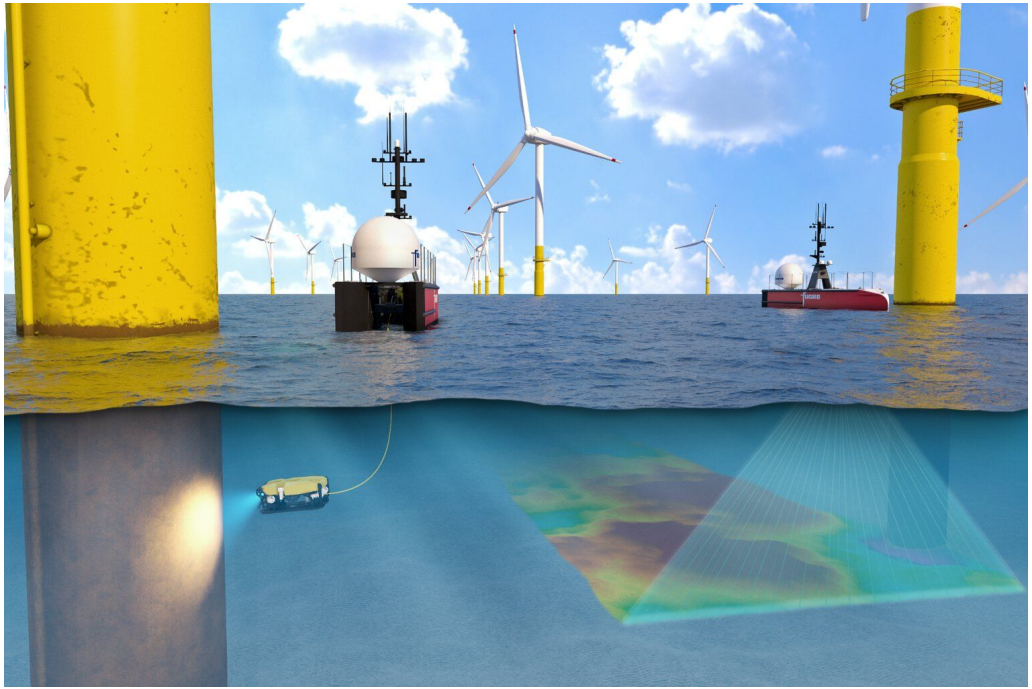
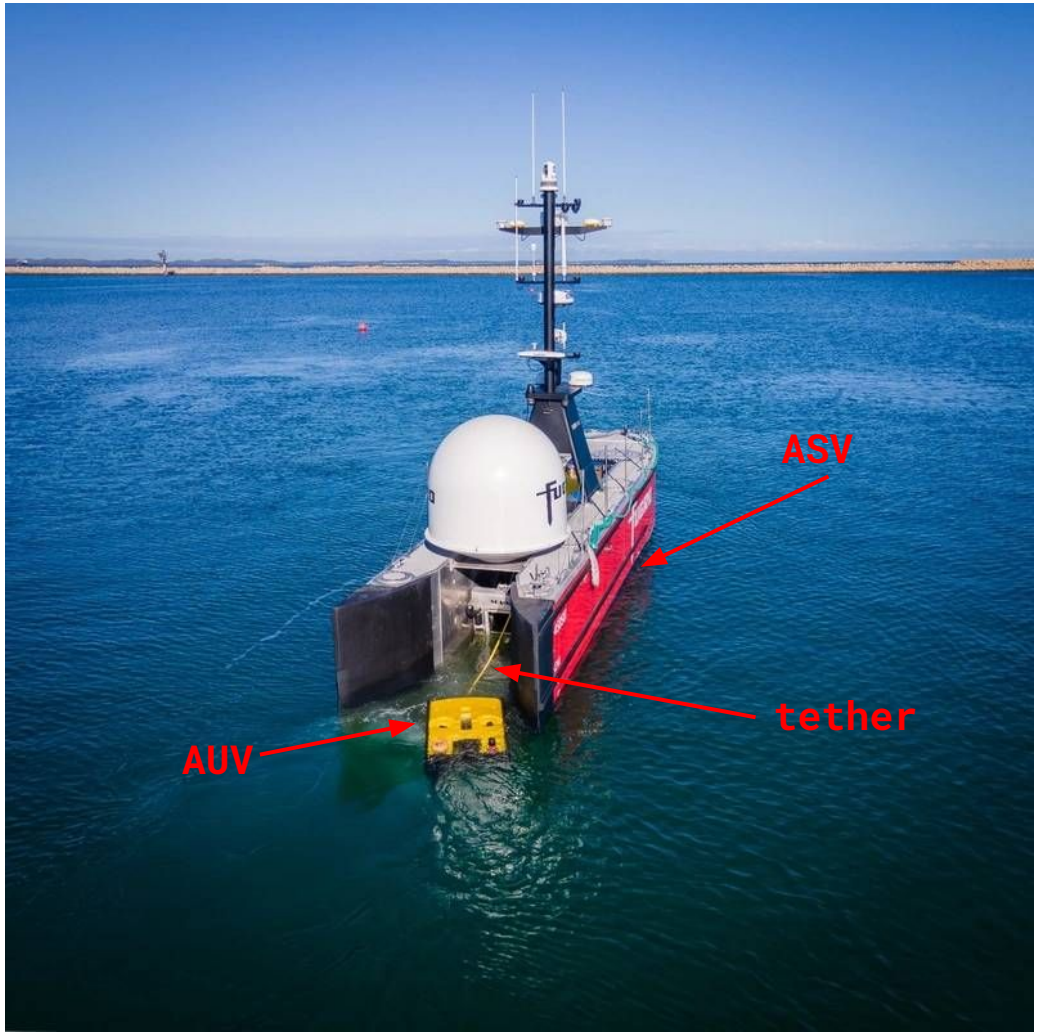
HERIOT WATT UNIVERSITY

