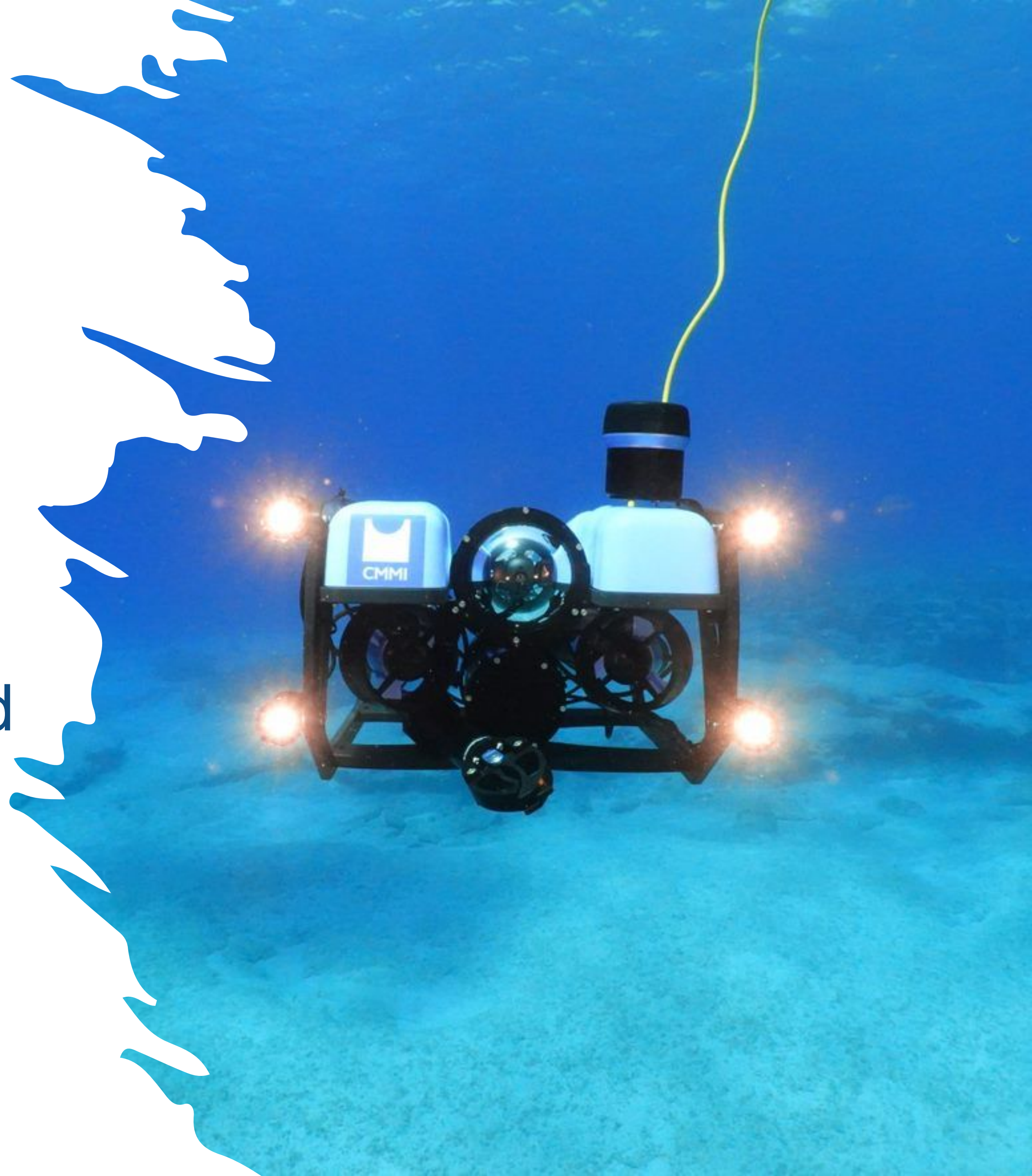
CYPRUS
MARINE &
MARITIME
INSTITUTE



Robotic System Implementation: From simulations to real-world field experiments

Building testing infrastructure and capacity

Overall Aims

- Research and development of marine robotics and marine sensing systems.
- Development of both hardware and software.
- Development of systems for provision of services, towards full self-sustainability of the institute.

Objectives for first 2 years

- Develop testing infrastructure and capacity for fast development of future robotic systems.

