BUMBLEBEE
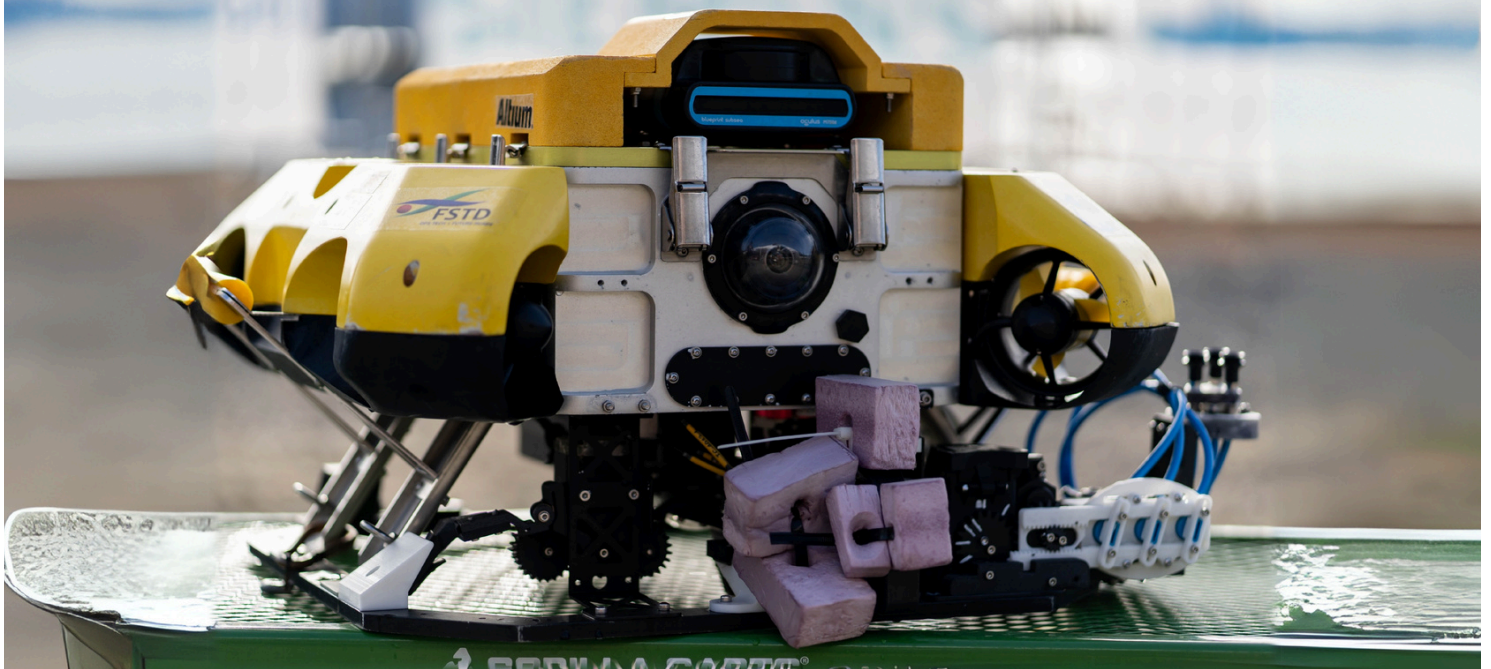
Engineering Autonomous Systems of the Future

2025-2026 SPONSORSHIP PACKAGE

NUS
National University
of Singapore

OUR STORY

Team Bumblebee comprises NUS students from various disciplines of Mechanical, Electrical, Computer Engineering, School of Computing, as well as Business School.

