Galician Maritime Technologies

nº10 // 2022

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GALICIAN MARITIME TECHNOLOGIES // nº10 // 2022

The Maritime Technology Industry in Europe: Evolve or Disappear?

The pandemic crisis, the war in Ukraine and the recent energy crisis have confronted the European Union with the inconvenient truth that some “holy principles” like “open markets” or “no protectionism” cannot be taken for granted. These crises force the European Commission to rethink its strategies in terms of “resilience” and “strategic autonomy”.

This political evolution is relevant for Europe’s shipyards and maritime equipment manufacturers (“maritime technology sector”) as the sector is also facing challenging times. However, unlike many other sectors, the pandemic and Ukraine crises came on top of a long-lasting unfair competition from Asia.

At the same time, the European Green Deal and “Fit for 55” package offer the opportunity to shipyards to build zero-emission vessels, retrofit polluting ships or regain some markets, whilst maritime equipment manufacturers will be able to produce zero-emission technologies and equipment.

However, this promising business opportunity is not yet achieved in Europe but in Asia, as EU shipowners still order vessels, including green ships, in China or South Korea. The reason for that is well known but not yet solved by EU policymakers: without a global level playing field and trade defence measures, European shipyards remain “unweaponed” to compete with Asia. An EU built ship is typically 30 to 40% more expensive than an Asian built vessel due to injurious pricing of ships in Asia. As a result, only 1% of EU shipowners order vessels in the European Union.

The recent crises, geo-political tensions and energy-dependency discussion should act as eye opener to EU politicians for the maritime technology sector as the EU has become too dependent on Asia’s shipbuilding. A crisis with China will have more far-reaching repercussions for the EU economy, supply chains and citizens than the current energy crisis with Russia.

The European Commission and Member States must therefore use the political momentum to rethink their political attitude towards the maritime technology sector and treat it as a truly strategic industry by putting in place a holistic maritime industrial strategy, offering tailor-made sectoral measures, notably:

- Trade defence tools against Asia’s competitive distortions and trade protectionism.
- Financial support for research, development, deployment and integration of mature green technologies and alternative fuels onboard ships.
- Easier access to finance for risk-intensive investments.
- Financially support the sectoral Pact for Skills that enables the sector to attract, retain and up/reskill workforce.

With a maritime industrial strategy, the maritime technology sector will be able to evolve and thrive. Without it, shipbuilding will disappear in Europe, with negative effects for the EU supply chains and shipowners, but ultimately also for Europe’s resilience and strategic maritime autonomy.

CHRISTOPHE TYTGAT

CEO at Sea Europe

Navantia Ferrol 132kV / 15kV Electrical Substation Upgrade Project in the Context of 4.0 Industry

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1·INTRODUCTION.

The Military Arsenal, the Antonio de Escaño Navy School, and the Navantia Ferrol Shipyard, including Shipbuilding, Ship Repairs, and Turbines Factory areas, are all military and industrial infraestructures with a high electricity power demand. They covers an immense surface area of arroun 2,000,000 square meters, and have an electrical substation which has a 132 kV power supply through a dedicated line from the Cornido substation and a transformation capacity of 2 x 15 MVA, to manage the electricity power requirements.

Figure 1. 15 kV electrical power supply affected area.

The aim of the project is twofold: the modernization of the 132 kV / 15 kV substation (30 MVA) dating from 1971 and the installation of a 10 MVA alternative power supply using the highest available technological level and adopting the 4.0 industrial perspective. The outdoor substation and the energy distribution center have undergone a comprehensive renovation to adapt the current technology.

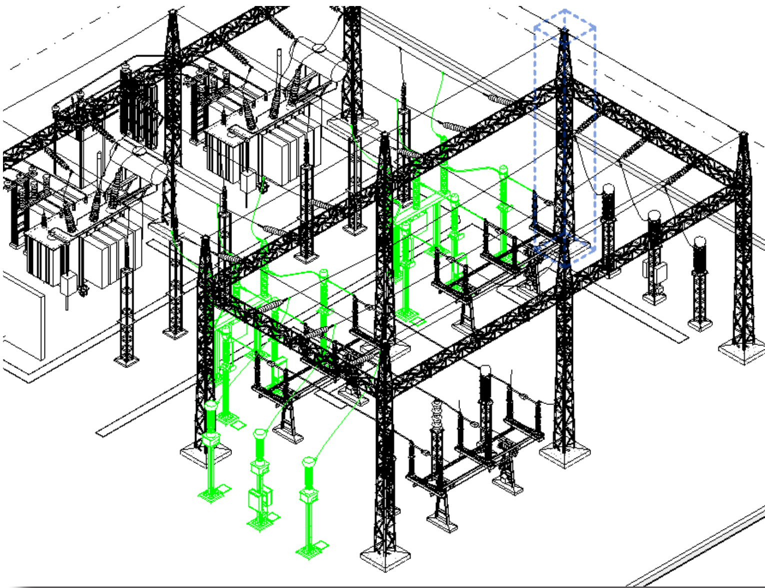

Figure 2. 3D design with 3D scanning and BIM technology.

2· TEMPORARY SOLUTION AND NEW 10MVA EMERGENCY POWER LINE.

As a first action, a bypass in the electrical installation was made assembling cells in two maritime containers, thus ensuring the continuity and functionality of the regular service.

Figure 3. Provisional portable substations used for the bypass of the main building.

A new disconnectors center was installed. It provides the Shipyard and the Navy with an alternative power supply in case of failure of the main power supply. This power supply was successfully tested while working in the outdoor substation. It has two emergency lines, each with a transport capacity of 10 MVA, for supplying independently each of the cell rooms.

Figure 4. New disconnectors center with new 15 kV power supply.

3· COMPLETE REFURBISHMENT OF THE BUILDING: REDUNDANT ROOMS 1 AND 2, ACCESSES, AND PERIMETER.

The accesses and the perimeter closure were completely renewed using plastic lined steel grating and a new access ladder made of AISI-316L stainless steel, shaped profiles and stretched sheet metal. **All entrances have video surveillance.**

In the building, the floor, walls, enclosures, etc., were completely refurbished. A raised registrable floor, new access stairs to the cable pit, and two separate rooms were built. For roviding redundancy to the installation partitions were defined and fire doors were installed to as well as different independent premises for housing the control room, servers, capacitor banks, backup UPS and an external 40 kVA generator set for auxiliary services in the event of a general power failure.

Figure 5. new access ladder.

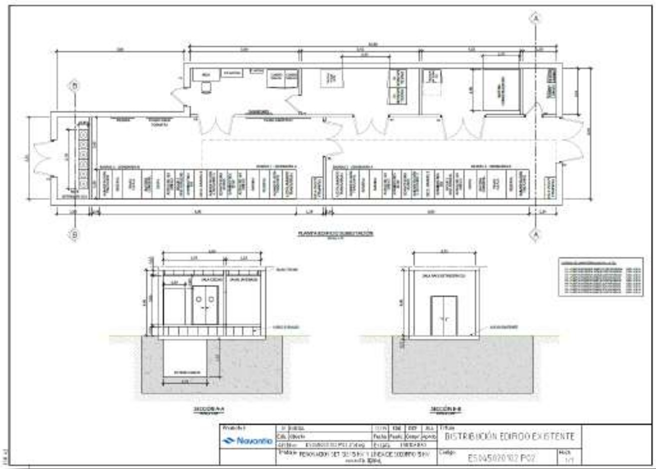

Figure 6. New plant layout with ***two main*** operating and control rooms.

All rooms are video-monitored, have air renewal and fire resistance EI2 60-C5. The pit is equipped with infrared vision cameras, thermal and flood sensors besides suction fire detection sensors.

The control room has a 65” touch screen for operatingand supervising the installation, 3 client stations are distributed throughout the shipyard for remote access.

According to the REBT (Spanish electrical standard) regulations, for the electrical installation of the auxiliary service panels/switchboards, once the nominal service voltage in AC and DC has been verified, also was validated the maximum admissible current on the cables, the cable section due to voltage drop, and the shortcircuit current, resulting in the choice of the largest section of the three sections. For this purpose, the following formulas were used:

Maximum admissible intensity	
Single phase lines	Three phase lines
$I=\frac{P}{V \times cos\varphi}$	$I=\frac{P}{\sqrt{3} \times V \times cos\varphi}$

Voltage drop section	
Single phase lines	Three phase lines
$S=\frac{2 \times \rho \times L \times I \times cos\varphi}{\Delta V}$	$S=\frac{\sqrt{3} \times \rho \times L \times I \times cos\varphi}{\Delta V}$

The intensity of short circuit
$I_{CC}=\frac{S_{CC}}{\sqrt{3} \times U}$

Figure 7. General view of the new operation and control rooms.

The cubicles contains a multifunction electronic control and protection unit, which allows the switch and disconnector to be operated local and remotely from the SCADA system, as well as the visualization and recording of all status information and network parameters. In addition, they integrate the protection equipment corresponding to the 132 kV switches and the power transformers of the outdoor substation, making awwowing the trip of the switches of the transformer connection cells.

4· ELECTRICAL SWITCHGEAR. 132 kV SWITCHES AND TRANSFORMERS.

Composedby a set of 34 free of maintenance, single bar with SF6 insulation, metallic enclosure, and compartmentalized medium voltage modular cells distributed in two blocks of 17 mirror-settled switchgear, achieving an operational redundancy which guarantees the maximum level of **continuity** of the power supply in the event of any incident.

Each block of cells receives two connection lines from the power transformers in the outdoor substationand one corresponding to the emergency line. All the metallic parts of the cubicle which are not in tension, including the cable shield, are connected to a 200 mm^2 section ground bar.

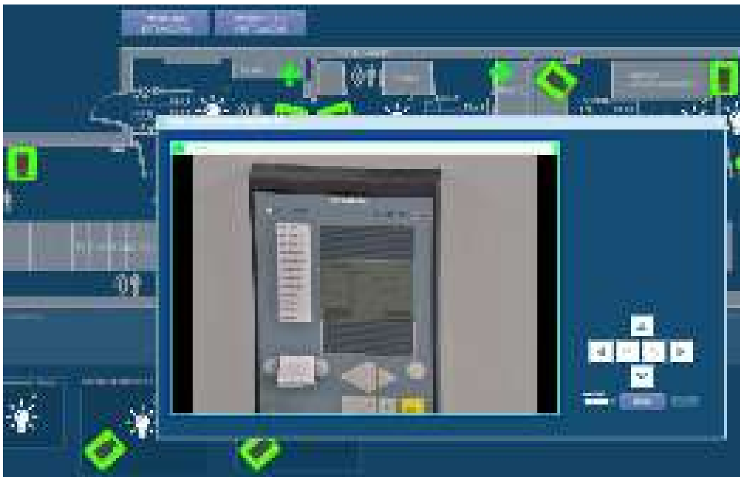

Figure 8. Detail of remote access by CCTV to the supervision panel and cell control.


Centro de Excelencia del Sector Naval - Impulsando la transformación digital
siemens.es/cesena
El Cesena da soporte a la industria la industria naval española en su travesía hacia el Gemelo Digital.
SIEMENS

The two switch positions of the 132 kV substation-have high-performance analysis equipment for monitoring the general status of the network and verify the quality of the electricity supplied.