Research Projects

- Sea Centaurs
  - Collaborative robotics system
  - Pattern formation
- Development of a novel underwater glider design
  - Unique glider design
  - Enhanced capabilities compared to State-of-the-Art
- Swarm Robotics
  - Area coverage applications
  - Intelligent coordination for maximum information gain

Algorithm Development

Areas of Algorithm Development

- Trajectory Tracking and Behaviour Optimization (Model Predictive Control, Reinforcement Learning)
- State Estimation (Moving Horizon Estimation, Particle Filtering, Kalman Filtering)
- Cooperative Robotics Control and Coordination (Heterogeneous Cooperative Control, Swarm Coordination)
- Actuation Control (Fuzzy Logic, PID)
- Decision Making (Finite State Automata, Behaviour Trees, Linear Temporal

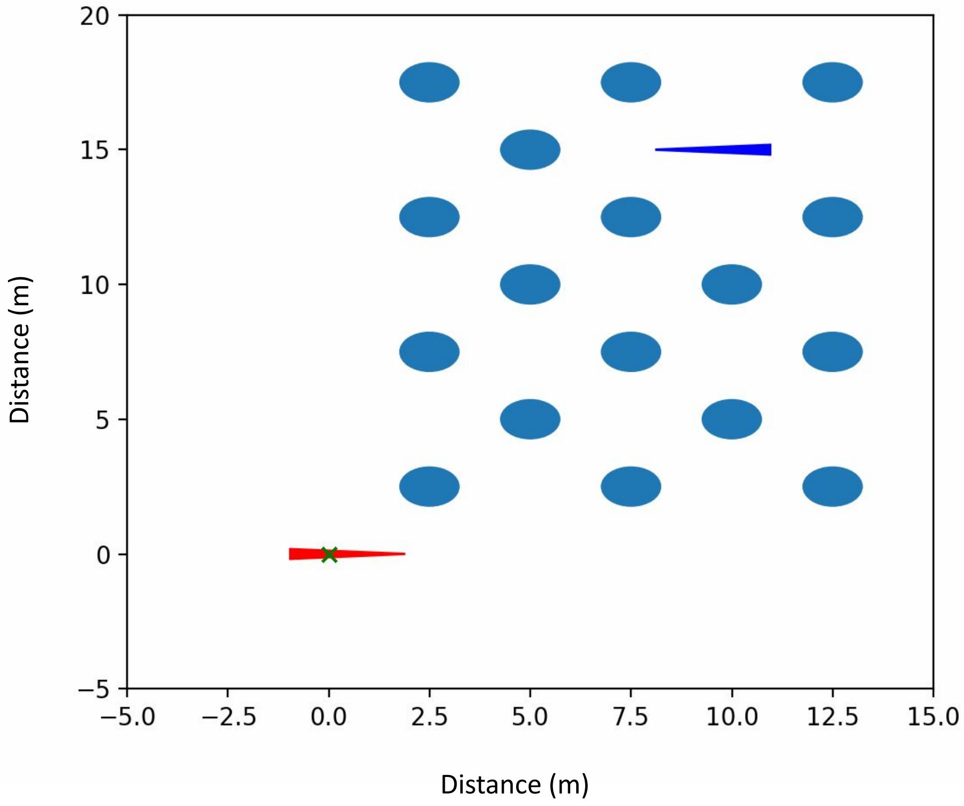
Simplistic Simulations (Python/Matlab)

- Fast implementation of a variety of mid-to-high level control and state estimation algorithms.
- Application to a variety of robotic platforms, using different motion models.