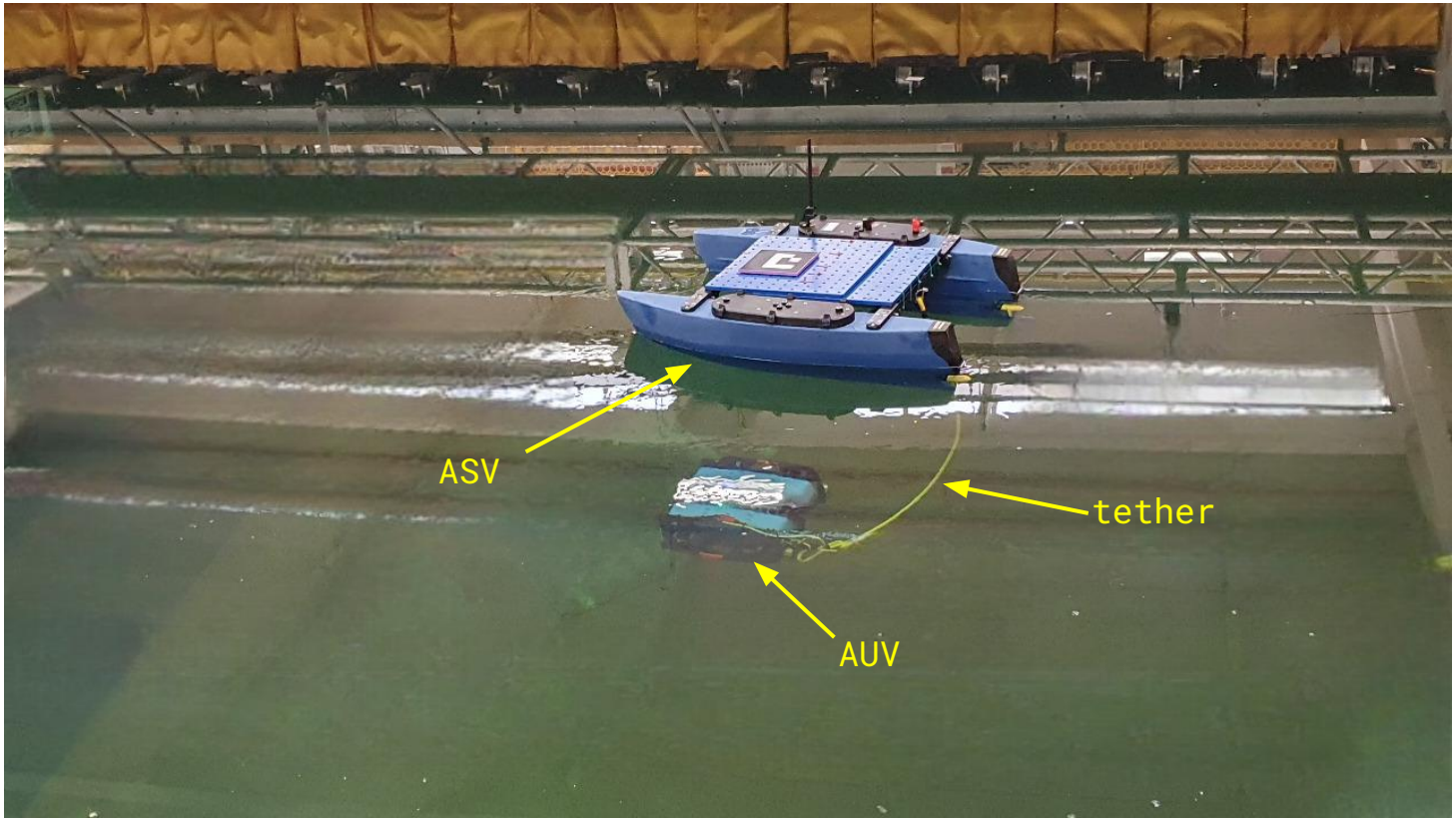
Motion Control for Tethered Multi-Robot Systems in Marine Environments with Disturbances

EDINBURGH CENTRE FOR ROBOTICS

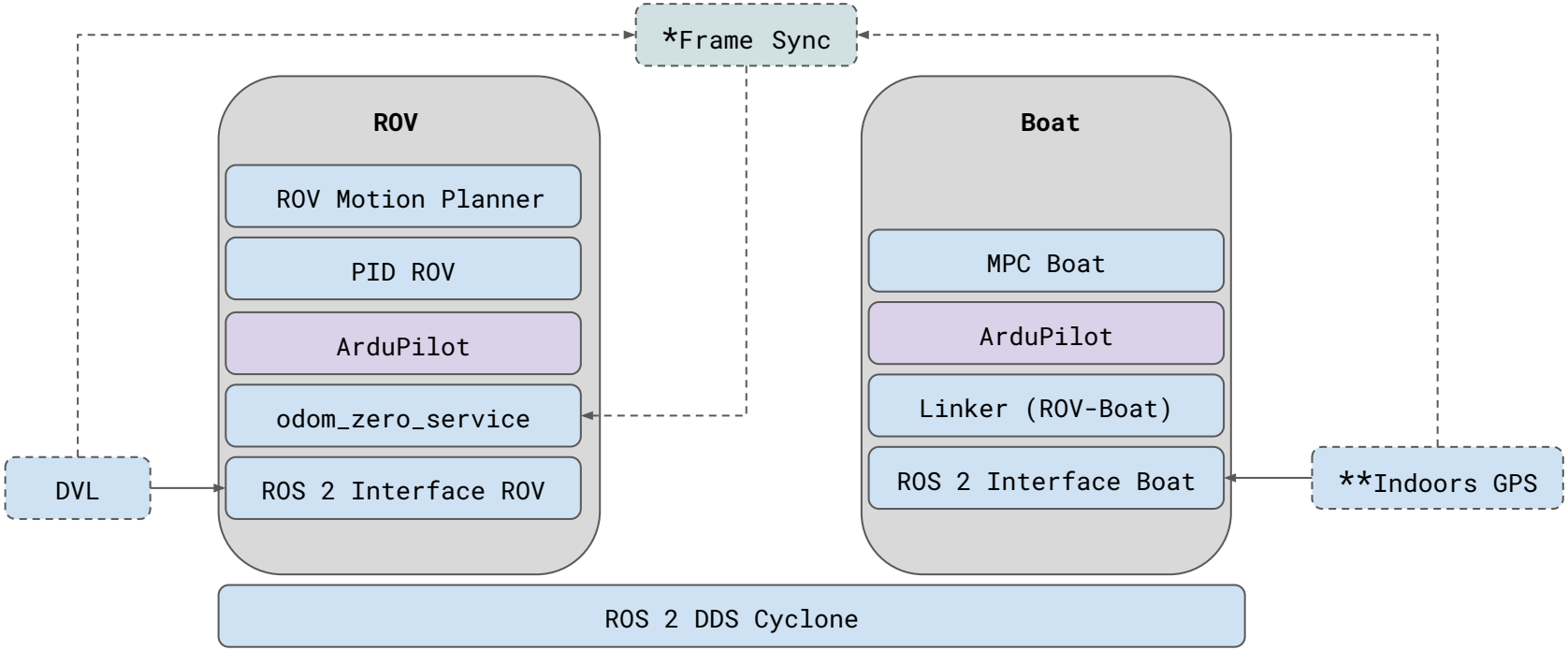
Motivation




ASV
tether
AUV


ASV
tether
AUV

Software architecture



* - applicable for tests in wavetank. Same vehicle frame in simulator.
** - applicable for tests in wavetank. GPS in simulator.

