IN 4.0

ADAPTATION OF INDUSTRY 4.0 MODEL TO THE NAVAL SECTOR

WP 4.2 Report on the existence of technologies adapted to the particular needs of SMEs companies in the shipbuilding sector in each of the paradigms of industry 4.0

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Report purpose.

The objective of this report is to improve the productivity of SMEs companies within the naval sector. In a first step to reach this objective, it has been planned to detect the needed technologies and knowledge that can bring a competitive improvement to the small and medium companies of the naval sector. This competitive improvement necessary to survive in a global market must allow us to face these new market rules by supplying innovative processes and products.

This report has focused on small and medium-sized companies, considering the risk that the naval shipyards & factories are disconnected from the advances and technical improvements that new technologies can contribute to the improvement of the overall results of the sector.

By experiences in other sectors, the identification of new and more efficient productive processes thanks to new technologies has meant a turning point and led to an improvement in efficiency and therefore to a very significant improvement in economic results.

The twelve new technologies identified in this report are focused solely on production processes. Other processes such as marketing, business management, after sales, etc., do not fall within the scope of the report.

The information presented here is structured identifying each technology with its repercussion in aspects such as commercial, technical, management and training needs, as well as the estimated return on investment for each of them. This last aspect ROI is based on estimations due to variability of business and size of companies involved..

European situation.

During the last twenty years, the panorama of the shipbuilding of the EU has changed significantly. The market has become global and competition has increased. The increase in environmental restrictions has made the demand for ships more environmentally friendly. Among the main regulations that can influence the construction of new ships and the retrofitting of existing ships, the Ballast Water Treatment Convention (BWTC), the Energy Efficiency Design Index EEDI and the Emission Control Areas (ECAs). This global competition manifests itself especially in countries with lower wages. These Asian countries (China, Korea and Japan) are currently accounted for 86% of all CGTs supplied in 2017, including the construction of standard ships, as well as the manufacture of many components.

Facing this situation, the EU has managed to maintain a leading position in highly specialized vessels and where qualitative excellence is a sales claim. The EU shipbuilding industry is recognized worldwide for its ability to develop and offer innovative solutions. These solutions, where high technology and innovative production processes are mixed, have allowed us to maintain a certain market share both for existing traditional markets and for new market niches, which demand strict compliance with international technical and safety requirements.

Europe builds and supplies new vessels for a wide range of specialized markets, although it is true that the order book shows the progressive specialization of European shipyards in passenger ships, offshore vessels and other non-cargo ships.

The European shipbuilding and ship repairing industry is composed by around 400 shipyards, of which most are "small and medium" shipyards (ships of 60-150 tons), with subcontracting that can reach up to 80% in terms of value.

Approximately 90% of the order book is destined to the export market. The sector employs more than 500,000 people and has an average annual turnover of around 72,000 million euros. With a rate in the international market of approximately 29%, Europe competes for the world leadership of civil vessels with a high added value.

The main causes that have driven the continuous evolution of the Shipbuilding sector are:

- New demands and requirements of maritime transport.
- Greater demand in compliance with environmental regulations, safety and health at work environment.
- Global market with very strong competition between shipyards (both among OEMs and in the auxiliary industry and suppliers).
- Increased customer demand in the quality and performance of the vessel.
- The need to reduce the operating costs of ships.

- The market pressure for a reduced Time to Market.

All these factors mentioned above have led to a real technological revolution in the manufacturing, organization and management systems in shipyards.

There are three factors that have been key to survive and reach the levels of competition of companies and shipyards dedicated to shipbuilding during the last decades, and these are:

- Technological innovation with the consequent evolution of construction techniques and systems in shipyards
- The efficient organization of the productive process, a determining factor given the peculiar characteristics of the construction system of a ship and
- The evolution of management systems.

The development of these factors and their fit in the parameters 4.0 of the industry must be key, so that the SMEs can reach the levels of competitiveness necessary to face the demands of the sector claims.

To segment the search for technologies we have identified some starting technologies that fall within 4.0 technologies and can be integrated or extended with other Key Enabling Technologies (KETs). These facilitating technologies are those technologies that will allow industries to maintain competitiveness and address new markets. In this report among the KETS identified by the EU, the advanced technologies for manufacturing are of special relevance. As 4.0 vertical technologies within the manufacturing scope have been considered:

- BigData /IoT
- Cloud computing.
- Cyber security.
- Mobile Remote access / Monitoring.
- Collaborative design platform.
- Virtual reality.
- Augmented reality.
- Additive manufacturing.
- Collaborative Robotics.
- New materials.
- Total or extended automation.
- Artificial vision.

4.0 Technologies / Process flow.

Design.

- Project Management.
- Design.
- Simulation / Digital mock-up.

Manufacturing Management.

- Enterprise resource planning.
- Factory yard digital twin.

Production

- Manufacturing execution system.
- Traceability solution.
- Product Lifecycle Management.
- Rapid prototyping.

Logistics.

