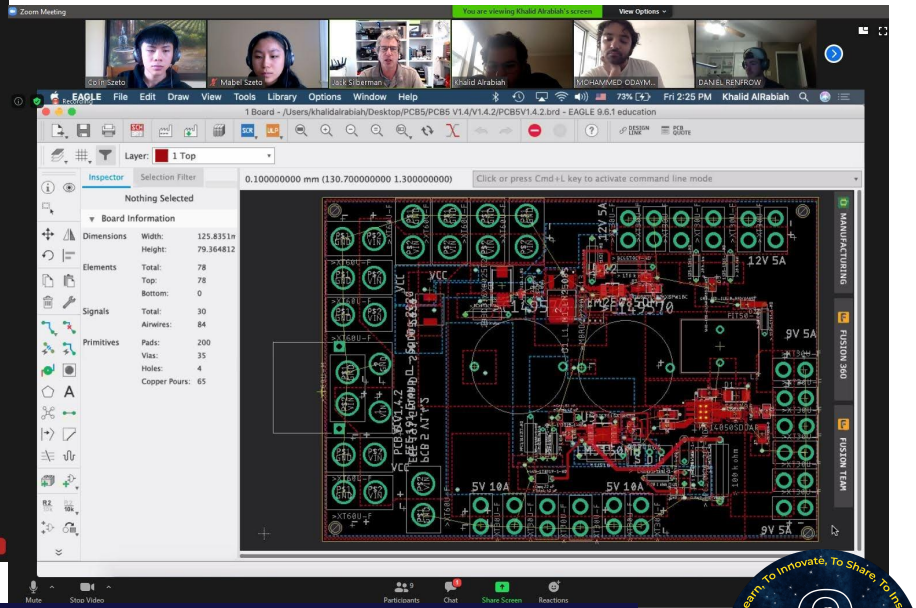
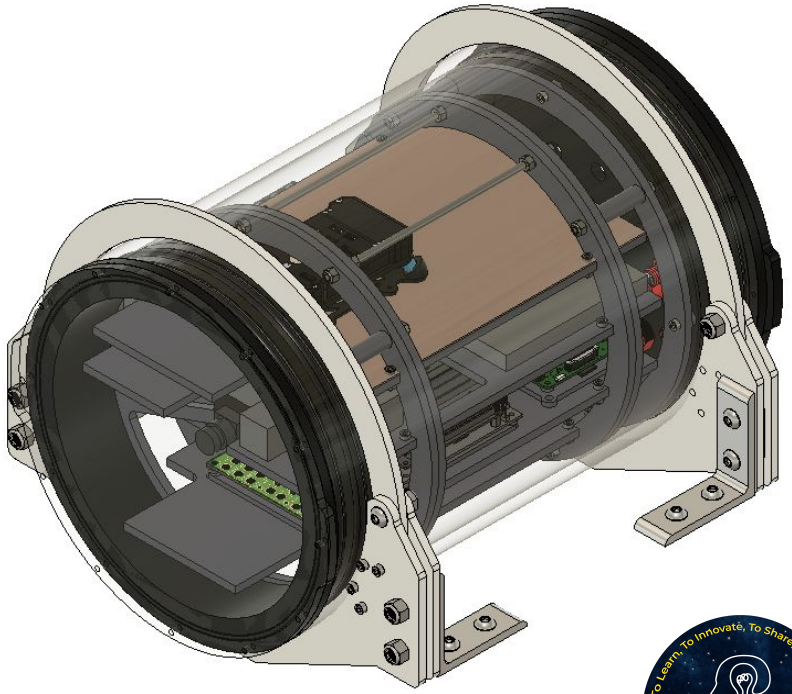
External Collaboration





Digital development enabled us to collaborate remotely. Surprisingly, we had more collaboration with professionals due to COVID-19.