The project started out in 2012 with an Autonomous Underwater Vehicle (AUV). We have evolved through the years, developing 4 Generations of AUV, 4 Generations of Autonomous Surface Vessel (ASV), and 2 Generations of Unmanned Aerial Vehicles (UAV) to participate in multiple international competitions – the Maritime RobotX Challenge, RoboSub Competition and Singapore AUV Challenge (SAUVC).
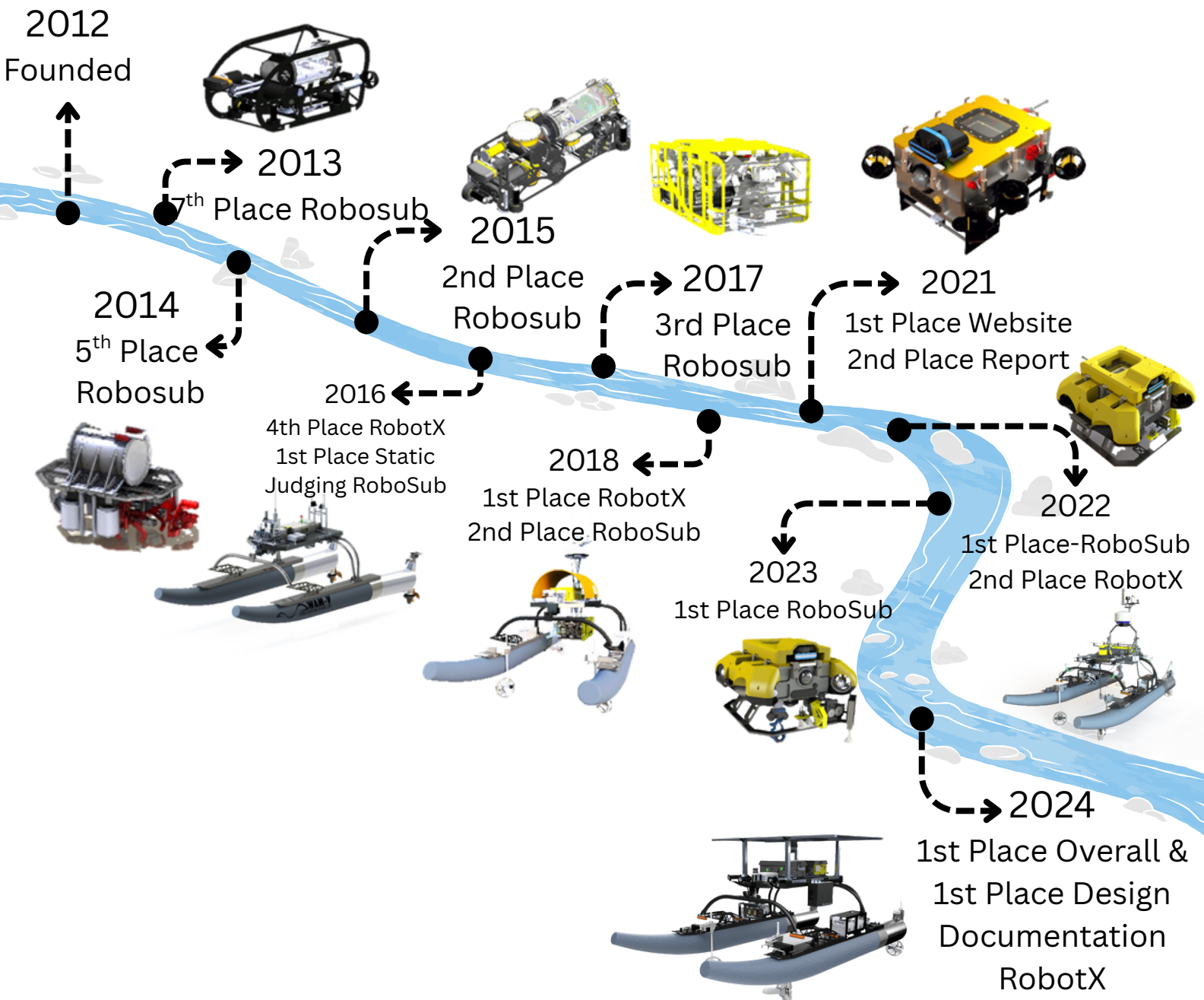
Core Vision & Key Objectives :