- Logistic management flow.

Maintenance.

- Predictive maintenance.
- Computer assisted maintenance.

Graphic synthesis I.

4.0 Technologies.	Process: 1.- Project Management. 1.1. Project Management software.	2.- Design. 2.1. Design.	2.- Design. 2.2. Simulation / Digital mock-up.	3.- Manufacturing Management. 3.1. Enterprise resource planning.	3.- Manufacturing Management. 3.2. Factory yard digital twin.	4.- Production. 4.1. Manufacturing Execution System.	4.- Production. 4.2. Electronic document Management.	4.- Production. 4.3. Traceability solution.	4.- Production. 4.4. Product Lifecycle Management.	4.- Production. 4.5. Rapid Prototyping.	5.- Logistics 5.1. Logistic flow.	6.- Maintenance. 6.1. Predictive maintenance.	6.- Maintenance. 6.2. Computer assisted maintenance.
BigData/ IoT			■	■	■			■	■		■	■	■
Cloud computing	■	■	■	■	■		■		■	■			
Cyber Security	■	■	■	■	■		■	■	■		■		
Mobile Remote access / Monitoring				■		■	■		■	■	■	■	■
Collaborative environment	■	■	■						■				
Virtual reality		■	■		■								
Augmented Reality		■	■		■		■					■	■
Additive Manufacturing						■				■			
Collaborative robotics.						■				■			
New materials		■				■				■			
Automation total/extended					■	■		■			■	■	■
Artificial vision						■					■		

Graphic synthesis II.

Process		Impact – Quality Low	Quality Medium	Quality High	Service Low	Service Medium	Service High	Product Price Low	Product Price Medium	Product Price High
1.- Project Management.	1.1. Project Management software.	X					X	X		
2.- Design.	2.1. Design.			X		X			X	
	2.2. Simulation / Digital mock-up.		X				X	X		
3.- Manufacturing Management.	3.1. Enterprise resource planning.	X					X		X	
	3.2. Factory yard digital twin.	X				X		X		
4.- Production.	4.1. Manufacturing Execution System.			X			X			X
	4.2. Electronic document Management.		X			X		X		
	4.3. Traceability solution.	X					X	X		
	4.4. Product Lifecycle Management.			X		X		X		
	4.5. Rapid Prototyping.	X					X		X	
5.- Logistics	5.1. Logistic flow.	X					X			X
6.- Maintenance.	6.1. Predictive maintenance.		X		X			X		
	6.2. Computer assisted maintenance.		X		X			X		

1.- Project Management.

1.1.- Project Management Software.

Project management software has the capacity to help Project managers, and project teams collaborate and meet goals, planning, organizing, and managing resources and tools and develop resource estimates. Depending on the sophistication of the software, it can manage estimation and planning, scheduling, cost control and budget management, resource allocation. Today, numerous PC and browser-based project management software and contract management software solutions exist. These solutions are finding applications in almost every type of business. There are different methodologies PMI, Prince2, Agile, Scrum, Kanban, Scrumban, Lean, XP, Waterfall, ... One of the most common project management software tool features is scheduling. Scheduling tools are used to sequence project activities and assign dates and resources to them. Scheduling tools may include support for: Multiple dependency relationship types between activities, resource assignment and leveling, critical path, activity duration estimation and probability-based simulation, Activity cost accounting. Project planning software can be expected to provide information to various cost centers, and can be used to measure and justify the level of effort required to complete the project. Recently the open and collaborative platforms are widely due more and more to the multiple located project team members. With these browser-based project management software, new apps to store information in one place are coming more and more frequent.

4.0 Technologies: Cloud computing; Cyber security; Collaborative platform.

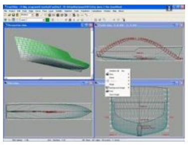
Example of use: Scheduling; Resources assignation; Forecast workload; Prevent shipment delays.

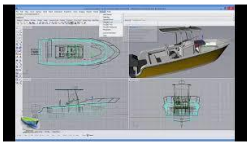
Implementation resources.	**Expected Results.**
RR.HH. needs - Training each department about each methodology of project management. - Training tools for project management system. **Technical.** - Setting-up new work-flows. - Defining a new organizational information management system. **Organizational.** - Changing from conventional paper follow-up to a more integrated process. - Potentially creating the figure of Project Manager.	- *Savings on quotation phase, keeping records from previous performed tasks.* - *Resources reliable assignment.* - *Personnel improved tracked performance.* - *Quality improvement.* - *Costs reduction by more efficient management by around 20%.* - *Improved communication with customer thanks to data available.* - *Less restrictive operative gaining flexibility.* - *Lower operating vessel costs.* - *Reduced Time to Market.*

Financial requirements.

Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition. - Low impact due to cloud-based applications. - In case of specific tool, investment < 10.000€.	Estimated ROI of short term, less than 1 year for simple systems and a maximum of 3 years in case of high performing systems.

2.- Design.





2.1.- Design.