Multi-agent system overview

BlueOS
192.168.2.12

EndPoint
192.168.2.70:14560

BlueOS
192.168.2.2

EndPoint
192.168.2.1:14550

ETH

WIFI

BaseStation
192.168.2.3

ETH Switch

USB/ETH

192.168.2.1

PC 1

192.168.2.40

PC 2

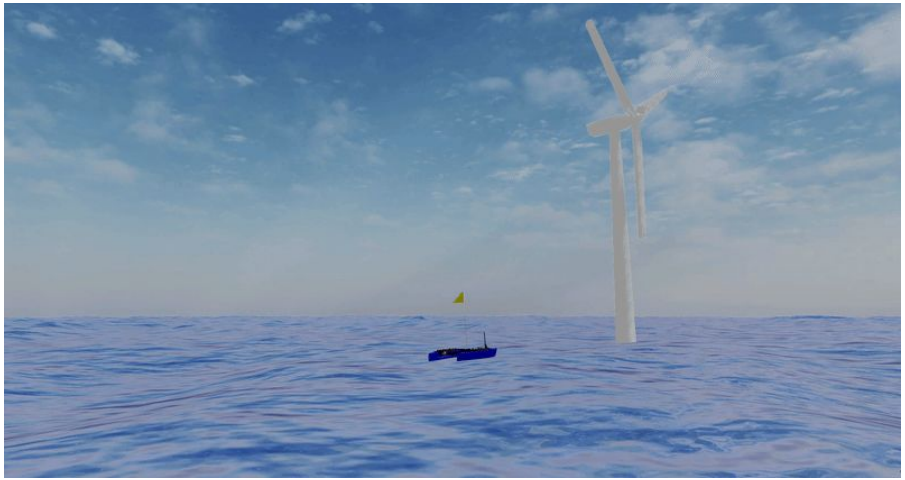
192.168.2.70

ETH

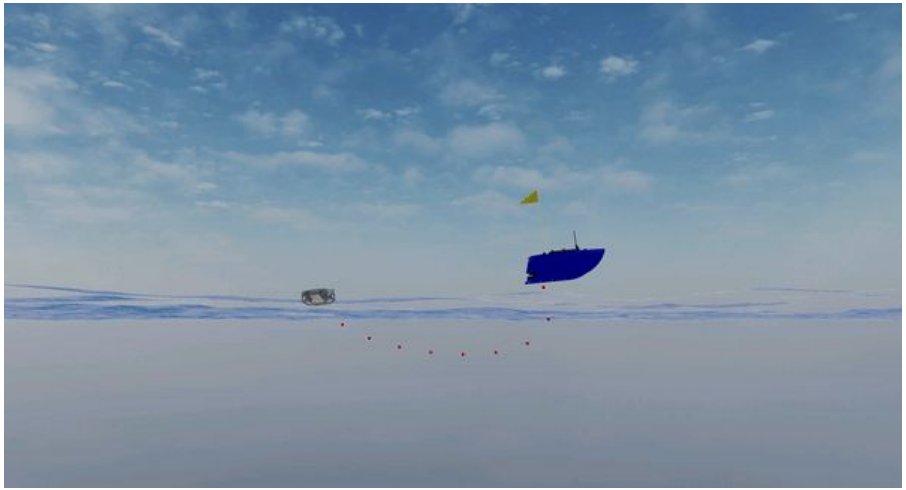
ETH

We employed an multi-agent **motion planning** and **control frameworks** capable of performing missions in ocean environments with **disturbances** (waves, wind and ocean currents).