The voltage transformers and the old 132 kV low level (PVA) circuit breakers (1971) were replaced and incorporated to the SCADA for remote operation, improving the safety, accuracy, reliability, and robustness of the installation.

All circuits, including the low voltage circuits associated to with auxiliary services, were are arranged for remote operation and, in particular, for each of the the operations maneuvers, both at 132 kV and 15 kV, the CCTV points towards the cell or switches for viewing of the real time performance.

The control and protection panels of the medium voltage cells and the high voltage cabinets have been subjected to exhaustive trials and functional tests. The cabinet construction was verified according to the engineering designs and subjected to a series of functional tests of power supply polarity and auxiliary relay actuation. All control and protection equipment were tested with binary inputs and outputs, current and voltage circuits, just as interlocks. The results of all the performed the tests were favorable.

The study of the magnetic field emissions outside the substation where it is accessible to the people was carried out using a software for simulating the magnetic field in electrical installations. The data input is the 3D topology of the set of substation conductors, as well as the currents which circulate through each of them.

In accordance with UNE-EN 62110, the calculation was performed at a 1 meter high and the results were verified at the outer limits of the substation where it is accessible to the public, considering a

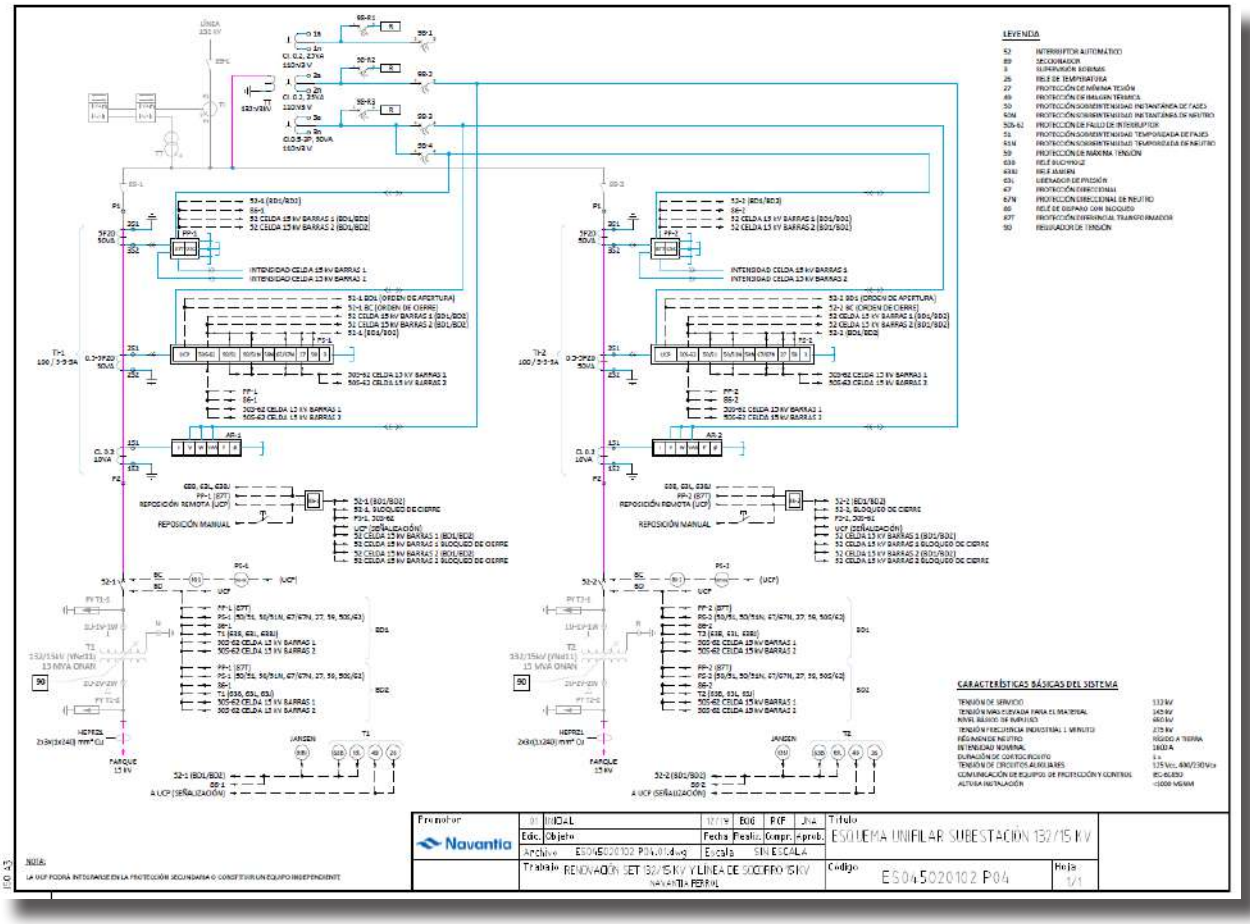

Figure 9. Substation protections plan.

distance of 0.2 meters from the perimeter fence, verifying that the results obtained did not exceed the limit established by R.D. 1066/2001 of 100 µT at 50 Hz frequency, not requiring restriction measures.

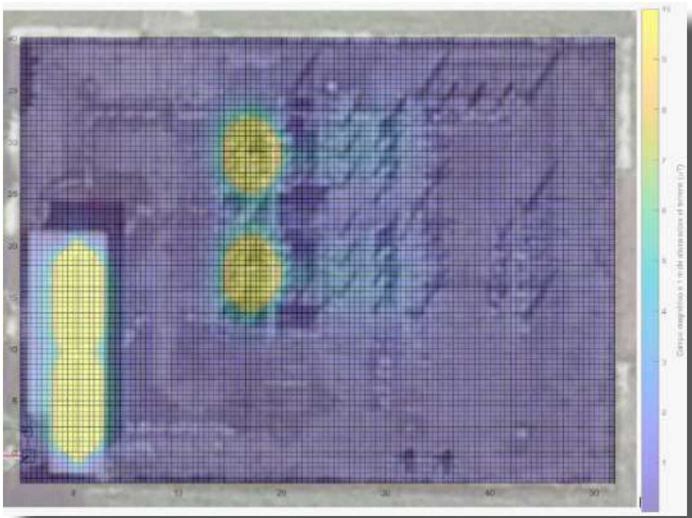

Figure 10. 2D magnetic field with 10 microtesla limit.

The entire underground network of High Voltage cables was verified according to UNE 211006. The status of continuity and phase order and the status of continuity and ohmic resistance of the shields were checked using a digital Megohmmeter and a 100 A Microhmmeter, as well as the condition of the cover stiffness with a portable MFM 10 Cover Leak Detection System, or the withstand voltage test using a VLF 60 Plus. **All tests** were **performed** using **calibrated equipment** and the results **were correct.**

Figure 11. High Voltage cable schematic.

5· FIRE DETECTION AND EXTINGUISHING SYSTEM.

The firefighting system integrated into Navantia's communications network allows the complete remote management in real time, providing the graphic visualization of the installation, configuration, consultation of the status of the equipment, recording, and management of events and alarms, activation, and deactivation.

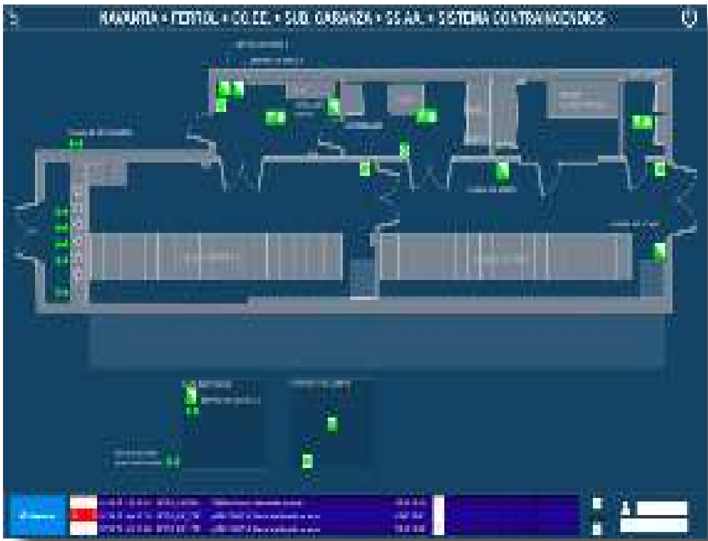

Figure 12. PCI screen.

It has **suction detectors**, with the installation of collection capillaries from the different rooms, and an automatic fire extinguishing system based on sectorized CO_2, discharge, located in medium voltage cells rooms, the capacitor bank, the batteries of the direct current system, the generator set and the cable cellar., There are manual buttons for blocking or activatingthe extinguishing system and external light indicators for active extinguishing in all the entrances.

Extinguisher agent bottles are structured stored in a rack equipped with differential pressure sensors and continuous weighing.

The intrinsic level risk (IRL) of each fire sector or area wasevaluated by calculating the weighted and corrected fire load density of the different fire sectors or areas that make up the industrial establishment, as indicated in the Fire Safety Regulations for Industrial Establishments.

For production, transformation, repair, or other activities different from storage, the evaluation was done through the following expression:

$$Q_s = \left[\frac{\sum_1^i (q_{si} \times S_i \times C_i)}{A}\right] \times R_a$$

Where:

- Q_s = Weighted and corrected fire load density of the fire sector or area.
- q_{si} = Fire load density of each zone with different process.
- S_i =Surface area of each zone with different process and fire load density q_{si} different.
- C_i = Dimensionless coefficient that weights the degree of danger, due to the combustibility, of each of the fuels (i) existing in the fire sector.
- R_α = Dimensionless coefficient that corrects the degree of danger (due to activation) inherent to the industrial activity carried out in the sector of fire, production, assembly, transformation, repair, storage, etc.
- A =Constructed area of the fire sector or occupied surface of the fire area.

The industrial establishment is formed by all the sectors with a total area of 185.54 m^2, a fire load density, weighted and corrected (Q_s) of 60,98 Mcal/m^2, is obtained, less than 100 Mcal/m^2, resulting in an IRL of sector LOW 1.

6· PROTECTION AND CONTROL: SCU Y PCU.

It was installed a scalable digital protection and control system based on a Substation Control Unit (UCS), primary and secondary protection relays in each position of the automatic switch-power transformer, position control units (UCP), and equipment control for the associated auxiliary systems, over a communications infrastructure based on IEC-61850.

With a cascaded control level architecture, the protection and control system is managed locally from the Position Control Units (PCU), from the medium voltage cell relays, and the substation human-machine interface, as well as remotely from the SCADA system operating stations.

The local control allows the selection of local or remote control, activate or deactivate the automatic regulation of power transformer outlets, raise or lower power transformer sockets, opening or closing 132 kV circuit breakers, opening or closing 30 kV cubicle circuit breakers and isolators, monitor events, alarms, incidents, etc., and consult and display measurements and reports on network analyzers.

