

# Remotely Operated Underwater Vehicle

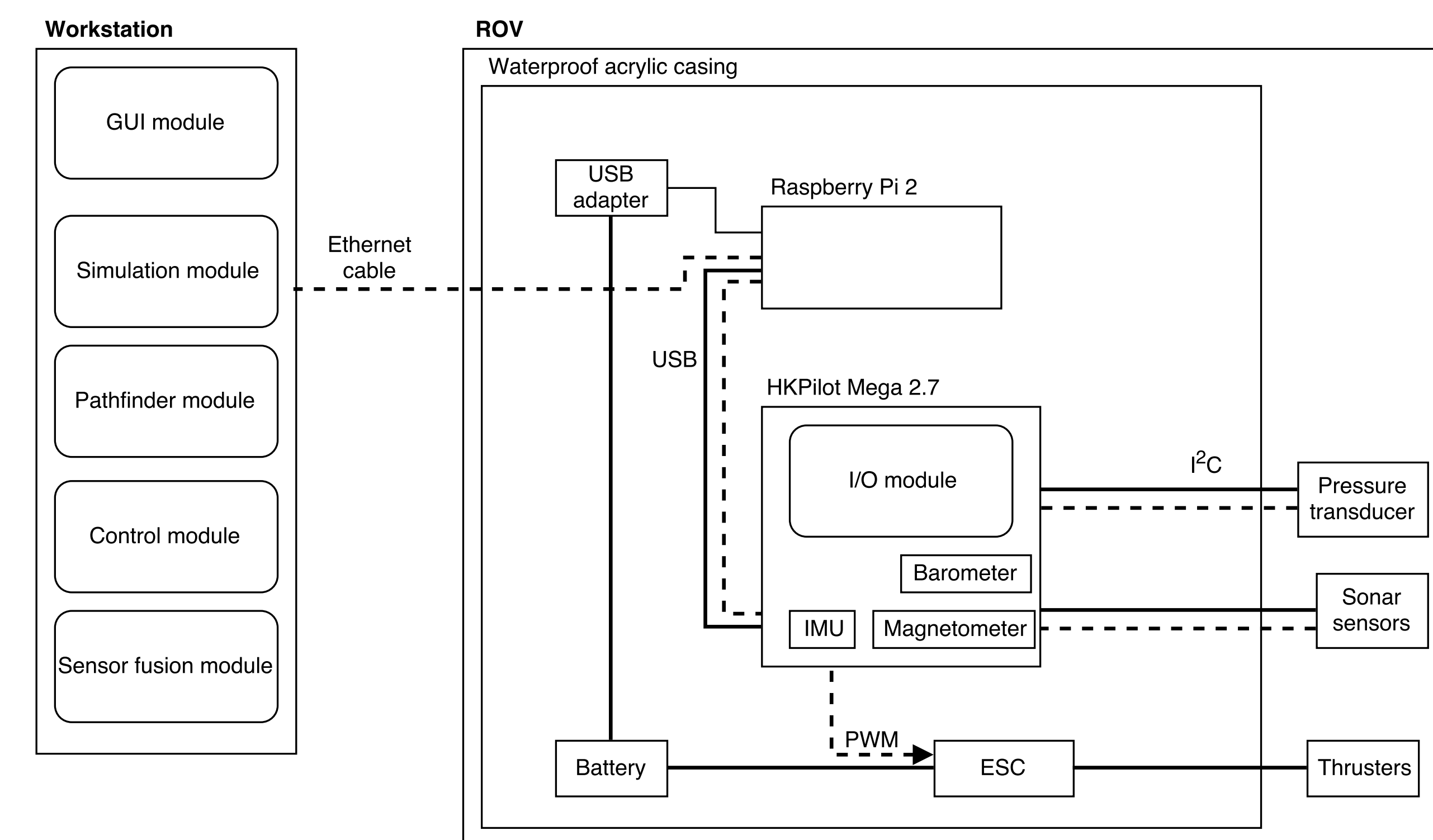
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## Summary

The goal with the project was to develop an autonomous Remotely Operated Underwater Vehicle (ROV) that can follow a given trajectory. Another goal was to develop a robust system to control the ROV and create autonomous behaviours in a pool environment.