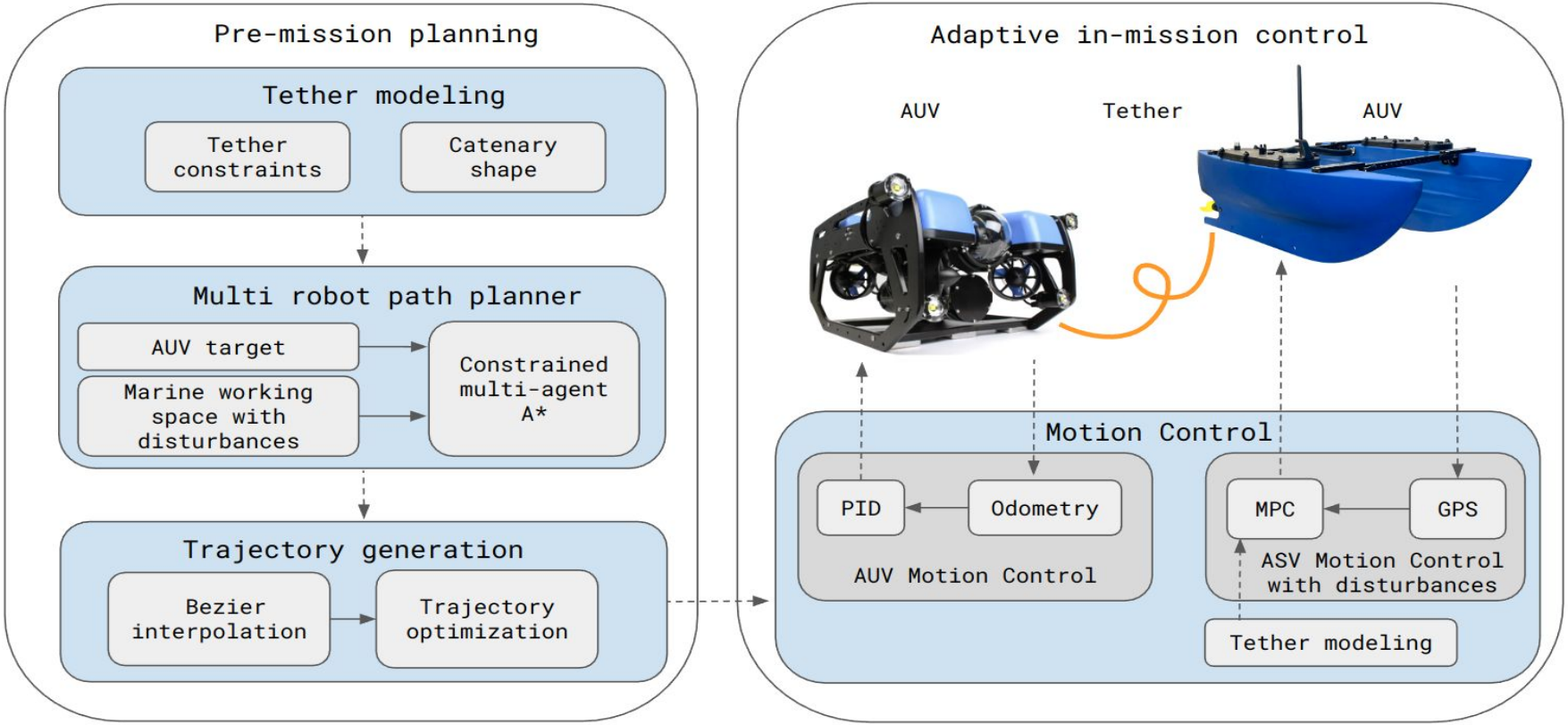
Ocean view



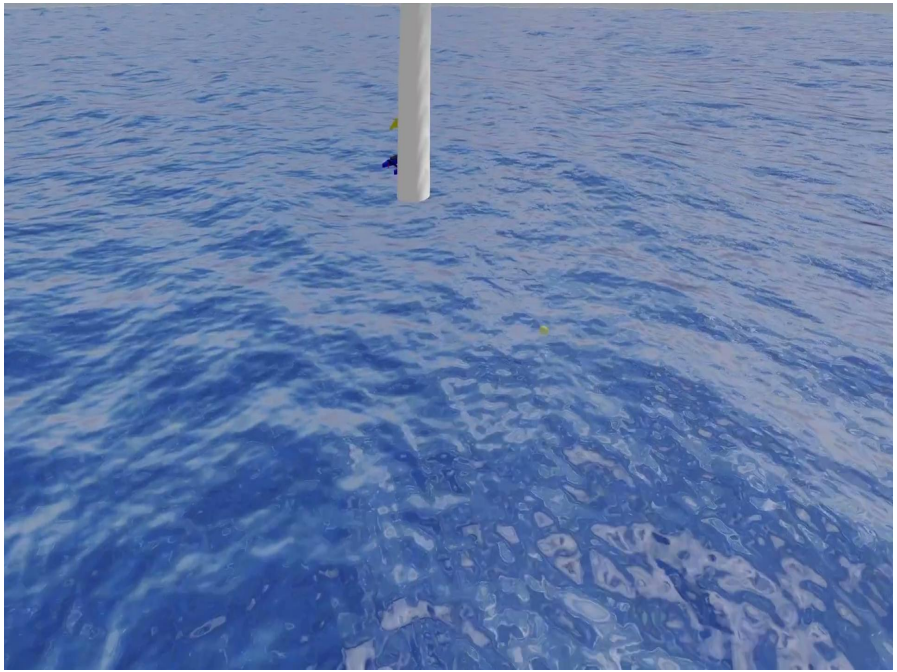
Underwater view

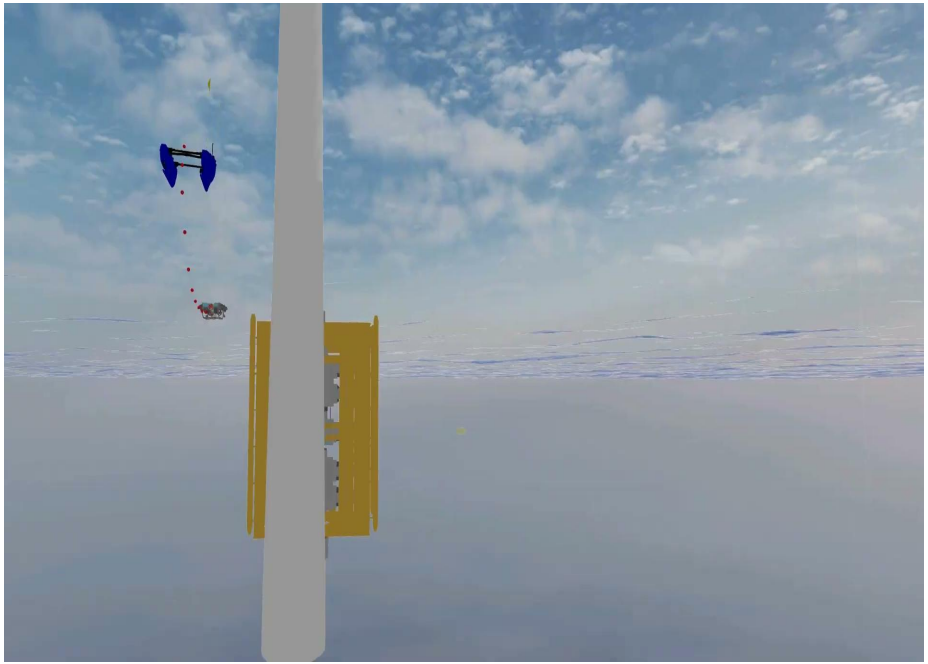


We introduce motion control framework for **maritime robotics**:



Once the goal is provided, we can evaluate agents in a simulated marine environment to demonstrate motion with all constraints compliant.