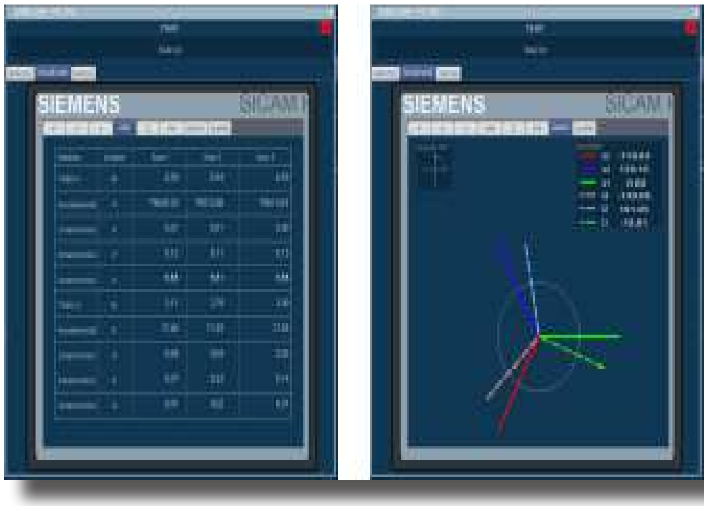

Figure 13. Detail of network analyzers installed at 132 kV and 15 kV.

Figure 14. Detail of 132 kV positions.

The remote control allows the same actions as the local control, except for the deactivation of the local controller.

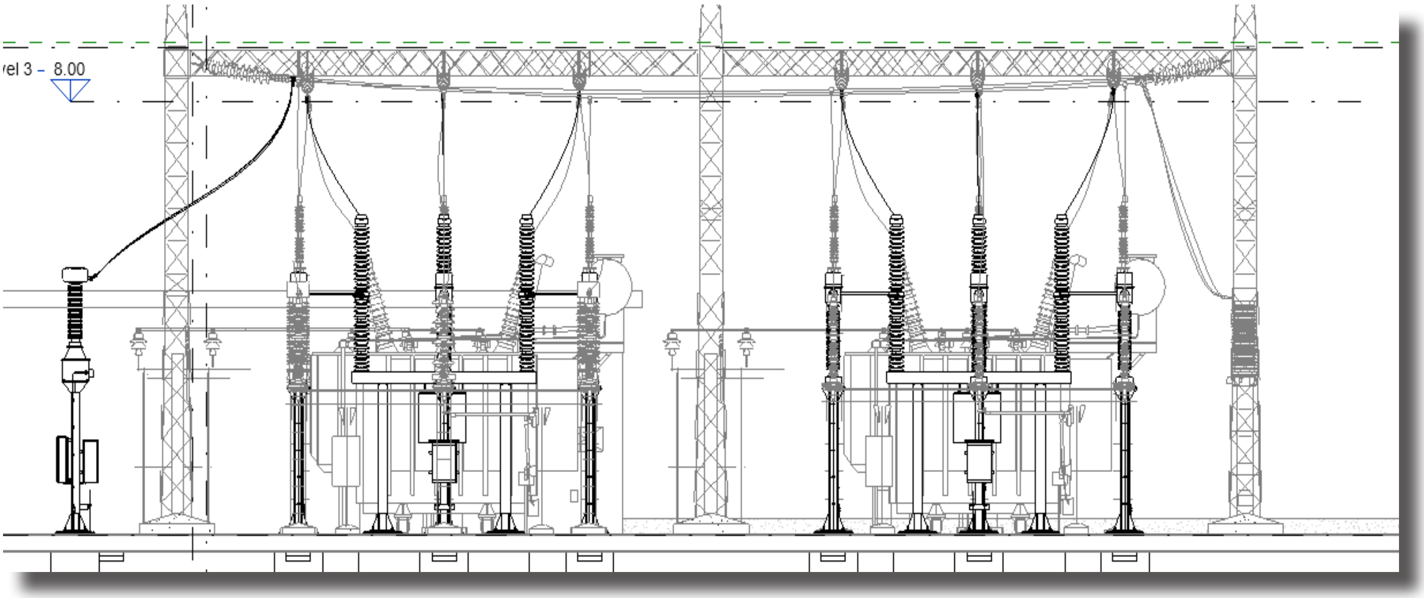

Figure 15. Elevation view of the 132 kV outdoor park.

The control system is equipped with the main protection for each power transformer position (digital transformer differential protection unit and oscillographic disturbance recording) and secondary protection for each 132 kV circuit breaker position (multifunction digital unit for phase and neutral overcurrent, overcurrent, minimum and maximum voltage between phases, circuit breaker failure and tripping circuit monitoring).

Each Automatic Switch-Power Transformer position has a Position Control Unit (PCU). This unit managesthe status information of each position and its associated protections and is integrated into the substation communications network, connected to the Substation Control Unit (SCU) switch, providing the SCADA system with all the information on the status of the equipment.

A system of thermographic cameras supervises the outdoor park´s areas that are susceptible to thermal control: transformers, disconnectors, etc.

The control system and at the PCU level allows the capture of double signals (open/closed) corresponding to the states of the 132 kV switchgear, automatisms and signaling on a local display, the emission of double commands (open/close) of the automatic switches, with the corresponding interlocks, the capture of simple signals corresponding to the associated signals/alarms, and visualization on the local screen, the capturing of analog voltage and intensity signals and their calculation, based on these, of power, power factor, energies... with local visualization of magnitudes, the integration of alarm and trip signals from the mechanical protections of the power transformer and tap changer and an oscillographic record of disturbances.

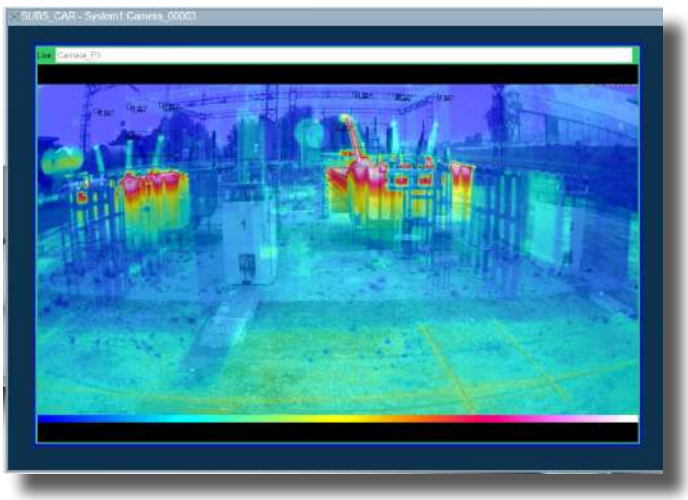

Figure 16. Thermographic monitoring of 132 kV / 15kV transformers.

7 · SCADA, COMMUNICATIONS, CYBERSECURITY AND DATA ANALYTICS.

A fundamental part of this project, the control and data acquisition system (SCADA) integrated into the installation allows real-time status visualization, equipment management and protection operation, the consultation of historical events and alarms, in addition to the control and visualization of the CCTV system, so that the operation of the whole installation is possible locally and remotely, with identical guarantees, and the highest level of digitalization.

Figure 17. SCADA control display.

A modular PLC type equipment is in charge of concentrating and processing the data captured in the different positions, providing the information both locally, through different consoles, and remotely, communicating with the remote control centers.

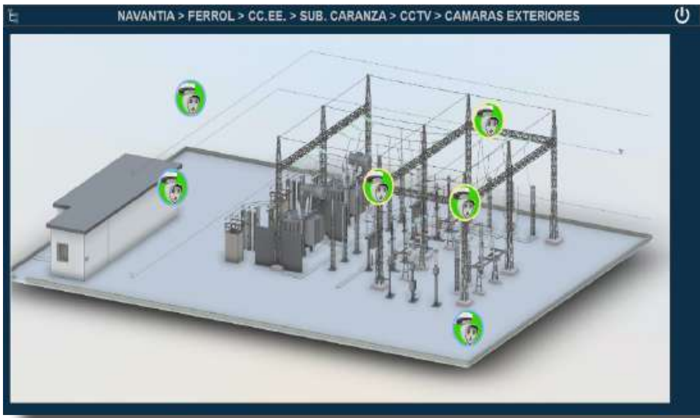

Figure 18. CCTV control screen and thermographic monitoring of the outdoor park.

A 1 Gbit/s HSR fiber optic ring with 0 ms switching time has been implemented inside the substation, according to a state-of-the-art OT architecture, to collect all the data from the automation and control system, including information from the protection relays, both trips, and actions as well as oscillography. It is totally isolated from the shipyard's network through a perimeter firewall.

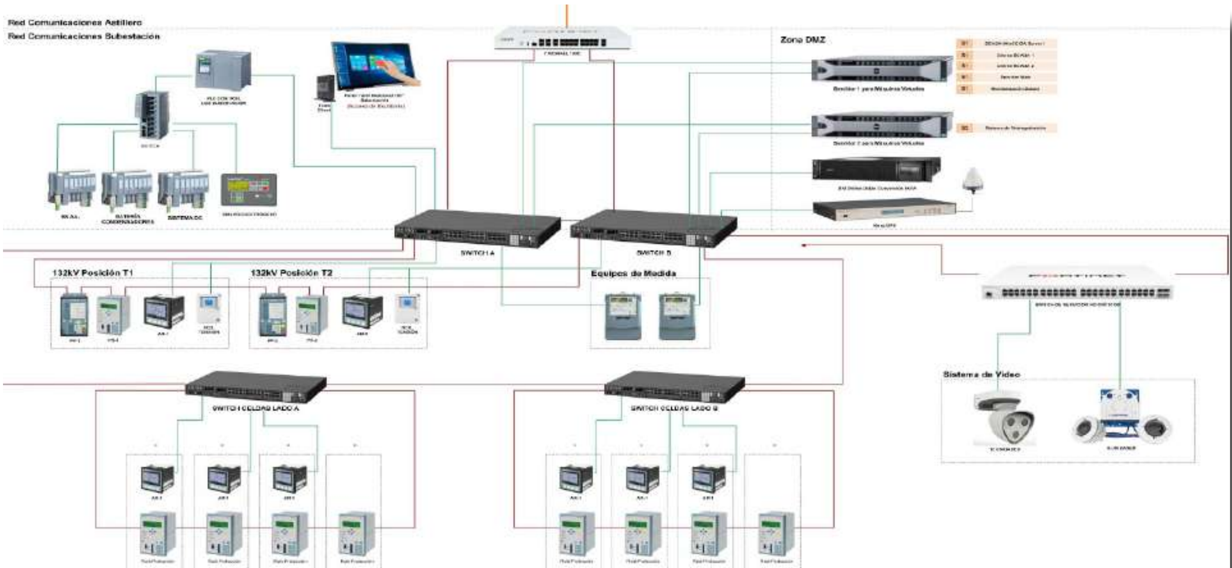

Figure 19. Communications network topology.

All the information collected in the system is stored for six months, giving rise to top-level data analytics, which allows achieving a high level of optimization and control in several fields, mainly resulting in economic and energy improvements.