Inspire & Inculcate Passion in Robotics and Engineering

Provide Opportunities to Learn & Lead

Explore Research & Development in Real-World Scenarios

BUMBLEBEE
AUTONOMOUS SYSTEMS

OUR ACHIEVEMENTS

2012
Founded

2013
7th Place Robosub

2014
5th Place Robosub

2015
2nd Place Robosub

2016
4th Place RobotX
1st Place Static Judging RoboSub

2017
3rd Place Robosub

2018
1st Place RobotX
2nd Place RoboSub

2021
1st Place Website
2nd Place Report

2022
1st Place-RoboSub
2nd Place RobotX

2023
1st Place RoboSub

2024
1st Place Overall &
1st Place Design Documentation RobotX

robotx

The **Maritime RobotX Challenge** serves to foster student interest in maritime autonomous robotic systems. Participants will build upon an Unmanned Surface Vehicle (USV) platform using sensors, control systems and integration of ASV/AUVs to complete a series of multivehicle collaborative autonomous tasks.

robosub

The **International RoboSub Competition** is an international AUV competition held in the US Naval Warfare System's Transdec pool, San Diego. It challenges engineers to perform realistic missions such as acoustic localization, object and target recognition, manipulation and navigation in an underwater environment.

BUMBLEBEE
AUTONOMOUS SYSTEMS

OUR MASTERPLAN

2 YEAR PLAN

Jan '25- Apr '25

Jan '25 : AUV 4.5 Hardware Development

Mar '25 : Integration and Pool testing

Autonomous Underwater Vehicle (AUV) 4.5
- Test bed for revamped electrical and software architecture towards AUV 5.0
- Ground up development targeting problems from the previous generation

May '25 - Aug '25

May '25 : AUV 4.5 Launch

Aug '25 : RoboSub 2025

Autonomous Underwater Vehicle (AUV) 5.0
- Next-generation AUV with state-of-the-art sensor and compute suite
- Hardware support for inter-vehicle collaboration be deployed at RoboSub 2026 with AUV 4.5

Sept '25 - May '26

Jan '26 : ASV 5.0 Launch

May '26 : AUV 5.0 Launch

Autonomous Surface Vessel (ASV) 5.0
- Next-generation ASV with state-of-the-art sensor suite and improved reliability
- Inter-vehicle collaborative behaviour with UAV 3.0

Jun '26 - Nov '26

Aug '26 : RoboSub 2026

Nov '26 : RobotX 2026

Unmanned Aerial Vehicle (UAV) 3.0
- Custom drone platform with new frame, motors, and actuators
- Aimed to complete all autonomy challenges at RobotX 2026 with the ASV

Key Technological Developments
- AUV-AUV collaborative operations through in-house underwater acoustic communication system
- Improved drone take-off and landing system

BUMBLEBEE
AUTONOMOUS SYSTEMS

Vehicle Design: AUV 4.5

Compute Stack:
- Intel i7 11th Gen Single Board Computer
- Nvidia Jetson AGX Orin 32GB

Manipulators:
- Capability to support 3x Servo Motors & 3x Stepper Motors
- Custom Grabber
- Mini-projectile Launcher
- Marker Dropper

Propulsion System:
- 7x Bluerobotics T200 Thrusters for 6-axis movement

Perception:
- 1x forward-facing Camera
- 1x downward-facing Camera
- 1x forward imaging Sonar

Battery Modules:
- 2 × custom CNC Battery sub-hulls
- Capability to perform hot-swapping of batteries underwater
- 2 × 230Wh batteries
- 2 hours operational run-time

Navigation Suite:
- 4 × Hydrophone array for acoustic localization
- External barometric pressure sensor
- VN-100 IMU
- 1-axis Fibre-Optic Gyroscope
- Teledyne Pathfinder DVL

