Interreg Atlantic Area
European Regional Development Fund

EUROPEAN UNION

IN 4.0

IN 4.0

ADAPTATION OF INDUSTRY 4.0 MODEL TO THE NAVAL SECTOR

Joint diagnosis of the current situation of the implementation of industry 4.0 in the naval sector in the Atlantic area.

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1. Background

This diagnosis is carried out within the framework of the European IN4.0 project, Adaptation of Industry 4.0 Model to the Naval Sector (EAPA-383/2016), co-financed by the ERDF (75%) under the call for proposals of the Interreg Atlantic Area Territorial Cooperation Programme 2014-2020.

Project objective

IN4.0 aims to improve the competitiveness of companies in the naval sector through their adaptation into an industry 4.0 model, guaranteeing the continuity of the sector in an increasingly demanding market, where innovation is a key factor in strategic positioning.

To achieve this, the main barriers that prevent the sector from adapting its business model will be identified and the degree of maturity of existing technologies, which can be implemented in SMEs, will be determined. Based on this initial study work, the project also aims to:
- Study and work on a redefinition of work organization systems in the naval sector;
- Provide training to sector personnel to support their transition towards 4.0;
- Design innovative strategies to save costs in the implementation of technologies, as well as to detect new marketing methods.

The IN 4.0 project finally seeks to implement the selected technologies to a panel of SMEs from the participating regions.

Project structure

The project will be implemented through 4 technical work packages:
IN CONTEXT: In this first work dedicated to the state of the art analysis, the existing naval sector conditions will be assess, as well as the current technology at the forefront of Industry 4.0. This WP is the starting point towards the adaptation to a new productive model, by developing a joint diagnosis of the current situation of the implementation of the industry 4.0 in the naval sector in the Atlantic Area. The project partners will work toward the production of:

- the validation of the existing state of art and needs in the naval industry;
- the identification of existing technologies in the market, tailored to the particular needs of the naval industry
- analysis of the degree of maturation of other existing technologies that can be applied to the naval industry transnational

- IN WORK AND IN TRAINING: This task will allow the redefinition of workers' functions and tasks adapted to 4.0 technological productions processes. The transformation of the naval companies towards the industry 4.0 model implies significant organizational changes. Both managers and naval labour force will be involved in highly technological processes, so a redefinition of positions, functions and skills will be necessary. Such change will raise a need for awareness and training to develop new tasks. The main actions imply new skills towards the achievement of:
    - improvement in processes through the implantation of collaborative robot systems
    - Improvement in communication systems
    - Improvement in simulation systems
    - Improvement in traceability processes
    - Improvement in customization processes

- IN COMMERCIALIZATION AND COSTS: This task focuses on the detection and development of new commercialization methods that can be transferred to the naval sector, as well as on the detection of innovative strategies to save costs in the implementation of technologies. Methodology in this WP will consist in benchmarking, measuring and analysing firm linkages across different sectors (automotive, aeronautics, logistics, etc.), identifying the vendors and partners they have utilized in the integration of new technologies, along with levels of internationalization and connection with the local ecosystem. This information is expected to lead to collaborative new ventures which can happen through additional automation and data exchange in manufacturing technologies. Geographical mapping capability tools and the development of the international IN 4.0 Connect Platform for naval sector companies to have the opportunity to connect with digital and ICT firms, will be the main expected results.

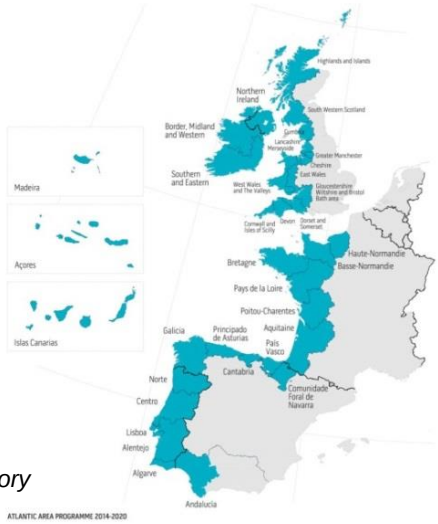
- IN ADAPTATION: The anticipated benefits obtained by companies after their adaptation to the industry 4.0 model will be determined and quantified. Expected results rely on the assessment of the Technology Readiness level (TRL) and naval SME Growth measurement. Measuring naval SMEs potential growth after the implementation of the innovation process implies a series of consecutive actions:
    - Analysis of success cases in the shipbuilding and ship repair industry across the participating countries
    - Counselling for the transformation of naval companies into intelligent companies
    - Development of a SME Growth measurement tool bases on the analysis of previously identified success case in the naval sector

- A pilot technological mentoring program carried out by experts who will guide SMEs through the process of transformation into innovative firms.

2. Purpose of the document

As explained above, the IN 4.0 project aims to promote the **modernisation of the naval sector** through the implementation of actions that help SMEs in their 4.0 transformation. With this document, we wish to review the current situation, as of 2018, of the implementation of the "factory of the future" technologies in the Atlantic area's naval sector, and identify the barriers that prevent the SMEs from integrating those innovative solutions.

The INTERREG Atlantic Area geographical coverage covers the western part of Europe, bordering the Atlantic Ocean and includes 37 regions in 5 countries: the western part of the United Kingdom, the north and the south western part of Spain, western France, Ireland and Portugal. The partner organizations which participate in the project are from the five countries mentioned above.



INTERREG ATLANTIC AREA territory

Partners' Name	Country	Region
Asociacion Cluster del Naval Gallego (ACLUNAGA)	Spain	Galicia
Asociacion de Industriales Metalurgicos de Galicia (ASIME)	Spain	Galicia
High Speed Sustainable Manufacturing Institute Ltd. HSSMI	UK	London
University of Strathclyde (NAOME)	UK	South Western Scotland
Cork Institute of Technology (CIT)	Ireland	Southwest region
Diputacion Provincia de Pontevedra	Spain	Galicia
Foro Maritimo Vasco	Spain	Basque country
Fórum Oceano – Association da Economia do mar	Portugal	Norte
Pôle EMC2 (EMC2)	France	Pays de la Loire
Bretagne Pôle Naval (BPN)	France	Brittany

This diagnosis is part of the work package IN CONTEXT - Task 4.1, in which we aim to validate the current situation of the companies of the naval sector throughout the Atlantic Area region, based on existing studies and report. With this joint analysis, we wish to give a European Atlantic Area view of the naval sector global situation, and the drivers and barriers to the transformation into 4.0 models.

WP 4 Task 1 Objective: "To validate in all the regions the previous studies about the current situation of the companies of the naval sector in the countries and regions of AA, analysing aspects such as the degree of innovation or factors that causes a loss of competitiveness in the sector".

This deliverable constitutes the first task of the overall State of the Art work package of the project. Action 4.2 and 4.3 will be based on this report. Action 4.2 will focus on the identification of existing technologies which might be tailored to the particular needs of the naval sector, in each of the industry 4.0 aspect: "increased flexibility in manufacturing, mass customisation, increased speed, better quality and improved productivity"[1]. Technologies that present the likelihood of a pay-off on the investment will be particularly considered. Furthermore, we will narrow down our analysis to 5 existing technologies or technological processes on the market that are being implemented in other sector but that could be adapted to the naval sector in order to increase its competitiveness, thanks to a field survey that will be distributed to 50 companies, including at least 33 SMEs amongst the target.

Methodology for this joint diagnosis

EMC2 provided a template (see Annexe 1) to the project partners in order to gather information on the current situation of the naval sector in each respective countries of the Atlantic area as well as on the state of the art of the implementation of 4.0 technologies among naval companies. This template was developed with the help of the naval expert at EMC2, and aimed at gathering representative data from the naval sector, in a harmonised way allowing consolidation and comparison. Each partner filled in the document with information regarding its country's naval sector and provided the literature review from which they have based their analysis.

To complete the global review, EMC2 has elaborated and sent out an on-line survey that project partners distributed to companies belonging to the naval industry value chain in their respective country, in order to collect data directly from companies, and especially SMEs.

[1] European Parliamentary research service, Briefing "Industry 4.0 Digitalisation for productivity and growth", Ron Davies, 2015.

69 companies from the naval sector responded to the survey, among which 48 SMEs, giving the partner a good overview of the SMEs situation.

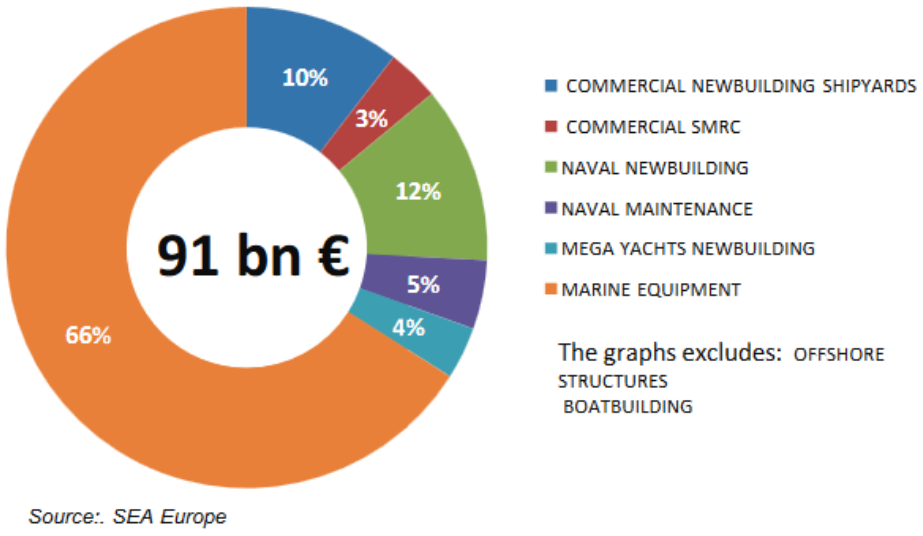
3. Overview of the naval sector in Europe

As stipulated by the European Commission, naval industries, and more broadly maritime activities is at the heart of European policies, as it is of major strategy for the continent: "The European coastline is approximately 136,000 km long and the oceans and seas are an integral part of the continent's traditional maritime orientation: it is a source of new opportunities for the future. Mankind's use of the sea is broad and includes maritime transport, the enabler of global trade; offshore oil & gas, the back-bone of energy supply in an economy which is still largely based on hydro-carbons; aquaculture activities, an essential source of protein for a growing world population; maritime tourism; marine renewable energy; coastal protection and land reclamation; off-shore mining; floating structures and factories; and various aspects of maritime and marine research.

Europe can be proud of its outstanding ability to design, manufacture and build the full range of high-tech vessels and maritime structures which meet the most stringent safety and technical requirements, allowing the continent to engage in global trade, exploit resources and when the necessity has arisen, defend its strategic interests. However, with the shift of focus from the West to the East, Europe's maritime capabilities are being challenged on a daily basis." [2]

In 2017, the European Naval sector represented 91bn€ of turnover and more than 500 000 jobs[3].

[2] LeaderSHIP2020 report
[3] SeaEurope, Anual report, 2017.



Graph 1 - Annual turnover of the European Maritime Technology Industry in 2017, SEA Europe, 2018. The European maritime technology industry encompasses all the enterprises involved in the design, construction, maintenance and repair of all types of ships and other relevant maritime structures, including the complete supply chain of systems, equipment, services and supported by research and educational institutions.

In 2013, the European Union has published the LeaderSHIP 2020 report, aiming to support the European naval sector that has been strongly impacted by the economic crisis of 2008 and Asian growing competition. The report highlights 8 "characteristics of a strong, sustainable and competitive European maritime industry in 2020"[4] of which:

- Innovative;
- Green;
- Specialised in high tech markets;
- Energy efficient;
- Capable of diversifying into new markets, etc.

According to the European Commission, "the European shipbuilding industry is a dynamic and competitive sector. It is important from both an economic and social perspective:

- There are approximately 150 large shipyards in Europe. Around 40 of them are active in the global market for large seagoing commercial vessels;

[4] LeaderSHIP 2020: the sea, New opportunities for the future, February 2013, European Commission

- Some 120,000 people are employed by shipyards (civil and naval, new building, and repair yards) in the EU;
- With a market share of around 6% in terms of tonnage and 35% for marine equipment, Europe is a major player in the global shipbuilding industry;"[5]

Sea Europe, the Shipyard and Maritime Equipment Association goes even further, stating that "The European shipbuilding and Ship Maintenance, Repair and Conversion (SMRC) industry is currently composed of approximately 300 shipyards specialised in building and repairing the most complex and technologically advanced civil and naval ships and other hardware for maritime applications. These shipyards produce an approximate turnover of EUR 31 billion yearly and employ more than 200,000 direct jobs in Europe, where up to 75% of those ships built go to export markets."[6]

For the purpose of this joint diagnosis, we have segmented the naval industry value chain into 6 main sub-sectors of activities:

- Engineering and conception
- Parts and components production
- Sub-assembly and pre-assembly
- Assembly
- Exploitation
- Maintenance

The main actors from the project partner's network are positioned along this value chain.

[5] European Commission, DG Growth, Shipbuilding Sector, retrieved from: https://ec.europa.eu/growth/sectors/maritime/shipbuilding_en
[6] Sea Europe, 2017 annual report, 2018

6 steps in the shipbuilding and repair industry						
	Engineering & conception	**Parts and components production**	**Sub-assembly and pre-assembly**	**Assembly**	**Exploitation**	**Maintenance**
Activities	Feasabilty study	Production of detail parts, structures and engines	Subset production (engines, electrics, armaments)	Panels assembly	Vessels operations	Retro-fit / retro-engineering
	Design and engineering system	Production of component system	Metalsheet cutting and forming	Systems installation		Maintain in optimal operational condition.
	Detailed product conception		Sheet metal pre-assembly	Armament		Dismantling
				Performances' adjustment and verification		
Actors	Manufacturers	Sub-contractors	Constructeurs	Constructeurs	Navy	Shipbuilders
	Engineering firms	Components manufacturers	Equipment suppliers	Sub-contractors for assembly or complete functions	Shipowners	Specialised shipyards
	Consultancy/expert firm		Engine manufacturers		Shipping companies	
Some examples						

Table 1 Shipbuilding and repair industry, EMC2, 2018.