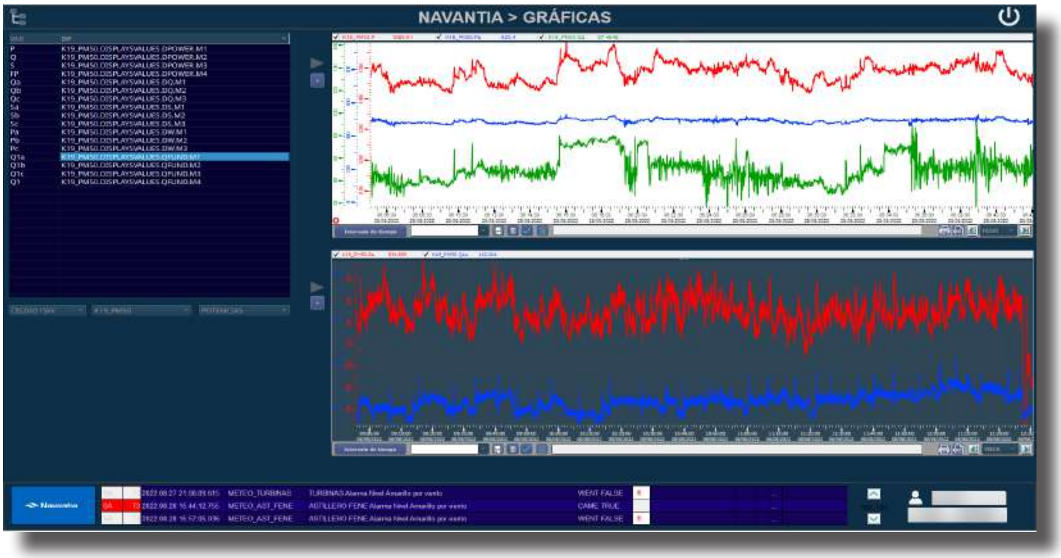

Figure 20. Detail of exportable parameter graphs.

Evolution of Motorized Valves in Shipbuilding Contracts

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1· INTRODUCTION

Valves are critical elements inside a vessel, on whose correct operation depends on the integrity of the platform and its basic management and habitability systems, such as ballast, bilge, fire, fuel, or ventilation systems, among others.

The general increase in the automation of on-board processes, the reduction in the cost of electronic equipment, or the appearance of specific products focused on the sector have caused the percentage of motorized valves to increase notably in recent decades.

As a result, the responsibility of motorized valve systems is increasing, the associated contracts are increasingly large, and the complexity of integration has become more and more notably. All this has led to a change in the management methodology of this equipment during the shipbuilding process in recent years.

In general, motorized valves were not usually treated as a differentiated package, but the components were acquired independently by the shipyard, being in charge of the design, integration and subsequent commissioning. The integration process was simple

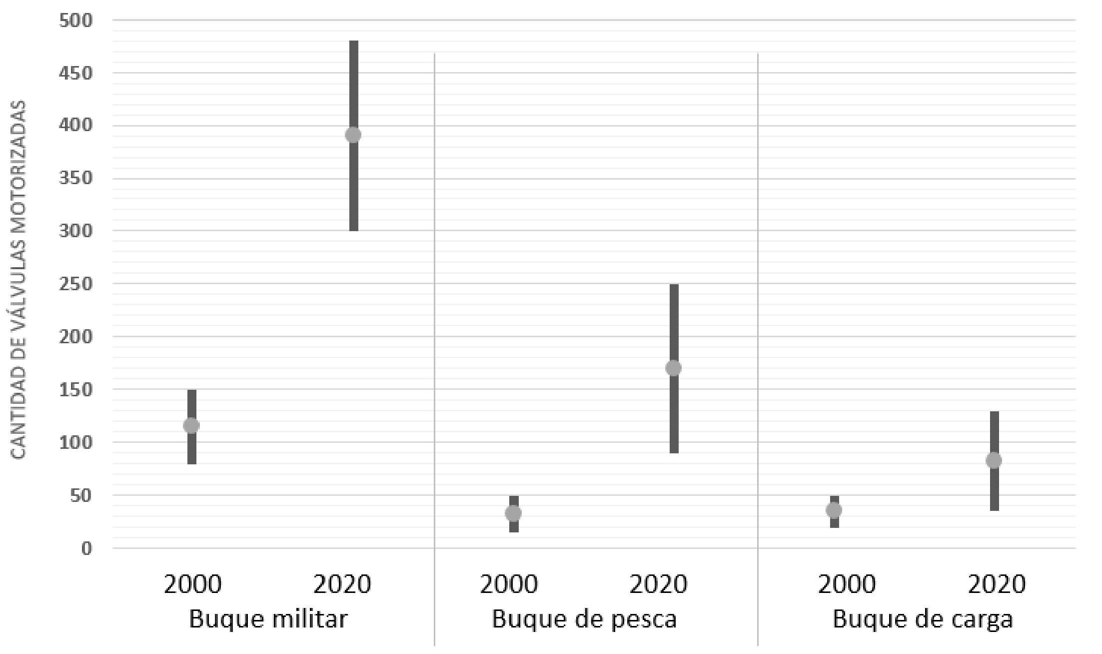


Chart 1: Comparison between the number of motorized valves in 2000 and 2020, according to type of ship. Average maximum and minimum ranges. Source: own development.

and limited in scope, due to the small number of equipment and the little information transmitted by each one. The equipment suppliers were not highly involved in the construction process, as they did not have a clear responsibility for the collective and final functioning of their equipment.

However, currently the motorized valve system is usually understood as a main element within the design and acquisition processes of the vessels components. Its design begins early, usually in the functional engineering stage, and the purchasing process often begins in the early phases of the construction. It is common for the supplier of this system to be involved from the initial stages of design (with different degrees of implication, depending on the complexity of the vessel), and its presence is a constant from start to finish of the construction process, usually being in charge of the final commissioning of the equipment.

This change in philosophy makes it necessary for this companies to be capable of managing complex projects, have sufficient technical solvency to participate in various stages of design and production and, in general, take a step forward in the provision of services to the shipyard.

2· COMPONENTS OF A SYSTEM OF MOTORIZED VALVES

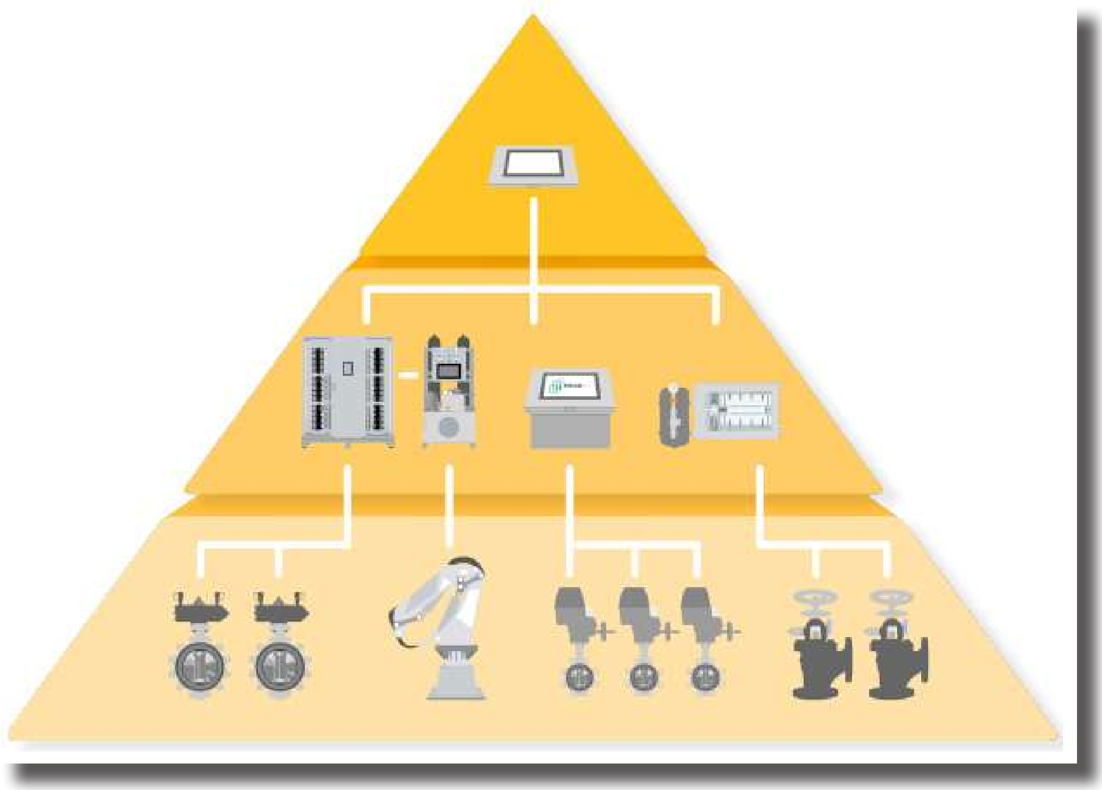
A motorized valve system is generally made up of:

- Valves
- Valve actuators
- Monitoring and control system

VALVES

Initially, the valves to be motorized were those for critical services, such as sea chests or fire-fighting collectors, and were traditionally globe or gate valves with metal seats, which are expensive to motorize and relatively large.

Currently, most of the motorized valves on a ship are butterfly valves with elastomer seal, due to their low cost, ease of operation and good performance in most scenarios. These are also the most widespread among the ship's manual valves, which means that, in most cases, the shipyard seeks to standardize manufacturers among manual and motor-driven valves.



The increasing focus of shipyards towards the sustainment and life cycle of ships makes the standardization and commonality of components and manufacturers essential in the purchasing process.

ACTUATORS

Since the automation of valves in the naval sector is not as widespread as in other sectors (such as oil & gas, chemical or petrochemical, where a large percentage of the valves are motorized), until relatively recently there was not a wide variety of actuators in the market focused on use in ships or marine environments.

According to this situation, the trend has been to use actuators designed for other applications and adapt them for the use on board, resulting in two different paths, separate from each other and with a difficult intermediate point: on the one hand, the use of large actuators high sizes and weights where the requirements are higher, with functionalities sometimes oversized and costs generally high; on the other hand, the use of actuators with low performance, little robustness and very low costs, not designed to withstand the aggressiveness of the marine environment.

Picture 1: SAVAL marine valves with electric actuator

Faced with this growing need, in recent years there has been a notable growth in the number of actuator manufacturers that have developed specific product ranges for the naval sector. These models are usually small in size, with specific control functionalities focused on a vessel, and with a cost generally adjusted to the features required in each project. There are even manufacturers with specific ranges focused on military ships, with specific certifications against shock, vibration, or electromagnetic compatibility standards.

MONITORING AND CONTROL SYSTEM

Regarding the monitoring and remote control of these valves, there are different factors that influence the increased use of equipment dedicated exclusively to this task, turning motorized valve systems into subsystems for the IAS (integration and automation system of the ship) itself.

Initially, motorized valves were integrated directly into the ship's IAS, using controls designed by the shipyard itself or integrated into control systems of other equipment (such as pump starter panels, etc.). The treatment was similar to any instrumentation element of the ship, without a specific differentiation. The number of signals to be manipulated was not very big, and the controls quite rudimentary (generally electrical logic by means of relays, etc.).

On one side, the increase in the number of motorized valves on board directly results in an increasing amount of information that must be integrated. At the same time, the evolution of actuator electronics means that they are increasingly capable of providing a greater amount of information, both for operation and diagnosis. This translates into a greater amount of data to the user, so that the number of signals that are integrated into the ship's platform control systems is significantly increased. A system of electric motor-driven valves can involve the integration of up to 20,000 signals in the IAS. Such number of signals leads to integrate a subsystem which facilitates the incorporation of all the data in the IAS.