Parallel Prototyping



Independent team members' concepts

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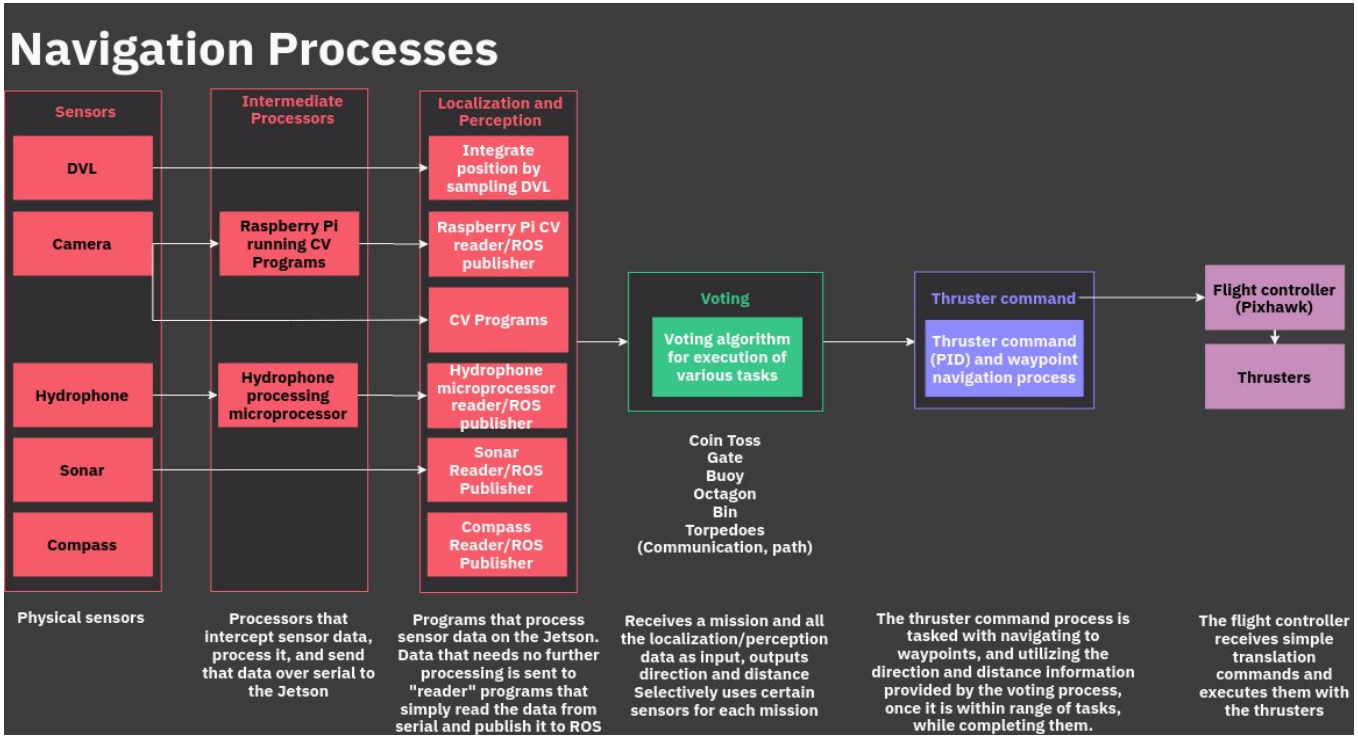
Navigation Software Architecture



