



# Altitude Control Simulation Results

Simulations were carried out using ROS2, Gazebo and Plankton simulator. The full simulation architecture is shown in Figure 4.

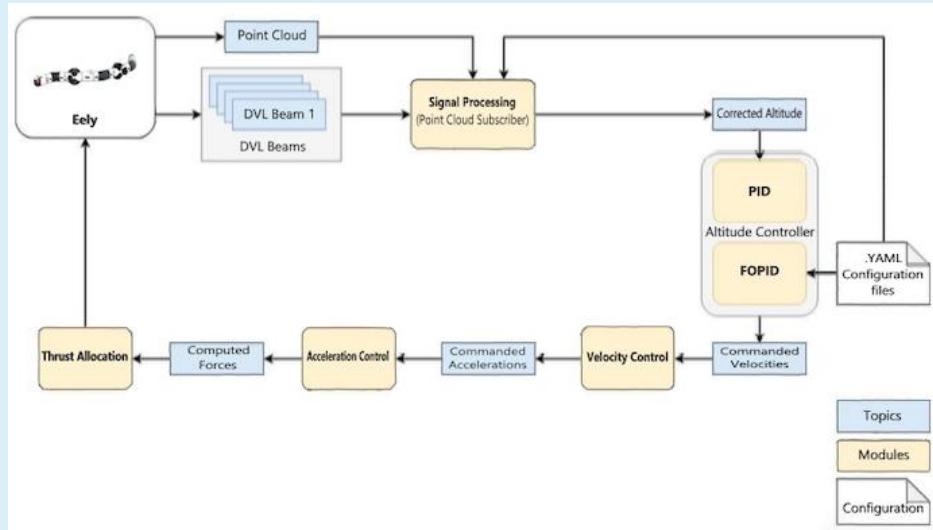


Figure 4: Simulation Architecture

Figure 5 shows the results for six different controllers over a seamount, namely Proportional, PID and four FOPID controllers. Figure 6 shows FOPID 4 controller which had superior altitude regulation performance in confined environments.

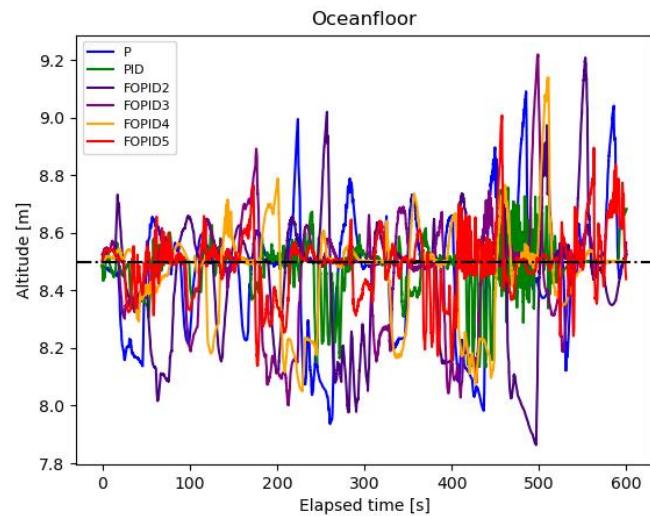


Figure 5: Combined Altitude results of different Controllers



Figure 6: Eely mapping a Confined Seamount with FOPID 4 Controller

Table 1 shows the performance of different developed controllers combined with the altitude controller for Eely.

Controller	Controller Parameters					Error (%)	Power consumed (%)
	Kp	Ki	Kd	$\lambda$	$\mu$		
Proportional	0.5	0	0	0	0	40	55
PID	0.5	0.2	0.05	1	1	20	12
FOPID 1	0.5	0.2	0.05	0.6	0.7	12	7.1
FOPID 2	0.5	0.2	0.05	0.4	0.7	5	5.2
FOPID 3	0.5	0.2	0.05	0.17	0.35	3	4.9
FOPID 4	0.5	0.2	0.05	0.2	0.6	1	60

Table 1: Performance comparison of Controllers and Error

## Field Experiments

Field experiments with Eely were performed in Trondheim Fjord to validate the simulator results. Figure 7 shows a scanned part of the seabed during the trials.

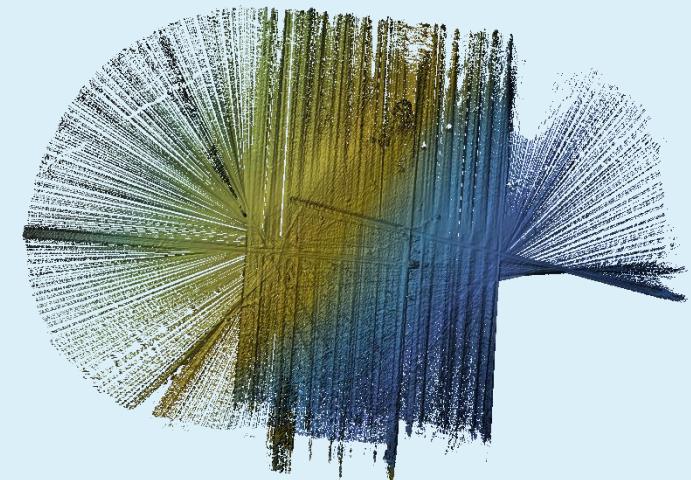


Figure 7: Eely in Trondheim Fjord and a scanned seabed part

## Conclusion

The results of the Bayesian risk assessment provided valuable insights into quantifying and mitigating the potential risks and uncertainties associated with Eely's missions. Simulation results revealed that the FOPID altitude controller exhibited superior altitude regulation performance in confined environments. However, it is important to note that field experiments presented some disparities compared to the simulated results.

## References

- [1] Eelume AS, "Eelume - subsea intervention robots," <https://eelume.com>.
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- [3] Bremnes, J. E., Thieme, C. A., Sørensen, A. J., Utne, I. B., & Norgren, P. (2020). A Bayesian approach to supervisory risk control of AUVs applied to under-ice operations. *Marine Technology Society Journal*, 54(4), 16-39.