The SMEs are under pressure to make the designs more efficient from energy point of view, reliable and respectful with the environment, all with better performance and lower operating costs. This involves developing future vessels and structures while facing intense competition and price pressure. All these demands are combined with the operational requirements during the life of a ship reducing the size of crew and allowing crew members to serve for longer. These design tools must be able to address all shipbuilding disciplines, including the hull and structures, the equipment (pipes, air conditioning, electricity), accommodation and mechanical aspects. Fast drawing generation serves as a starting point for all subsequent information needs for the product manufacturing and document management. More and more the design must face and include the advances in construction, efficiency, communications, security and lower emissions, these items must fit with the health and well-being of those on board. Nowadays there is a big need of standardization and block to cope with highly technological specifications including shape optimization, light-weighting, miniaturization of electronics, … Could be worth to consider into the design scope the HMI (Human Machine Interface) as well as the energy management systems.

4.0 Technologies: Cloud computing; Cyber security; Collaborative platform; Virtual reality; Augmented reality; New Materials.

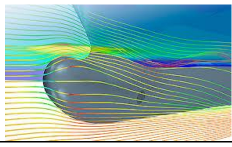
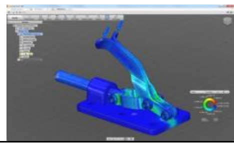
Example of use: Design product documentation can be shared directly in the production line and other automated processes avoiding interferences.

Implementation resources.	**Expected Results.**
RR.HH. needs - Training design department about software tool management. - **Technical.** - Design software based on 3D modelling - Defining a new organizational information management system. **Organizational.** - Integrate new tools on document management system.	- *Improved design consistency applying continuous design improvement philosophy.* - *Savings on design costs (man-hours) after design toll is implemented and daily used around 15%* - *Reduced costs caused by unneeded rework* - *Improved design control due to faster information access and analysis.* - *Faster time to market thanks to modularity design concept is applicable, using same design with minor amendments for different applications.*

Financial requirements.

Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition. - Low impact due to cloud-based applications. - In case of specific tool, investment < 10.000€	Estimated ROI of short term, less than 3 year for simple systems and a maximum of 3 years in case of high performing systems.

2.- Design.

2.2.- Simulation and Digital Mock-up (DMU).

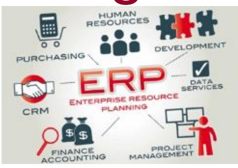
The simulation and digital mock-up (DMU) have emerged as one of the major pillars of what became to be called Virtual product validation. DMU in particular has revealed itself as an excellent means of anticipating a lot more questions during development than ever before, at lower costs, in shorter time and with higher quality output. Within a few years the DMU has become nearly a standard in high-tech manufacturing industries. It has also marked the beginning of the downturn of the former exclusive reliance on Hardware Mock-ups in support of product developments. Computer-aided engineering simulation allows engineers to see the future and predict the consequences of any design change on the actual performance of their products. Developed effectively, it can be used to improve its design through multiple iterations. It provides information to the design process from its early stages, to production and beyond. The simulation tools propose predicting the real behavior by minimizing the costs of the actual tests with the time and cost saving that this means. Especially significant is the analysis of product entire life cycle saving physical prototypes costs & validation impact on project lead time. Software must be: Cost- Efficient; Affordable – accessible for any size of budget; Flexible – easily adaptable to specific needs; Quality – good correlation between digital and real results.; Compatible – standard interface to connect to external equipment; Ease of use – user-friendly.

4.0 Technologies: Big Data / IoT; Cloud computing; Cyber security; Collaborative platform; Virtual reality; Augmented reality.

Example of use: Validate designs earlier and reduce design cycles by 50%. Reducing product development costs by minimizing the number of physical prototypes that need to be built to achieve the expected product performance.

Implementation resources.	**Expected Results.**
RR.HH. needs.	**Results.**
- Training operators & technicians about new simulation system. - Training about new management system associated to new tools.	- *Minimizing risks at design phase.* - *Reducing development and validation costs.* - *Improving Time to Market.* - *Improving quality due to reduced re-design processes.* - *Minimize environmental impact.* - *Reduced cost by improved documental managing.* - *Accomplishing new legal regulations.* - *Improvement costs of vessel exploitation.* - *Increased overall vessel performance.*
Technical.	
- Changing the new validation system from physical model tests to simulating model test validation	
Organizational.	
- Transforming current physical paperwork to e-documentation. - Defining an organizational system to manage information flow.	
Financial requirements.	
Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition. - Design equipment acquisition 14k€. - Software 10K€-40K€.	Estimated ROI medium-long term 5 years, because it is necessary to endow the system with results obtained against tested physical models.

3.- Manufacturing Management.



3.1.- Enterprise Resource Planning (ERP).