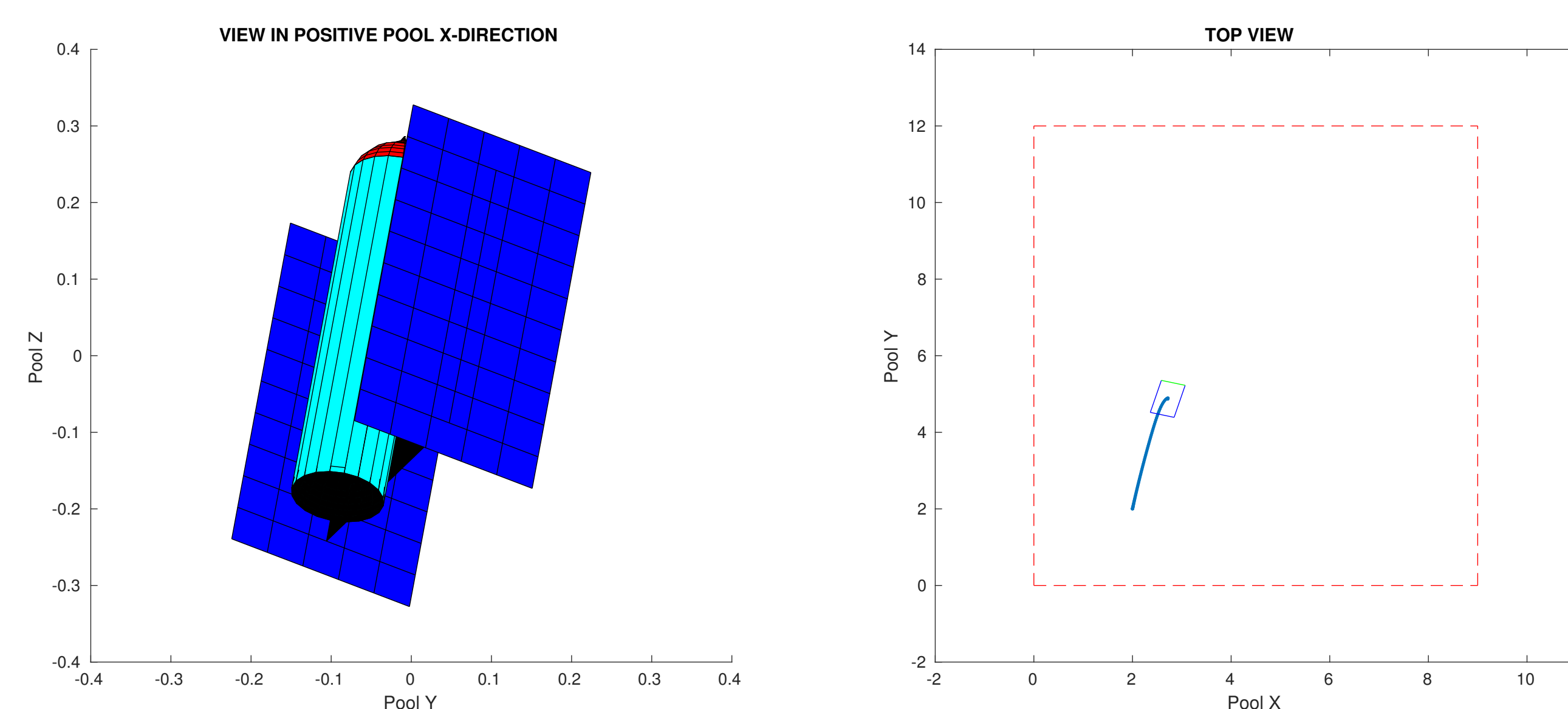
## System Overview

An overview of the system, consisting of the ROV and the workstations, with its subsystems are shown below.



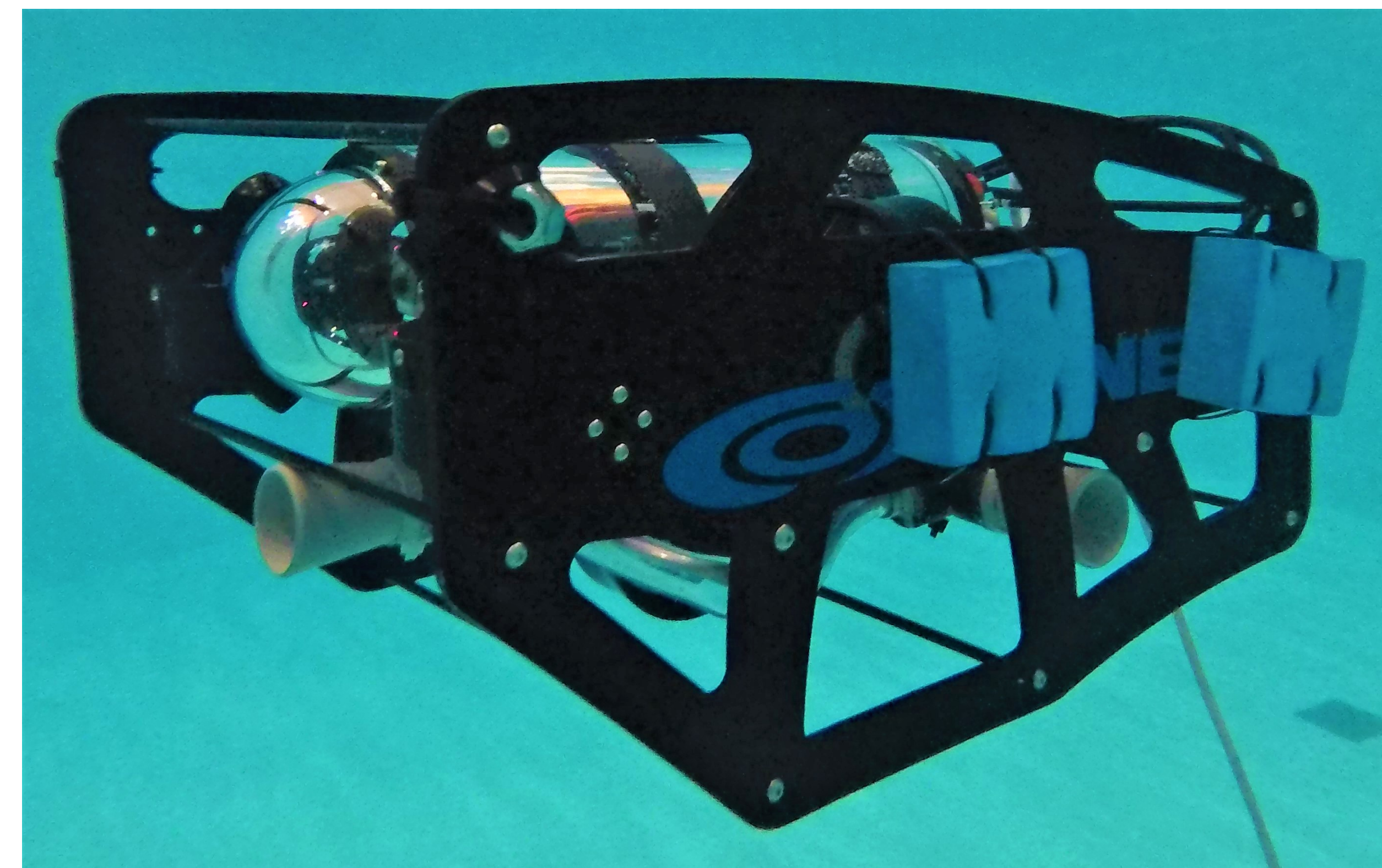
## Simulation and Visualization

- MATLAB/Simulink simulator to simplify testing of software
- Simulated states by using a simplified model of the ROV, calculates and outputs sensor data to ROS
- SIL simulation of sensor fusion and/or the controller can be run
- A 3D visualization tool is implemented and plots of all states during a simulated run are shown in MATLAB