The European shipbuilding industry is very wide in company size and structure, from SMEs with sometimes less than 10 employees to large enterprises and shipyards counting thousands of employees. The production also varies a lot, from shipyards dedicated to building new ships, repair and maintenance, specific innovative ships, process innovation etc. Shipyards are also very different depending on their clients: commercial companies (e.g. cruise passengers), individual consumers or national governments (such as military or specialised vessels).

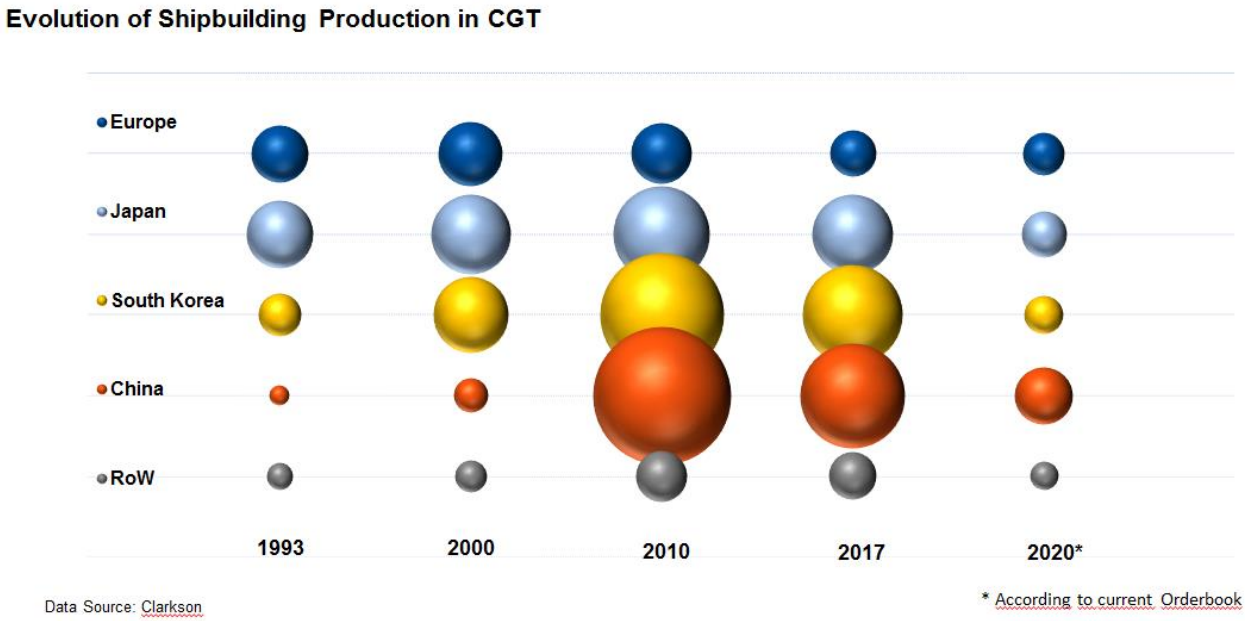
The European naval equipment value chain is diverse as well, and formed of small and large enterprises with activities such as delivery of materials, systems & equipment, service providers (engineering and consulting), subcontractors in pre-production and assembly. "The industry provides a very wide range of supplies, from 5mm titanium bolts to 50 MW diesel generators with everything in between, for an equally diverse range of vessel types and sizes. The European marine equipment industry generates an average yearly turnover estimated at around EUR 60 billion. It is made up of around 22,000 enterprises, directly employing more than 350,000 workers and generating more than 436,000 indirect jobs. The majority of the companies are small, but it is led by some large multinationals." [7] The European marine equipment industry is a world leader for a wide range of products ranging from propulsion systems, large diesel engines, environmental, and safety systems, to cargo handling and electronics[8].

An increased competition:

As shown by graph 2, the European naval sector is facing growing competition from countries such as China and South Korea. In the last two decades, Asian countries, and particularly China and South Korea, have increased their production capacity and became strong competitor to the European leadership.

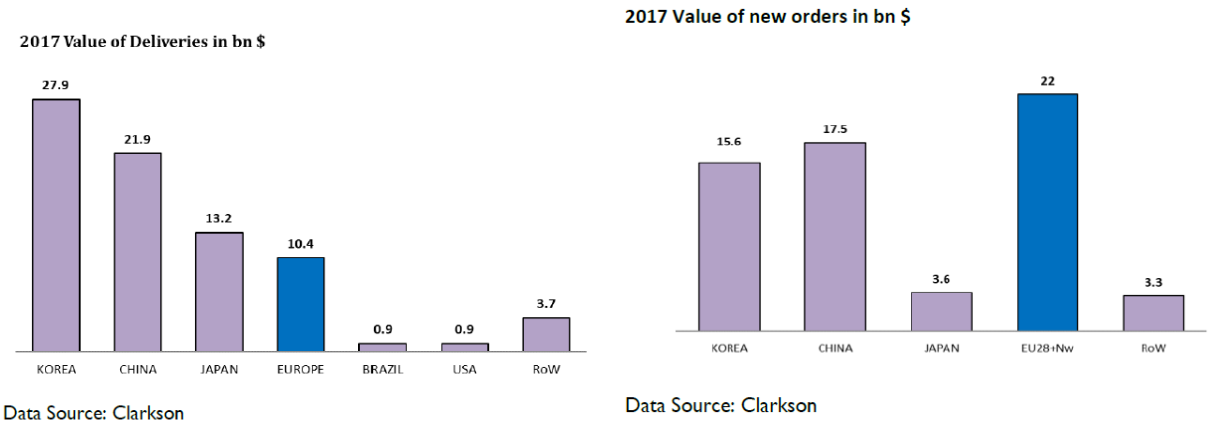
[7] Evolution of Supply, Employment and Skills in the European maritime technology Sector. Sea Europe for the European Commission, 2016.

[8] European Commission, DG Growth, Op. cit.



Graph 2 – Evolution of Shipbuilding Production in Compensated Gross Tonnage (CGT). Asia has increased its manufacturing capacity after 2000. Sea Europe, Clarkson, 2017.

However, Europe has been able to compete with low-cost labour countries thanks to the sector added value: its ability to innovate and to produce high value vessels.



Graph 3 Value of Deliveries and new orders in bn$ per area.

Due to the European companies specialisation in building the most complex high-tech vessels in high value market: cruise ships, ferries, offshore, other non-cargo carrying vessels (ONCCV) and naval ships, Europe is able to keep up the competition with Asia, and is gaining back some market share (as shown per graph 3). Taking into consideration the civil and naval shipbuilding, the European orderbook has a higher value than its counterparts in China, South Korea and Japan.

This is why the naval sector needs to pursue its effort in technological development. “The best way to counter this threat is by maintaining Europe’s technological lead at the Prime/System Integrators level as well as across the full supply chain through increased, more supported, more coordinated and more focused investments in Research, Development and Innovation (RDI) at national and European level”[9]

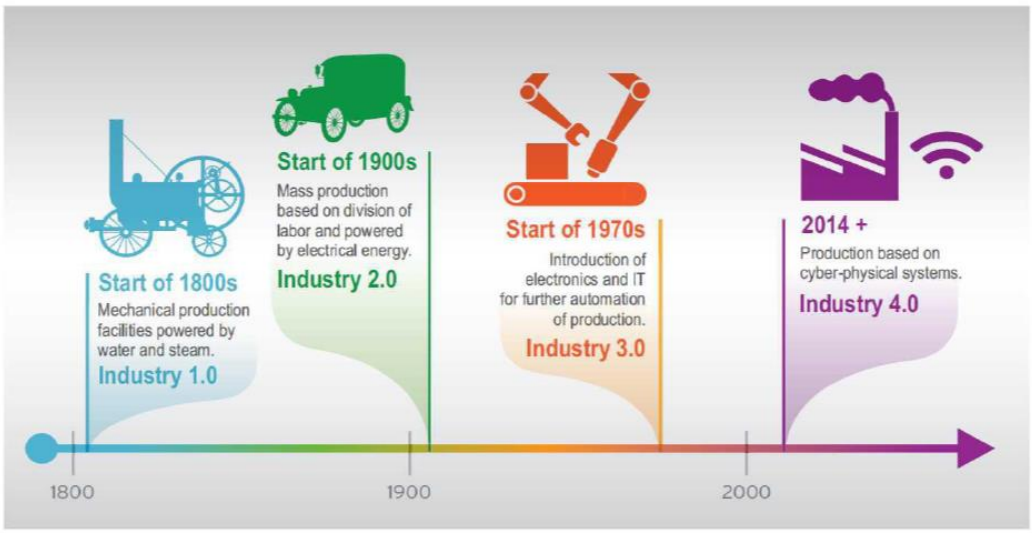
Keeping EU naval companies at the forefront of technology innovation is then of utmost importance, considering the increasing worldwide competition, for Europe to remain a global leader in shipbuilding.

4. Industry 4.0 definition

Even though each European country has defined its own national strategy, the European parliament has made a tentative common definition of the industry 4.0 concepts: “Industry 4.0 is a term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products. The 4.0 designation signifies that this is the world's fourth industrial revolution, the successor to three earlier industrial revolutions (see Figure 1) that caused quantum leaps in productivity and changed the lives of people throughout the world. The term Industry 4.0 originated in Germany, but the concept largely overlaps developments that, in other European countries, may variously be labelled: Smart factories, the Industrial Internet of Things, Smart industry, or advanced manufacturing.”[10]

[9] European Defense Agency, “EU naval industry in good shape but more R&T investment needed”; Brussels ; 06 October, 2016

[10] European Parliament Briefing, “Industry 4.0, Digitisation for productivity and growth”, September 2015. http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf



Source: Cognizant, Informed Manufacturing: The Next Industrial Revolution

Figure 2 - From Industry to Industry 4.0

Industry 4.0 depends on a number of new and innovative technological developments and is therefore constantly adapted to latest innovation. Nevertheless, the European parliament has defined a proposition for a definition of 4.0 technologies:

European Union parliament proposition for a definition of 4.0 industries[11] **:**

- The application of information and communication technology (ICT) to digitise information and integrate systems at all stage of production (including logistics and supply), both inside companies and across company boundaries.
- Cyber-physical systems that use ICT to monitor and control physical processes and systems. These may involve embedded sensors, intelligent robots that can configure themselves to suit the immediate product to be created, or additive manufacturing (3D printing) devices;
- Network communications including wireless and internet technologies that serve to link machines, work products, systems and people, both within the manufacturing plant, and with suppliers and distributors;

[11] *Ibid;*

- Simulation, modelling and virtualization in the design of products and the establishment of manufacturing processes;
- Collection of vast quantities of data, and their analysis and exploitation, either immediately on the factory floor, or through big data analysis and cloud computing;
- Greater ICT-Based support for human workers, including robots, augmented reality and intelligent tools.

European Parliament Briefing, "Industry 4.0, Digitisation for productivity and growth", September 2015.

Ultimately, 4.0 technologies will allow more flexible production processes, allowing mass customisation and production of small lots. Smart factory and 4.0 technologies allow to go beyond large scale production and to produce more customised products, adjusted to customer needs. This brings about a de facto integration of customers, suppliers and even competitors into a continuously changing business cycle, where everyone receives and processes information from everyone.

To face the global competition (as described in chapter 3), the European naval value chain must increase its research and technology investment to transform traditional industries into industries of the future.

5. Common analysis of the implementation of 4.0 technologies in the naval sector in the Atlantic Area

National Key Data (2016)	France	Ireland	UK	Spain (Basque country)	Spain (Galicia)	Portugal
Turnover (M€ in 2016)	85 000	121 (2014)	112 000	2 943	1 500	336
Number of Employees (direct jobs)	42 000	906	90 000	14 738	11 340	3074
Exportation (share in %)	80%	n/a	25%	80%	90%	62%
Number of SMEs	400	156	5000	120	287	339 and 59 SMEs
Presence of the entire value chain? (as explained in figure 2)	Each regional/national sector has representative actors from the entire value chain					

Table 2- Atlantic Area Naval sector key indicator

Naval sector context in the Atlantic Area

- **Diverse national situation in the Atlantic Area.**

Despite national differences, the naval sector in Atlantic Area countries represents a strategic sector with more than 162 000 direct jobs and 6000 SMEs.

France and the United Kingdom show the highest levels of production with the existence of large players and European shipyard leader (STX, Naval Group, BAE Systems Maritime, Babcock Marine etc.). Spain, in particular the Galicia and Basque country regions, also shows a strong naval sector with the presence of the Spanish navy shipyard Navantia and its value chain. Portugal and Ireland have smaller production levels (see table below), though still representing a significant global turnover and employment share.

In each of those countries, we can observe that most suppliers and auxiliary industries of the naval value chain are mainly SMEs. We identified a total of more than 6000 SMEs directly related to naval activities in the 5 countries represented in the project.

	France	Ireland	UK	Spain (Basque country)	Spain (Galicia)	Portugal
SME	400	50	5000	120	287	59

Table 3- Number of SME working in the naval sector in the Atlantic Area

Most SMEs have a limited investment capacity inhibiting their access to new technologies. When large companies can invest in new technologies such as digital twin, virtual reality, electronic document management and document sharing (etc.) most SMEs lack the financial capacity to invest in such tools and the vertical as well as horizontal value chain is fractured in between highly equipped manufacturer and traditional SMEs suppliers. The survey implemented in the framework of this project has indeed showed that financing issues have been identified as the main barriers for adopting 4.0 technologies (see survey results p21).