Another point to keep in mind is that, in recent years, there has been an evolution in marine regulations that requires greater sophistication in the control of certain equipment and systems on board. Among the systems included are ballast and bilge services, which motorized valves are critical. Examples of this are the SOLAS regulations II-2 21, II-2 22, II-2 23 and II-1 8, introduced in MSC.1/Circ.1369

(June 22, 2010) and collectively referred to as 'Safe Return to Port (SRtP) Regulations'. These regulations apply to passenger ships built since July 1st, 2010, with a minimum length of 120m and 3 vertical levels, and they establish that certain critical systems for the navigability and stability of the ship must remain operational after a fire or flood, with the aim of achieving a safe return to port using their own means. Classification societies have issued their guidelines for the adaptation and implementation of this regulation, such as DNVGL-CG-0004 from DNV-GL, or NR 598 DT R01 E from Bureau Veritas. Within these regulations, the need for a double control of the motorized valves is exposed, which clearly points towards the need to have control systems of a certain sophistication.

At the same time, and for various well-known reasons, more and more emphasis is being placed on the cyber-security of the equipment on board, so as to minimize the risks of compromising the security of the ship due to a cyber-attack on the management systems. This is evidenced in IMO circulars such as MSC.1/Circ.1526 (June 1, 2016) or MSC-FAL.1/Circ.3/Rev.1 (June 14, 2021), and various recommendations and adaptations made by societies of classification. Since the motorized valves manage critical services for the survival of the ship, the automation systems that manage them are not exempt from including security mechanisms that limit these threats as much as possible.

Since the IAS is a clear target for any possible cyber-attack, a strategy followed more and more often is, again, segmentation into subsystems. In this way, in the event of a possible general cyberattack that disables or limits control from this system, healthy subsystems can be isolated and manipulated independently. This aspect also enhances the use of control systems dedicated to motorized valves.

As a result of all the above, the need for a more complex, sophisticated, robust, and safe valve control is evident, resulting in the appearance of specific commercial solutions for the naval sector, something that was not usual before.

3·NEAR FUTURE OF MOTORIZED VALVE SYSTEMS

The levels of automation of the ship are becoming higher, even developing projects for fully autonomous ships (the IMO has even published preliminary guidelines on the testing of these ships, among others in the publication MSC.1/Circ.1604 of the June 14, 2019). It is therefore expected that the level of valve automation will also gradually continue to increase, at a similar rate to that of recent years. The classification societies themselves are expanding and reviewing the requirements on motorized valves, actuators of various types (there is still discrepancy between the CCSS on the specific requirements to apply to electric actuators, for example) and associated control systems.

The inclusion of new technologies (such as the digital twin or additive manufacturing) and new requirements, especially in terms of security (including the cybersecurity of systems), will have an important role in shipbuilding and, therefore, in these systems.

In this framework, companies like ours, Fernández Jove Integral Supply (www.fernandezjove.com), that can offer end-to-end solutions, integrating (or even manufacturing) the different components that compose a motorized valve system, take on special importance.

Picture 2: PRIOR control system, specific for motorized valves on a ship, developed by Fernández Jove Integral Supply.

AISTER's La Demoiselle and La Charente river cruisers for the Charente river

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La Demoiselle and La Charente, manufactured by the Vigo-based AISTER, are the two latest incorporations to the fleet of vessels that make river cruises on the Charente River, emulating the old barges that centuries ago moved cognac from the vineyards inland to the ports on the coast and from there to the north of Europe.

The Charente twists for 381 kilometers through southwestern France, from its source at Chéronnac to its mouth at the Atlantic Ocean near Rochefort. The "river of calm waters", as it is known in France, has been an important commercial axis since the Middle Ages, hosting significant river traffic linked to the salt, wood, wine and stone trade.

Its waters cross the vineyard areas of the cities of Cognac or Jarnac, where the white grapes are grown, which after being distilled twice give rise to cognac, and for years the barges transferred this brandy from the trading houses located on the banks of the river to its mouth where it was shipped to the countries of northern Europe and the British Isles.

The arrival of industrialization replaced the barges, first with more modern motorboats, then with railroads and finally with road traffic in the middle of the 20th century. Abandoned for decades, it has only been in recent years that river traffic has been recovered, but from a totally different perspective. Now barges ply the river with tourists and passengers seeking to reconnect with nature thanks to the river cruises that run along the Charente during a day.

To that end, in 2021 the Charente Department launched a tender to build two twin vessels emulating the old cognac transport barges with a budget of 771,000 euros. Following the design of the French engineering firm SDI, the Vigo-based company AISTER was commissioned to build the two units, christened La Demoiselle and La Charente.

The boats are built in aluminum covered with wood, with dimensions of 20 meters in length and 4.5 meters in beam and a draft of only 0.45 meters. They can comfortably seat 69 passengers who can enjoy three routes a day of approximately one and a half hours in length. The boats also have the capacity to transport two bicycles, in case any passenger wishes to continue the tour along the river on two wheels.

One of the keys to the project is the hybrid propulsion of these vessels. The requirements of the specifications stipulated that the vessels had to travel part of the route in electric mode and the rest in diesel mode, but AISTER's experience in this type of motorization, which began in 2011 with the construction of the electric vessel Juan de Homar for the Canal de Castilla, ensured that the boats delivered by the shipyard can travel the entire hour and a half route in electric mode at a speed of six knots, completely reducing polluting emissions and improving the onboard experience by eliminating both noise and vibrations.

After completion of their construction, the barges were transported to France where they have been making their river cruises from Quai des Flamands in Cognac to Saint-Brice and back to Cognac.

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PLM - A Realistic Approach to Success

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Shipbuilding is a unique industry and yet few take note of this in the context of Product Lifecycle Management (PLM). Its culture, processes, and leadership hamper the adoption of commonly available technology and realistic, pragmatic implementation strategies.

It should also be recognized that a PLM environment is not reserved to shipyards. On the contrary, it is immensely useful for all companies running parallel and/or large projects.

A true digital transformation and a clear vision of the current status and future goals are *sine-qua-non* prerequisites for a successful PLM initiative. A symbiotic corollary is that monolithic toolsets might not address the complexity of the multiple concurrent processes spanning the ship design and ship building ecosystem.

The simple essentials of a successful PLM implementation include (but are not limited to): identifying and how to pursue the end goals, assessing available and required resources, where to start, what to do and who to call, recognising the multiple and parallel processes involved and remaining very alert to changes and equally flexible.

Then, it follows that a true Digital Transformation can only take place within a sincere Business Transformation.

IDENTIFYING AND PURSUING THE END GOAL

The end goal- the "vision"-is defined by people and its feasibility is based on resources. The vision can be abstract, for example "increase turnover by 10% in 3 years' time", but achieving is a practical exercise, for example by establishing an asynchronous data processing, automated PLM environment.

The backbone of a PLM effort it to create value out of the ecosystem by exploiting the significant (and in general equally fragmented and disconnected) amount of digital information already present while developing and integrating the missing mosaic tiles and links.

Evolving from the generally misunderstood Business Process Assessment (BPA), a Value Creation Process (VCP) will pursue the end goal by cross-matching processes and resources over a number of major business objectives and identifying the corresponding information flow and deliverables.

A working PLM environment requires many software tools to work together: 3D CAD, ERP[1]/MRP[2], MES[3], HR[4], Planning, VR/AR[5], PLM, etc. -And, realistically, an AGILE and LEAN approach will select software from several sources. Each tool can be considered to be a Platform and a multiple tool environment is generally referred to as a Platform-of-Platforms. Each tool must provide the required functions and

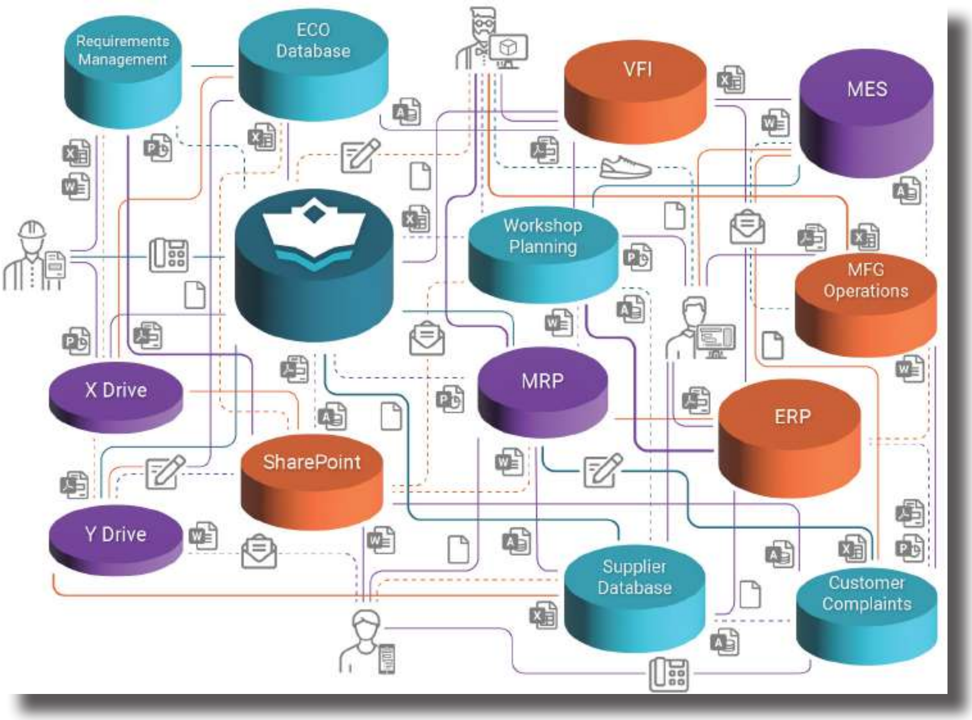
1· ERP: enterprise resource planning

2· MRP:material requirement planning

3· MES: manufacturing execution system

4· HR:human resources

5· VR/AR: virtual reality/augmented reality



be capable of communicating with others out of the box, but also lend itself to being developed further as will often be required. In some cases, two similar platforms actually operate in parallel, for example local and global strength FE tools sharing the same model.

The successful pursuit of the vision will be valuably supported by adopting AGILE and LEAN principles form the start of the digital transformation which, in this case, is symbiotically embedded in the implementation of the PLM environment. Possibly surprising, the bigger the organization the shorter should the initial, progressive steps be. Amongst other advantages, such an approach will protect the integrity and enhance the quality of the evolving PLM eco-system by allowing the inevitable corrections to the Implementation Road Map.

ASSESING AVAILABLE AND REQUIRED RESOURCES

The inefficient reality is that information is often difficult to find and its reliability unknown, work handoff procedures rely on people's manual actions, deliverables are not composed using consistent procedures, errors are found late in the game, change orders are hard to manage, various stakeholders repeat work "just to be sure", etc.

The key paradigm is *Availability replaces accessibility*. Availability means managing the delivery of the appropriate data and information to the intended recipient in a purpose-specific format - the "M" in PLM. "M" may also stand for Master: people must know, monitor and control what is happening, especially if processes are automated.

An objective VCP and a realistic digital transformation strategy are the first, crucial steps towards satisfying such data and information transparency. Ironically, some commonly available technology negates availability: content-rich emails, unmanaged documents, WhatsApp chats, SMS messages, notes scribbled on drawings (included digitally) and all similar information "silos".