Enterprise resource planning (ERP) is the integrated management of business resources, in real-time by a dedicated software to achieve proper data analysis and decision making. ERPs usually referred to as a category of business management tools typically a suite of integrated modular application software that the organization uses to collect, store, manage, and interpret data from daily activities and normally in a JIT way. The software is normally composed by different modules (production, purchasing, inventory, sales, finance, accounting, human resources), all to improve information access to gain efficiency and improve competitiveness providing users easy visibility of all operations. ERP systems track business resources—cash, raw materials, production capacity and the status of business commitments: customer orders, external purchase orders, and payroll. The applications that make up the system share data across various departments (manufacturing, purchasing, sales, accounting etc.) that provide each individual data. ERP facilitates information flow between all business functions and manages connections to outside stakeholder. ERP systems run on a variety of hardware and computer network configurations, typically using a Database as an information repository source. Depending of company size and activities it must be decided to implement an ERP on-premise or cloud-based.

4.0 Technologies: Big Data / IoT; Cloud computing; Cyber security; Mobile remote access / Monitoring.

Example of use: Knowing the cash flow status early in advance matching payments & receivables linking all companies' resources.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Training operators & technicians about new system. - Training about new management system associated to new tools.	- *Security about Regulatory compliance.* - *Integrating and consolidating information for an easy and solid decision making* - *Precise forecasting.* - *Scaling up your organization in an efficient way.* - *Improved customer service.* - *Lowering management costs by operator time efficiency* - *Lean management.* - *Improving accounting financial management.* - *Lowering overall costs of exploitation.*
Technical.	
- Generating coding system - Redefinition of work instructions. - Standardization of reporting processes.	
Organizational.	
- Team dedicated to system debugging and personalization.	

Financial requirements.	
Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition. - Software 150K€.	Estimated ROI medium term 3 years, because it is necessary to endow the system with starting data.

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3.- Manufacturing Management.

3.2.- Factory yard digital twin.

Factory yard digital twin is a digital replica of the yard physical entity. By bridging the physical and the virtual world, data is transmitted seamlessly allowing the virtual entity to exist simultaneously with the physical entity. Digital twin refers to a digital replica of physical assets (physical twin), processes, people, places, systems and devices that can be used for the digital representation of both the elements and the dynamics of how an Internet of things device operates and lives throughout its life cycle. The concept of the digital twin can be compared to other concepts such as cross-reality environments or co-spaces and mirror models, which aim to, by and large, synchronize part of the physical world with the cyber world. Digital twins integrate internet of things, artificial intelligence, machine learning and software analytics with spatial network graphs to create living digital simulation models that update and change as their physical counterparts change. A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position. This learning system, learns from itself, using sensor data that conveys various aspects of its operating condition; from human experts, such as engineers with deep and relevant industry domain knowledge; from other similar machines; from other similar fleets of machines; and from the larger systems and environment in which it may be a part of. A digital twin also integrates historical data from past machine usage, occupied yard to factor into its digital model.

4.0 Technologies: Big Data / IoT; Cloud computing; Cyber security; Virtual reality; Augmented reality; Automation total / extended.

Example of use: Factory yard digital twin twins using to optimize and plan the operation logistics and big parts movements at the real factory yard.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Training operators & technicians about new system. - Training about new management system associated to new tools. **Technical.** - Generating information. Manuals, production sheets, assembly instructions and 3d files. - Standardized processes. **Organizational.** - Assigning and manage new workflow. - Transforming current physical paperwork to e-documentation.	- *Self-guided operators.* - *More flexible work-force.* - *Improved productivity and operational efficiencies.* - *Predict and detect defects sooner on product and equipment.* - *Reduced production costs for long-time-lead product and improved overall equipment Effectiveness (OEE) through minimized downtime.* - *Increased overall performance.* - *Lower after sales costs.* - *Lean Management.* - *Improved time to market.*
Financial requirements.	
Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition. - Software 150K€.	Estimated ROI medium-long term 3 to 5 years, because it is necessary to endow the system with starting data.

4.- Production.

4.1.- Manufacturing Execution system.

The planning tools have a direct impact on the operating result of the SMEs companies. The overlapping of planning system with design system is basic to be able to properly plan the tasks within production processes. Manufacturing execution systems (MES) are computerized systems used in manufacturing, to track and document the transformation of raw materials to finished goods. Manufacturing Execution System provides information that helps manufacturing decision makers understand how current conditions on the plant floor can be optimized to improve production output. MES works in real time to enable the control of multiple elements of the production process (e.g. inputs, personnel, machines and support services). MES may operate across multiple function areas, for example: management of product definitions across the product life-cycle, resource scheduling, order execution and dispatch, production analysis and downtime management for overall equipment effectiveness (OEE), product quality, or materials track and trace. MES record, capturing the data, processes and outcomes of the manufacturing process. The idea of MES might be seen as an intermediate step between, an enterprise resource planning (ERP) system, and a supervisory control and data acquisition or process control system on the other. MES normally should manage / collect and integrate the following data: Management of resources; Scheduling (production processes); Dispatching production orders; Execution of production orders; Collection of production data; Production performance analysis; Production track and traceability; Data integration; Check individual and overall performance.