BUMBLEBEE
AUTONOMOUS SYSTEMS
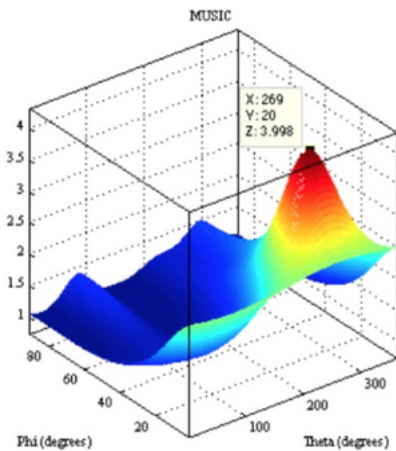
Acoustic Localization: AUV 4.5 has the capability to detect and localize to an underwater locator beacon (ULB) from far. This is accomplished by a hydrophone array and custom-made analog filters and amplifiers. We have also integrated a COTS Data Acquisition Module to help capture and process the acoustic signals. The data is then used in the MUSIC (MUltiple SIgnal Classification) algorithm and provides the localization capabilities for the AUV to locate the ULB.
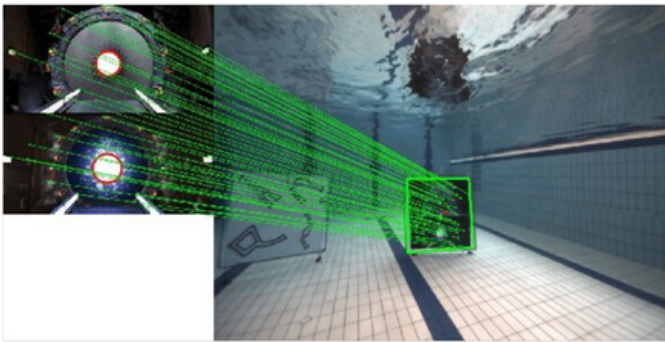

Underwater Perception and Tracking: AUV 4.5 is equipped with two machine vision cameras and an imaging sonar for forward and downward perception. Leveraging upon the benefits of both sonar and cameras, the AUV is capable of highly robust perception and tracking objects underwater. This is further enhanced with our Machine Learning pipeline that runs on the compute stack.

Navigation Suite: The navigation sensor suite consists of a 9-axis VectorNav VN-100 IMU, a DVL, a barometric pressure depth sensor, and a 1-axis fibre optic gyroscope. An Error-State Kalman Filter is used to obtain much higher accuracy than each sensor can provide independently. The AUV navigation system can perform accurate local and global navigation via waypoints.
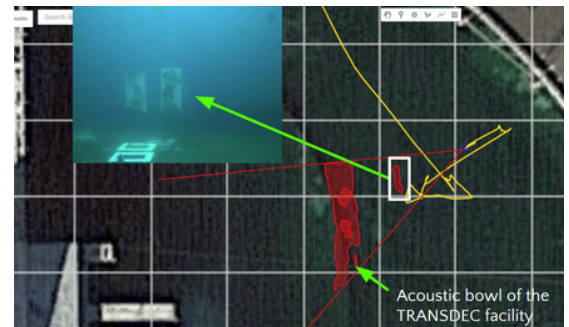
Autonomous Manipulation: With a highly accurate navigation suite and robust object perception and tracking, the AUV is capable of fully autonomous object manipulation underwater. We have tested on various types of manipulators ranging from grabbing drink bottles, dropping markers, as well as firing mini projectiles.
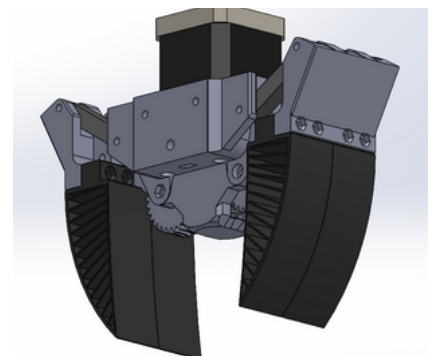
Vehicle Design :
ASV 4.0

Battery Modules:
- Operational run time of 4 hours
- 2 × 3500WH 25.2V Lithium-ion batteries

Datalink:
- Up to 500Mbps 5GHz Radio for high bandwidth data transmission
- 2.4GHz RC Link for manual operator remote control
- 900MHz Radio Datalink with our UAV 2.0