WHERE TO START, WHAT TO DO, WHO TO CALL

The vision is the lighthouse, but a moving one, and I like to resume and refer to the above as the steam-roller approach: go slowly, never stop, change directions if needed, and compound the power of AGILE and LEAN increments. A little like in disrupted

6· *Availability not accessibility:* expression coined by Denis Morais (SSI, Ca) ca. 2011, this concept is discussed by the author in several conference papers optimization processes, the digital transformation efforts will keep on pointing towards the lighthouse while navigating environmental conditions predictable only in the short-term.

Bottlenecks and inefficient processes are very often due to human factors. Identifying the easiest ones to resolve consists in a "local", low-level approach towards fixing them by evolution, not by evolution. This is in fact a form of "industrial meditation" that reveals the most hidden aspects of why a company works the way it does (objective vs subjective constraints, etc.). Rallying people to the cause will support the process and allow everyone to benefit because the company overall is benefitting.

A PLM implementation is therefore tailored to the objective environment of each shipyard, and it takes time and an objective perspective to prepare appropriately. Moreover, although it is a "forever" process, significant milestones can be met in a matter of weeks or months (or, in some cases, even days).

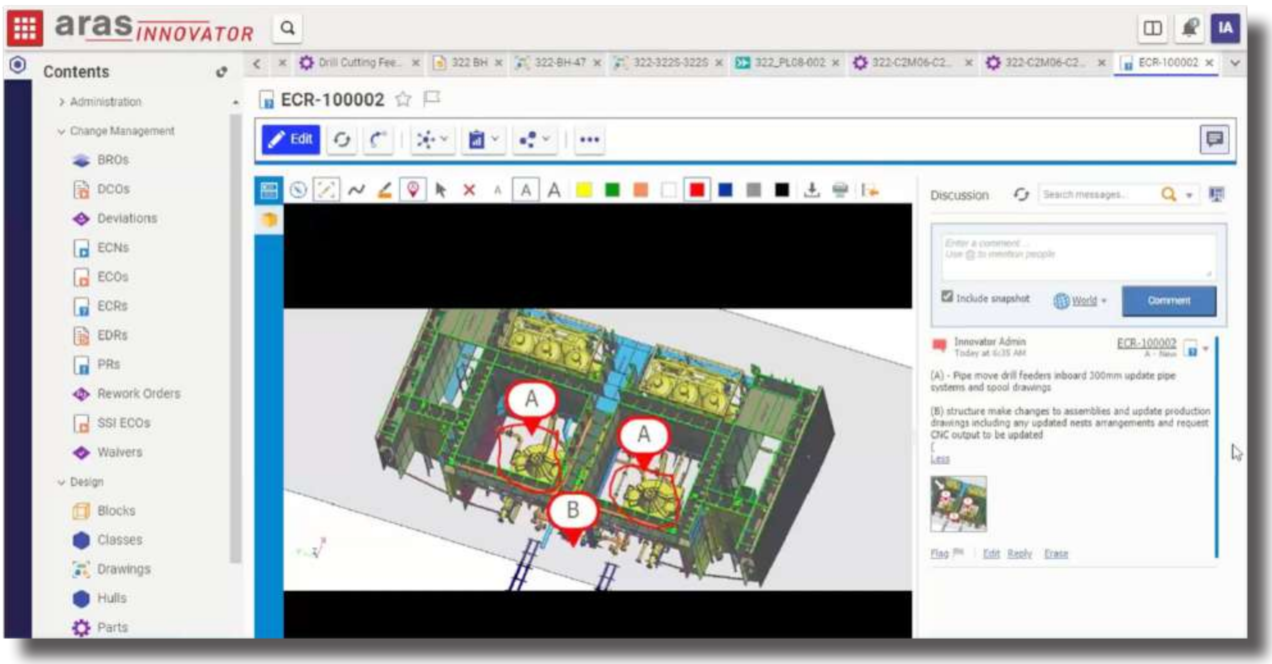
For example, agnostic sharing of stakeholder-tailored 3D models that includes integrated meta-data, better still interactive and collaborative reviews, etc. are easily achieved with off-the-shelf platforms like Autodesk Navisworks, Aerys[7] SmartShape, etc., which also serve the Digital Twin Approval initiatives of various Class Societies. Similarly focused on PLM, SSI's ShipbuildingPLM software provides the ability to trace the history of a given part with a couple of clicks in a web client (ex. on a smartphone via the LAN or the cloud).

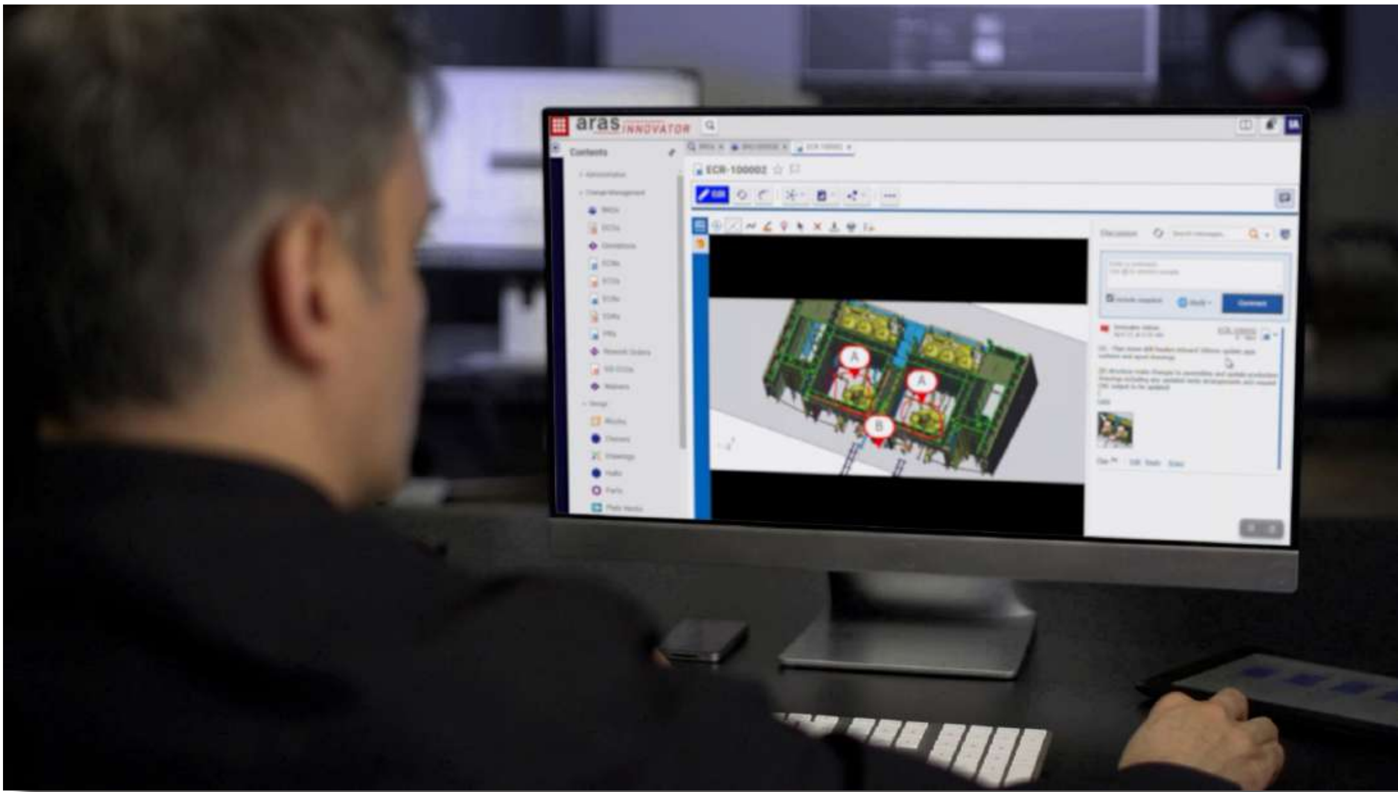
While experienced, "fresh" eyes are especially useful during a VCP, the analytical contribution of a Shipbuilding-specific PLM expert will soon be required. Field experience and hands-on knowledge of software tools along with the ability to see the big picture are decisive discriminating factors. In the author's experience (not meaning to exclude anyone), successful PLM have been achieved by PROSTEP[8], Hamburg, SSI[9], Canada and their respective partners.

7· Aerys, www.aerys.in: software création and developers of SmartShape (www. Smartshape.io). References: Bureau Veritas, Chantiers de l'Atlantique, etc.

8· PROSTEP, www.prostep.com: vendor-agnostic provider of PDM and PLM solutions. References include Austal (AUS), Fassmer (D), Ulstein (N), GERMAN NAVAL YARDS (D), ABEKING & RASMUSSEN (D), etc.

9· SSI, www.ssi-corporate.com: creators and developers of ShipConstructor, ShipbuildingPLM, ShipExplorer, etc. References: Huntington Ingalls (USA), Austal (USA and AUS), Seaspan (Ca), etc.





CONCLUSION

Digital transformation and PLM implementation require a committed management and their realistic vision, that is a sincere Business Transformation. An honest VCP, small practical steps and expert support will feed evolution towards high performance, adaptive design bureaus and shipyards. To begin is easy, tools and ways are readily available, but one must want to do it.

ABOUT THE AUTHOR

Nick Danese, founder of NDAR and SYRRKLE, holds degrees in Mechanical Engineering (BS, University of Arizona) and Naval Architecture (MS University of Michigan). Nick's main role is to assist NDAR customers in maximizing ROI while using NDAR software solutions. Nick has published numerous research papers over the years, contributed to several industry magazines and regularly presents at ship design and ship building conferences.

AKNOWLEDGMENTS

Special thanks to Denis Morais (SSI) for having been my "PLM sparring partner" for over 15 years, to Matthias Grau (PROSTEP) for freely sharing ideas and brainstorming and to Greg Goulanian (SSI) for help in making my writing (more) readable.

NDAR & SYRRKLE

NDAR provides software solutions for Naval Architecture and Shipbuilding and related services including Training, Project assistance, Value Creation Assessment, Implementation and System Integration Consulting.

SYRRKLE SYRRKLE specializes in plug & play IIoT and IIIoT&S solutions for the marine and other industries and worksfa only by reference.

Applying ANNs to Derive Empirical Design Formulas for Harbor Tugs

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ABSTRACT

This paper describes how a database of harbor tugs was used to derive simple design formulas for conceptual design. The approach used artificial neural nets to predict power and displacement based on speed and bollard pull, using length as additional parameter that may be estimated using conventional design formulas for tugs. The agreement of predictions with an independent validation data set is very good.