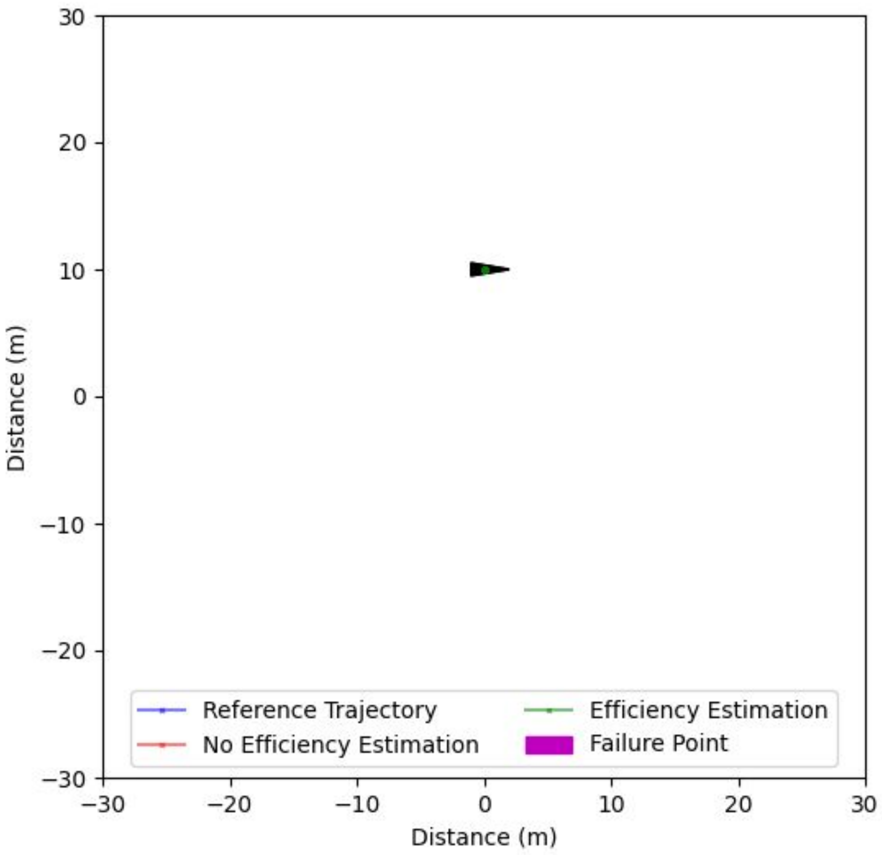
Motion models used so far

- Differential Drive, Ackerman Steering, Mecanum Ground Vehicles.
- Fully-Actuated Floating Platforms, Differential Drive Vessels, Azimuth Thrusting Vessels.
- Fully-Actuated ROVs, Electrically-Propelled AUVs, Underwater Gliders.
- Underactuated and Fully-actuated Drones.

Simplistic Simulations (Python/Matlab)



Obstacle Avoidance



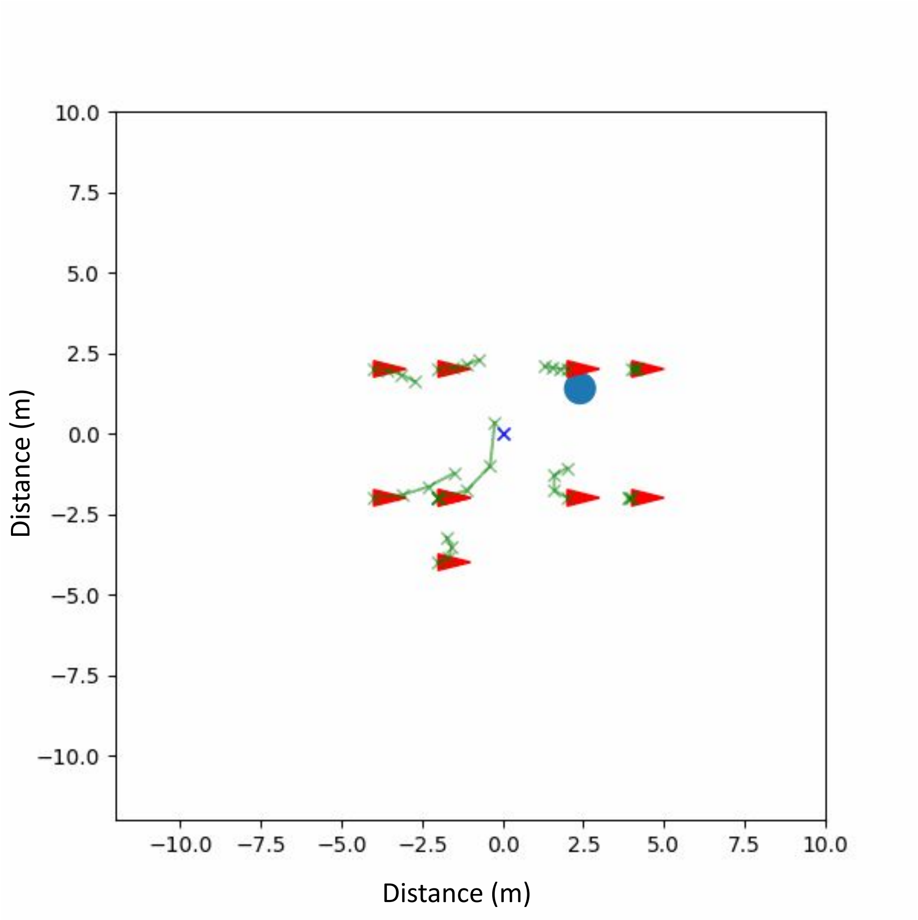
Fault Detection

Simplistic Simulations (Python/Matlab)

Distance (m)

