University of Southampton

MSc Maritime Engineering Science: Yacht and High-Performance Craft

DEVELOPING AN INTERNATIONAL MOTH TESTING PLATFORM IN A DVPP-DRIVEN REAL-TIME SIMULATOR

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1. INTRODUCTION

The lack of information publicly available worldwide about the development of sailing simulators compared with the real importance that this type of tool has in the industry right now, together with the opportunity of developing this project with the help of D3 Applied Tech. (D3) and what this means for me personally as a learning opportunity is the main motivation behind the project.
The participation of D3 and Simulator in Motion (SiM) in this project makes it as state-of-the-art as it can be, as of 2025. The access to the SiM tool opens the opportunity to test multiple configurations and develop initial methods of analysis that would be useful in the future, and difficult to develop without the data that the sim provides.

2. BACKGROUND

Development of new hydro-foiling technology applied to sailing boats during the recent years has brought new challenges, so the use of a VPP alone is no longer sufficient to physically describe the dynamic nature of foiling. This compelled the development of a time-domain VPP (DVPP) and the use of a sailing simulator, that acts as a critical tool for training and design improvements in America's Cup (AC) teams and in high-performance foiling boats.

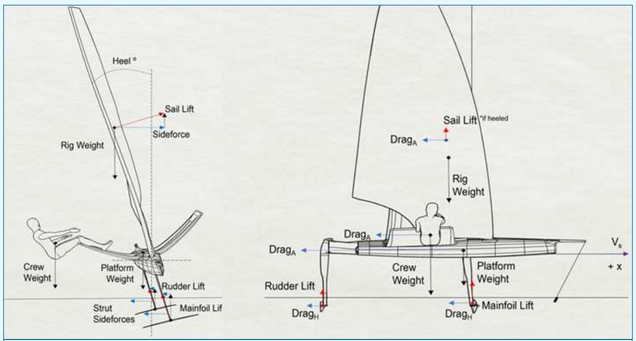

Fig. 1. Forces existing in the International Moth

The chosen vessel is a 3.35-metre-long sailing foiling monohull, built in carbon fibre under the International Moth Class Rules, that establish a set of dimensional, design, and performance restrictions to promote real-time racing competition among boats designed by different shipyards and designers.

3. METHODOLOGY

With the aim of having a robust testing platform inside the simulator, that allows for different analysis and studies, the geometry of the Exploder MD3, together with the latest set of foils available thanks to D3 was used and put together inside the SiM environment. All the physics models were made specifically for this project, all of them based on the similar models that the D3VPP uses, like the LLFSI Hydro model for the underwater lifting surfaces. Successfully linking this physics models inside the simulator and developing 3 different PID's to dynamically control heel, TWA and heave were the main challenges of this project. This allowed for controlled and comparable simulations afterwards.

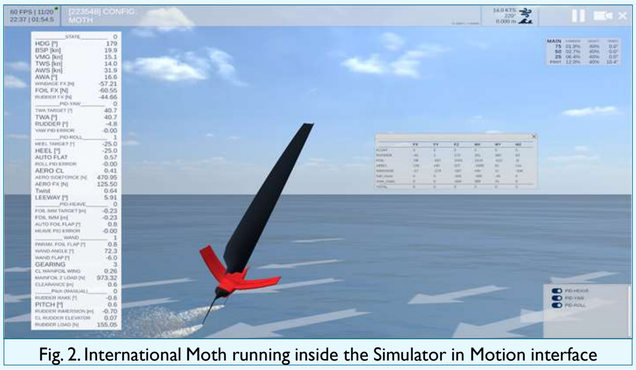

Fig. 2. International Moth running inside the Simulator in Motion interface

4. SIM-TO-VPP

The first study aimed to compare the simulation outputs with those from the D3VPP. The objective was to verify that the magnitudes of the forces and variables were consistent in order to assess the level of precision achieved when modelling the system inside the simulator.
Outputs of the simulation in the upwind and downwind condition - extracted from the best-VMG sailing points achieved in the D3VPP – were compared to the VPP data, showing a high-level of similarity.
Since the D3 VPP has already been extensively compared with real boat data (as this is the third generation of moth designs developed using the VPP as the main tool), this provides confidence in the reliability of the simulator results.

5. FLIGHT CONTROL SYSTEM

The first system developed was a PID controlling the mainfoil flap angle as function of the moth's ride height. The second, replicates the boat's actual mechanical wand + pushrod system, using the wand angle between the bowsprit and the free surface to output a flap angle, modified with a gearing mechanism.
A set of analyses were conducted to assess the sensitivity of the two flight control systems, in flat seas and excited by a regular wave of H = 0.1 m, in upwind and downwind conditions. The influences of the gearing (shown in Fig. 3 below), the Kp, Ki and Kd of the PID controller, are among the variables studied.

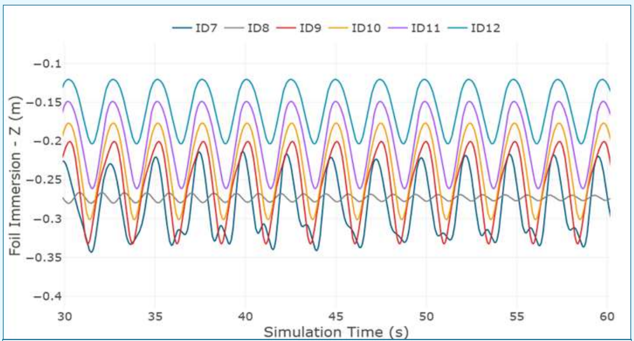

Fig. 3. Wand control system in waves. ID-8 shows the effects of a correct gearing

Presented in Fig. 4. is one of the main takeaways from the comparison between control systems. Vertical wave response using the wand (ID-10) has more final amplitude than when using the PID (ID-29). However, there is one gearing that reduces the amplitude of the response and stabilises the boat quicker (ID-8).

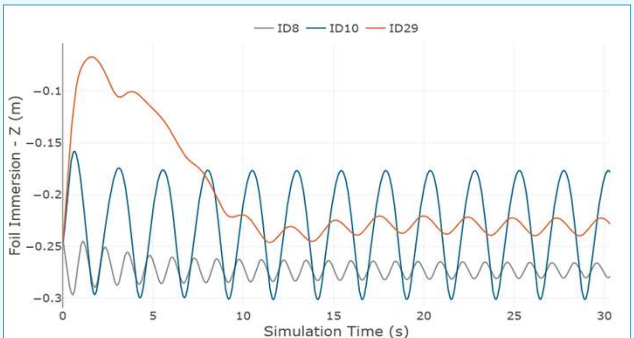

Fig. 4. PID controlled response (ID-29) versus different gearings (ID-8, ID-10)

This shows that a well gearing adjusted flight system can improve a PID controlled system. This removes the immediate need for a electronically control system prototype, although the PID offers greater customisability.

6. CONCLUSIONS

- **C1.** The simulator is a **useful platform** for testing dynamics and control.
- **C2. Results match VPP outputs**, giving confidence in the model.
- **C3. Wand gearing defines stability**; PID more customizable.

Limitations: simplified physics, few wave cases, no crew dynamics.
Future work: heel sensitivity, varied sea states, refined wand model.