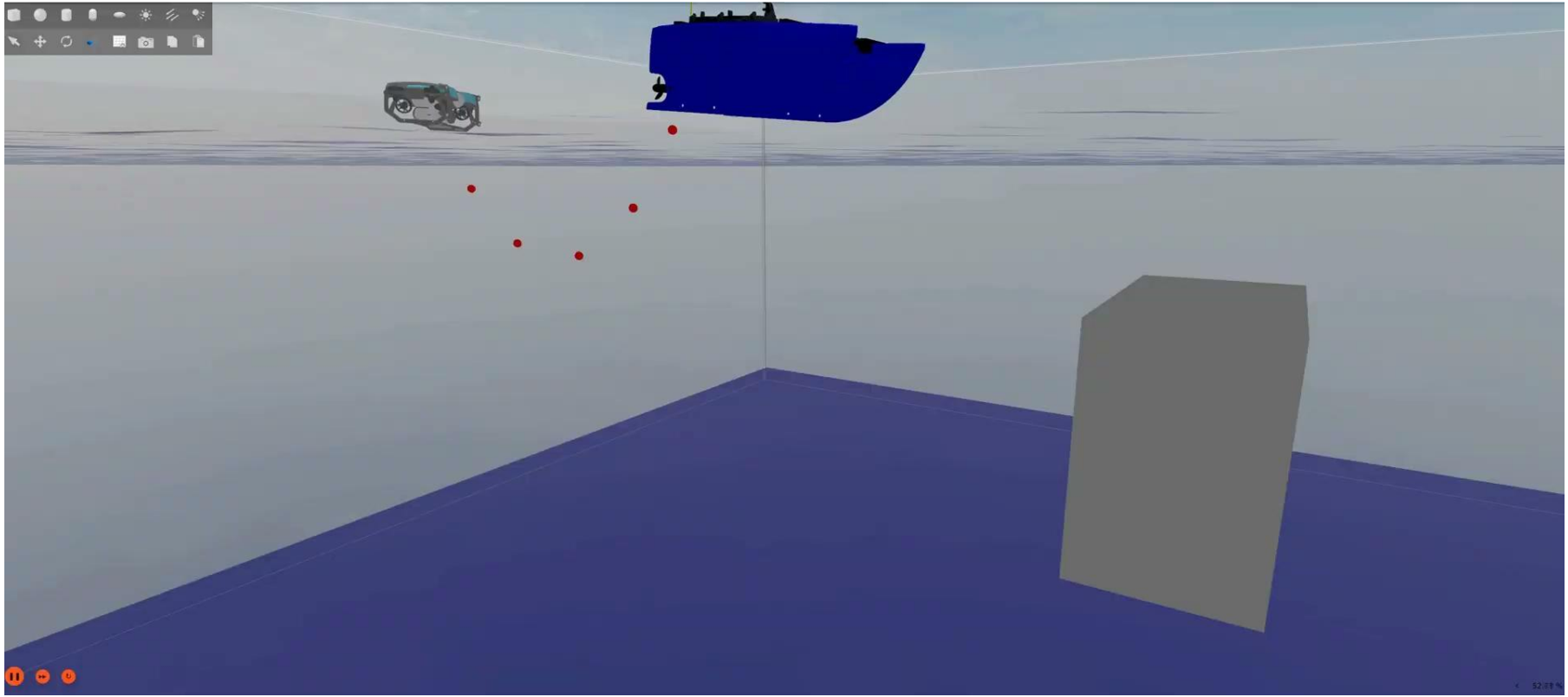




We evaluated our framework under real conditions.

DEMO 2

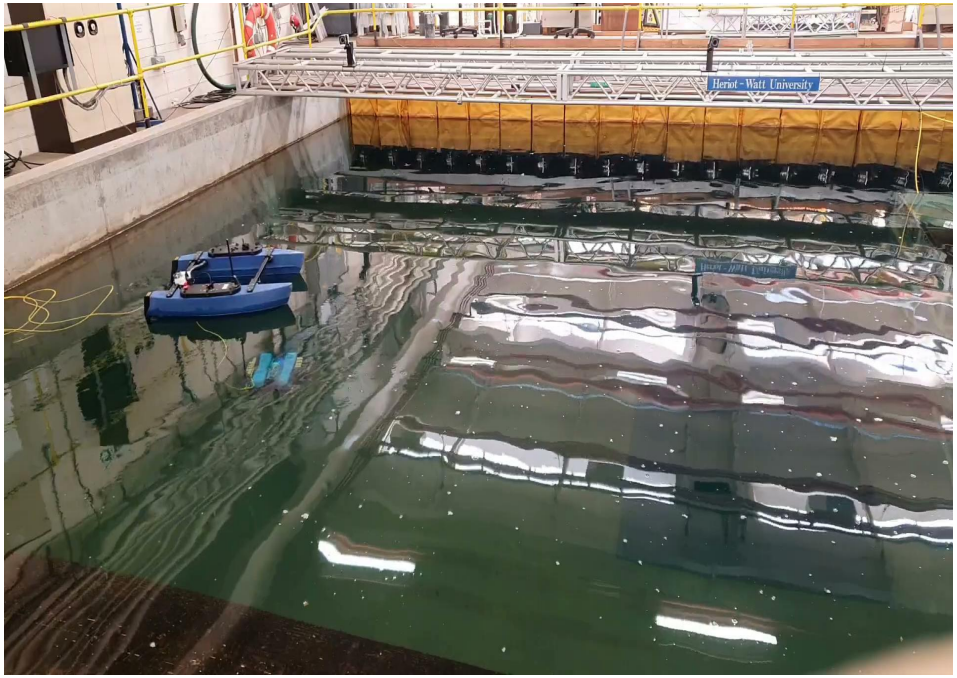
Simulation (3x)



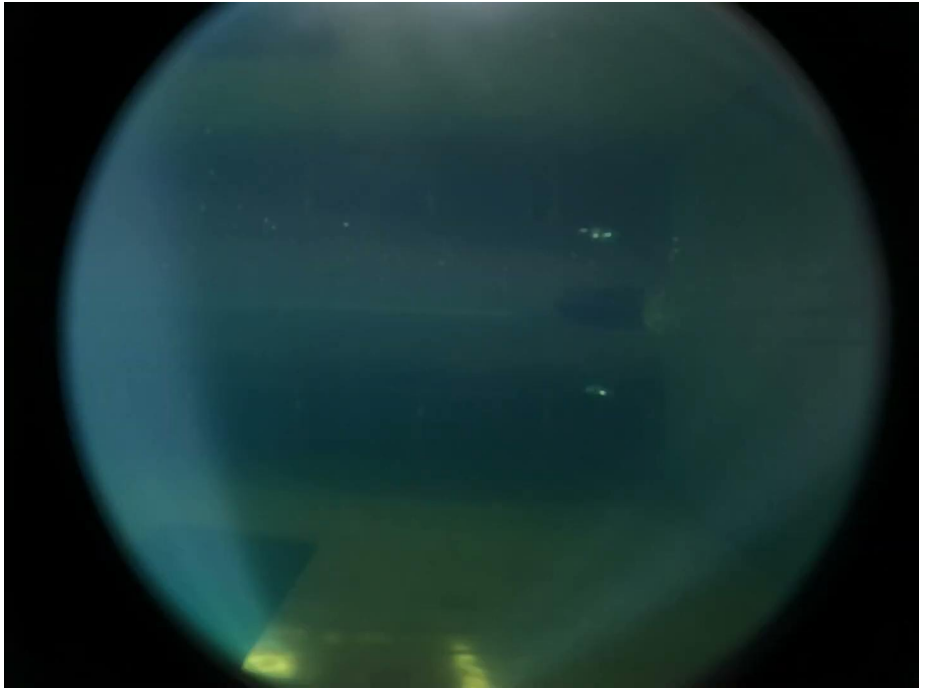
We evaluated our framework under real conditions.