1·INTRODUCTION

Tugs are work boats which differ in many aspects from normal cargo ships, Fig.1, *Allan* (2003). The main design specification concerns manoeuvrability and ability to assist escort vessels in manoeuvring. Design experience and empirical design formulas for conventional cargo ships or fast pleasure craft are not applicable to tugs. This was the motivation for us to develop corresponding semi-empirical formulas for harbour tug design, *Bentin and Bertram (2000), Bertram and Bentin (2001).*

Conventional regression analysis has been extensively used in naval architecture in system identification to provide required factors and coefficients. Based on databases of existing designs, coefficients are then interpolated or even extrapolated to calculate coefficients for a new application, e.g. for simple design methods as in *Watson (1998), Schneekluth and Bertram (1998), Bertram (2012)*. This procedure requires specification of not the main input parameters, but also the type of functional relation be-

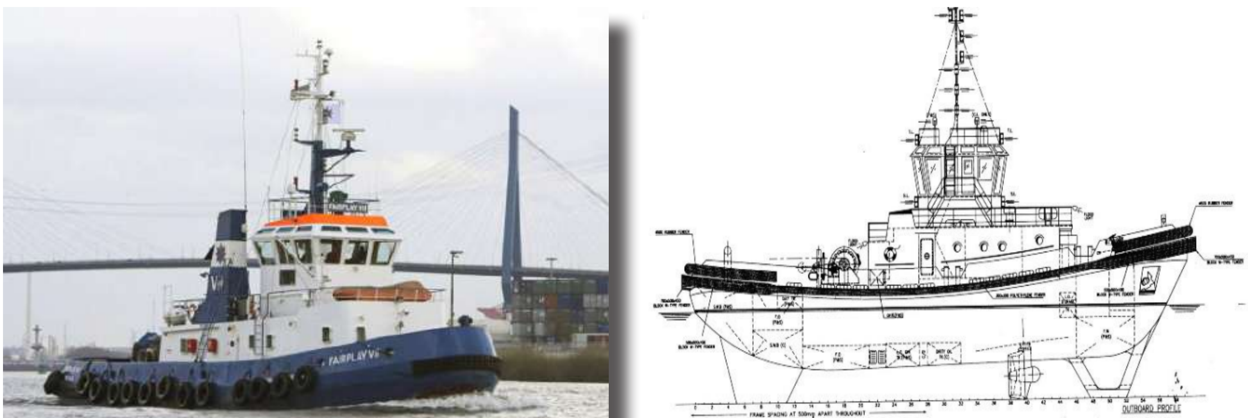

Fig.1: Typical harbor tug

tween input and output parameters. Most often in the past, simple linear relations (or even worse just constants) have been chosen. Designers plotted data and by visual inspection sometimes chose also simple polynomial relations. Higher-order polynomials have the unfortunate tendency to introduce unphysical oscillations.

This approach is cumbersome and unsuitable for many nonlinear relations. Unsatisfactory approximations in conventional regression analyses stem mainly from the inappropriate choice of inherent function used in statistics. In the language of Germans and mathematicians, we fail from the 'ansatz'. Wouldn't it be nice to have some mathematical way of mimicking the curve we would instinctively draw through such data sets, ignoring implausible outliers and following the trends our eye sees, something flexible yet smooth and free of inappropriate oscillations? For the naval architect, this is old hat. We have approximated arbitrary point sets for centuries, Fig.2), using first flexible thin beams (splines), Fig.3, and later using aptly named spline curves, which do not oscillate and form smooth curves and surfaces, see e.g. *Veelo (2004)*.

The machine learning community prefers other functions, such as sigmoid functions, Fig.4. Combining many of these, we have similar basic qualities of flexible approximation and avoiding oscillations

Fig 4: Traditional splines for ship design, source: TU Berlin

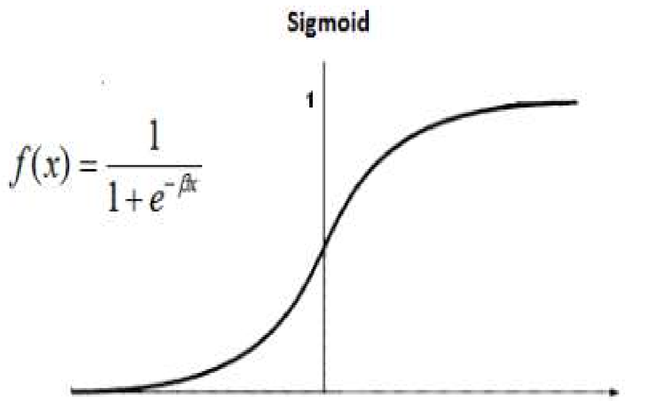

Fig 4: Sigmoid function (typically β = 1 in our applications)

Fig. 3:Rembrandt painting of shipbuilder using smooth curves to describe ship lines

2· ARTIFICIAL NEURONAL NETS FOR FUNCTIONAL APPROXIMATION

Artificial Neural Networks (ANNs) offer a more versatile and user-friendly approach to system identi-fication, *Mesbahi (2003)*, https://en.wikipedia.org/wiki/Artificial_neural_network. ANNs can generally represent the mapping of multi-dimensional input/output data sets, i.e. an arbitrary number of input variables x_i and output variable y_i. An ANN structure consists of several layers; each layer consists of several nodes. In the example in Fig.5, we have the input layer, the output layer, and one hidden layer.

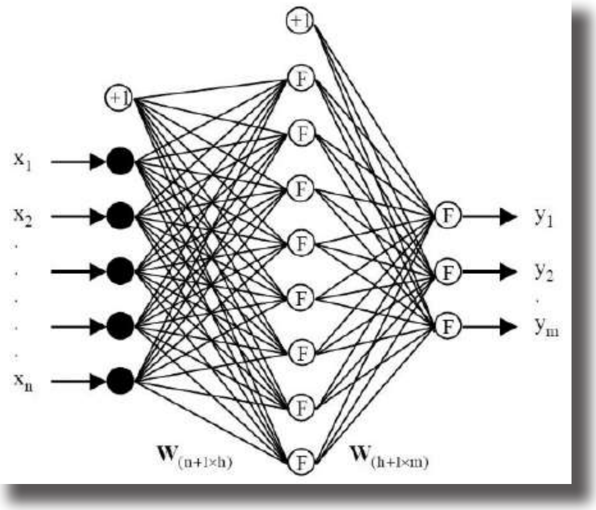

Fig.5: General structure of an Artificial Neural Network

The ANN is “trained” on data sets. This training process results in mathematical relationship output variables y_i and input variables x_i, e.g. of the form (for a single-input, single-output ANN):

$$y = c_0 + c_1 \cdot \mathrm{sig}[b_0 + b_1 \cdot \mathrm{sig}(a_{10} + a_{11} \cdot x_1 + a_{12} \cdot x_2 + \ldots) + b_2 \cdot \mathrm{sig}(a_{20} + a_{21} \cdot x_1 + a_{22} \cdot x_2 + \ldots) + \ldots]$$

Here, sig denotes the sigmoid function. After sufficient training, adjusted values for the coefficients *a*, *b*, and *c* are derived and the non-linear relationship is determined. Now the ANN can very rapidly determine values y_i for given values x_i. For numerical reasons, it is advisable to normalize input and output values between 0 and 1:

Normalised Value =
(Real value - Min. Value)/(Max. Value-Min. Value).

“Deep Learning”, https://en.wikipedia.org/wiki/Deep_learning, is a more recent buzz word used when neural nets with two or more hidden layers are used. Having an additional layer means that the transfer function (e.g. the sigmoid function) is calling in itself a transfer function. This adds more flexibility in approximating functions, but requires also more data for training to be successful.

ANNs are a powerful tool in numerical statistics for many applications, and particularly in our context for empirical formulas used in conceptual ship design or formal optimization applications, when fast and moderately accurate estimates are needed. They are not a magic bullet; they cannot perform mira-cles. ANNs reach their limitations in several cases, *Bertram (2022), Colle y Morobé (2022)*:

- random or quasi-random processes
- scarce data sets
- extrapolation far beyond the data set used in the system identification

3·APPLICATION TO HARBOR TUGS

The starting point of each ANN analysis is a database. In our case, the database was developed using tug designs of Kölln/Jacoby consulting engineers in Hamburg, enriched by additional data supplied by Hitzler shipyard, Schottel, and Voith Hydro. 58 tugs of different size, age, and propulsion systems re-trieved from paper files to feed the database.

For the ANN analyses, between 70% and 80% of the datasets were used for training the ANN; the rest was set aside for validation. The accuracy of the ANN predictions was presented by calculating the correlation between the real and predicted outputs.

Key input parameters are design speed V in [*kn*], bollard pull t in [*t*] and length L_{pp} in [m]. The non-metric units of knots and tons (for forces) are used, as these are the customary units in the tug design community.

Key output parameters are mass displacement Δ in [*t*] and engine power P in [kW]. If L_{pp} is not known in early design (as it depends in turn typically on installed power), it may be estimated based on required bollard pull t and propulsion type:

- Schottel: $L_{pp} = (60.513 \cdot t - 40.278)^{0.1560}/0.1269$
- Voith-Schneider: $L_{pp} = (72.103 \cdot t - 8.0)^{0.2244}/0.1996$
- Conventional: $L_{pp} = 7.272 \cdot t^{0.4063}$

To make the results accessible for the wider community, we extracted the internal representation from the ANN software to derive the following explicit and programmable formulas, *Bertram y Mesbahi (2000):*

$$\Delta=26+886\cdot sig[-4.36\cdot sig(-0.1093\cdot t-0.6485\cdot V+14.1646) -3.08\cdot sig(-0.0579\cdot t-0.6912\cdot V+7.402)+36\,]$$

$$P=1060+3354\cdot sig(1.23-6.44\cdot sig(0.08652\cdot L_{pp}-0.3171 \cdot t-3.84\cdot V+60.4709) +2.97\cdot sig(0.8539\cdot L_{pp}+0.2307\cdot t-0.484\cdot V-23.07) -5.98\cdot sig(0.2596\cdot L_{pp}+0.0856\cdot t+0.51\cdot V-17.577) +2.61\cdot sig(0.2857\cdot L_{pp}+0.7132\cdot t+0.476\cdot V-25.7645))$$

After training the neural network on the data subset for training, predicted results were compared with real values from the data subset for validation. Agreement was good, e.g. for the power prediction, Fig.6, with a correlation coefficient of 0.9945.

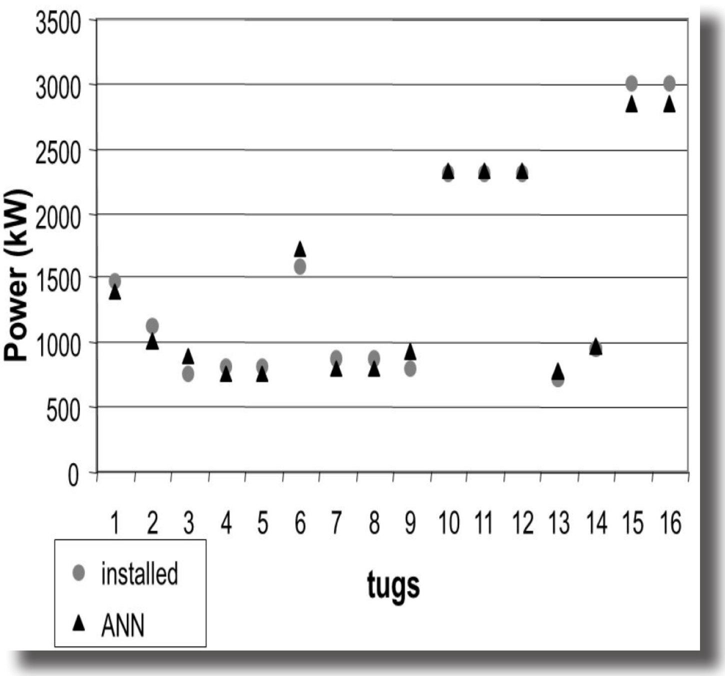

Fig.6: Comparison of ANN predicted and installed power in validation data set

4 · CONCLUSION

Artificial neural nets are a powerful tool to derive empirical design formulas. They require a sufficiently large data set; this can be a challenge in some applications in ship design, namely for unconventional ship types. Training process and application are straight-forward in comparison.

