Abstract

The design of high-performance sailing craft has shifted from experience-driven iteration to data-driven workflows based on 3D modelling, computational fluid dynamics (CFD) and velocity prediction programmes (VPP). Hydro-foiling introduces inherently dynamic behaviours that exceed the scope of steady VPPs, motivating dynamic-DVPPs and simulators derived from them for design and training in America's Cup (AC) and other high-performance contexts.

This thesis implements an International Moth inside Simulator In Motion (SiM)—a DVPP-based sailing simulator—aligning geometry, mass properties and aero/hydro models, and establishing a workflow to compare predicted performance and controller behaviour across configurations. Simulations were executed in this independent environment, while D3-VPP® targets and the Exploder MD3 geometry supplied by D3 Applied Technologies, S.L. (D3) defined the reference conditions and baseline configuration. The work first benchmarks SiM against D3-VPP targets at two representative operating points (best-VMG upwind and downwind, TWS = 14 kn), then exercises two flight-control approaches: (i) a mechanical wand (sensitivities to gearing and wand length) and (ii) a heave PID (sensitivities to Kp, Ki and Kd), in flat water and a simple regular sea state.

The simulator reproduces the VPP targets within $\sim 1\%$ (speeds and VMGs), with attitudes close to target and force balances coherent at both points, supporting its credibility for controller studies in the tested envelope. For the wand, lower-response gearing attenuates wave-induced oscillations without degrading mean ride height, and increased wand length primarily biases the mean flight level while preserving a common steady wand angle. For the PID, a moderate tuning (baseline near $K_p \approx 4$, $K_i \approx 2$–3, $K_d \approx 6$) offers the best compromise between rise time and damping; relative to the wand the PID shortens settling and improves disturbance rejection in both flat and waves. Notably, electronic ride-height control is currently prohibited by the International Moth Class Rules, restricting such benefits to non-official contexts.

Overall, the platform meets its objectives: it (i) matches VPP targets credibly at 14 kn upwind/downwind, (ii) captures expected controller trends (gearing, wand length, PID gains), and (iii) provides a practical, repeatable bench for flight-control development. Future work should broaden the envelope (TWS/TWA and irregular seas), refine wand mechanism modelling, and test crew dynamics and manoeuvres.

Keywords: Dynamic Velocity Prediction Program (DVPP), Flight Control System, High-performance sailing, Hydrofoils, International Moth, Performance Data Analysis, proportional–integral–derivative controller (PID), Sailing Simulator, Simulator In Motion (SiM).