ID30- Coefficients estimation in the dynamic equations of motion of an AUV

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Abstract–This article is about the development of the equations of the movement in 6 DOF of AUV (Autonomous Underwater Vehicle) SIRENA carried out by students of UPCT. As it is a pre-programmed submersible, one of the main targets is to model mathematically the movement of the submarine to achieve simulations of it. The equations are a non-lineal system of EDPs and EDOs and are simplified using its own hydrodynamic coefficients. The aim of this study is to present a non-lineal system of differential equations, function of these coefficients.

INTRODUCTION

To establish a mathematical model that reproduces the movement and control of an autonomous underwater vehicle (AUV) is a critical step in the process of its design and development.

The complex set of equation that reproduces the movement of the submarine and its six degrees of freedom [1] must be simplified to obtain a practical EDO's system that could be implemented and used to simulate the vehicle behavior. These equations present a numerous set of hydrodynamic coefficient of the forces and moments produced by the linear and angular velocities of the vehicle and its derivatives.

The various effects described by the equations must be assessed and an additional effort of simplification must be done in order to obtain a decoupled and simplified system of equations to be introduced in a simulator. This work explains how this process has been done for the SIRENA AUV, which can be seen in Fig.1.

DESCRIPTION

Each of the hydrodynamic coefficients previously mentioned is a dimensional parameter that models the influence of any linear of velocity component in any Cartesian directions on any external force of moment applied to the vehicle. It is important to remind that to obtain a force or moment applied over a rigid body, it would be necessary to obtain the distribution of pressure and shear stress from the momentum equation and to integrate them along the external body surface.

Computationally, it seems impossible to obtain the distribution of pressure and shear stress in real time depending of the velocity and orientation of the vehicle, to integrate them and to obtain forces and moments that could be included in the movement equation system. Therefore, the linearized and simplified equations based on the hydrodynamic coefficients, as explained before, are a better alternative for the simulation of the movement, and the estimation of these coefficients becomes of a great importance.

Normally, in submarine design, these coefficients are obtained experimentally. This implies the need of building and testing a scale model which cost would be difficult to handle for SIRENA's project. In addition, the experimentation channel and all kind of instrumentation needed for this task would be also non-viable for SIRENA's project.

Therefore, all coefficients have been obtained following the project philosophy:

- Compiling information: this task has been orientated to obtain the coefficients from the applicabe technical literature
- Synthesis of operative methods: different ways to achieve results must be found and compared, and the best method will be applied.
- Obtaining the results. The elected method is applied and the pertinent results are obtained.
- Discussion of the results: with a critical approach, the obtained results must be assesses and validated.
- Comparison with other methodologies: in the case that the results are not conclusive, comparison with other methods must be done.

RESULTS

Following the guide lines previously detailed, the results have been introduced in a simulator developed by SIRENA project's members [2]. It allows reproducing and analyzing trajectories of the vehicle and possible responses against perturbations.

This procedure allows obtaining similar results to the fully experimental approach but with a much lower cost.

REFERENCES

[1] T. Prestero, Verification of a Six-Degree of Freedom Simulation Model for the RE-MUS AUV, Massachusetts: Massachusetts Institute of Technology, 2001.

[2] J. J. García García, Desarrollo de una herramienta informática para la simu-lación dinámica de vehículos submarinos no tripulados, Cartagena: Universidad Politécnica de Cartagena, 2013.

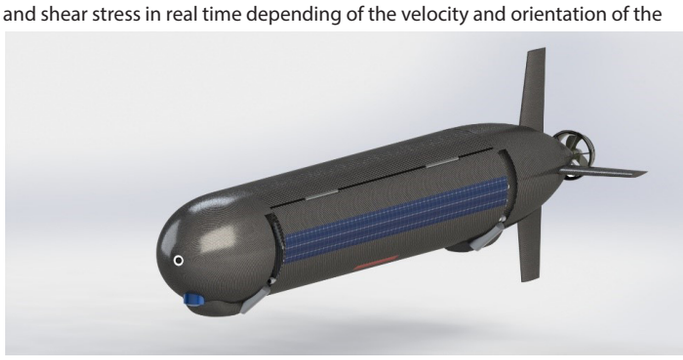

Fig. 1. SIRENA AUV.

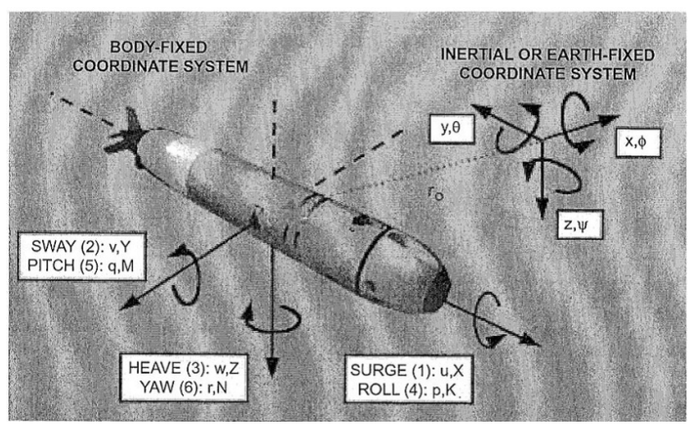

Fig. 2. Reference systems.