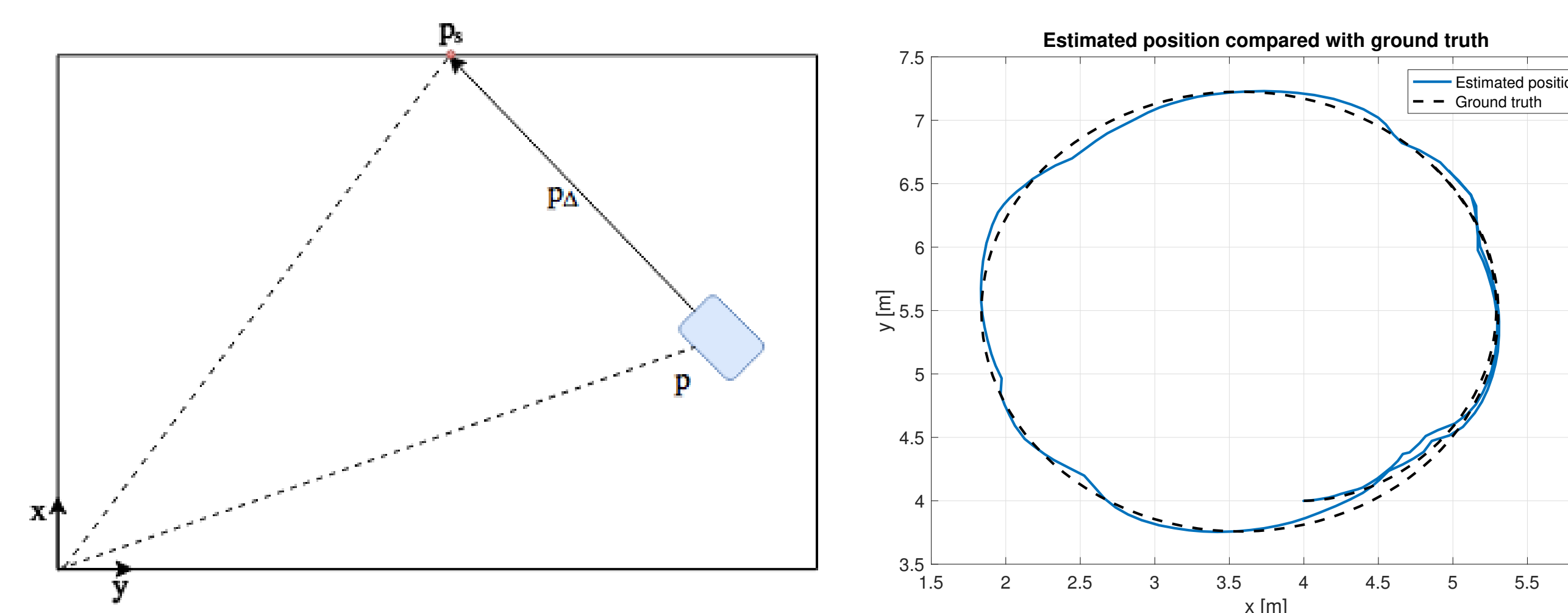
## Sonars

Ultrasonic sonars are used to estimate the ROV's position and attitude. The ROV is equipped with three sonars, they are mounted in forward, right and left direction. Each sonar has a measurement range of 1.3 – 20 meters. The ROV with the mounted gray sonars can be seen below.