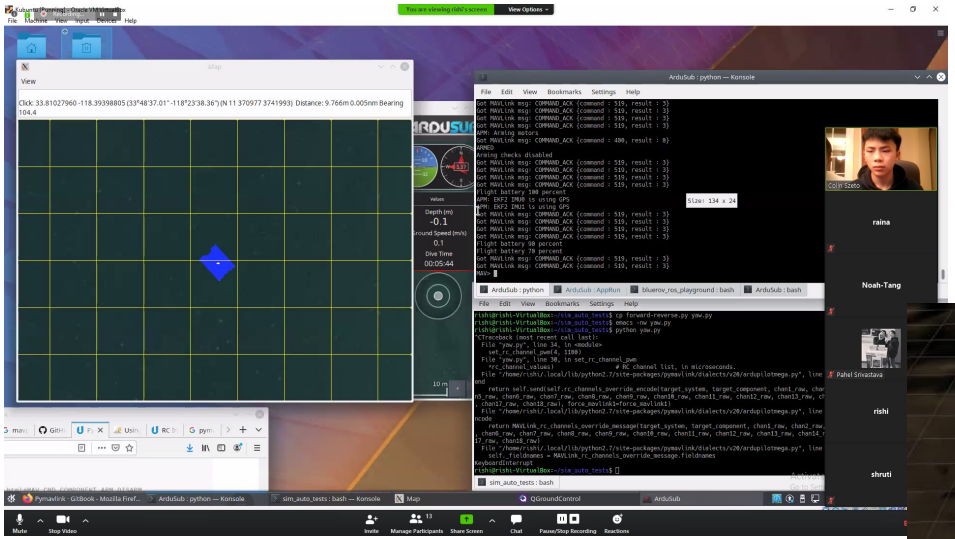
Clear Architecture and Flow Diagrams

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

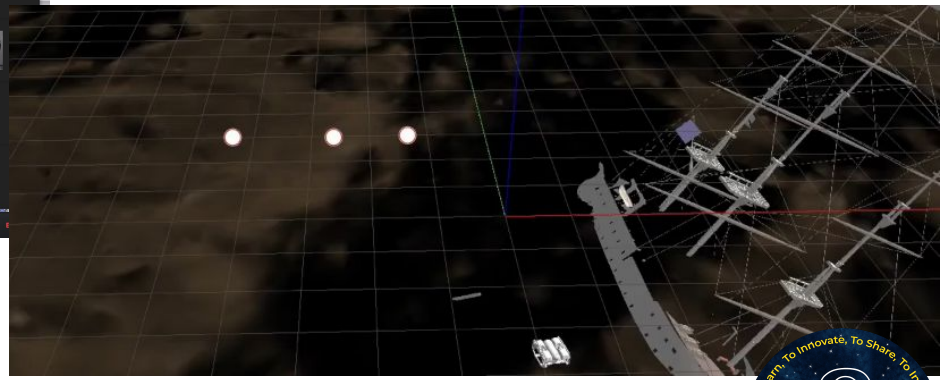
Sensor fusion program combines localization programs' data to produce estimate of location and env.

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

Virtual Simulation



A software in the loop (SITL) 6DoF simulation that simulates our flight controller runs in an Ubuntu virtual machine. SITL is linked with Gazebo to provide a 3D model/visualization. Gazebo also provides information like coordinates/heading which we can use to verify simulation results. We model sensor inputs using the position and velocity information Gazebo gives us.



Utilizing Gazebo and ArduSub software-in-the-loop simulation in place of in-water testing

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RoboSub Motion Conceptualization

Visualizing the movement and communication to others

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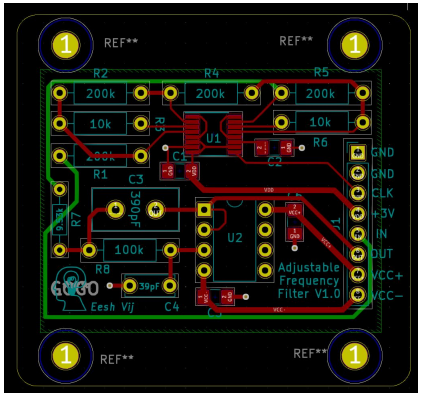
Hydrophones