Navigation Suite:
- Eclipse-D: Miniature INS/GNSS
- Sparton AHRS8 IMU
- 4x Teledyne Reason T4013 Hydrophone Array

Compute Stack:
- Intel i7 12th Gen CPU
- NVIDIA RTX 4000 SFF

Perception:
- 3 × Cameras for 260° FOV
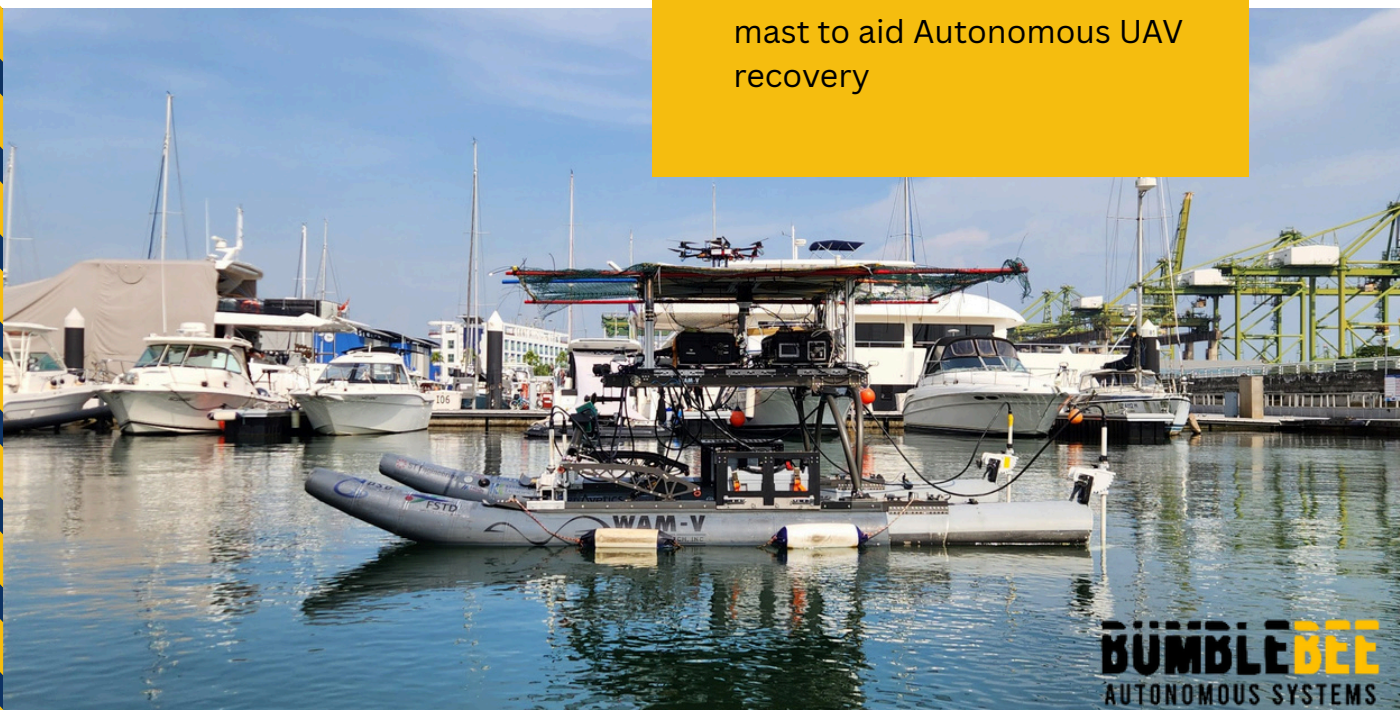- 2 × Ouster Lidars