- **Facing the global competition, a need for continuous innovation efforts**

Following the global crisis of 2008, naval industry, as well as the overall European industry (as shown by the renewed industrial policy strategy of the European Commission[12]) is characterized by the need for reindustrialization. In addition to the crisis, international competition forces companies to work toward high added value product to compete against low labour countries (mainly Asia). This competition has enabled the production of complex products with increasingly low price and shortened market delays.
To stay competitive in the global market, industries need to develop and invest in advanced manufacturing technologies: "European stakeholders, shipyards and suppliers, can only compete in these markets and maintain a competitive position, due to continuous innovation in engineering processes, product innovation, the superior proficiency to manage processes and logistics and close co-operation with strategic partners in order to maintain the timely advantage in innovation."[13] This is particularly relvent for the Atlantic Areas' countries where naval industries are particularly represented.

- **High customisation level, low volume of production**

[12] Communication on a renewed EU industrial policy strategy, DG Growth, September 2017.
[13] Study on Competitive position and future opportunities of the European marine supplies industry - final report – European Commission, 2014

However, the naval sector can be distinguished from other main industrial sectors because of the particularity of its product: highly personalized and short production series. This explains the lack of automated production means, as most technical tasks are still manually accomplished, and the lack of innovation compared to other sectors such as in aerospace and automotive sectors in which processes are highly innovative with high levels of automation.

The lack of innovative processes of production in the naval production value chain added to some others factors has also made it difficult for companies to attract young and highly skilled workers.

The Atlantic area naval industry is not different from the rest of the EU and presents a fragmented value chain with companies of different size and capacity, from SMEs to large group, with various technological capacities.

Industry 4.0 and 4.0 technologies in the Atlatic Area

Each country from the Atlantic area has defined a "4.0" national strategy to enhance industrial capacities, and promote digital industrialization.

In the UK, the "Made Smarter Review" (previously referred to as the Industrial Digitalisation review), which was announced by the UK government in the Industrial Strategy Green Paper in January 2017, defines Industrial digitalisation as the application of digital tools and technologies to the value chains of businesses who manufactures (e.g. in the automotive and construction industries) or are otherwise operationally asset intensive (e.g. power grids and wind farms). These technologies enable the physical and digital worlds to be merged, and can bring significant enhancements to performance and productivity. Some of the key technologies identified are: Robotics and process control automation, IIOT, Additive manufacturing, AR/VR, Simulation, Data and systems integration, Big data and analytics, Industrial security, Cognitive computing and artificial intelligence, Mobility and wearable, Cloud based platforms.

In Spain, the Ministry of Economy, Industry and Competitiveness has launched the "Connected Industry 4" initiative in order to stimulate the digital transformation of Spanish industry by a joint coordinated action from both private and public sectors. This initiative is aligned with two previous national actions: the Digital Agenda and the Agenda to strengthen Spanish industrial sector from 2014. More specifically, Galicia and Basque Regions have launched their own initiatives:

***Galicia**:* the "Competitiveness Agenda Galicia 4.0" is led by the IGAPE (Galician Institute for Economic Development), to foster the implementation of Industry 4.0 in the region. The study of Industry 4.0 opportunities has led to identify the emerging technologies and classify them into 3 categories: Materials and intelligent Manufacture, Connectivity and Data Analytics, Production Management.

***Basque Country**:* The Basque government has developed a specific strategy: "Basque Industry 4.0" in which 4 technological areas where defined as of strategic importance for the future of industries: Advanced Material and processes, Energy efficiency, Flexible, Smart and efficient manufacturing systems, and Digital Connected Factories.

In Ireland, the Ireland's Business & Employers' Confederation has defined in 2016 the Manufacturing Ireland Strategy that focuses on 4 pillars:

1. Manufacturing for Competitiveness (research and innovation, better regulation, utility costs, funding & investment, regional development, extending global reach.)
2. Partnering for future growth (partnering for collaboration, lean manufacturing.)
3. Skills for the 21st Century (Education, training & funding for tomorrow, promoting STEM)
4. Factory of the future (Technology & Security)

In Portugal, the Industry 4.0 initiative, integrated into the National Strategy for the Digitalization of the Economy developed in 2017, intends to create favourable conditions for the development of the national industry and services in the new paradigm of the digital Economy, through a set of measures based on 3 axes of actions:

1. Accelerate the adoption of industry 4.0 by the Portuguese industry.
2. Promote Portuguese technological suppliers as industry 4.0 players
3. Making Portugal an attractive hub for investment in industry 4.0.

In France, the French alliance for Factory of the Future (Alliance pour l'industrie du futur) is dedicated to industry 4.0 and detailed in 2016 its vision for the industry of the future in 6 pillars:

1. Internet of things and industrial internet (sensors, data management, cyber security, RFID, big data etc.)
2. Advanced production technologies (high added value and eco-friendly process and material, highly functional steel, bio sourced materials, additive manufacturing, clean and energy efficient process, robotics, multi-functional machine, etc.)
3. New approach of Human at work, innovative management and organisation (zero-paper technologies, process optimisation, mobile application etc.)

4. Online factories and connected, piloted and optimised blocks (break free from siloed structure, simulation and modelling, 3D prototyping etc.)
5. Integrated customers/suppliers relationship (network through value chain integrated conception, automated supply chain flow, etc.)
6. New economic and business model, strategy and alliances (marketing break-through, investment capacity, technological alliances, internationalisation, agile companies, etc.).

Despite different national vision, IN4.0 partners' have agreed to define a list of technologies considered as 4.0 and of strategic importance for the futur of the naval industries:

- **Design and Simulation Software** – Advanced engineering software packages utilised for modelling products and real-world phenomenon.

- **Rapid Prototyping –** A group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or additive layer manufacturing technology.

- **Product Lifecycle Management Software –** software utilised to manage a products data from inception to disposal.

- **Digital Mock-Up** – Concept allowing for the description of a product, typically in 3D for its entire life cycle.

- **Project Management Software –** Software used for project planning, scheduling, resource allocation and change management.

- **Virtual Reality –** Interactive computer-generated experience which takes place in a simulated environment. This allow a better inclusion of upstream needs (work ergonomics, maintenance operation…).

- **Augmented Reality –** Technology which superimposes a computer-generated information into the real-world environment.

- **Additive Manufacturing –** The process of joining materials layer by layer to make objects from 3D modelled data.

- **Internet of Things –** Systems of interlinked embedded devices, machines, objects or wearables each with a unique identifier and the ability to transfer data.
- **Collaborative Design Environment –** A suite of engineering tools used to for design and management of products.
- **Mobile Solutions –** The use of mobile digital technology in order to access and process data as a standard way of working as opposed to traditional paper-based data transfer
- **Cyber Security –** The protection of internet connected systems.
- **Machine Tools –** Machine for shaping or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformation.
- **Computer Assisted Maintenance –** Systems that utilize software to organize planning and optimised scheduling and support of maintenance and repair. (e.g: intervention task planning management, equipment fleet availability management…).
- **Management and Traceability Solutions (Alter this to Smart Logistics?) –** The ability to trace and track physical assets through the use of digital technologies (e.g. RFID tags).
- **Manufacturing Execution Systems –**information system dedicated to manufacturing operation that connects, manage, monitors and controls in real-time the execution of complex manufacturing systems and data flows on the factory floor.
- **Logistic Flow Simulation –** The use of software for discrete event simulation on digital mock-up to optimise logistics and throughput performance.
- **Cloud Computing–** The practice of using a network of remote servers hosted on the internet to store, manage and process data.
- **Enterprise Resource Management Tool –** Software which integrates the management of core business processes in real time
- **Collaborative Robot –** The use of robots which are intended to physically interact with

humans in a shared workspace.

- **Predictive Maintenance –** Techniques and sensors used to determine the condition of in-service equipment in order to predict when maintenance tasks should be performed, just before dysfunction, as opposed to systematic maintenance.

- **Digital Twin –** a digital replica of physical assets, processes, people, places, systems and devices that evolve in time as its real twin and that can be used to simulate and optimise the production line, to enable the digital thread of the product, to simulate manufacturing operation etc.

Local strategy dedicated to 4.0 in the naval sector

When it comes to the application of 4.0 technologies to the naval sector, each partnering country has one or more support structures dedicated to promote the 4.0 technologies and facilitate the modernization of the value chain actors. Those structures are of different nature (industry federation, professional associations, governmental bodies, regional development agencies, etc. They can provide different level of support such as:

- Strategic and sector perspectives guidance / roadmap;
- Access to funding for implementation of 4.0 technologies in the factories;
- Showcase industrial transformation success case;
- Promote and raise awareness of 4.0 technologies amongst SMEs;
- Promote collaborative projects in between research centre/RTO and industries to develop optimised 4.0 industrial solutions dedicated to the naval sectors;
- Support and develop business opportunities;
- Promote cross-fertilisation to gain experience from other sectors.

Each partners of the Naval 4.0 project has indicated the initiative and/or programs dedicated to research and innovation in the naval sector they are involved in, either as direct participation or indirect.

National programs/initiative dedicated to research in naval industrial sector					
Portugal	**UK**	**Ireland**	**Spain - Galicia**	**Spain - Basque Country**	**France**
Shipbuilding and Ship repair	UK Marine Industrial Alliance	Irish Marine Industry Network	Joint Research Unit (UMI) : Shipyard 4.0 "the shipyard of the	ADIMDE: Basque Maritime Industries	Construction and Naval Activities Industrial Group

Association			future"	Association	(GICAN)
	Society of Marine Industries	Irish Maritime Development Office	Shipbuilding 4.0: agreement between the Galician Innovation Agency, the Galician Institute of Economic Promotion, ACLUNAGA and AIMEN to boost the innovation capacity of the maritime industry.	HAZITEK: Basque government R&D program	Orientation Council for Research and Innovation in Construction and Naval Activities (CORICAN)
					The French Maritime Cluster

Table 4 - National programs/initiative dedicated to research in naval industrial sector

PORTUGAL:

Associação das Indústrias Navais：Shipbuilding and Ship repair Association: As a shipbuilding regional cluster, it aims to improve competitiveness and stimulate development within all companies of the Galician naval sector. Its activities include identification of company needs, provision of strategic information, etc. At the moment, it represents 205 companies, whose products and services cover all segments of the shipbuilding value chain.

UNITED KINGDOM:

The UK Marine Industries Alliance is bringing together all aspects of this diverse sector with the goal of working together to secure the maximum opportunity for the industry to flourish. All UK companies, trade associations and public sector agencies operating in the marine sector are offered free membership of the UK Marine Industries Alliance, and use of its brand identity. UK ships, boats, marine systems and equipment, skills and expertise are recognised throughout the world. The 'marine industries' manufacture and provide support services in the Leisure, Naval, Commercial, Offshore Renewable Energy and other sectors.

The Society of Maritime Industries (SMI) is the voice of the UK's maritime engineering and business sector promoting and supporting companies which design, build, refit and modernise ships, and supply equipment and services for all types of commercial and naval ships, ports and terminals infrastructure, digital technology, maritime defence and security, marine science and technology, maritime autonomous systems and marine renewable energy. SMI provides a wide range of activities both internationally and in the UK for the benefit of the maritime engineering business community. The

members' interests are represented by six councils which focus on the markets in marine science and technology, commercial marine including ship building, repair and equipment, maritime autonomous systems, digital technology, ports and terminals infrastructure and maritime defence and security including naval platforms, systems, security and safety.

IRELAND:

Irish Maritime Development Office: The Irish Maritime Development Office (IMDO) is Ireland's national dedicated development, promotional and marketing office for the shipping and shipping services sector.

It provides support to national and international maritime businesses in Ireland. It is the aim of the IMDO to be the focal point for maritime business in Ireland. The IMDO provides government and industry with a range of information and reporting across the sector and works with international businesses to help them set-up or expand in Ireland. The IMDO is also Ireland's designated Shortsea Shipping Agency and provides independent advice and guidance on EU funding initiatives.

The IMDO has been involved in the launch of an **Irish Marine Industry Network**, an initiative of strategic importance for positioning Ireland at the forefront of marine innovation through maximising collaboration and cross-sectoral opportunities.

SPAIN:

ADIMDE - Agrupación de Industrias Marítimas de Euskadi (the Association of Maritime Industries of the Basque Country), is a non-profit making organisation focused on boosting the maritime culture and its related activities, and promoting cooperation among its associated companies. The aim of this is to improve the industry's competitiveness and help it to deal with all business offers, both national and international.

Shipbuilding 4.0: this initiative is an agreement between the Galician Innovation Agency, the Galician Institute of Economic Promotion, ACLUNAGA and AIMEN to boost the innovation capacity of the maritime industry.

HAZITEK: Basque government R&D program financing Industrial research, experimental developments in advanced manufacturing.

FRANCE:

The GICAN, the French Marine Industry Group, affiliates more than 180 industrialists in the maritime industry. It brings together shipyards, system and equipment manufacturers, subcontractors,

engineering and architect businesses that are involved in the design, construction, maintenance and implementation of military and civilian vessels, and those who work in the domain of maritime security and Marine Renewable Energies. **The vocation of this group is to defend the interests of its members before the State and European institutions**, to promote their know-how on the international stage and lead its network of members. The GICAN also organizes the Euronaval and Euromaritime exhibitions. The GICAN has launch in 2011 the CORIMER: the Orientation Council for Research and Innovation in Construction and Naval Activities which gather representatives from the French naval sector (NGOs, public actors, companies, trade unions…) and aims to contribute to R&D&I activities toward the vessels of the future.