DEMO 2

Ocean view



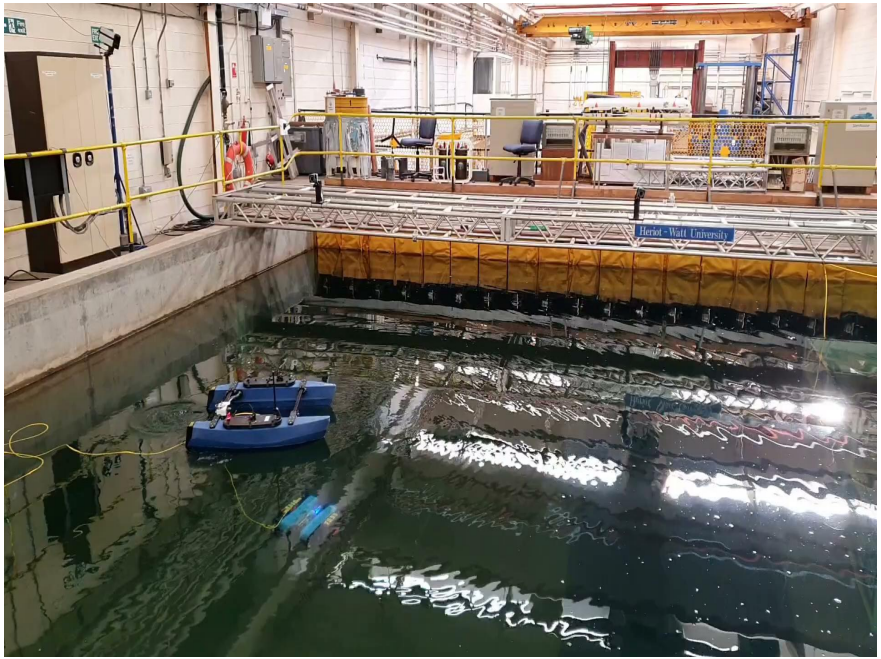
Underwater view



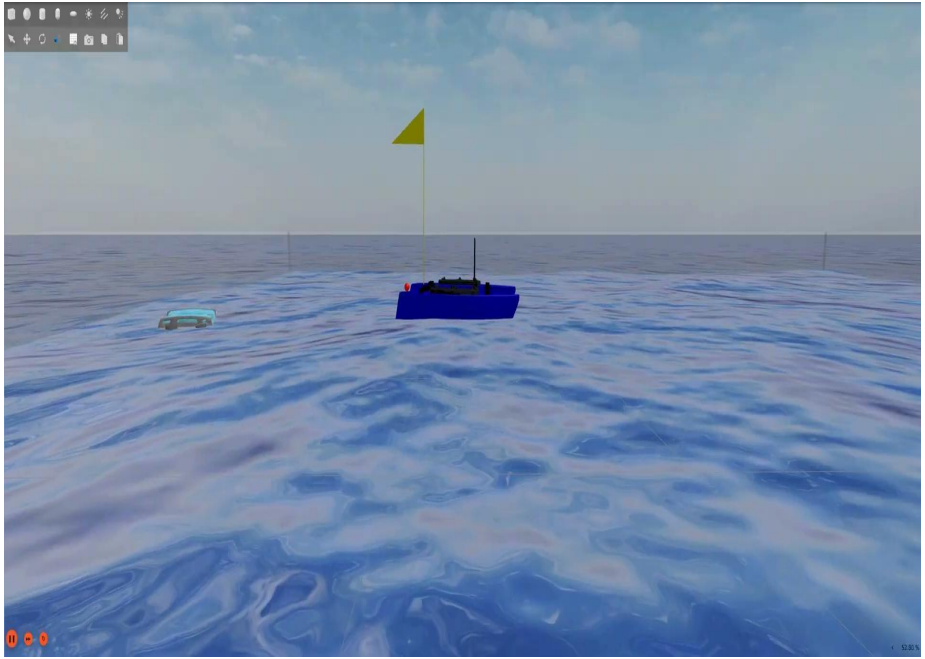
We evaluated our framework under real conditions.