4.0 Technologies: Mobile remote access / Monitoring; Additive manufacturing; Collaborative robotics; New materials; Automation total / extended; Artificial vision.

Example of use: Getting immediate plant output by defined driven parameters replacing spreadsheets.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Define implementation project team, project leader and key-users. - Training whole organization about new system.	- *Reduce obsolete documentation.* - *Reduce inventory.* - *Reduced manufacturing costs.* - *Decrease downtime.* - *Improved ability to evaluate each job and its tasks.* - *Improved management by costs capture more efficiently.* - *Improved competitiveness.* - *Improved Time to Market.*
Technical.	
- Create a functional MES vision to successfully and efficiently leverage the technology within the manufacturing operation. - Integrating design system with planning system.	
Organizational.	
- Tackle the biggest problem first. - Setting-up assigning systems for work flow. - Defining tasks and control systems. - Exposing to the company new organization advantages.	
Financial requirements.	
Investment description	ROI.
- Hardware for a SME of 50 people estimated 15 hardware equipment. - Software 8 licenses.	Estimated ROI medium term no longer than 3 years for simple systems.

4.- Production.

4.2.- Electronic Document Management / Document Management System.

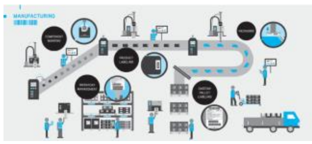
A document management system (DMS) is a system (based on computer programs in the case of the management of digital documents) used to track, manage and store documents and reduce paper. Most are capable of keeping a record of the various versions created and modified by different users (history tracking). In the first place, it must be said that it makes it possible for these organizations to carry out their tasks in a simpler, faster and more economical way since their employees can access, instantly, all the files they need to carry out their activity. It also solves the problem of physical storage space and location. Document management systems commonly provide storage, versioning, metadata, security, as well as indexing and retrieval capabilities. Here is a description of these components: A document management system (DMS) is a system (based on computer programs in the case of the management of digital documents) used to track, manage and store documents reducing paper consuming. Most are capable of keeping a record of the various versions created and modified by different users (history tracking). Integrated document management comprises the technologies, tools, and methods used to capture, manage, store, preserve, deliver and dispose of 'documents' across an enterprise. The electronic document management comprises different steps but most relevant the storage, retrieval, security and versioning (this one specially regarding drawings and manufacturing instructions). As most of the applications some cloud-based applications are being more and more frequent.

4.0 Technologies: Cloud computing; Cyber security; Mobile remote access / Monitoring; Augmented reality.

Example of use: Easier retrieval and safer document conservation even for old projects. Protected customer data.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Instructing operators and different teams about specific procedures and process. **Technical.** - Defining new paperwork management. - Paradigm design change considering physical drawing against e-drawing. **Organizational.** - Evaluate workflow involved in the information development and publication process. - Plan properly the implementation process. - Assign rights and permissions (network administration).	- *Reduced storage space.* - *Enhanced security and information privacy.* - *Improved regulatory compliance.* - *Easier retrieval.* - *Costs savings by better backup and disaster recovery.* - *Cost savings (copies / paper)* - *Lower environmental impact.*
Financial requirements.	
Investment description	ROI.
- Hardware acquisition. - Software licenses acquisition.	Short term ROI, estimated 1 to 3 years for an averaged investment of 20K€. Considering published the costs related to the average time spent managing paper documents and they range from \$20 in labor to file a document, to \$220 in labor to reproduce a lost document and professionals spend 5 to 15% of their time reading information, and up to 50% of their time looking for it.

4.- Production.



4.3.- Traceability solutions.

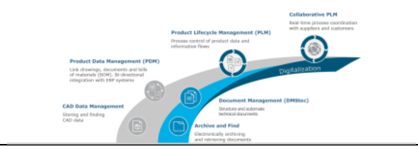
Globally speaking, traceability makes it possible to track each step in the process that add a value to the product. Traceability can be applied to a service, to a product a part or batch. Traceability is the ability to trace all process from its starting point to the consumption and disposal point to know when and where the product was produced by whom. Talking about product point traceability assigns a unique code to each part / or batch produced. Product traceability is an important link in allowing to more quickly and accurately identifying the placement/ assembly of wrong parts source and destination, removing them from the marketplace or warehouse, and communicating to the supply chain. Reducing cost impacts for recalls. Because traceability systems can provide information on the source, location, movement and storage conditions of the product, they also allow whole supply chain to identify factors affecting quality and delivery and at disposal time identifying precise recycling process. Currently used technologies for traceability are quite wide. They can range from a barcode label printing / scanning on the cartoon box to a RFID on each part. The traceability solutions must be integrated with ERP and MES and frequently must be shared with customers. The traceability is more than just a quality documentation system. It was designed specifically for manufacturers to increase process repeatability, reduce variation, increase production throughput and reduce defects. It is must consider the external inputs (customers and suppliers for traceability).