Propulsion System:
- 4 × Minn Kota RT80 Trolling Motors

Actuators:
- Pan-and-Tilt Ball-launcher with a flywheel design
- Actuated Thrusters and Hydrophones for ease of stowing and deployment when wet berthed
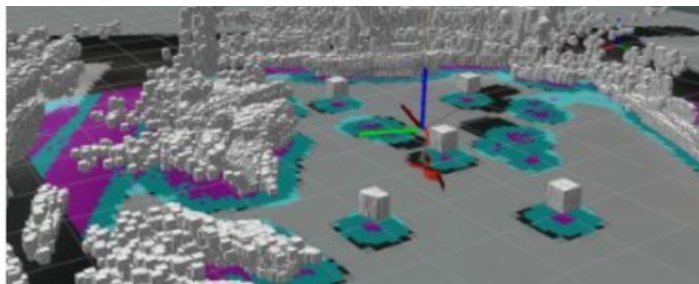
Drone Take-off and Landing:
- Visual markers installed on the mast to aid Autonomous UAV recovery

BUMBLEBEE
AUTONOMOUS SYSTEMS

CURRENT CAPABILITIES
2023/2024 VEHICLE

PERCEPTION & COLLISION AVOIDANCE

ASV 4.0 performs target recognition with the deployment of 3 cameras for 260° surround vision. It has 2 LiDARs for immediate collision avoidance and crowded environment mapping for long-range collision avoidance and sea navigation. The software uses sensor fusion to combine the input from the cameras and LiDARs. We also leveraged on the Nav2 framework to enable autonomous navigation.

FEEDBACK FOR OPERATIONS

The ASV 4.0 can be controlled with a remote controller, with a customized firmware that we developed to display key information of the ASV including battery usage and temperature readings of key components. A Telegram chatbot service was also integrated to publish vehicle data to a common channel where all users can monitor the key statuses, helping to ensure the safety and reliability of our system.

CONTROLS & NAVIGATION

ASV 4.0 has a vectored thruster configuration which allows for many precise maneuvers such as dynamic positioning, path tracking, encirclement and side movement. ASV 4.0 has achieved dynamic positioning capabilities of less than 0.5m accuracy for Sea State 3 conditions.

DRONE PAYLOAD
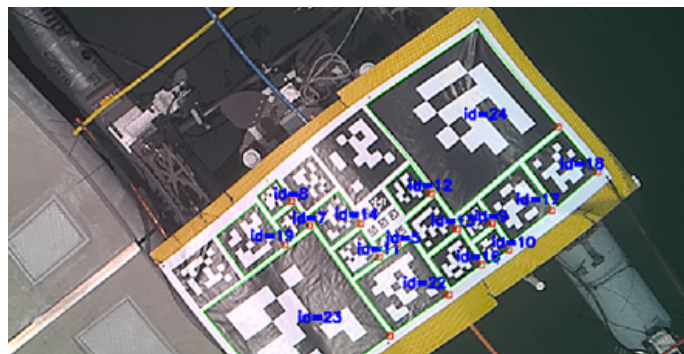
We have further improved on our inter-vehicle communication system to allow ASV 4.0 to reliably launch and recover our UAV 2.0 without human control. A simplified landing platform comprising of visual markers is installed on top of the mast to further enhance the reliability of recovery.

BUMBLEBEE
AUTONOMOUS SYSTEMS
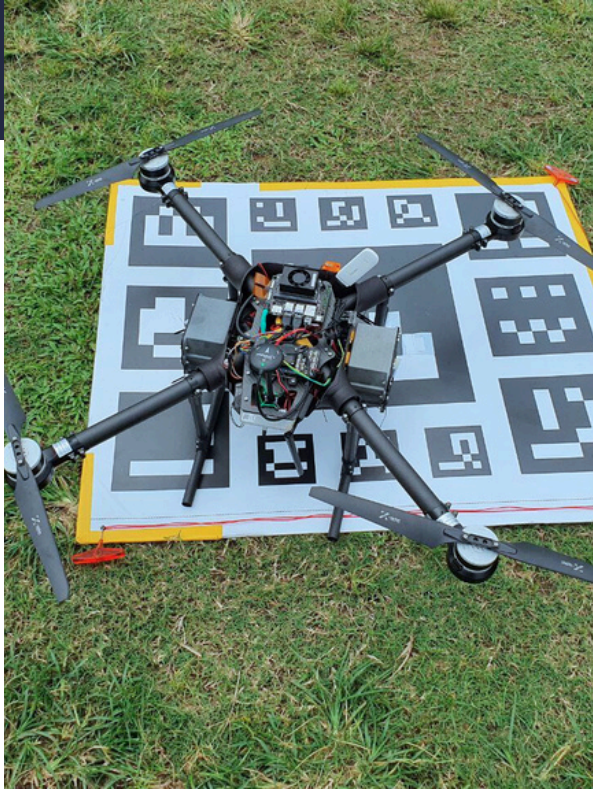
Vehicle Design:
UAV 2.0

Compute:
- Jetson Orin NX 16GB

Perception:
- FLIR Blackfly USB 3.1
- Arducam IMX219 160 Deg FOV

Propulsion System:
- Integrated Propulsion System with Multi-Rotor FOC ESC

Battery Modules:
- Operational flight time of 20 minutes (fully ladened)
- 2 x 16000mAh Li-Po Battery

Datalink:
- 4G LTE Wi-Fi Modem
- 2.4GHz RC Link for manual operator remote control
- 900MHz Radio Datalink with ASV 4.0

Navigation Suite:
- Holybro M9N GPS
- Holybro Pixhawk 6X


BUMBLEBEE
AUTONOMOUS SYSTEMS

Lightweight Rainproof Structure: UAV 2.0 is designed specifically to combat the harsh, unpredictable weather in Singapore. It consists of a laser cut frame made of carbon fibre. All peripherals are mounted onto the frame, while a composite shell that is fabricated using Multi Jet Fusion (MJF) 3D printing envelops the frame to protect the internals from weather elements. To allow the internals to be properly cooled, S ducts and exhausts are integrated to the cover of the shell to allow for airflow, while still preventing water ingress to allow the drone to withstand light rain.

Flotation: A fully independent floatation system allows for retrieval of the UAV in the unfortunate event of a crash into the water. Two floats are inflated via a servo-activated gas canister when sensors come in-contact with water.

Search and Report: UAV 2.0 runs a mission planner to allow it to run custom search patterns and report back GPS coordinates of targets back to the ASV.
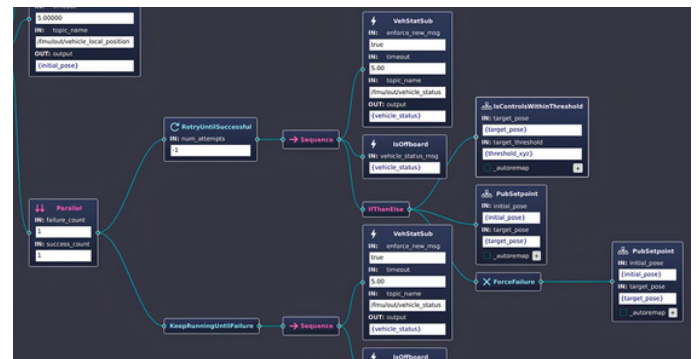
Inter-Vehicle Communication: The UAV is able to communicate with the ASV 4.0 reliably through a radio datalink. This allows it to transmit data back and reliably coordinate launch and recovery operations from the mast of the ASV.

BUMBLEBEE AUTONOMOUS SYSTEMS

Training &Learning Program

Over the past few years, our members have been exposed to a wide range of hands-on work that includes 3D printing, turning/milling manufacturing processes, designing of complex circuit boards, developing of custom algorithms, and large-scale systems integration.

Team Bumblebee

Team Hornet

All new freshmen embark on a year-long Training Programme under Team Hornet which will see them design a low-budget AUV. The goal of Team Hornet is a developmental one, allowing the freshmen to hone their technical skills in an environment not bounded by the requirements of the main vehicle.

The program aims to balance learning and mentorship, offering Bumblebee prospectives a glimpse into the working and technical expectations of the main team. Their newly developed capabilities and expertise will allow them to be welcomed into the main team and given greater challenges and responsibilities.

Industry Visits

Team Bumblebee also actively takes part in industry visits to expand our knowledge. We visited private companies such as Fugro to learn about their operations as well as the systems used in their line of work. Similarly, we visited ST Engineering who gave us a tour onboard their USV.