DEMO 1

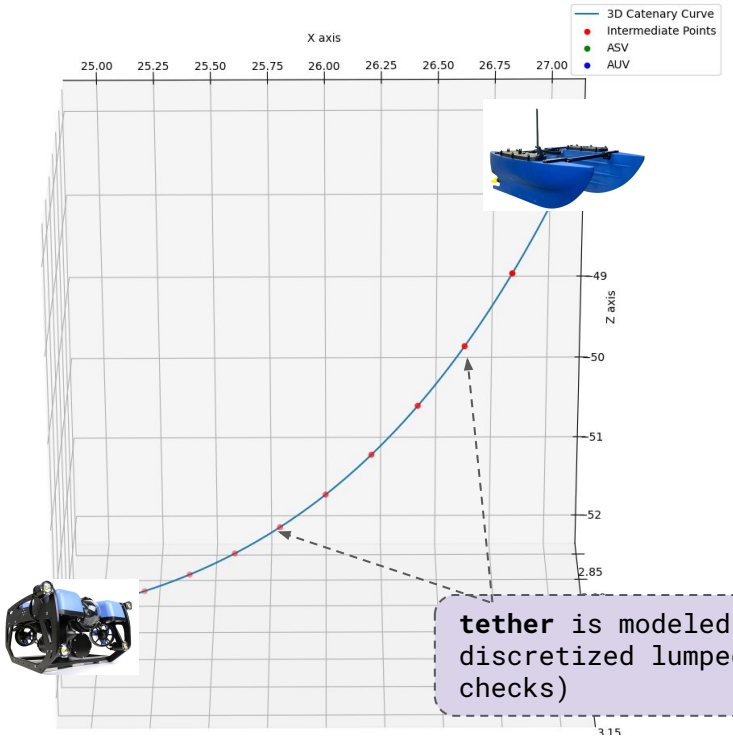
Ocean view



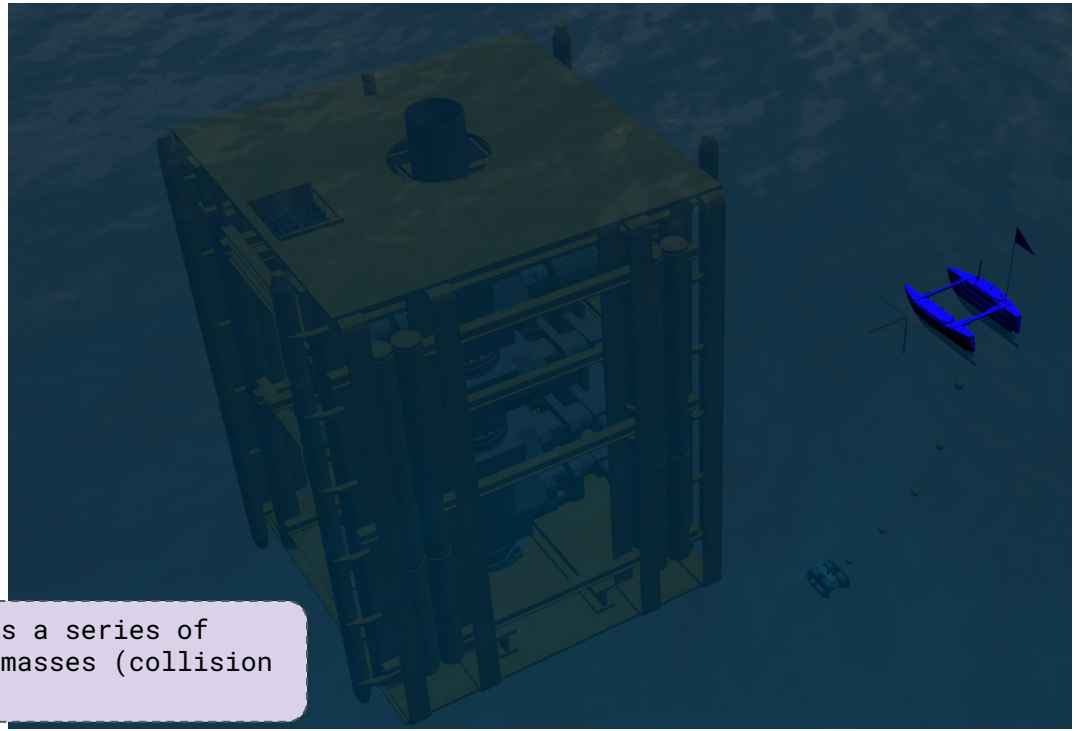
Simulation



We introduce **CoralGuide** **framework for** multi-robot motion planning system to overcome challenges in **underwater operations**.



tether is modeled as a series of discretized lumped masses (collision checks)



We provide:

1. Motion planning and control **ensure safety** under all ocean conditions, providing reliable operation even in the harshest ocean environments.

2. Advanced control strategies enhance **mission success**, **saving time** through precise control and autonomous decision-making.

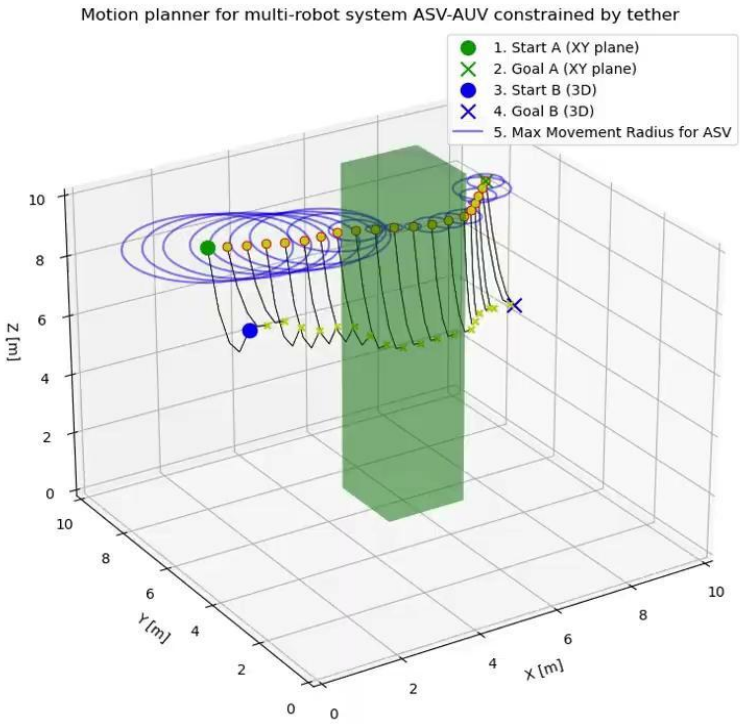
3. Missions can be **simulated and optimized** to increase safety and achieve real objectives more efficiently.

We are first (**State-of-the-art**):

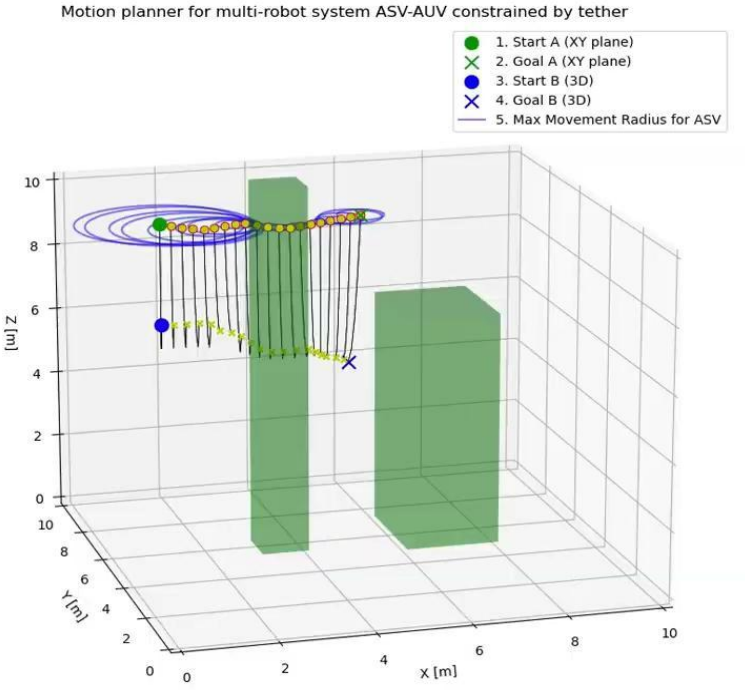
- to **formulate and test** complete motion control framework for this type of system (ICRA 2025).
- to provide **realistic marine simulator** of the multiagent system constrained by tether.
- to introduce dynamic **safety corridor and coordination strategies** to boost ocean mission influenced by disturbances.

First, we employ a **path planner** with A* algorithm and heuristic strategies designed to account for both environmental disturbances and the tether constraints to compute synchronized motion for both vehicles.