4.0 Technologies: Big Data / IoT; Cyber security., Automation total / Extended.

Example of use: Recall identified units with a needed rework instead of recalling the whole batch of parts.

Implementation resources.	Expected Results.
RR.HH. needs	**Results.**
- Instruction about HMI process. - Networking and communications flow definition.	- *Minimize recall size.* - *Improved efficiency by lowering Non-Quality costs.* - *Improved data consistency and accuracy.* - *Tailor-made traceability in case of legal compliance mandates.* - *Minimized downtime.* - *Reduced scrap and unused rest of materials.* - *Improved purchasing process due to lowered stocks.* - *Improved Time to Market.*
Technical.	
- Minor impact on technical side except production flow review. - Define data analytics. - Integration of sensors and actuators (Physical systems.	
Organizational.	
- Defining process and new organization. - Data and data services - Setting up optimized work flow and materials.	
Financial requirements.	
Investment description.	ROI.
- Minor hardware equipment acquisition. - Integration traceability data into MES and ERP.	Estimated long term ROI, over 3 years for investment around 50.000 €

4. Production.



4.4.- Product Lifecycle Management.

In industry, product lifecycle management (PLM) is the process of managing the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal of manufactured products. PLM integrates people, data, processes and business systems and provides a product information backbone for company. Within PLM there are five primary areas:

<u>System Engineering</u> is focused on meeting all requirements, primarily meeting customer needs, and coordinating the systems design process by involving all relevant disciplines. An important aspect for life cycle management is a subset within Systems Engineering called Reliability Engineering;

<u>Product management and Portfolio</u> is focused on managing resource allocation, tracking progress, plan for new product development projects that are in process. Portfolio management is a tool that assists management in tracking progress on new products and making trade-off decisions when allocating scarce resources.

<u>Product design</u> is the process of creating a new product to be sold by a business to its customers.

<u>Manufacturing process management</u> is a collection of technologies and methods used to define how products are to be manufactured.

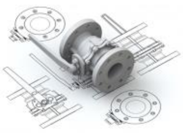
<u>Product data management</u> is focused on capturing and maintaining information on products and/or services through their development and useful life. Change management is an important part of PDM/PLM.

4.0 Technologies: Big Data / IoT; Cloud computing; Cyber security; Mobile remote access / Monitoring; Collaborative environment.

Example of use: Savings through the re-use of original data to achieve a framework for product optimization. REACH standardization form project kick-off.

<u>Implementation resources.</u>	**<u>Expected Results.</u>**
RR.HH. needs	**Results.**
- Minor training in digital workflow management. - Internal leader for implementation	- *Improve communication / collaboration among all team members.* - *Drive innovation gaining team flexibility and agility.* - *Formalize and set up transversally compliance requirements.* - *Reduce administrative and clerical overhead.* - *Accelerate revenue growth.* - *Improved costs by doing right the first time.* - *Improved product quality.* - *Operational scalability.* - *Reduced del Time to Market.* - *Improved competitiveness.*
Technical.	
- Plan for product development. - Integrate learned-lessons into design reliability parameters.	
Organizational.	
- Plan for design activities coordination - Tracking implementation process. - Product portfolio strategy. - Implementation of historical product track.	
Financial requirements.	
Investment description	ROI.
- Hardware equipment acquisition. - Integration traceability data into MES and ERP.	Estimated long term ROI, over 3 years for investment around 100.000 €

4.- Production.




4.5.- Rapid prototyping.

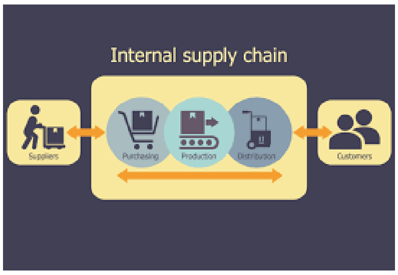
Using rapid prototyping to manufacture parts to test for component fit and function can help get your product to market faster than your competition. The first methods for rapid prototyping are used for a wide range of applications and are used to manufacture production-quality parts in relatively small numbers if desired, without the typical unfavorable short-run economics. Some other purposes are assembly/ fit testing, functional testing, life testing, regulatory testing. The rapid prototyping application ensures the product is manufacturable. New techniques present the ability to reproduce designs from a dataset. It is now possible to interpolate volumetric data from one-dimensional images. As with CAD-CAM workflow in the traditional Rapid Prototyping process starts with the creation of geometric data, either as a 3D solid using a CAD workstation, or 2D slices using a scanning device. For Rapid prototyping this data must represent a valid geometric model. In other words, the object must have an "inside". The model is valid if for each point in 3D space the computer can determine uniquely whether that point lies inside, on, or outside the boundary surface of the model. More frequently is being used the additive manufacturing with its different technologies mimicking in reverse the layer-to-layer physical building process.