The French Maritime Cluster, a non-profit organization incorporated under the Laws of France, whoseobjective is to gather and promote the French maritime economy. The **CMF** brings together over 400 members in maritime related activities : shipping companies, shipbuilding and repair, offshore oil and gas service, supply industries, maritime safety and security industries, ports, insurance, ship brokering, shipping finance, classification, etc. It offers special support to SMEs such as professional training, assistance for certifications, registration office for new companies, support for business events, assistance with International actions, legal assistance on European issues, etc.

Each Naval 4.0 partners are currently involved in the National initiatives mentioned above, in their respective country, and help build the present report, defining the state of the art in 4.0 technologies use in the naval sector.

The use of 4.0 technologies in naval industries

Based on their extensive knowledge of their ecosystem and of the sector, the partners gave estimation of the level of adoption of 4.0 technologies in the naval sector. The technologies have been chosen based on our bibliography and research work and recognised amongst the partner as technologies of interest for the future of the naval manufacturing sector (see P.22).

According to our studies, “Engineering and conception industries” and “production and maintenance activities” should be distinguished in their use of 4.0 technologies as their needs might differ due to their specific and dedicated work and activities.

We considered 4 level of technology’s adoption:

0. The technology presents no interest for the naval sector;

1. Some experiment have been conducted in naval companies, but not largely deployed in the sector yet;

2. The technology has been partially deployed in the naval sector (some companies are not equipped);
3. Fully deployed: the technology is commonly used among the naval value chain.

We have then established two common tables that reflect the level of adoption of 4.0 technologies in the naval value chains in the Atlantic Area. You will find in annex 2 the original tables per partner.

Engineering & conception industries	
Technologies	**Level of adoption**
▶ Design and simulation software	2. Partially deployed
▶ Rapid prototyping	1. Some experiments
▶ PLM Tool (Product Lifecycle Management)	1. Some experiments
▶ Digital mock-up	2. Partially deployed
▶ Project management software	2. Partially deployed
▶ Virtual reality	2. Partially deployed
▶ Augmented reality	2. Partially deployed
▶ Additive manufacturing	1. Some experiments
▶ Internet of things	1. Some experiments
▶ Collaborative design environment	1. Some experiments
▶ Mobile solution (application/remote access)	2. Partially deployed
▶ Cyber security	1. Some experiments

Table 5 - Level of adoption of 4.0 technologies in the engineering and conception industries

Production and maintenance industries	
Technologies	**Level of adoption**
▶ Machine tools	2. Partially deployed
▶ Computer-Assisted Maintenance Management and traceability solution	2. Partially deployed
▶ Manufacturing Execution System	1. Some experiments
▶ Logistic flow simulation	2. Partially deployed
▶ PLM Tool (Product Lifecycle Management)	2. Partially deployed
▶ Digital mock-up	2. Partially deployed

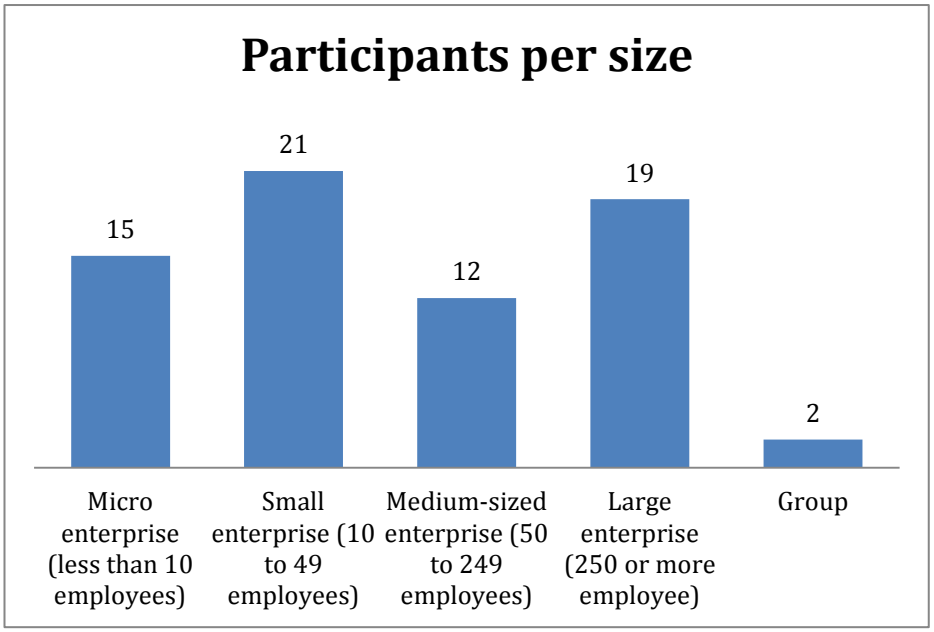
▶ Project management software	2. Partially deployed
▶ Electronic document management & document sharing	2. Partially deployed
▶ Enterprise Resource Planning	2. Partially deployed
▶ Augmented reality	1. Some experiments
▶ Collaborative robot	1. Some experiments
▶ Additive manufacturing	1. Some experiments
▶ Predictive maintenance	1. Some experiments
▶ Internet of things	1. Some experiments
▶ Mobile solution (application/remote access)	2. Partially deployed
▶ Cyber security	1. Some experiments
▶ Factory/ yard digital twin	1. Some experiments

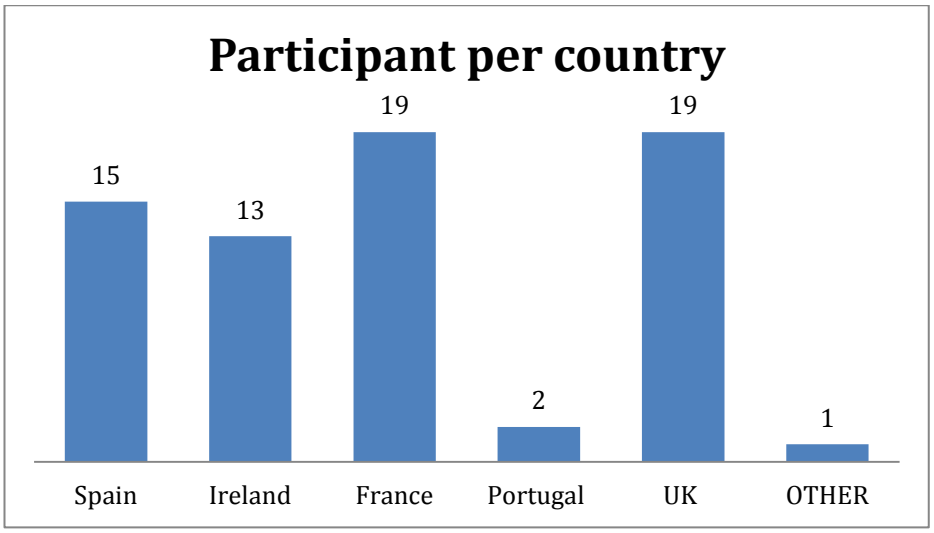
Table 6 - Level of adoption of 4.0 technologies in production and maintenance industries

These tables are based on the aggregation of data received from all partner (see Annexes 2). We can observe that there is no identified technology in the table that is largely deployed in the Atlantic Area. We will see in the next part of the report, that this assumption is confirmed by the survey results. Indeed, although some partners reported a level "3. Fully deployed" for a technology, it is not the case of the others, which led to set up the consolidation to a level 2 maturity to be largely developed in their region; it is not the case for others.
Table 5 & 6 reflects the delay in 4.0 technologies adoption, while the level of interest expressed by the company interrogated reflects the slow progression of 4.0 technologies implementation into the naval sector and the lack of clear strategy toward factory of the future.

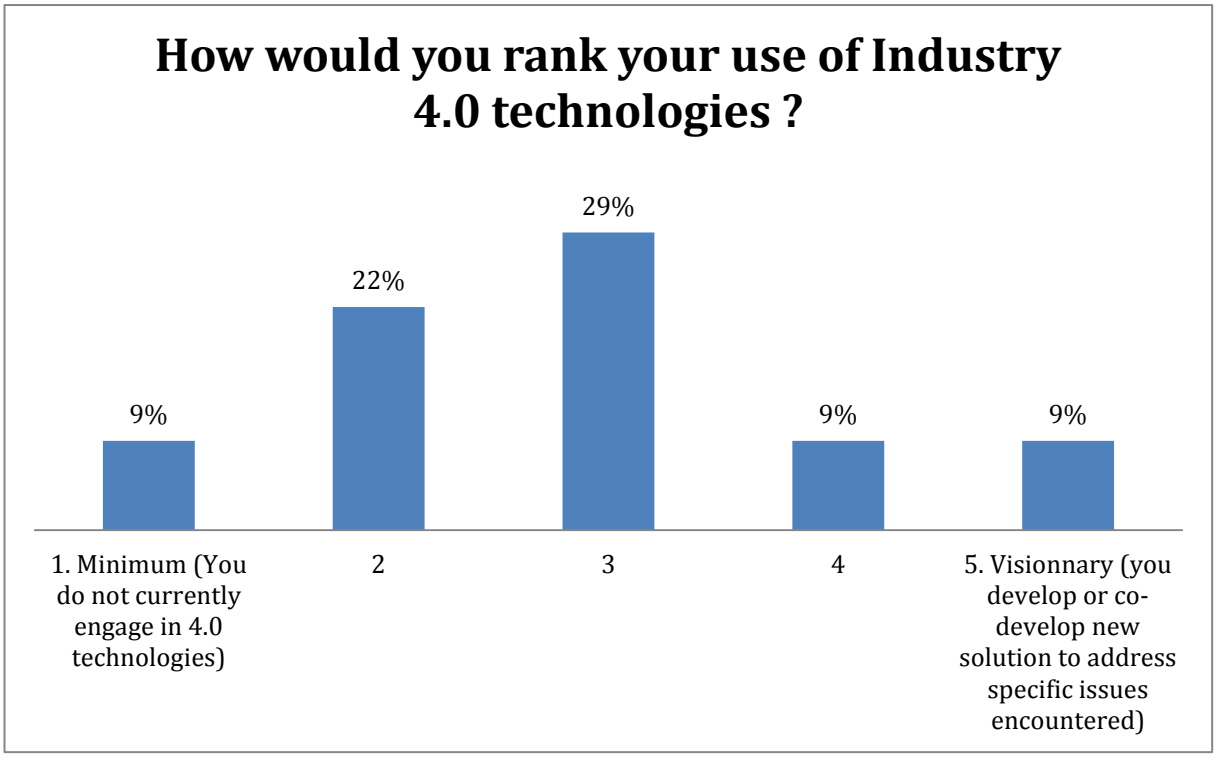
Analysis of the survey results:

The survey has been open from November 2018 until March 2019 and was designed in English and translated into French to maximise the number of respondents. In total, 69 structures responded to the survey, from the 5 partners' countries, including 48 SMEs, 19 large enterprises and 2 groups.