## Sensor Fusion

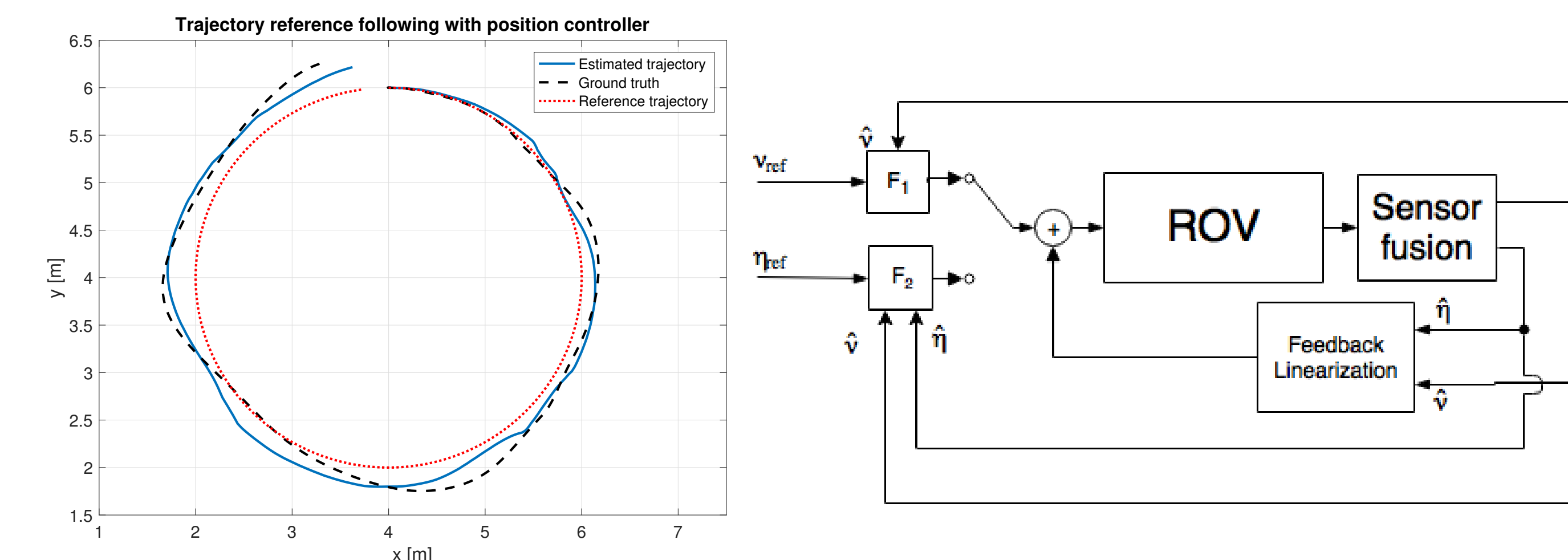
An Extended Kalman filter (EKF) is used to fuse measurements from sonars, IMU, magnetometer and pressure sensor with a motion model. The EKF has 15 states; 6 global for position and attitude, 6 local for linear and angular velocities and 3 for biases in angular velocity. The motion model is used to improve state predictions. The sonars measurements are compared with the expected distances, given the current position and attitude of the ROV. This is illustrated below together with a result from a comparison between estimated and ground truth position.