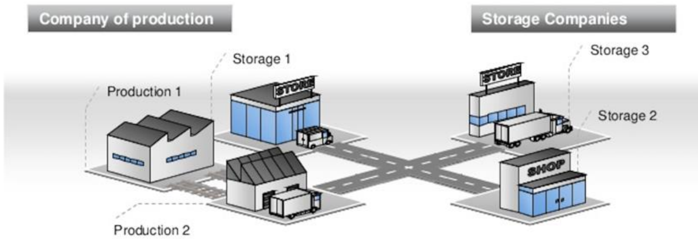
4.0 Technologies: Cloud computing; Mobile Remote access / Monitoring; Additive manufacturing; Collaborative robotics; New materials.

Example of use: Knowing the cash flow status early in advance matching payments & receivables.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Training design & manufacturing teams for 3D files preparation. - Training in specific machines utilization.	- *Early proof of concept* - *Saved time on validation steps.* - *Minimizing design flaws.* - *Improved customer feedback.* - *Reduced manufacturing costs for advanced trials.* - *Improved global planning.* - *Faster improvement identification due to realistic look and feel.* - *Reduced Time to Market.*
Technical.	
- Training in parametric modeling and CNC programing. - Automated manufacturing control.	
Organizational.	
- Make or Buy Analysis. - Search for potential partners. - Planning machinery workload. - Planning serial workflow.	
Financial requirements.	
Investment description	ROI.
This investment is very variable depending on the technology choose for prototype manufacturing. It can be from plastic to metal, for sintering powder to EBM the investment can vary form 200€ to over 500K€.	Estimated a ROI between immediate to 5 years, variable according to the work load and depending on the number of recurring pieces to be manufactured.

5. Logistics.





5.1.- Logistic flow management.

In a general business sense, logistics management is the management of the flow of things between the point of origin and the point of consumption in order to meet requirements of customers or corporations. The resources managed in logistics can include physical items as well as intangible items, paperwork and legal procedures. The logistics of physical items usually involves inbound and outbound transportation management, fleet management, inventory, materials handling, order fulfillment, logistics network design, supply/demand planning, and management of third-party logistics services providers. To varying degrees, the logistics management is also related with customer service, sourcing and procurement, production planning and scheduling, packaging and assembly. Logistics management is part of all levels of planning and execution strategic, operational and tactical. The complexity of logistics can be modeled, analyzed, visualized, and optimized by dedicated simulation software. The minimization of the use of resources is a common motivation in all logistics fields. The logistic flow management must be easily integrated into the ERP system. Part of the logistic flow must include storage optimization based on the dispatching function. Thanks to real time monitoring of storage status, the quality of operations improves and the company can react faster to market changing needs.

4.0 Technologies: Big Data / IoT; Cyber security; Mobile remote access / Monitoring; Automation total / extended; Artificial Vision.

Example of use: Planning the required space for a certain batch in advance, using a Warehouse Control System.

Implementation resources.	Expected Results.
RR.HH. needs	**Results.**
- Educate and Train operators in implemented system.	- *Improved space consumption by precise parts allocation.* - *Reduced lost time for missing parcels.* - *Optimized material workflow.* - *Improved fleet management.* - *Optimized inventory costs.* - *Savings from improved scheduling.* - *Increased customer service.* - *Possibility of data integration into ERP and MES.*
Technical.	
- Minimum impact from technical form of view. - Review logistics design. - Analyze variability in logistics processes	
Organizational.	
- Distribute and defining lay-out. - Analyze network and implement logistics organization. - Ensure data can be integrated and automated.	
Financial requirements.	
Investment description	ROI.
- Hardware equipment acquisition. - Integration traceability data into MES and ERP.	Estimated long term ROI, over 3 years for investment around 50.000 €

6. Maintenance.

6.1.- Predictive maintenance.

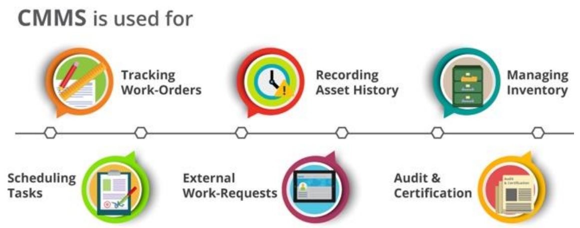
The aim of predictive maintenance (PdM) is first to predict when equipment failure might occur, and secondly, to prevent the occurrence of the failure by performing maintenance. Monitoring for future failure allows maintenance to be planned before the failure occurs. Ideally, predictive maintenance allows the maintenance frequency to be as low as possible to prevent unplanned reactive maintenance, without incurring costs associated with doing too much preventive maintenance. Compared with preventive maintenance, predictive maintenance: ensures that a piece of equipment requiring maintenance is only shut down right before imminent failure. This reduces the total time and cost spent maintaining equipment. Predictive maintenance seeks to define the best time to do work on an asset so maintenance frequency is as low as possible and reliability is as high as possible without unnecessary costs. Utilizing the IoT is key for implementing a successful predictive maintenance program, as is the use of predictive maintenance sensors and techniques, such as vibration analysis, oil analysis, thermal imaging, and equipment observation. Although there are some disadvantages to predictive maintenance, it allows maintenance to be performed only when required, helping facilities cut costs, save time and maximize resource. Model based condition monitoring for predictive maintenance programs involves a comparison of real parameters with known parameters.

4.0 Technologies: Big Data / IoT; Mobile remote access / Monitoring; Augmented reality; Automation total / extended.

Example of use: Avoiding unexpected failures optimizing maintenance activities, reducing installation downtime.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Re-engineer your maintenance culture. Train engineers with new set of skills.	- *Reduces equipment costs.* - *Reduces labor costs.* - *Reduces lost production time.* - *Increases safety* - *Increases efficiency of employee time.* - *Studies have shown that implementing predictive maintenance practices - both automated and manual - could represent cost avoidance and savings up to 15%.*
Technical.	
- Set-up insights and alerts to optimize engineering resources. - Define starting standard algorithms.	
Organizational.	
- Define data to gather, analyze and act upon. - Use case prioritization. - Set evaluation criteria	
Financial requirements.	
Investment description	ROI.
Two approaches to pricing predictive maintenance services and products. **Value based pricing:** Ensures maximum value for vendor while aligning incentives of vendor and customer. It is difficult to estimate or measure value. **Fixed + variable pricing:** Most commonly used model as it reflects vendors' cost structure	Estimated a ROI of medium term, approximately 3 years, due to productivity increase.

6. Maintenance.



6.2.- Computer assisted maintenance.

The Computer-assisted maintenance refers to systems that utilize software to organize planning, scheduling and support of maintenance and repair controlling assets and property. A common application of such systems is the maintenance of complex systems that require periodic maintenance, such as reminding operators that preventive maintenance is due or even predicting when such maintenance should be performed based on recorded past experience. This information is intended to help maintenance workers do their jobs more effectively and to help management make informed decisions. The data must consistently allow properly control the maintenance of a facility, information is required to analyze what is occurring. A computer assisted maintenance also allows for record keeping, to track completed and assigned tasks in a timely and cost-effective manner. Manually this requires a tremendous amount of effort and time. In recognition of this, companies have started using computer assisted maintenance extensively to better control and organize maintenance management. Computer assisted maintenance packages can produce status reports and documents giving details or summaries of maintenance activities. The more sophisticated the package, the more extensive analysis facilities have available. Computer assisted maintenance packages can be either web-based, on an outside server, or LAN based.

4.0 Technologies: Big Data / IoT; Mobile remote access / Monitoring; Augmented reality; Automation total / extended.

Example of use: calculating the cost of machine breakdown repair versus preventive maintenance for each machine, possibly leading to better allocation of resources.

Implementation resources.	**Expected Results.**
RR.HH. needs	**Results.**
- Training in auto-positioning systems	- *More flexible maintenance strategy.* - *Tracking the right maintenance metrics.* - *Get control over inventory.* - *Manage work requests.* - *Access historical information* - *Improved competitiveness.* - *Lean management systems.*
Technical.	
- Calibrating systems for process control.	
Organizational.	
Description.	
- Defining new requests and tolerances applied for previous operations.	
Financial	
Investment description	ROI.
Automated aligning manufacturing line for pipe welding system. Position control installation of welding by artificial vision. Estimated an investment of 100k€ for the two lines.	Estimated an ROI of long-term, 5 to 8 years depending on the installed systems.

Conclusions.

After analyzing a typical production flow, we believe it is appropriate to make a first selection of the 4.0 technologies relating their impact on the different elements of improvement within the shipyards and a second selection based on their multiplier effect. The considered points of impact have been:

- Enabling 4.0 technologies that impact the production process technical evolution and construction systems related to the product.
- Enabling 4.0 technologies that lead to a more efficient organization of the production process and company management systems.

At each point of impact, the classification has been made considering the return of investment for short term to long term, being short term the first choice

Regarding the 4.0 technologies of technical evolution it is worth highlighting:

- Cloud computing,
- Collaborative environment,
- Collaborative robotics
- Additive manufacturing,
- New materials,
- Artificial vision,
- Augmented reality.

Regarding the organizational and management efficiency improvement of the production process we have considered for a first level 4.0 technologies:

- Big data / IoT,
- Cyber security,
- Mobile remote access / Monitoring,
- Virtual reality,
- Automated total / extended.

Into a second level impact technologies it is worth to highlight:

- Internal logistics
- Augmented reality.

As can be seen from the previous considerations, the 4.0 enabling technologies are cross-cutting technologies that affect or can affect globally any SME shipyard.

The decision on the implementation of any of them in any SME requires an analysis of the present situation and the expected objectives, as well as the risks that may be caused in the current process and its impact, both internally and from the customer point of view. In this implementation it is essential to try taking advantage of the synergies and lessons learned during previous implementations, applying them methodically to the entire organization and if possible to the entire supply chain.

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