ACKNOWLEDGMENTS

We thank Ehsan Mesbahi for introducing us to the world of Neural Net analyses almost 25 years ago, the late Georg Stockdreher of Kölln/Jacoby Consulting Engineers in Hamburg for his considerably tug expertise and data material. Thanks are also due to the companies Schottel, Voith Hydro, and Hitzler for supplying additional data material.

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The Interview: THUNE EUREKA S.A.

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ThuneEureka

The origin of Thune Eureka dates back to 1815, when in Drammen (Norway) Thune was created, which later merged with Eureka giving rise to the engineering and manufacturing group KVÆRNER EUREKA. In 1973 they settled in Spain, founding the first factory outside Norway, in Galicia: Thune Eureka Española, initially conceived for the manufacture of pumps and equipment for the Shipbuilding sector. Today, Thune Eureka is a full service provider of complete capital goods manufacturing services. It has sections for boilermaking, welding, machining, assembly, integration and functional testing, as well as a highly qualified, motivated and committed team of professionals.

The competitive advantage lies in the fact that the manufacturing of its products covers the complete cycle, from the acquisition of raw materials to delivery to the customer, passing through various intermediate stages and subjecting the equipment to rigorous acceptance tests. It exports 99% of its production. The Nordic countries are its main customers, although its products can also be found in other parts of the world (U.S.A., China, Germany...). Thune Eureka's goal is to satisfy all the needs of its customers by achieving the highest levels of quality, preserving and maintaining the environment and the health of its workers.

• ***Since its foundation, have you continued to maintain the original lines of activity, or have you diversified your activity?***

The company was established in Spain in 1973 to be exclusively a pump factory. From its origins, and through the different stages and evolutions that the company has gone through, we have reached the current situation, in which we provide engineering support and manufacture metal-mechanical capital goods globally for multiple industries.

• ***Would you say that the way of competing has changed nowadays, in what sense? In both the domestic and international markets, do you consider that there has been any significant change in the way of doing business, of obtaining contracts?***

The way we compete is constantly changing. In a company with such a long tradition as ours, we have lived multiple stages. Not so long ago, when in order to bid for a project we received the documentation and physical drawings by courier, to the current situation where the same email, with all the information, is sent to suppliers in different parts of the world so that they can offer at the same time.

Our customers are trying to make increasingly aseptic purchases through the supply chain and the different players act as a filter to the real decision makers. Commercial work is becoming more difficult. Basically, it is a matter of listening to customers, understanding their needs and adapting our company to what they demand. Also, in the search for new customers and markets, it is important to focus actions appropriately and target those customers who fit the company's characteristics.

• *What are the particularities and challenges of the Shipbuilding sector from your point of view?*

At the level of local shipyards there is a very high pressure on prices, which is mainly due to the high number of auxiliary companies. Our location, which is far from the main shipyards, means that we can only be competitive in the manufacture of special projects.

Internationally, we are collaborating with clients in the offshore industry market. If we include offshore wind power within the marine industry, there are good business opportunities, but only for those companies that specialize in a specific product line and adapt their production means to the demands of the sector.

• *What makes Thune Eureka different from its competitors in terms of specific products and services?*

There are three key elements that distinguish us from the competition:

The first, as indicated in the introduction, is to have facilities in which the integral manufacturing cycle is addressed. The installation in assets is accompanied by a strong investment in non-tangible assets, licenses, quality certifications, homologations, etc...

The second is the international vocation that characterizes us and that is inscribed in the company's DNA.

The third is our highly qualified team, which is very focused on customer service and maintaining a high standard of quality in the processes we carry out.

• *How do you plan to further develop and expand the business, and what are your objectives for 2023?*

The effects of the pandemic, the situation caused by the war in Ukraine, the shortage of materials, price increases and, in general, the current situation make it difficult to make long-term forecasts; it is time to prepare, to get stronger and to continue moving forward, but with safe steps and considering that prudence must prevail in decision making. We foresee an acceptable start to the year, but the specter of recession in Europe is present and we will obviously suffer its consequences.

Spending control and investment targeting become fundamental elements; it is important to maintain a very controlled level of leverage, which does not represent an excessive burden in times of difficulties.

On the one hand, internally we continue to expand our capacities, we have recently acquired a larger milling machine and we continue to expand our staff both in terms of structure, at engineering and commercial level, as well as with workshop personnel; with all the difficulties involved in recruiting qualified workers in the sector. In the medium term we foresee the expansion of our facilities, with a new building to centralize the material logistics.

On a commercial level, we are developing the market with clients related to the energy transition and scientific developments, although paradoxically the current situation, which has produced an increase in oil prices, has led to the reactivation of old projects in the oil&gas market and we are currently working intensively on this line in the short term as well.

• *Thune eureka develops its activity for several productive sectors, including the Shipbuilding sector. What are the medium and long term plans for the peninsular market, and for the international market?*

We do not understand the business without an international approach. Company-client communication is conducted in English, which is still a pending issue in this country.

The three current focus areas revolve around energy transition, large scientific facilities, and transversal business growth with existing customers.

Our value proposition is aimed at engineering companies and technology holders, and these are concentrated in Northern Europe. This is where we focus our commercial efforts. The commercial work has an important technical component and the barriers to entry are difficult to overcome. The period from the first contact with a customer until orders are consolidated on a more or less repetitive basis is in most cases more than two years. The process is a wearing one, since the downward price pressure in the initial phases is very intense and a good financial situation is necessary to be able to withstand it. Quality and process audits also make the road difficult. Only constancy and the continuous demonstration of doing things right will consolidate customers. On the other side of the balance, it should be noted that once the relationship is consolidated, it is generally long-term. Most of our commercial activity is focused on maintaining and strengthening the relationship with current customers, while at the same time carrying out market research and specific actions to approach potential clients.

• ***We talk about innovation as one of the pillars for the development of companies. To what extent has R+D+i been important in Thune Eureka's trajectory, and how far has it taken them?***

It is important to understand that Thune Eureka is a company whose main activity is manufacturing, so we do not deal with research.

As far as process innovation is concerned, we are constantly evolving, either internally or through collaborators. I would highlight that we have recently carried out a work in which by electron beam welding, we have executed a joint between copper and stainless steel, and also an abradable coating on a component for a gas turbine.

In addition, we are opting for consortium participation in a European project of additive manufacturing by welding, and internally we are in the final stages of development of an industrial refrigeration equipment that we intend to market under our own brand.

• ***Digitalization and the implementation of new technologies will be key in the industry, is a company like Thune Eureka ready to tackle this digital transformation?***

Although it may seem strange, the mechanical manufacturing of industrial equipment for single parts or short batches still retains a touch of craftsmanship, even if numerical control machines are involved.

The digital transformation at the information level is a fact and we are trying to adapt to it. We have already migrated data to the cloud, automated tasks that were previously done manually and implemented electronic devices to control processes in the workshop or stock in the warehouse.

As far as machine learning, business intelligence and artificial intelligence are concerned, we are attentive to market developments, but for the moment we have not found any application that could be a boost to our business.

Perhaps the biggest leap in the short term in the sector will come from the popularization of robots in the field of welding and additive manufacturing, combined with traditional processes.

• ***Another challenge we are facing is the renewal of the workforce, why are younger people not attracted to the industry, how can companies attract young talent, do you have this problem/difficulty at Thune Eureka?***

The problem of attracting workers in the sector is well known, and it is not only at a regional level, but also extends to a global level. This is strange, since historically, professionals in the sector have been characterized by their easy employability and metalworking agreements enjoy good conditions. Part of the problem is due to the fact that young people prefer to be trained in professions more related to technologies, and as the sector requires "trade" and the environment is not so pleasant, talent does not approach.

Then, there is also the lack of initial productivity of workers, because it takes time to learn the trade, in Thune we believe that a worker with good skills, who joins the company from a training cycle takes between two and five years to begin to master the profession.

Perhaps from the sector should do more promotional campaigns to encourage new students to opt for metal professions. I encourage groups such as Aclunaga or similar, and the administration, to pick up the idea and do some promotion. We have been doing this for a few years now and we are having very positive experiences with dual training.

I would also like to highlight the increasing presence of women in the sector. Until a few years ago this was something extraordinary. At Thune Eureka, five women now work on the factory floor, which represents about 8% of the workforce, and if we talk about office positions, the number rises to about half of the employees.

• *It is said that productivity rates in Spain are still relatively low compared to the European average, how is this problem related to the training of professionals?*

Productivity is a term that can be confusing depending on how it is measured. It is basically an economic indicator that takes into account the value of the products produced and the inputs consumed in the production of goods.

I do not believe that the productivity of European countries is due to the greater efficiency of their workers, but because they are able to put more value on the goods they produce and this improves the numerator in the indicator.

• *Environmental protection is one of the challenges facing the industry, do you think that measures are being taken, do they affect you negatively, where could they be improved?*

Yes, of course they are being taken. All levels and companies are to a greater or lesser degree aware of environmental protection. We have been ISO14000 certified for years, and in addition to the legislation or the requirements of the regulations themselves, our customers periodically audit our levels of compliance.

Actions to improve and reduce environmental impact are associated with changes in processes and heavy investments that do not have a direct effect on productivity. Of course, this is reflected in the profit and loss account, and this increase in costs makes us lose competitiveness; but it cannot be otherwise, it is something that must be faced and in which we must move forward. We have an obligation to take care of the planet.

I have to say that our customers in general not only value, but also demand that we are environmentally friendly, therefore, in our particular case, what directly affects the cost level negatively, in turn becomes a differentiating element.

As for improvements, at the operational or investment level, they are endless. This year we will install almost 200kW of solar panels for self-consumption, and we have improved waste sorting.

One idea for external improvement could be, for example, for the administration to take over waste management. This would relieve the economic and administrative burden on companies, improve competitiveness and encourage better behavior by companies that are currently less responsible.

• *At the end of the year, what is your assessment of the company in a year of some recovery after the special situation experienced in recent years, and where would you like to see Thune Eureka in the medium and long term?*

Somewhat, part of the answer to these questions has already been explained above.

After 2020 and 2021, which although we have resolved with positive results, have meant a slowdown in the good inertia that we brought from 2019, the current year, in effect, marks a recovery in the growth path.

With a firm and prudent step, we will continue to focus on moderate and sustained growth, anchored in the three areas of work that I mentioned earlier.

Our long-term challenge is to be up to the level, and to be considered at European level a reference in the metal-mechanical manufacturing of industrial equipment.

• *Considering the challenges ahead, are you optimistic about the future?*

Yes, optimistic but cautious. We foresee a scenario of great uncertainty, and as we pointed out earlier, with a strong recession around 2023. The world will continue to turn and it is necessary to supply industrial goods; and wherever there is an opportunity, we will be there.

The key is to find the niches in which we can defend our value proposition, and to work hard to access them and do business.

The company is at its best moment in terms of equipment, and the human team is ready to face the future.

ACKNOWLEDGMENTS:

SEA EUROPE

NAVANTIA

DNV GL

NDAR

FERNÁNDEZ JOVE

SSI

SIEMENS

Va de Barcos.net

SURCONTROL

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