## Controller

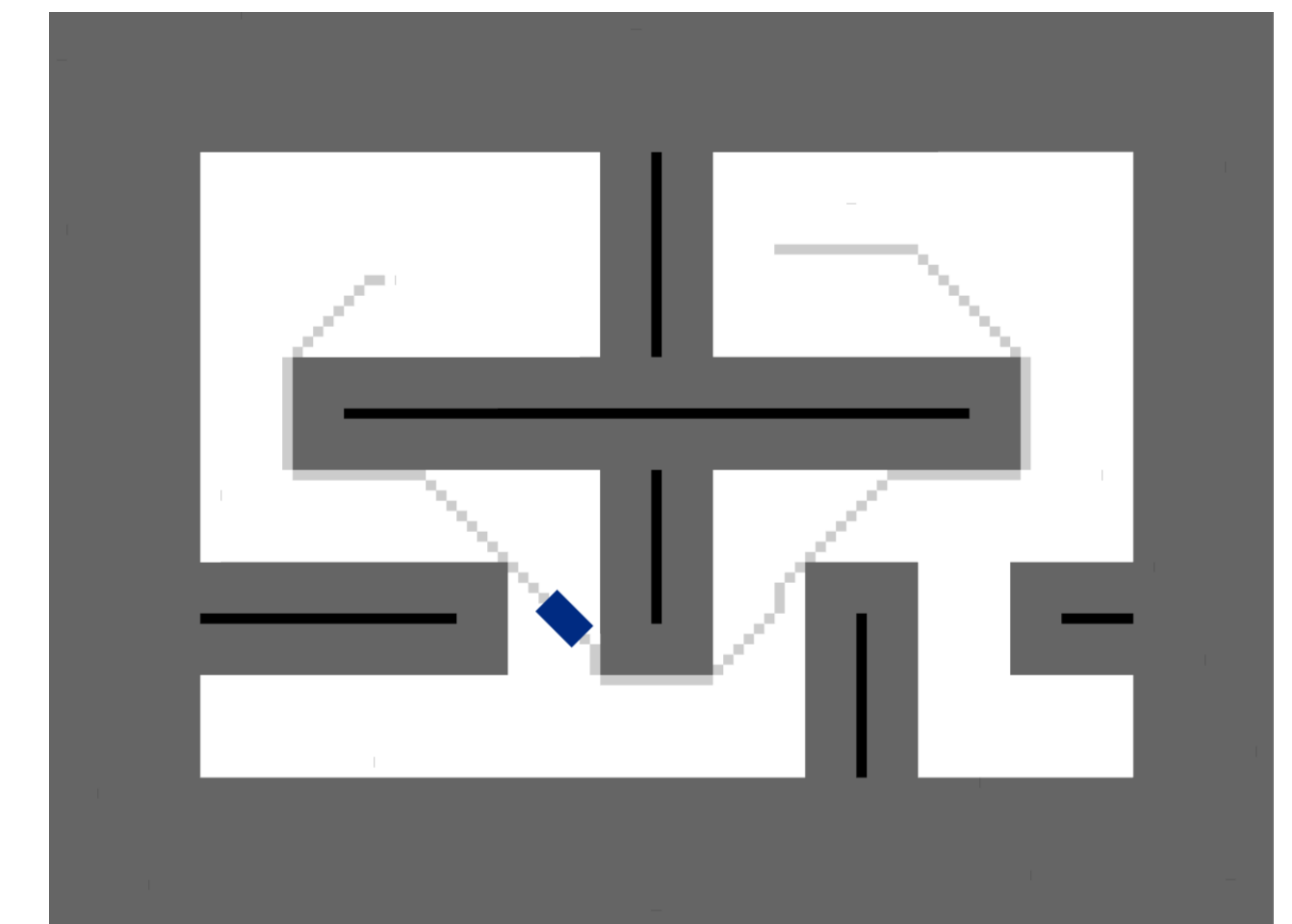
The ROV's velocity and position controllers are of LQ-design which are based on linear models of the system. Feedback linearization is

used to cancel nonlinearities and get linear behavior of the system for both controllers. The ROV can follow a path by reference regulation. The plot below presents the ROV following references sent from the pathfinder and a block scheme for the controllers.



## Pathfinder

Paths are generated using the A\* search algorithm. The start and end positions can easily be selected from the GUI. The path chooses the shortest path between the points while taking into account the obstacles on the map. The pathfinder, with the ROV following the determined path can be seen below.



## Achievements

- Integration of ultrasonic sonars
- Positioning in a known environment
- Position, velocity and trajectory controllers
- Simulation environment for the ROV
- Path planning in known environment.