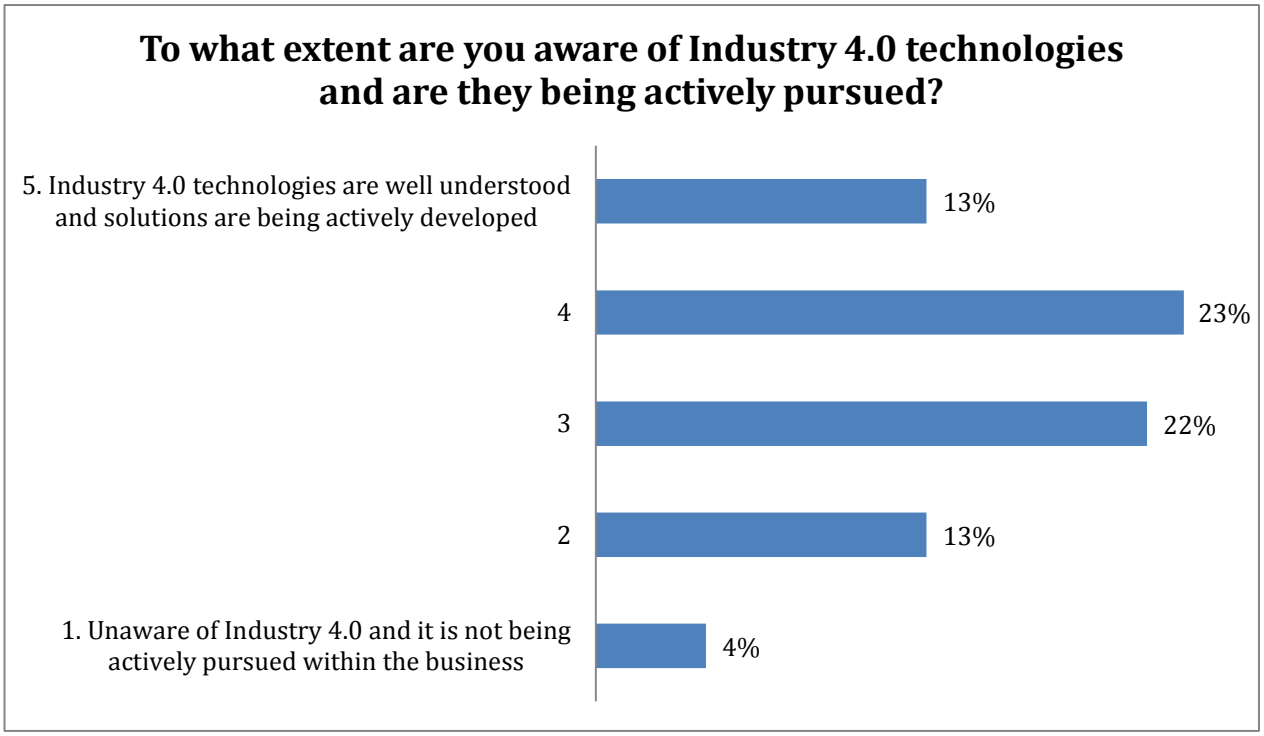




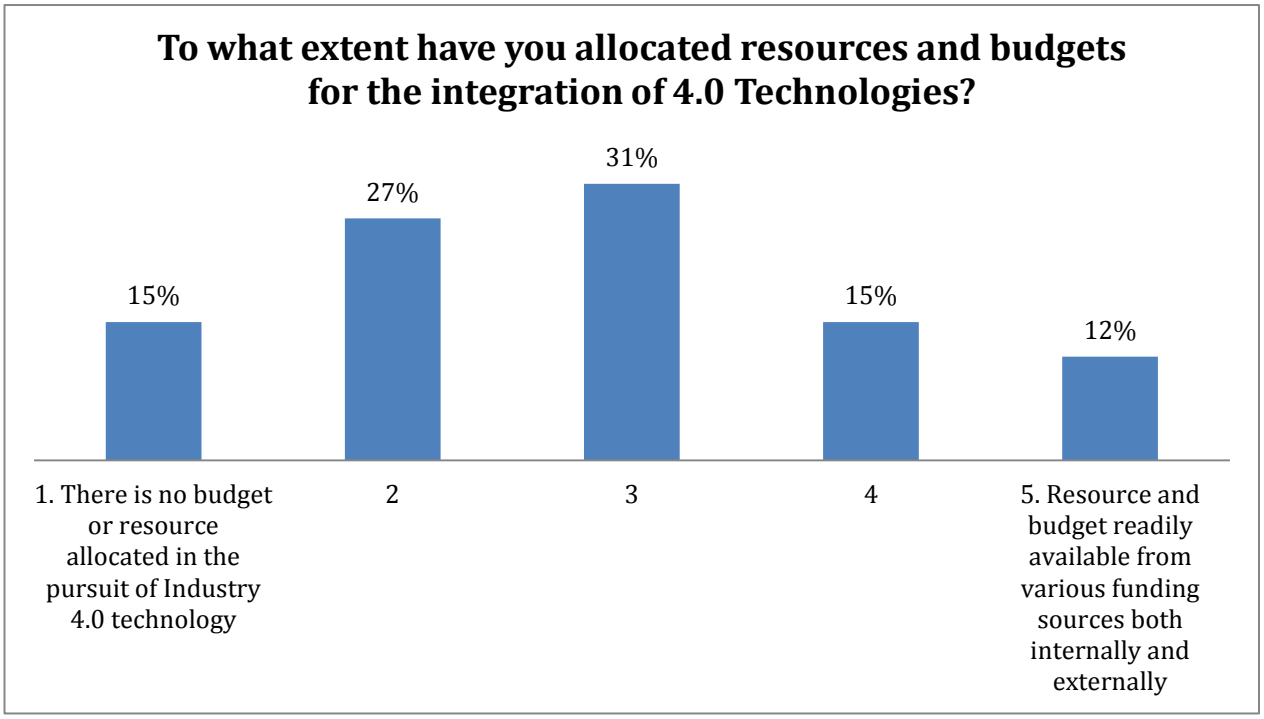
It is interesting to notice in the first place that most respondents do not evaluate their use of industry 4.0 technologies as visionary, nor even optimal. Most companies reckon that they are not fully digitalised yet, or at the forefront of the 4th industrial revolution.



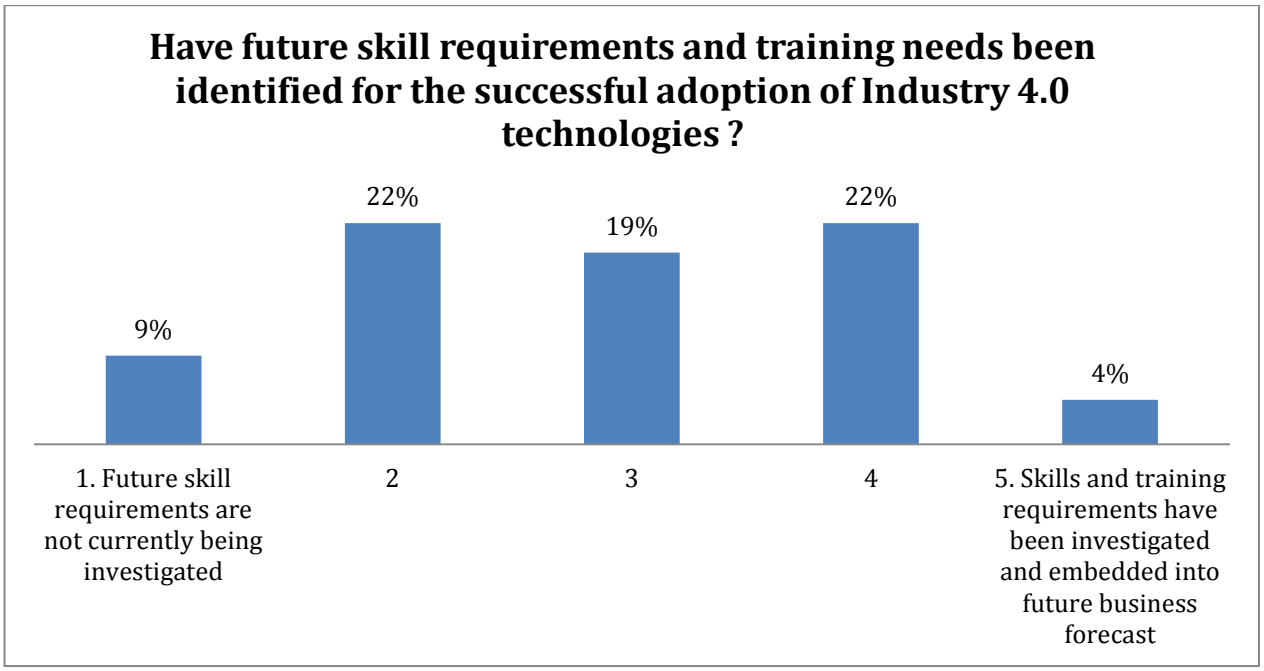
Despite this quite low use of Industry 4.0 technologies, most respondents have a good understanding of 4.0 technologies and their importance for the future of industries, though only few of them are actively pursuing a factory of the future strategy.

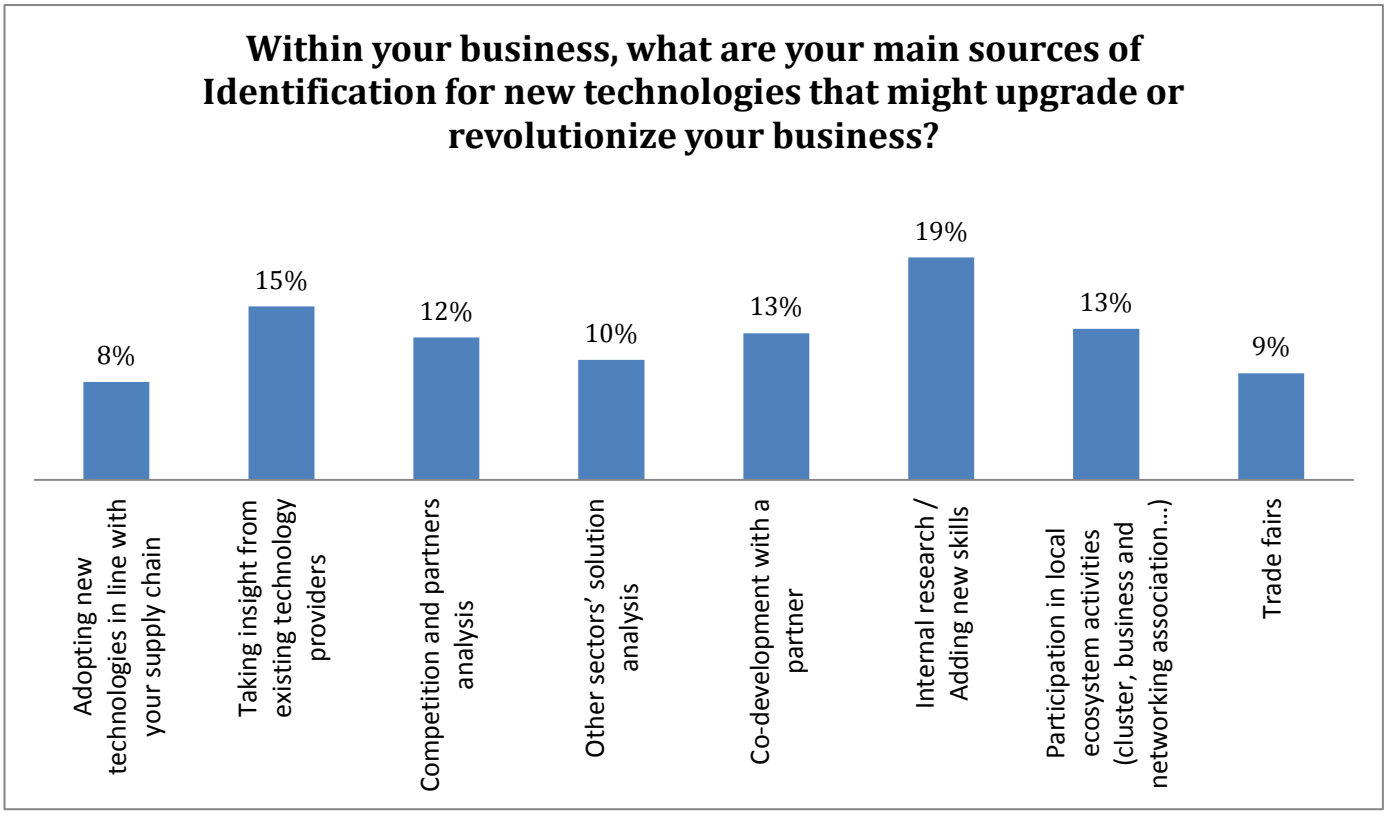


A slightly reverse trend can be observed when it comes to the allocation of ressources and budget to the implementation of 4.0 technologies. Though some respondents have allocated some resources dedicated to the integration of 4.0 technologies in their facilities, most of them judge that resources allocated are not important or readily enough.



The situation on skills and training identification is quite balanced amongst the value chain and we can say that almost half of the respondents have a clear idea of what skills will be needed in the future, although very few of them have truly investigate and forecast future training. The other half of the companies may need guidance as to what type of training is needed to fully embrace 4.0 technologies.





Finally, when it comes to the identification for new technologies that might upgrade their business, companies from the naval sector take their inspiration from various sources, the first ones being internal research and skills and technology providers. It is interesting to notice those local ecosystems are of importance to identify new technologies, as trigger of networking activities and innovation facilitator.

The implementation of 4.0 technologies in naval industries: Survey results.

Engineering & conception industries:

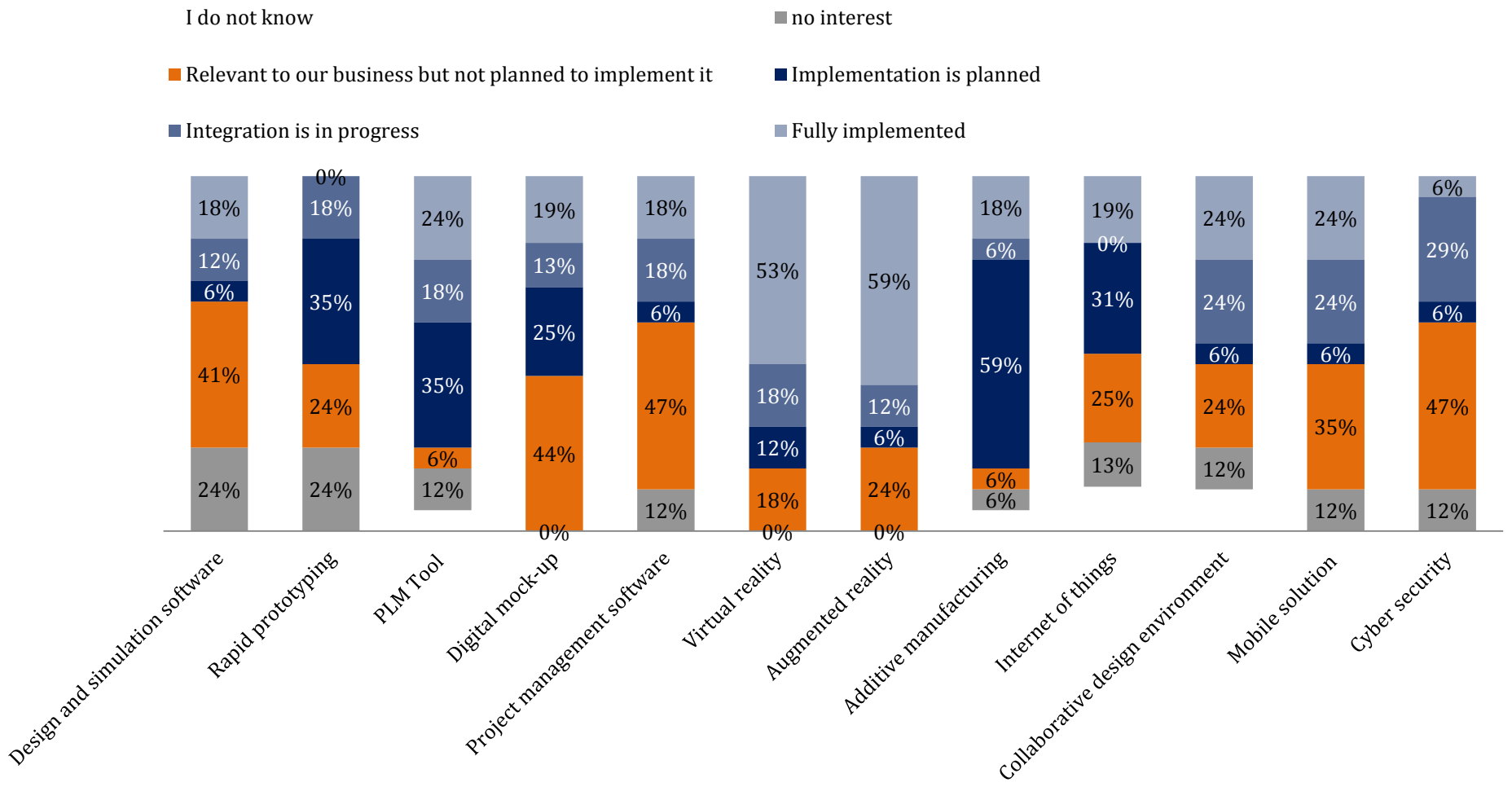
Once put aside the respondents that where classified in "other" (Research centre, academic, technology providers, etc.) 18 structures with activities fully linked to engineering and conception in the naval sector have been answering our online survey regarding their use of 4.0 technologies.

To the question "What is the state of Implementation of these 4.0 technologies in your company?" for each technology, 6 choices where given to the structures:

- I do not know
- Our organisation have no interest in this technology

- This is relevant to our business but we have not planned to implement it
- The implementation of the technology is planned
- Integration of the technology is in progress
- It is already implemented and we have regular use of this technology

Engineering and conception: What is the state of implementation of these 4.0 technologies in your company ?



We can see that, as described previously, there is no technology fully deployed and implemented in most companies specialised in engineering and conception for the naval sector.

- Current investments in technology are being focused on Rapid prototyping, PLM tools and additive manufacturing as they are the technologies most planned to be integrated in the year to come, especially additive manufacturing with more than 50% of the respondent having planned to integrate it.
- Design and Simulation software, Digital mock-up, project management software and cybersecurity are technologies declared as very relevant for the naval sector, especially in the engineering and conception activities, but not yet implemented. Those technologies can be considered as most strategic for the future of the naval industry, but not yet implemented in the value chain of the sector.
- Finally, virtual reality and augmented reality are the most declared technologies as fully implemented.

What we can see, is that the status of the implementation of the technology is various and no technology is fully implemented, or on the contrary, fully rejected by the engineering and conception companies. We can assume that each company run an internal assessment and defines the technologies of strategic importance considering their own production process and activities.

Based on the most popular response amongst our panel, we have established a table summing up the companies' interest for each technology. This table is a reflection of the response from the survey, but it is important to bear in mind that no technology has established a consensus amongst companies (more 60%), this reflect the majority.

Engineering and conception	
Technologies	**Level of interest/implementation**
Design and simulation software	Relevant to our business but not planned to implement it
Rapid prototyping	Implementation is planned
PLM Tool	Implementation is planned
Digital mock-up	Relevant to our business but not planned to implement it
Project management software	Relevant to our business but not planned to implement it
Virtual reality	Fully implemented
Augmented reality	Fully implemented
Additive manufacturing	Implementation is planned

Internet of things	Implementation is planned
Collaborative design environment	Relevant to our business but not planned to implement it Integration is in progress Fully implemented
Mobile solution	Relevant to our business but not planned to implement it
Cyber security	Relevant to our business but not planned to implement it

Based on those results, we can say that the adaptation and implementation of 4.0 technologies is very much depending on each structure context and need.

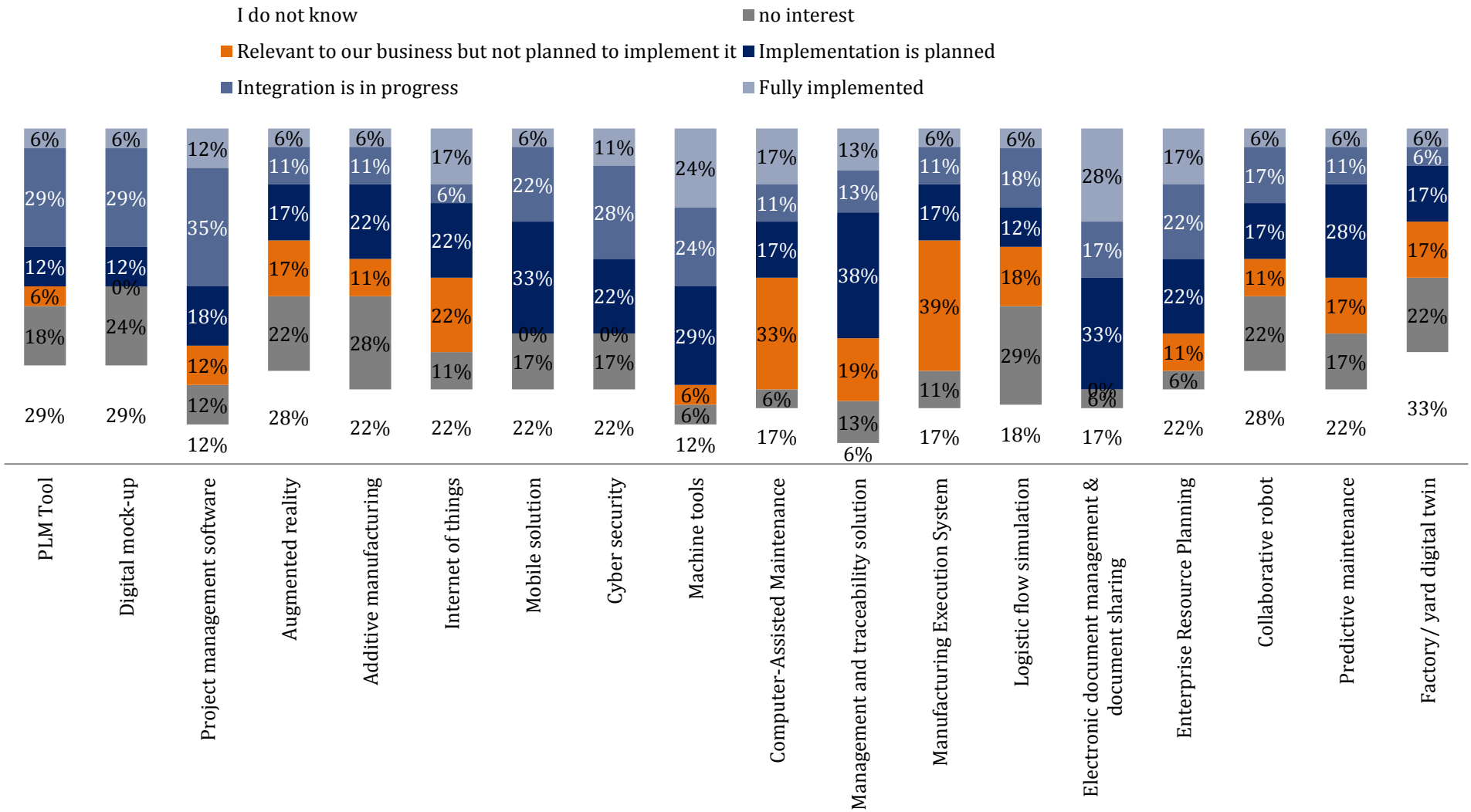
Production and maintenance industries:

Once put aside the respondents that where classified in “other” (Research centre, academic, technology providers, etc.) 18 structures with activities linked to production of part and component; Sub-assembly and pre-assembly; assembly, production and maintenance in the naval sector have been answering our online survey regarding their use of 4.0 technologies.

To the question “What is the state of Implementation of these 4.0 technologies in your company?”; for each technology, 6 choices where given to the structures:

- I do not know
- Our organisation have no interest in this technology
- This is relevant to our business but we have not planned to implement it
- The implementation of the technology is planned
- Integration of the technology is in progress
- It is already implemented and we have regular use of this technology

Production and maintenance: What is the state of implementation of these 4.0 technologies in your company ?



The survey has shown that, on the production and assembly activities of the naval sector, the 4.0 technologies most implemented in industries are Electronic document management & document sharing, Machine tools and Internet of Things. Though, as we can see, there is no technology that is fully implemented in the production and maintenance area of naval sector.

Project management software and cyber security are the technologies being the most implemented, together with PLM tools and Digital Mock up, technologies also revealed as of importance in the engineering and conception area. Indeed, those four technologies are part of the digital continuity of the value chain, fostering and assisting data exchange and connexion along the supply chain in shipbuilding.

Management and traceability solution, mobile solutions and electronic document management & document sharing are the technologies that will be the most implemented in the coming years, being of strategic importance for the sector.

Computer assisted maintenance, Manufacturing Execution Systems (MES) are the technology on which company will probably focus in the coming years, as they are declared as relevant for the sector, but not yet implemented.

Based on the most popular response amongst our panel, we have established a table summing up the companies' interest for each technology. This table is a reflection of the response from the survey, but it is important to bear in mind that no technology has established a consensus amongst companies (more 50%).

Production and maintenance industries	
Technologies	**Level of interest/implementation**
PLM Tool	Integration of the technology is in progress
Digital mock-up	Integration of the technology is in progress
Project management software	Integration of the technology is in progress
Augmented reality	I do not know
Additive manufacturing	Our organisation have no interest in this technology
Internet of things	Relevant to our business but not planned to implement it Implementation is planned
Mobile solution	The implementation of the technology is planned
Cyber security	Integration of the technology is in progress
Machine tools	The implementation of the technology is planned

Computer-Assisted Maintenance	This is relevant to our business but we have not planned to implement it
Management and traceability solution	The implementation of the technology is planned
Manufacturing Execution System	This is relevant to our business but we have not planned to implement it
Logistic flow simulation	Our organization have no interest in this technology
Electronic document management & document sharing	The implementation of the technology is planned
Enterprise Resource Planning	Integration of the technology is in progress
Collaborative robot	The implementation of the technology is planned/Our organisation have no interest in this technology
Predictive maintenance	The implementation of the technology is planned
Factory/ yard digital twin	This is relevant to our business but we have not planned to implement it / Our organisation have no interest in this technology

It is interesting to notice that, on both type of activity, our survey does not reveal any global consensus on one or several technology being of strategic importance for the future of the naval sector. This being said, the factory of the future does not depend on the implementation of only one or two technologies but is mostly the result of a combination of 4.0 technologies, ensuring more flexible and productive process, depending on the factory situation and productive context.

Drivers for the adoption of 4.0 technologies in the naval sector:

Based on their extensive knowledge of the naval sector and their closeness to their industry members, the Naval 4.0 partners have shared and agreed on common drivers for naval companies to adopt 4.0 technologies:

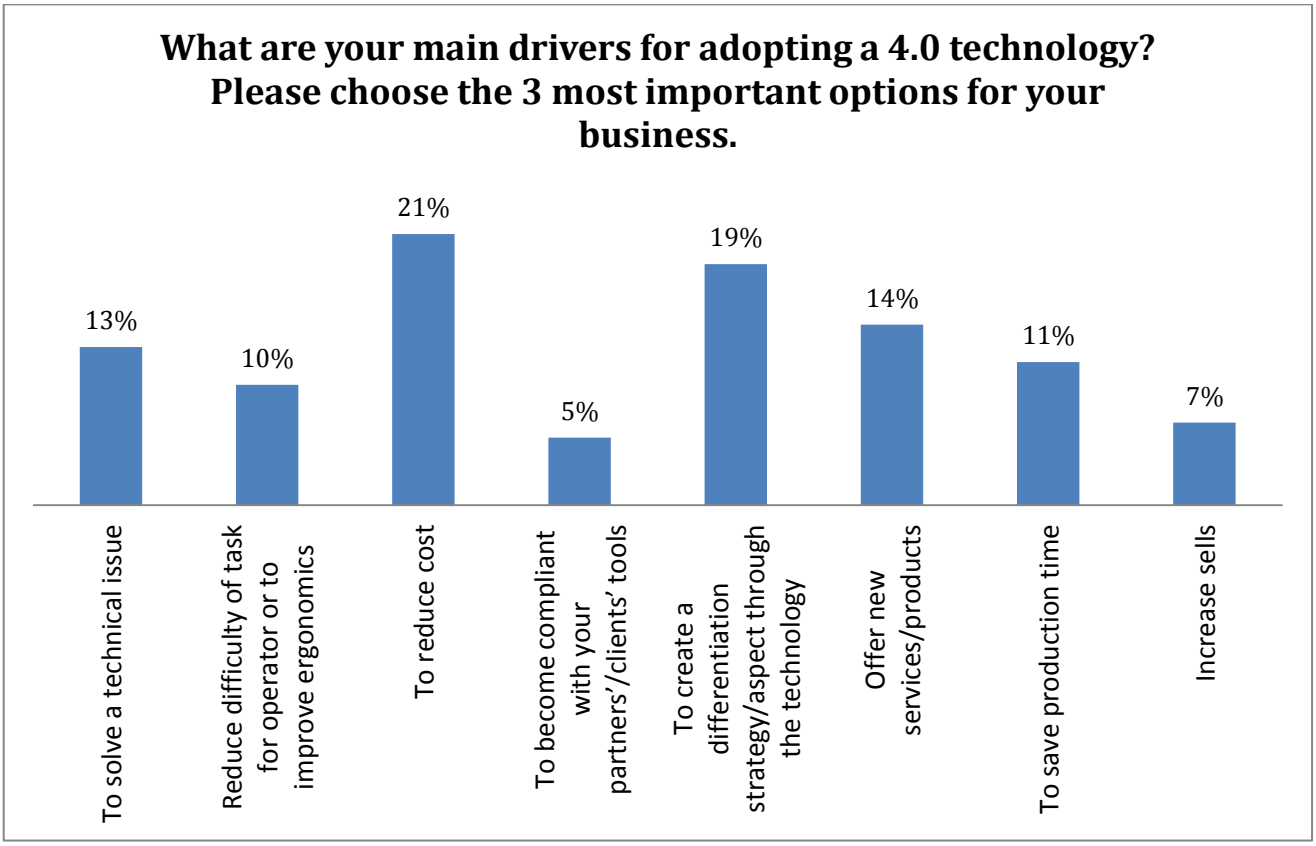
COMPETITION	▶ International competition pushes companies to increase the added value of their product through new technologies and services in order to differentiate from competitors and thus keep their competitive advantage.
DIGITAL VALUE CHAIN	▶ 4.0 Technologies allow a better integration of the vertical and horizontal value chains, thus improving the productivity of the sector, shortening production time. Indeed, digital production tools, integrated management tools or even production robots could improve operational efficiency of the entire value chain by ensuring qualitative and effective communication between clients and suppliers.

SAFETY & SECURITY	▶ 4.0 technologies enhance safety at work during production processes (robot, cobot, exoskeleton, etc.) and provide increased security of the product itself (quality control, warnings, traceability…)
REGULATIONS	▶ European and global regulation is increasingly strict, notably regarding recyclability, security and energy consumption. Shipyards have to secure activities and quality to respond to increasingly demanding norms and regulation. For instance, industries are now required to perform a documentation work linked to traceability, environmental norms, parts and components replenishment capacity etc. This documentation work constitutes a large amount of activity that 4.0 technologies could help reduce.
PRODUCTIVITY	▶ Innovative solutions help develop the efficiency of production and management processes. Indeed, companies continually seek greater efficiency and cost reduction and drive for increasing profits in order to reduce production time, delivery time and in the long run to remain competitive in the market.
CLIENT NEEDS	▶ Finally, companies are driven by their clients' needs, whether it is a major shipyard trying to satisfy its client needs, or a SMEs aiming to fulfil the shipyard requirements and specifications. New products and innovative business model are attractive to clients: high quality, environmentally friendly, maintenance as a service, etc.

Our survey revealed that the 3 main drivers for adopting a 4.0 are:

- To reduce the cost of production;
- To create a differentiation strategy;
- And to offer new services and/or products.

As shown later own when explaining the main barriers for the adoption of 4.0 technologies, cost and finance are at the heart of the 4.0 transformation, weather as a trigger or as a barrier.



Barriers to the adoption of 4.0 technologies in the naval sector:

IN 4.0 project partners exchanged as well on the barriers that imped the implementation of 4.0 technologies into the naval sector, explaining the delay with regards to others sectors:

- The naval value chain can be distinguished from others sectors due to highly personalised product and short product series of product – even one of a kind product, for instance major cruise boat. It is indeed very unusual to see a production of more than 10 ships. This characteristic is reflected in the low – or even inexistent – automation of production processes. Most technical work (welding, pipework etc.) are still manually performed with relatively basic machinery and very few numerical control machine.

  However, major players and shipyards (Les chantiers de l'Atlantique, Naval Group, Navantia, BAE Systems Maritime, Babcock Marine etc.) are used to collecting, analysing and managing data and encourage the reuse of models and knowhow to improve production follow-up and a gain in delays and quality thanks to the tracking of those data. For those major players the high number of parts to be machined or assembled is sufficient to justify the investment in robotic solutions. But this is different for auxiliary industries, their clients as well are their subsets are varied and so are the corresponding hardware and software solutions. This leads to difficulties to amortise new

equipment and raises issues regarding data incompatibility (the need for the digital continuity calls for data operability to design to modify, traceability file to adapt etc.)

This first barrier led to two main issues:

- The vast majority of shipyard suppliers are SMEs who struggle to (1) invest in expensive 4.0 technologies, and (2) are unsure of the critical gain from the adoption of expensive 4.0 technologies such as robotics. = first : unsure about the critical gain, étant donné le cout still expensive, ROI is not clearly identified.

- The fragmentation of the sector, the inability for business partners to collaborate around digital solutions and the presence of diverse levels of digital abilities and adoption between companies along the supply chain, hinder the global technological development of the naval value chain.

- All partners have observed a lack of qualification in the current naval workforce which can lead to resistance to change the companies' processes: fear and concerns due to lack of expertise on the technologies suggested by Industry 4.0 paradigms. This lack of technical skills dedicated to 4.0 technologies hinders the deployment of new technologies.

- In addition to that, it has also been admitted that naval companies and particularly SMEs have trouble defining a clear and measurable return of investment that would help define an informed innovation strategy.

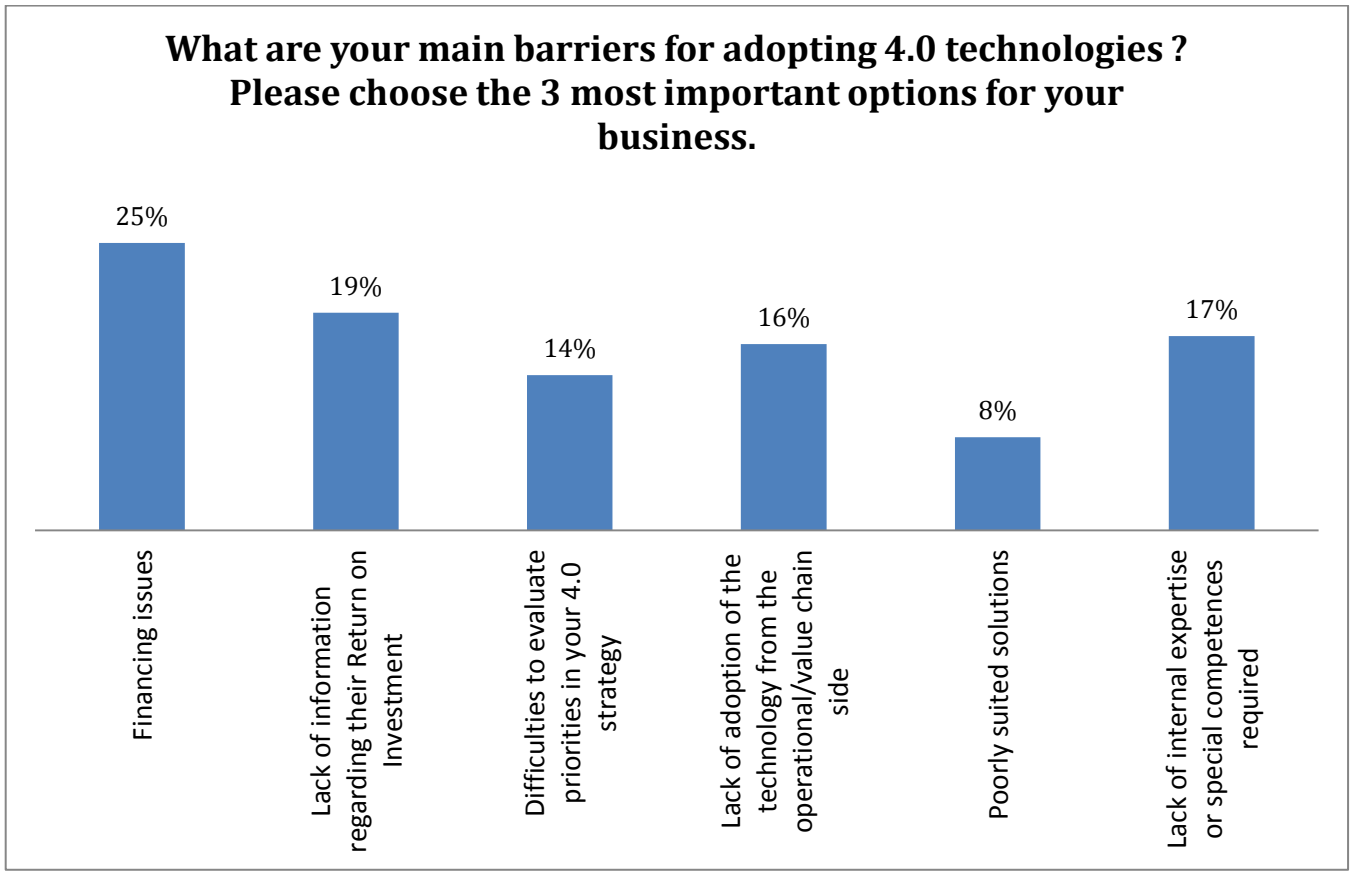
- Similarly, it has been observed that implementation of 4.0 technologies into existing hierarchies can be complex as companies lack a clear digital operations vision and leadership from top management. This can be explained by the unawareness of the potential of involved technologies.

- It has also been reported that most existing companies in the naval sector show a very low existing level of digitalisation, which conflicts with industry 4.0 paradigms. Due to the accumulated delay in digitisation (compared to other sectors) legacy IT systems are in need of overhaul and upgrading within companies.

- This lack of strategic vision for the 4.0 development of the naval sector coupled with low level of digitisation led to difficulties to attract new skills in the company. Talented workers see in the naval sector a traditional and arduous work.

- Cluster from our partnership also reported that companies in the naval sectors are mostly uncertain around issues relating to cyber security, and there is a growing concern over companies' intellectual property management when using such ICT tools.

- Finally, the lack of investment capacity from naval companies is a major barrier toward the implementation of 4.0 technologies which can be expensive. We can also highlight the lack of financial initiative from government or investment coming from private funding which would incentive the modernisation of the production means.



The barriers identified by the project partners have been demonstrate by our survey, the main and for most barriers being financing issues, followed by the lack of information regarding potential ROI.

The Naval 4.0 project intend to support SMEs overcome the barriers identified here, raising awareness and knowledge on 4.0 technologies and their ROI, and offering solution to financing issues (orientation toward national funding, analysis of the best value for money technologies etc.).

Suggestions to support the adoption of 4.0 technologies in the naval sectors:

- Facilitate the development of a shared naval 4.0 vision; for the global value chain (including SMEs), in terms of skills, technologies and governance, so that the entire sector is working toward a shared goal and is capable of enabling efficient integration along the value chain.

- Promote cooperation amongst naval actors to share good practices, success stories and develop collaborative project. This would be a practical way to foster replication of digital project with actions such as:
  - Internal audit/diagnostics of areas with potential benefits from 4.0 technologies,
  - Collaborative pilot project to test Proof of Concept,
  - Involve centre of excellence in the collaboration to provide technical knowledge.

- Development of Industry 4.0 training and support programs, especially for SMEs who can lack the investment capacity and vision for such programs.

- Develop the work force by determining skills requirements for the adoption of 4.0 technologies and method to attract talented workers.

- Work with local state/government to develop new financial/incentive tools to increase innovation capacities in naval companies. For instance, a government-industry partnership to support the adoption of 4.0 technologies through awareness raising and sponsorship initiatives.

6. Diagnosis per region of the Atlantic Area

PORTUGAL

Naval sector context and challenges in Portugal:

Sectorial: The Portuguese Shipbuilding and Ship Repair sector is very small comparing with other sectors. It is mainly formed by small shipyards (less than 10 workers). Comparing with other industries shipbuilding is characterized by being highly personalised and short production series. This contributes to the lack of automated production means; most technical tasks (welding, pipework etc.) are manually accomplished.

Economical: The Portuguese Shipbuilding and ship Repair sector suffered with the collapse with the financial crises of 2008. The turnover dropped 64 % between 2008 and 2011. Presently is growing at a fast pace. Between 2011 and 2016, the turnover increased 66 %. The competition is high and is increasing every day.

Social: The Portuguese Shipbuilding and Ship repair sector struggles to attract people to the industry, mainly with high added value competencies. Manual work is not attractive to younger generation. The adoption of 4.0 technologies implies new competencies that need to be anticipated.

Technological: The Portuguese Shipbuilding and Ship repair sector did not anticipate future evolution, as did the aerospace or automotive sectors for instance. 4.0 technologies were not adopted, creating a gap with the European industry that already did ther own advanced production tools.
The Portuguese Shipbuilding and Ship repair sector is not prepared to use the technologies 4.0. It was recognised in the meeting with industry representatives, the need of identifying smart solutions of low cost, easily customized and friendly.
One of the common challenges identified is the need to harmonise digital solution use for more integration, currently impeded by the large diversity of software used in the naval sector.

Competition: The Portuguese Shipbuilding industry has the main competitors in the European shipyards with high technological value. The major competition in the Ship repair sector is on European yards with very low production costs, such as, Turkey ship repair industry.

Portugal approach of 4.0 transformation

The Portuguese approach for Industry 4.0 was led by the Ministry of Economy.
Through the Industry 4.0 initiative, integrated into the National Strategy for the Digitalization of the Economy, the Ministry of Economy intends to create favorable conditions for the development of the national industry and services in the new paradigm of the Digital Economy, through a set of measures based on 3 axes of action:

1. Accelerate the adoption of i4.0 by the Portuguese industry. Provide the industry with knowledge and information and promote a set of tools that facilitate business transformation.
2. Promote Portuguese technological suppliers as players i4.0. Capitalize the scientific and technological ecosystem, creating a favourable context for the development of i4.0 startups that can present projects with impact on the digitalization of the economy.
3. Making Portugal an attractive hub for investment in i4.0. Communicate Portugal as a HUB to share experiences and know-how to attract resources, creating favorable conditions (legal and fiscal) for investment directed to i4.0.

The initiative was launched in a bottom-up principle associated with the participation of companies operating in the market, and a hearing space was added to several non-corporate entities, as well as a strategic committee, which included some international entities with proven experience in Industry 4.0, which guided and supervised the results.

4.0 technologies in Portuguese naval industries:

The existing technologies and competencies in the Naval Construction, Maintenance and Repair (CM & RN) industry have not changed significantly in the last decades and there are no human resources dedicated to innovation or continuous improvement of knowledge and innovation.
The European shipyards that are part of large business groups, see STX, Naval Group, Damen Shipyards, have already begun to adapt to Industries 4.0, which will allow all the yards in which they participate, greater productivity and consequently competitiveness.
The gap of skills between Portuguese shipyards and those shipyards tends to increase with a consequent loss of market by Portuguese shipyards.
The survey carried out on the field and a meeting with the representatives of the main Portuguese Shipbuilding and Ship Repair yards, service providers to the shipyards and a supplier of intelligent technologies allowed to draw the following conclusions:

- The Portuguese CM & RN shipyards are not yet ready to assimilate the technologies that constitute Industry 4.0;
- In the short term, intelligent, cost-effective, user-friendly and user-friendly solutions for productivity and security enhancements need to be found **without the need for long periods of training, new skills or significant organizational changes.**
- It is necessary to internalize a culture of innovation, step by step, facilitating adaptation to digital transformation.

