ABSTRACT

A digital twin is a replica of a physical asset with the ability to replicate the behavior of the real system. It can be assumed that a ship can be considered as an aggregate of systems, then, the digital twin of the ship will be an aggregate of twins (or a “twin of twins”). The development of a digital twin for a ship system will be relied, at least, on three enabling technologies: Industrial Internet of things, Simulation and Data Analysis. The work that is presented has focused on these main concepts that enable the digital twin to be implemented in the system of a real ship, in this case, the saltwater firefighting system.

KEY WORDS: Digital Twin, Firefighting, Simulation, Machine Learning, Neural Network, Failure detection.

INTRODUCTION

A digital twin is a virtual copy of a physical system with the capacity to reproduce the behavior of the real system. Between the physical and virtual systems there is an exchange of information. The digital twin must be able, not only to reproduce the functioning of its physical twin, but it must also allow to analyze the goodness and health of its functioning, it must propose possible corrections or operating advice to users. Additionally, it must be able to self-adjust and it must have the ability to generate operating simulations independently of the physical system. A ship can be considered as an aggregate of systems, then, the digital twin of the ship will be an aggregate of twins (or a “twin of twins”). The development of a digital twin for a ship system will be relied, at least, on three enabling technologies: Industrial Internet of things, Simulation and Data Analysis:

- Industrial Internet of things technologies will allow to carry out the capture of real data from the sensors of the ship's firefighting system.
- With the development of simulation models, we will achieve that the behavior of the system can be replicated.
- Finally, application of data analysis methodologies will allow, from the available information (real and simulated data), decision-making and the application of corrective actions on the system. In this case, methodologies for data analysis based on artificial intelligence will be used.

Through the tests and developments made in a real ship, it will be seen how the implementation of these technologies will allow the development of a functional digital twin for a ship system, in this use case, the saltwater firefighting system.

A BRIEF HISTORY OF DIGITAL TWIN

The "digital twin" concept is quite recent. Its origins date back to 2002, when Dr. Michael Grieves included, during a presentation on PLM systems (Product Lifecycle Management) at the University of Michigan, a slide illustrating the basic scheme of the digital twin (Grieves and Vickers, 2017). As we can see in Fig. 1, in a digital twin we must find:

1. the real system under study,
2. a virtual representation of that real system,
3. a way for data transfer between the real system and its virtual representation and
4. a way for information transfer from the virtual representation towards the real system.

In the words of Dr. Grieves, a digital twin is “a construction of digital information about a physical system, created as an entity in itself and that is connected to that physical system.”

Fig. 1: Main components for a digital twin implementation

Digital Twin in Naval and Maritime Sector

The idea of the ship's digital twin has evolved since the 1990s when the first basic concepts emerged. In the following table, based on (Erikstad, 2018), we can see in a summarized way how digital twins have evolved over time, considering that we can speak of 6 generations: