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# Internet of Ships: The Future Ahead

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## Abstract

There are many advantages of using Computer Aided Design (CAD) Systems in a shipbuilding environment: ease of design, speed of construction, use and reuse of information, etc. It is expected that in future CAD tools will advance further and allow greater information management and virtual access through smart devices. The authors of this paper talk about a new concept in shipbuilding, the Internet-of-Ships (IoS) which would have a deep impact on the ship design and production, with a huge diversity of present and potential applications.

## Keywords

Internet of Ships, Ship Design, Shipbuilding CAD Systems

## 1. Introduction to the Future of the Shipbuilding CAD Systems

There are several fields where CAD systems could be improved in near future. However, here the focus is on functionalities that are being improved right now. E.g. in hull forms fairing, the global shape modelling or the advance continuity and capping could transform complex surfaces with excellent results, less interaction, high accuracy, and full control. These techniques shorten dramatically the design time, from days to minutes while obtaining excellent results [1]. Another area of improvement concerns one of the most time-consuming tasks in outfitting design, the routing of pipes, HVAC ducts and cable trays. Automatic routing options minimize this time, but without redusing the robustness of the design.

Automatic routing provides simple solutions, with optimization of material, and several algorithms exist. But the matter is not only to consider existing elements for future routings; it is also necessary to assign priorities, and eventually handle automatic modifications of existing elements as a consequence of new ones. The complexity of the problem explains that there is not yet fully satisfactory solution for the automatic routing in practice. Current solutions provided by CAD systems solve partial problems, offering already significant support.

Another area where the CAD companies are active is Virtual Reality. The objective is to create a user-friendly environment in order to review, audit, obtain metrics such as the progress of a project, etc. This type of review process of the model does not need to use tools for design, just a simplified tool allowing easy access ("viewer"). In **Figure 1**, a 3D visualization model is reviewed in a tablet, where the authorized designers/engineers could have all the project information. These navigators allow access for reading 3D information in order to load the component tree of any customer project to obtain information about any item. Other basic tools available in these programs have different modes, allowing navigation commands to take action such as measuring distances or angles, creating sections to access internal components, etc. The interface with the program is via a mouse, but Virtual Reality opens windows of opportunities, with globes, glasses or helmets.

Advanced browsers allow incorporating human models in order to study ergonomic aspects, creating highlights and textures for advanced renders, movements of components to perform simulations, etc. Browsers can connect to the database of a project in order to access information in real time. Sometimes there is a need to take information from an on-line database and if there is an Ethernet network through the shipyard, it is possible to implement a shared computer with a viewer that allows connecting to a project. If there is not an accessible database, viewers should be able to read files with the project information required for 3D modelling of the product and component data with optimal performance. So far it was prevalent to implement viewers on laptops, because laptops are usually equipped with processor and graphics cards that allow navigating through the entire project. In recent years there has been a breakthrough in mobile devices like tablets or smartphones. This hardware progressively incorporates new processors that enable enhanced graphics. On the software side, operating systems have been developed specially adapted for such devices (such as Android or IOS) allowing interfacing naturally by touch gestures.


**Figure 1.** Marine design future, information in each stage of the ship in electronic devices.

The widespread use of these devices nowadays has precipitated its use by software companies. Software developers have taken their time preparing oriented solutions and among those that allow us to have project plans or 3D models on tablets or other electronic displays. In modern projects, there is need, for technicians, to carry these devices to work better, with a quick access to the 3D model of the project, with all parts information and construction drawings needed. A wi-fi connection would allow connecting to an information server to update the information needed, mainly in files, as for example: 3D models, classification or production drawings, between others. Another advantage of mobile devices is that the user interface might interact with the project model or parts using gestures just as everybody does every day with smartphones. One develop line of navigator's evolution would incorporate augmented reality technology. It would be helpful for production technicians to scroll through the project and pointing the camera of their mobile device to a particular component to obtain information from it and have the actual image of the same 3D design model displayed. It is possible through the use of markers that help the device to position itself within the project and also for the use of QR codes.

CAD systems must handle the information necessary for creating a collision-free design and for generating all production and assembly information, but not only this. The 3D model information is, at the same time, necessary for other activities and other departments involved in the construction of the ship, as planning, purchasing, subcontracting, accounting, etc. It is common that several design agents collaborate in the same project; so it is necessary that 3D model information should be shared among them to serve as reference. The paradigm of this problem appears when two or more design agents collaborate in the same project, using different CAD tools. In this case, the CAD systems must provide data exchange between them, leading to different degrees of integration, like visualization, spatial integration and cross manufacturing, depending on the characteristics and size of 3D model information transferred. At least, it should be geometry and key attributes. A worldwide format for data transfer has not yet been found. Despite recognized international standards, in most cases we see dedicated formats or particular adaptations from standard ones. Transfer of 3D model information could produce loss of performance due to different geometrical approaches to represent elements in both CAD systems. In this case, special solutions must be adopted in order to minimize this impact.

Another recent milestone is the integration between different CAD systems and Product Lifecycle Management (PLM) tools, e.g. the FORAN Product Lifecycle Management (FPLM) tool with a neutral architecture. In this case, all the information generated in FORAN may be transferred to a PLM and may be subject to all processes: control, configuration and releases lifecycle and process management. FPLM consists of a series of tools and features that enable bidirectional integration between different modules of FORAN and PLM tools. The solution is based on standards such as XML, Web Services and Common Object Request Broker Architecture (CORBA). **Figure 2** shows an example of tool integration. The colors highlight parts or elements that are or are not to be transferred to PLM.

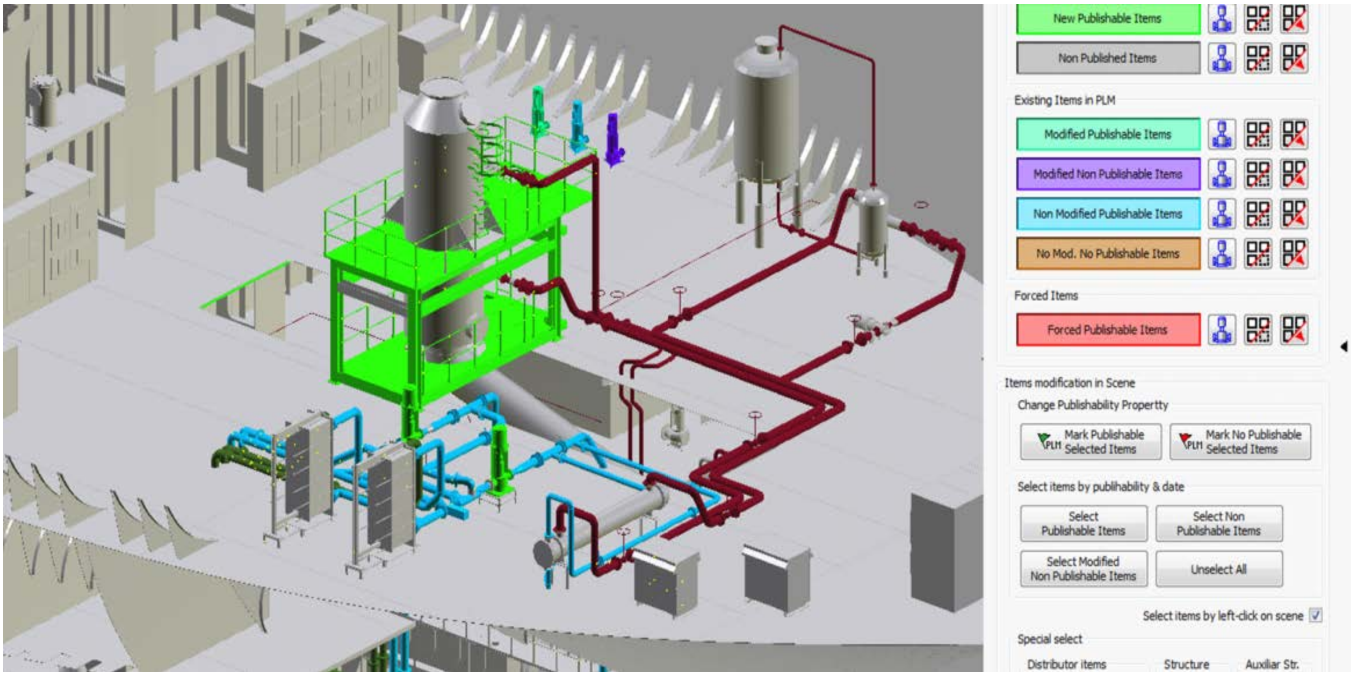


**Figure 2.** Integration between FORAN and a Project Lifecycle Management tool [2].

## 2. What Is IoT and How to Be Applied on the Software World?

IoT is the abbreviation of Internet of Things which is known as technology and process of connecting objects to internet. The objective is to make objects exchange data with internet and among each other. The concept IoT was born in the research center Auto ID in MIT abound 1999 in research for realizing the object identification using radio frequency (RFID) which is the main idea of Kevin Ashton. The idea of the research was to identify all the objects and all the people in some way permitting some of the objects could exchange data with others through internet. The object identification was the prerequisite of IoT.

Humans interact with objects in a more or less direct way. But if the objects are allowed to interact among each other, it would be possible that the objects themselves can exchange data for their own needs. This would create a network of Smart Objects that they can interact independently in the context of its mission. This network is known as IoT. The "Intelligence" property of objects or devices does not need to be complex and exhaustive. For example, a refrigerator would require a way of measurement of the elements which can get information of the refrigerant and request recharge when it is lower than required. These examples clearly shows what is intelligence of the devices.

To make connectivity it is required to meet certain requirements among which exclusive identification is one of the requirements. But more importantly, it is necessary to determine whether the object is connected to the global network. The object will be related to its mission, but also be related to the needs of the object such that the object can fulfill its mission. The connectivity of objects requires several technical properties: hardware, the connection method and software. Hardware are physical devices that are "intelligent" and software are intelligent programs for the object and connection method is way with which objects can communicate through physical devices or virtual devices (for instance radio frequency, wireless etc). Obviously this is a very simply description of connection but it is enough for illustrating the components involving in this concept.

The following four aspects can identify whether a product is connected to the IoT:

- Be able to monitor the use and function of the product or object.
- Be able to be operated remotely or designed appropriately for their use.
- Be able to be diagnosed predictively, repaired or improve its performance.
- Combination of the above.

IoT can induce extraordinary potential economic growth. Report from the McKinsey Global Institute titled "disruptive Technologies: Advances that will transform Life, Business, and the Global Economy" [3] concludes that the economic impact of IoT in 2015 has a potential annual growth of 2.7 - 6.2 billion dollars. Furthermore it predicts that 80% - 100% of the market of manufacturing will use IoT applications with an economic impact of 0.9 - 2.3 billion dollars [4].

The meaning of objects in IoT should not only be limited to physical objects. The concept can be extended to those programs called "virtual objects" and do not have a physical element in the world. So we can know what the programs for IoT should be. In particular, how should the programs be oriented in the world of IoT. These concepts can be applied not only to objects and devices but also to their own CAD programs.

## 3. A New Concept: The Internet of Ships

It is estimated that in 2020, 25 billion of devices will be connected to Internet [5]. This revolution began a few years ago has aroused enormous interest in all industries and in some of them already works with apparent normality. We could define the IoT as consolidation through the network of networks a "network" that staying a multitude of objects or devices, that means, to connect all things of this world to a network, we are talking about vehicles, appliances, mechanical devices, or simply objects such as shoes, furniture, luggage, measuring devices, biosensors, or anything that we can imagine. At its core, IoT is simple: it's about connecting devices over the internet, letting them talk to us, applications, and each other. But IoT is more than smart homes and connected appliances, however. It scales up to include smart cities–think of connected traffic signals that monitor utility use, or smart bins that signal when they need to be emptied–and industry, with connected sensors for everything from tracking parts to monitoring crops.

In this context the question is if the naval sector is ready for this revolution. Is it possible that this traditional and conservative sector moves into this technology? There is already evidence that the shipbuilding industry is no stranger to these developments and is already connected to the Internet some components of ships, as it is shown on **Figure 3**.

As smart home or smartphone, there are new smart ships that will be equipped with a network of sensors that capture a range of voyage information, including:

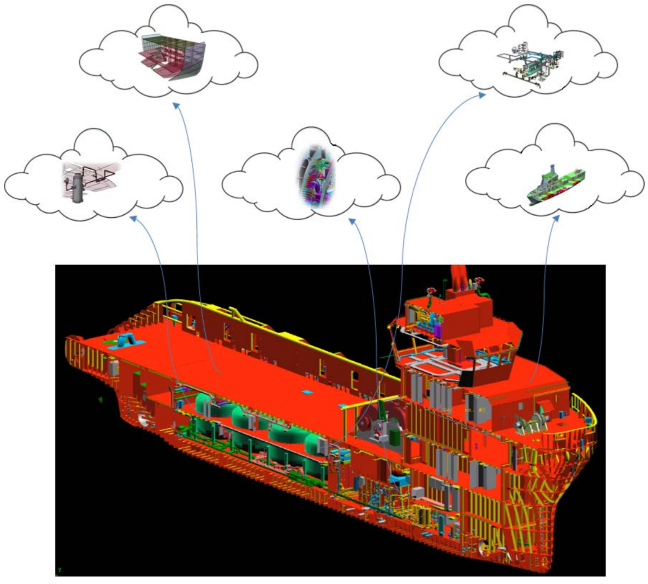

**Figure 3.** Ideal representation of a 3D model with access to the different ship design disciplines.

- Location.
- Weather.
- Ocean current.
- Status of on-board equipment.
- Status of cargo.

Ship owners can monitor the vessel's status in real time and apply analytics to current and historical data to make decisions that enable them to run more efficiently, saving time and fuel. Sensors and IT technologies are facilitating the introduction of new applications at sea, like energy distribution, water control and treatment, equipment monitoring in real time.

The aim is to take this technological revolution also acting in the design and production phases in order to build efficient, safe and sustainable vessels. In a decentralized sector, like naval, where often the engineering and production are in different locations and where critical decisions cannot wait, the Internet of Ships (IoS) or connection through the network of critical components in the design/shipbuilding, starts to glimpse as something that the sector cannot obviate. he idea is to monitor all those parts in which early detection of events allows us to make the right decisions.

In this sense, the available sensors during the early stages of construction of the ship, allow us to identify if the construction of the boat is completely according to the design we have created with CAD. If we can reduce materials or use another material, if we must change anything according with naval architecture calculations…

The continuous monitoring integrated with a naval design CAD as FORAN will reduce costs and avoid mistakes and make decisions in real time from the shipyard, design offices or from remote locations. Nowadays solutions CAD like FORAN can be used in a pocket tools, making it the indispensable ally in this new technological revolution (see **Figure 4**).

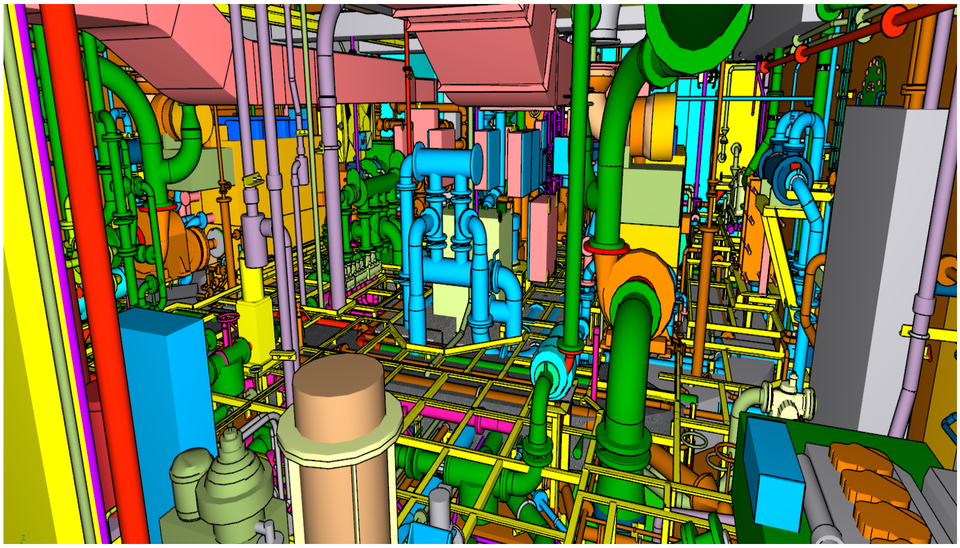

**Figure 4.** 3D model on a virtual portable solution like tablets or smartphones.

Shipbuilding process, generates a lot of information and data, which a priori makes it seem impossible to have all this data in real time, but the new processors, simpler and smaller, with a good connection to the Internet, make it possible. The data management is, however, only one side of the coin of the IoS. Energy efficiency is a fundamental aspect also in new devices that connect to the network.

But IoS not only covers the stages of design or production of the boat. Once the sensors are in the components whose information want to monitor, we will be able to obtain information throughout the life of the ship. IoS is presented as a solution capable of detecting when a component on a boat is close to fail and must be replace, when we take the boat to repair when we have to paint again, when corrosion has reached a certain limit and all this from our pocket tool and early enough to avoid late or unforeseen performances. IoS reaches this sector to ensure profitable production, or safe, efficient and sustainable process for all types of fishing vessels, tugboats, tankers, charges, ferries, dredgers and oceanographic.

## 4. The IoS in a CAD Shipbuilding Environment

How this revolution could affect the shipbuilding world? Could we consider the concept IoS? The ship projects are developed with CAD platforms, but every day we are looking for integrated development of the product involving all its Life Cycle. CAD system integrated with PLM and from the PLM we can conceive all the design but also control the production and include the use of the vessel.

The PLM can contain information of all systems of the vessel and also all its components. If the components are designed for the IoS it will have technology that allows to share their situation, diagnosis, functionality with the PLM system which distributes the initial design.

The PLM system can use this information for knowing whether they are working properly or if we can improve its performance. It is also possible to identify whether it is necessary to make maintenance of the object or if it is necessary to replace it because its life ends or because it's working wrongly. It will be possible to determine and evaluate its performance comparing to other similar components or comparing to it different operating periods. It will also be possible to know how their performance affects the functioning of the whole product, *i.e.*, the vessel. Furthermore, if the connection of the objects is realized with its PLM, it would be possible to record their history status, make change tracking, and know what is its function or its performance after realizing programmed maintenance.

In case of a vessel, this connectivity will be extended to the commercial mission to act autonomously in operation conditions. A commercial vessel can transmit its navigation situation, load situation, the things to be discharged or to be recharged. All these means a huge amount of information to be managed and analyzed. New programs have to be developed to obtain the best use of such information so that the design can be improved from real function information of the design and it can be self-maintained with the connection with this huge cloud information to create method that the objects can achieve certain "Intelligence".

The growth of the IoS is linked to the increase of Information and the management of big data, with the property that somehow IoS identifies Information and direction and order to a specific purpose, while the concept of big data is more generic. The possibilities are countless, but the beginning is the same. It must begin in the initial design. It is necessary to consider what is needed to correctly fulfill the mission of the atomic elements. These requirements must be configurable in the initial design from where it will be extended to relations between each of them with other entities. CAD is one of the first steps, because it is where begins to collect systematically the concept of each component. That is why it is necessary to provide CAD tools to carry out the design for IoS.

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