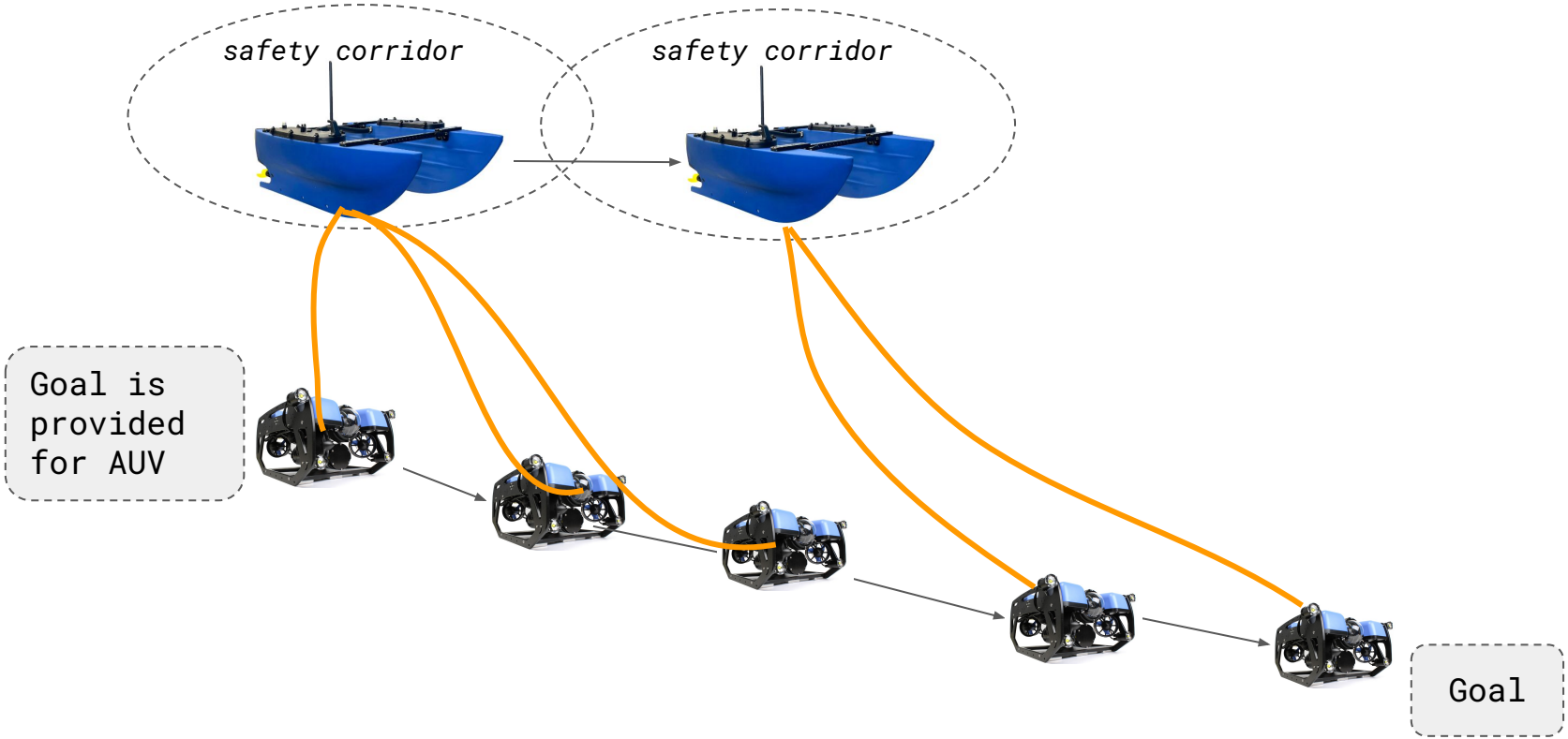
Motion around wind turbine



Motion around wind turbine and BOP

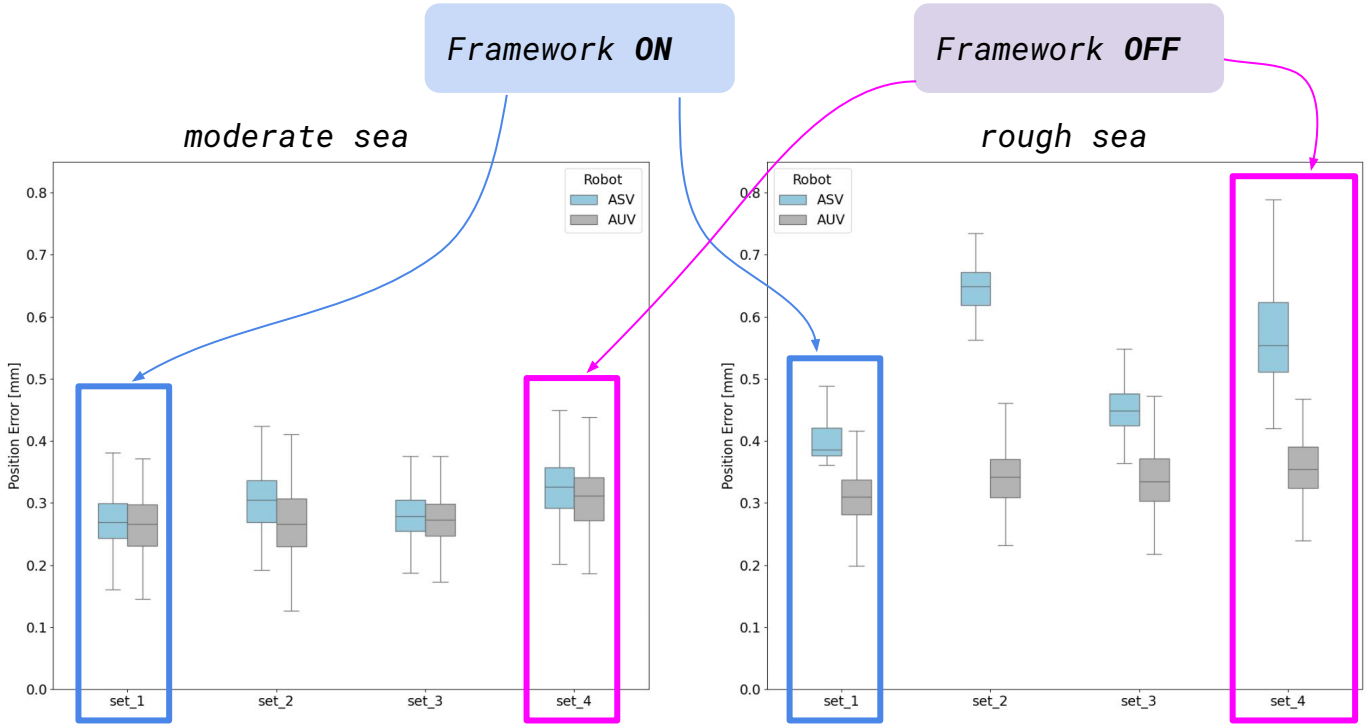


Further, we developed **adaptive MPC control** strategies for ASV to compute optimal motion within safety corridors to withstand disturbances and comply with constraints.



We achieved:

- significant improvements in **precise** and collision free motion in marine environments with disturbances.
- A novel synchronization strategy ensuring **tether integrity** under varying environmental conditions.



We will continue with:

- Improve motion control of ASV, deploy MPC for AUV.
- Deploy robot arm on AUV.
- Understand behavior of tether behaviour and control. (we use underwater motion tracking system)