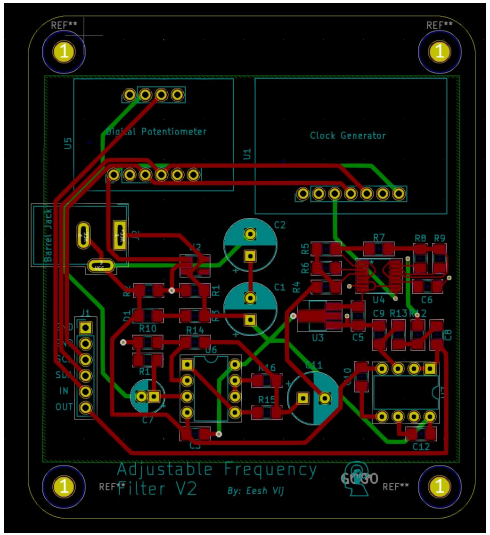
- Three hydrophones used around Græy in the vertices of the largest possible equilateral triangle that fit in our design
- Sampling at 200 kHz at a 12-bit resolution allowing for precise signal processing
- The signal processing takes place on single custom designed PCB which offloads the amplification, noise isolation, and frequency selection to a hardware based solution, freeing resources on the processor.
- The algorithm takes into account the Differences in the Time of Arrivals (DTOA) of each signal to calculate the approximate heading of the pinger.