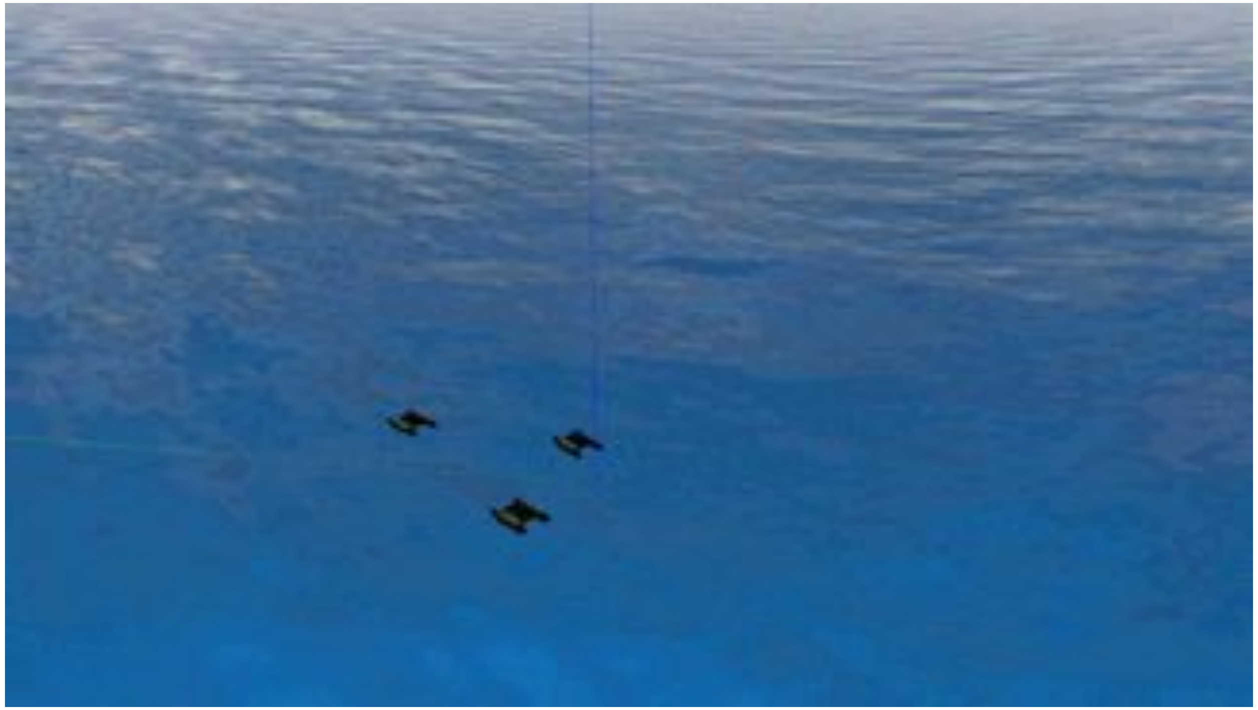
Distance (m)

Pattern Formation



Swarm Coordination

Realistic Simulations (Gazebo/Unity)



Cooperative Trajectory Tracking (Gazebo)

Gazebo Limitations:

- Simplistic physics engine
- Required to hardcode motion model coefficients

Unity-based Simulations:

- More detailed physics engine
- Capable of calculating the motion model coefficients of a given vessel 3D model

Small-Scale Prototype Testing

Aiming to:

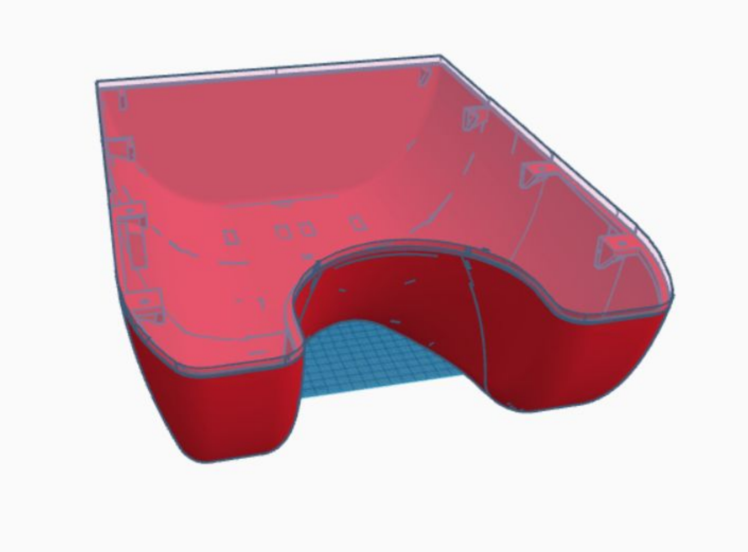
- Validate the control algorithms in simplified scenarios
- Answer questions regarding implementation of different sub-systems
- Steady progression towards full-system implementation and testing

Prototype Buoyancy Engine Experiments

Small-Scale Prototype Testing

Pattern formation experiments

Small-Scale Prototype Testing



Propulsion:

- Different configurations of propeller thrusters
- Hydrojet drive

Processing Units:

- Raspberry Pi 4/ NVidia Jetson
- Pixhawk Cube (with Here3 GPS)
- Arduino

Small-scale USV

Small-Scale Prototype Testing

SeaPerch (Small-scale ROV)

SeaGlide (Small-scale underwater glider)

Controlled Environment and Field Testing

Cooperation with:

- Local, European and international universities
- Marinas and ports around Cyprus
- Maritime companies
- Local authorities and maritime training centres