Members are also given the opportunity to go on internships with our sponsors and even take up Final-Year Projects with them.

Not only does engaging our sponsors help hone the soft skills of the team members, but it also gives our members insight into current developments occurring in the industry directly and inspire them to pursue a meaningful career with them.

OUTREACH PROGRAMS

Team Bumblebee also regularly hosts lab visits for fellow robotics teams and marine robotics enthusiasts. These are done in the collaborative spirit of learning.

Lab Visits

Exhibitions

Every so often, Team Bumblebee is given the opportunity to present about marine robotics and the research that we do.

Previous exhibitions that we have attended include: RoboSoft 2023, SAUVC guest lecture, NUS iDP Exhibitions, NUS Open House & Robotics Fair.

Sponsor's Appreciation

At the launch of a new vehicle, Team Bumblebee organizes a Sponsor's Appreciation Event to recognize the support that our sponsors provide. During this event, our members also take the opportunity to interact with our industry partners to not only network but exchange technical expertise.

School Sharing

Team members also visit their alma maters to share their experiences in developing autonomous vehicles and participating in international competitions. We hope to inspire future batches of engineers to develop their passion in maritime robotics.

BUMBLEBEE
AUTONOMOUS SYSTEMS

Become part of our valued sponsor community.

BUMBLEBEE
AUTONOMOUS SYSTEMS

Sponsorship

*Inclusive of cash, equipment or software equivalent to the amount stated

S$20000* AND ABOVE

- **Extra Large Logo** displayed on vehicles
- Equipment Review on our blog
- Priority for test-bedding technologies
- Access to members' resume database
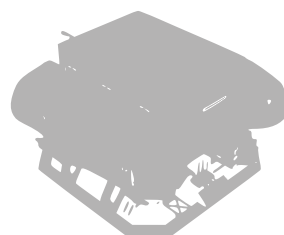- Company logo on Journal Paper, Website, Apparels, Facebook

Platinum

BETWEEN S$10000–20000*

- **Large Logo** displayed on vehicles
- Equipment Review on our blog
- Access to members' resume database
- Company logo on Journal Paper, Website, Apparels, Facebook

Gold

BETWEEN S$6000–S$1000*

- **Medium logo** displayed on vehicle
- Equipment Review
- Company logo on Journal Paper, Apparels, Website, Facebook

Silver

S$6000 AND BELOW*

- **Small logo** displayed on vehicle
- Company logo on Website and Apparels

Bronze

Title

NUS
National University
of Singapore

Platinum

FSTD
OPS-TECH · FUTURE-READY

DSO
NATIONAL
LABORATORIES

ST Engineering

Altium.

REPUBLIC OF SINGAPORE
1826
YACHT CLUB

DHL

THANK YOU
for your support

Team Bumblebee is immensely thankful
and grateful to all our wonderful sponsors.
Our achievements and successes today
would not have been possible without
their support.

Gold

FUGRO

MacArtney
UNDERWATER TECHNOLOGY

WE WÜRTH
ELEKTRONIK
MORE THAN
YOU EXPECT

Silver

SBG SYSTEMS

sparton

FESTO

DS
SOLIDWORKS

southco®
CONNECT · CREATE · INNOVATE

Jane Street®

Avetics

samtec

MEDs
INTERCONNECT

Bronze

WaterLinked

TGN
Technology Pte Ltd

LIONSFORGE

BOSSARD
Proven Productivity

BLUE TRAIL
ENGINEERING

Pololu
Robotics & Electronics

Φ Kraus & Naimer

ROHDE&SCHWARZ

BUMBLEBEE
AUTONOMOUS SYSTEMS

Contact Us

Advanced Robotic Centre (ARC)
National University of Singapore
College of Design and Engineering
1 Engineering Drive 3
Block E8 #01-03 Singapore 117580

bumblebeeauv@gmail.com

bumblebee.sg

linkedin.com/company/nus-bbas

facebook.com/bumblebeeAS/

instagram.com/nus_bbas/