Algorithm development

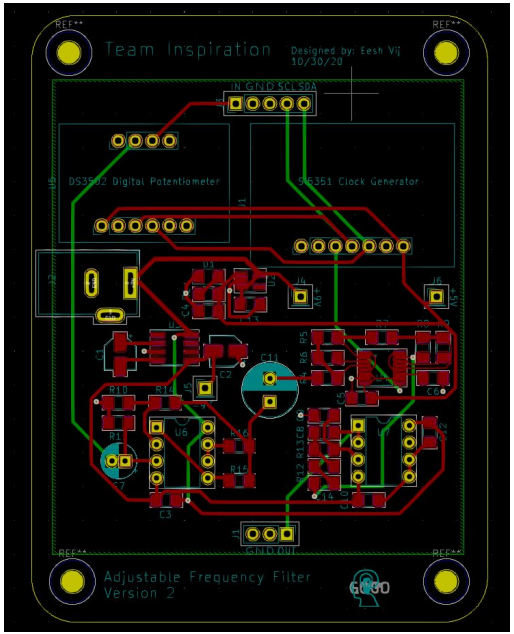
PCB Designs



V1



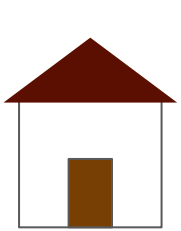
V2



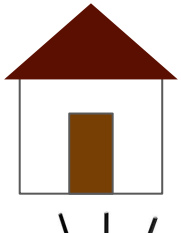
V2.1

Everything is developed in iterations

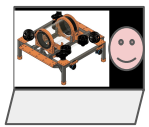
Network of Online Testing



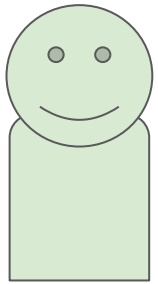
INTERNET



WIFI

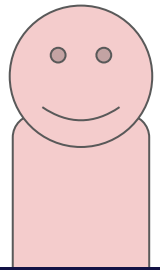


VNC connection to access sub computer with SSH access, video calling



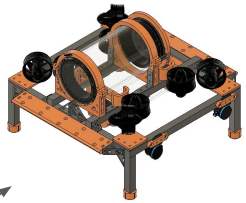
WIFI

Video calling



WIFI

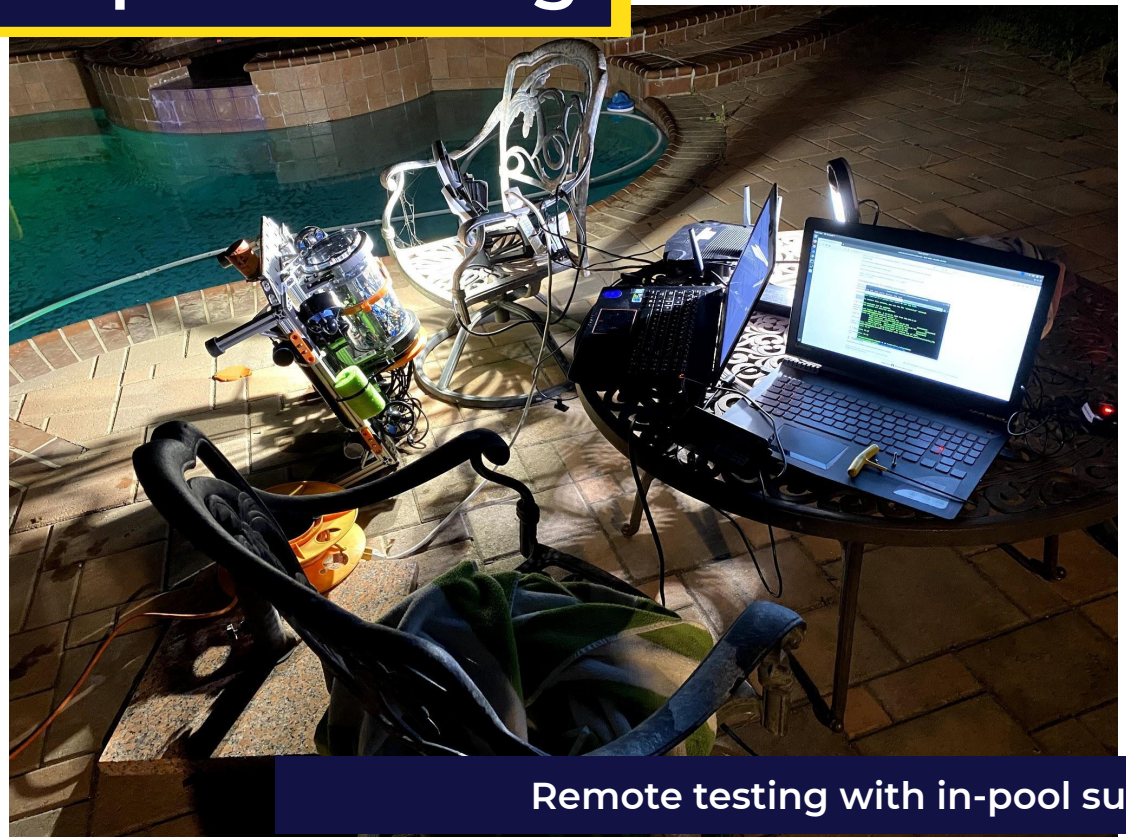
Option 1:
ethernet tether
(SSH)



Option 2:
WIFI (SSH) for
autonomous execution

Remote configuration, control & operation

In-pool Testing



Remote testing with in-pool support

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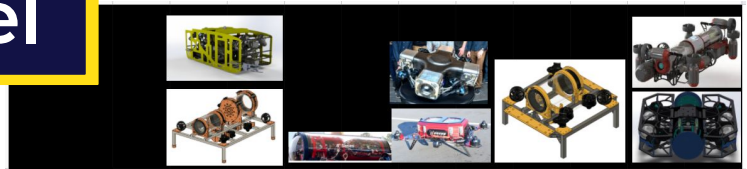
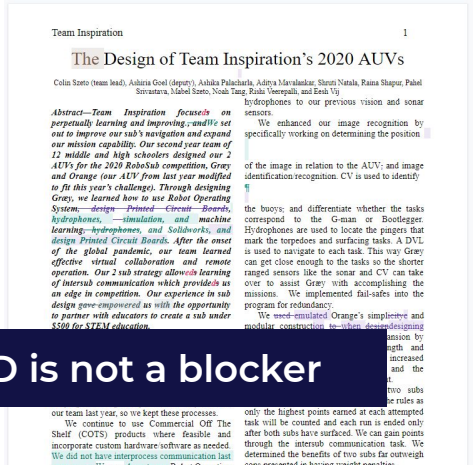
What Made Our Team Excel

- 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), Ashiria Goel (deputy), Ashika Palacharla, Aditya Mavalankar, Shruti Natala, Raina Shapur, Pahel Srivastava, Mabel Szeto, Noah Tang, Rishi Veerepalli, and Eesh Vij

Abstract—Team Inspiration focuseds on perpetually learning and improving, andWe 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 allowseds learning of intersub communication which providesds 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.

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

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 simplicitye and modular construction to when designdesigning

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

Because we are solution oriented COVID is not a blocker

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Global Changes In Systems Engineering

- Everything is accelerating
- Scrum allows to meet the demand
- Systems Engineering and planning becomes paramount
- Online collaborative environments allows designers and collaborators to see the big picture
- In person environments are not necessary to learn and collaborate

Digitization demands speed, accuracy, documentation, and configuration control

Attributes of a Successful Systems Engineer

- Be curious
- Requirement driven
- Use the systems engineering processes
- Plan out system architecture
- Observes and adapts
- Be flexible
- Test, test, test
- See both the big and small picture
- Trust but verify
- Ensure every task moves the team toward the end goal

Ability to focus on the big picture and adapt accordingly. System Thinking is Key.

Questions?

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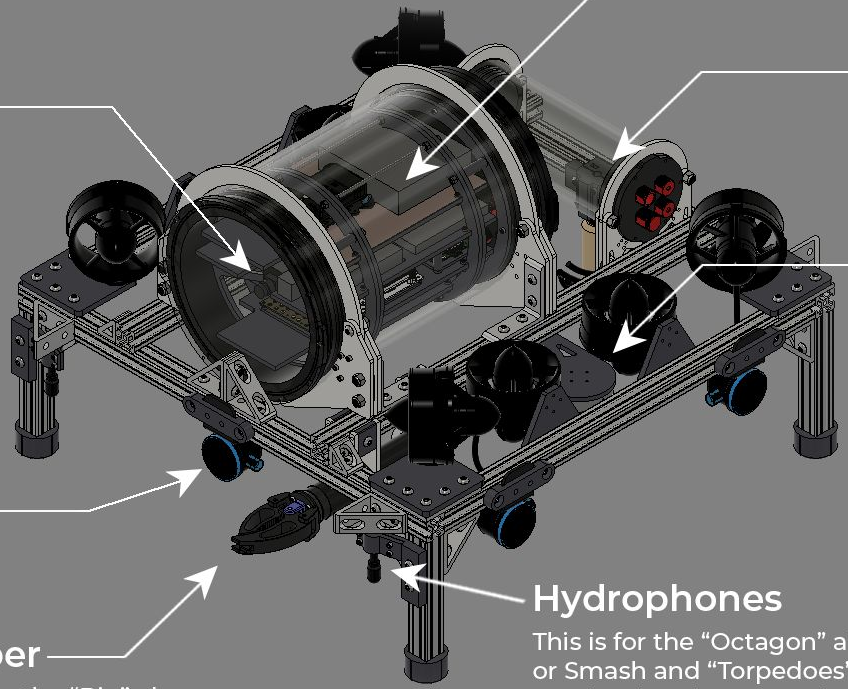
Email: 11128inspiration@gmail.com

Græy



Navigation

We used several sensor inputs and used ROS as our interprocess communication software to integrate the programs.

Modem

This is for the intersub comunication mission.

DVL

This is for navigating to every mission.

Computer Vision

This is for the “Gate” aka Choose Your Side, “Buoys” aka Make the Grade, “Bin” aka Collecting, “Torpedoes” aka Survive the Shootout, and “Octagon” aka Cash or Smash missions.

Sonar

This is for the “Buoys” aka Make the Grade and “Torpedoes” aka Survive the Shootout missions.

Gripper

This is for the “Bin” aka Collecting and “Octagon” aka Cash or Smash missions.

Hydrophones

This is for the “Octagon” aka Cash or Smash and “Torpedoes” aka Survive the Shootout missions.