The comparison of questionnaires received from Portuguese industries confirmed that the “Engineering and conception industries” and “production and maintenance activities” should be differentiated regarding the level of adoption of 4.0 technologies as well as the level of interest.

Level of adoption of technologies 4.0		
Engineering & conception	Level of interest	Prodution & maintenance
1	0 - No interest	11
3	1 - Some experiments	4
6	2 - Partially deployed	2
2	3 - Largely deployed	0

The largest differences identified for the common technologies to the Production and Engineering industries questionnaires were in PLM Tool (product lifecycle management) and digital mock-up.

Drivers and barriers towards the adoption of 4.0 technologies:

- *What are the drivers of the implementation of 4.0 techno in the industries?*
    - International competition;
    - Reduce prices and delivery time in the long run, to remain in the market.
    - To satisfy specific needs of clients;
    - To interact with external entities;
    - To increase safety, efficiency and quality.

- *What are the barriers to the implementation of 4.0 techno in the industries?*
    - Personalised and short series production
    - Lack of automated production process
    - Lack of critical gain from the adoption of expensive 4.0 technologies
    - Investment vs return of investment
    - Unawareness of the potential of involved technologies
    - Use of non-standard documentation
    - Low level of knowledge of employees

- *Suggestions for the adoption of 4.0 technologies (strategic actions)?*
    - Mobilisation of various actors for a common reflexion on the sector
    - Raising SMEs awareness to operational and strategic challenges linked to digital transformation
    - Foster companies' cluster structuration and replication of digital projects
    - Share design means (shared platform for digital twin)

- Integration of internal processes (planning, purchasing, accounting, etc.)
- Integrated Logistic Support (ALI) - Configuration management, maintenance management, documentation management, training and after-sales services, etc.
- Optimization of manufacturing processes
- Information sharing between national shipyards
- Internal audit of areas with potential benefits
- Pilot experiences
- Visits to companies that have already implemented the methodologies

- *Do you have any stand out example of success stories of a successful implementation of 4.0 technologies in naval industries?*

  - Integration (partial) of internal processes
  - Integrated Logistics Support (ALI)
    [obs: Applied to the shipbuilding of Navy vessels]

SPAIN - Galicia

Naval sector context and challenges in Spain

Sectorial: The Galician naval sector is characterised for the great effort made in the last decades to reindustrialise itself, adjusting its capacity to the market needs, and developing a supply industry where the shipyards can externalise part of their activity. Therefore, naval sector in Galicia has become an industry of synthesis where the shipyards are now like assembling plants where the hull and the basic structures are made, and were the rest of ship components are integrated, provided by the suppliers.

Economical: with a small number of relevant shipyards (10 in Galicia), which production is mainly for export (90% approx.) and a high number of suppliers (more than 200). Because of this, it´s one of the more significant sectors in Galicia, representing around 3 % of its regional GNP. To really understand the whole picture of the naval sector in Galicia, we need to bear in mind that the supplier´s industry is totally fragmented.

Social: The Galician naval sector struggles to attract high added value competencies and therefore can lack skills. The average age in the industry workforce is high and skilled in complex manual tasks, and manual work is not attractive to younger generation, and has no technical competencies to adopt 4.0 technologies nowadays. An effort in the acquisition of these competencies and technologies needs to be made.

Technological: The Galician naval sector is mainly formed by 9 middle/small size shipyards and approximately 200 suppliers, mostly SMEs has a limited investment ability which inhibits the access to new technologies that will permit the increase of sector productivity. This lack of investment also explains the lower of participation in R+D projects. In most cases, the executive level is also not trained to face the challenges associated with the implementation of 4.0 technologies.

Competition:

- Technified ships: European competitors.
- Non-technified ships: Asian and European market competitors
- Internal market.

National approach of 4.0

There is a national approach in Industry 4.0 at national level, led by the Minister of Economy, Industry, and Competitiveness which has launched an initiative called Connected Industry 4., in order to stimulate the digital transformation of Spanish industry by a joined coordinated action from both private and public sectors. This initiative is aligned with two previous national actions: the Digital Agenda and the Agenda to strengthen Spanish industrial sector from 2014.

Apart from these national initiatives, there is a line of specific regional initiatives, led in Galicia by the IGAPE (Galician Institute for Economic Development), to foster the implementation of Industry 4.0 in the region. One of this was the creation of a specific agenda "Competitiveness Agenda Galicia Industry 4.0" in 2015.

In early 2018, IGAPE with the collaboration of the main R&D centres of Galicia (ATIGA Alliance) has developed a more detailed study of the strategic sectors in Galicia in terms of Industry 4.0 opportunities. In these studies, classifies the emerging technologies 4.0 in three categories:
1. Materials and intelligent manufacture:

- Automation, Advance and collaborative robotics
- Human-Machine Interaction
- Additive Manufacturing
- Intelligent Material Technology
- Sustainable Manufacturing

2. Connectivity and Data Analytics

- Cyberphysical systems and IoT
- Big Data, Cloud Computing and Data Analytics
- Safety and Security

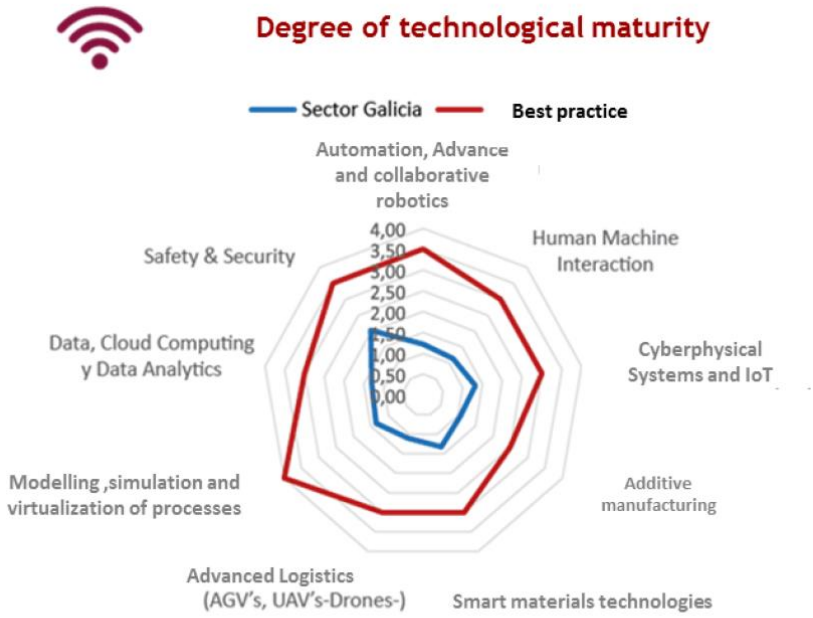
3. Production Management

- Advance Logistics
- Modelling, Simulation and Process Virtualization

4.0 technologies in national shipbuilding industries:

According to the report made by IGAPE with the collaboration of the main R&D centres of Galicia (ATIGA Alliance) "Oportunidades Industria 4.0 in Galicia" and published in March 2018.

In this study 40 companies of the naval sector were interviewed regarding several Industry 4.0 topics.



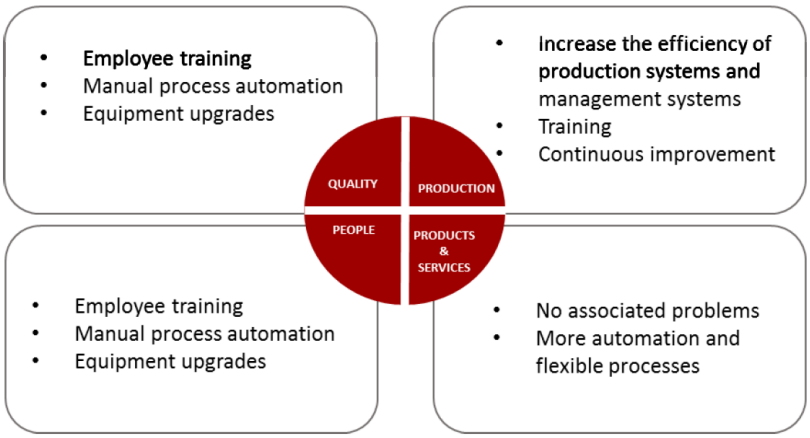
And the results showed that, in general, the naval sector is very far from Industry 4.0, and except in the case of specific companies, the degree of maturity of the companies is very incipient.
One of the findings of the study was that the level of leadership in 4.0 technologies was still very low. Around 7% of the companies said they are leaders in emerging technologies, 12.5% of the companies said that they are in an intermediate level and 80.5% of the companies are considered less advanced than Industry 4.0. 45% of the companies of the sector interviewed have not carried out any action aimed at Industry 4.0 and are considered in Phase 0.

If we consider the forecasts for the implementation of these technologies in companies of the sector, we can see in the following graph that in none of the cases is higher than 25%, clearly showing that this is one of the sectors where there are more barriers to the implementation of these technologies, due to the lack of knowledge about them and their expected return, as well as the financing needs.

Forecast of 4.0 technology implementation	
Safety and Security	23%
Human-Machine Interaction	18%
Additive Manufacturing	15%
Big Data, Cloud Computing and Data Analytics	15%
Automation, Advance and collaborative robotics	10%
Cyberphysical systems and IoT	10%
Modelling, Simulation and Process Virtualization	10%
Smart Material Technologies	8%
Advanced Logistics	3%

If we consider the opportunities for improvement that companies consider by elements that generate value in 4 main areas: Quality, Production, People and Products and Services:

Opportunities for improvement



In Galicia, ACLUNAGA has carried out a study of the degree of maturity of some critical technologies in the naval sector, focusing on 5 main lines of research:

- Straightening and forming of parts
- Cutting and joining technologies
- Surface treatments
- Study of materials
- Design and construction

The following diagnostic table shows the following: all of them according to their degree of maturity:

RESEARCH LINE	CRITICAL TECHNOLOGIES	LEVEL OF MATURITY
Straightening and Forming of Parts	Straightening and induction forming	In Development
	Laser forming	Emerging
	Non-contact 3D dimensional control	In Development
	Automatic forming by means of heating lines	In Development
	Pipe bending	Mature

RESEARCH LINE	CRITICAL TECHNOLOGIES	LEVEL OF MATURITY
Superficial Treatment	Introduction of mobile and flexible painting equipment	In Development
	Systems for the collection of paint residues	In Development
	Organic coatings and paints	In Development
	Metallization and Galvanic Coatings	Mature
	Hydrophobic coatings	Mature
	HVOF projection coatings	Emerging
	Anti-fouling coatings with low environmental impact. Live shot	In Development
	Introduction of mobile and flexible painting equipment	In Development
Joining and Cutting Technologies	Laser-MAG hybrid welding	Mature
	Repair with composite patches	In Development
	Steel/composite solutions (lightweight reinforcements)	In Development
	New fire-resistant composites	In Development
	Union of dissimilar materials	In Development
	Adhesive bonding	Matured in small vessels and composite, emerging or developing shipyards and shipyards
	Repair Resins	composite shipyards, emergent or
	Welding by FSW	under development in steel shipyards
	Automated pipe cutting	Under Development-Mature for some naval applications
	Advanced arc welding processes with high productivity	Emerging in steel vessels/under development in aluminum vessels
	Repair of high value components added by laser-cladding.	Mature
	Robotization of welding and cutting operations on non-serial parts	In Development
	Numerical simulation	In Development

RESEARCH LINE	CRITICAL TECHNOLOGIES	LEVEL OF MATURITY
Study of materials	Integration of life cycle analysis into the conception and design of maritime works	In Development
	Composites for shipbuilding	In Development
	Nanocomposites for shipbuilding	Emerging
	Shielding materials	In Development
	HSLA Steels	In Development
	Numerical simulation	In Development
	Multi-material and hybrid structures	In Development
	Aluminum alloys	Mature
	Structural foams	In Development
	Automated Modular Construction in small boats of small length	In Development

SPAIN- Basque Country

Naval national sector context and challenges in Basque Country

The Spanish shipbuilding sector is almost exclusively devoted to exports. It has an excellent international reputation due to its construction quality and tradition, and guarantees high standards in highly technologically sophisticated ships such as those which provide support to offshore oil rigs, oceanographic research vessels, factory ships, etc.

The sector is primarily made up of medium-sized enterprises of recognised standing, many of them family companies which have established themselves generation after generation and directly and indirectly provide work for 87,000 families. Shipbuilding activity in Spain is concentrated in the industrial areas of Galicia, Asturias and the Basque Country, but it also has an impact on companies and families all over Spain.

The shipbuilding sector has proven its ability to create short-term employment and it is the engine of ancillary industry.

Spanish shipyards set the global standard in shipbuilding and are at the forefront of technological progress.

Innovation: Technology and R&D&I are the calling card of private Spanish shipyards. Over the last seven years, the sector has invested more than €428 million in innovation, making it competitive enough to face up to the most demanding challenges.

Spain specialises in advanced ships, with technical requirements which other competing countries are not able to provide. Niche markets such as offshore ships or oceanographic research vessels require a high level of technology. In these markets, the shipyards' technological capacity wins out over the financial advantages and cheap labour costs offered by other countries.

4.0 REGIONAL APPROACH

Basque Industry 4.0 is a move towards the incorporation of intelligent systems into production plants, the improved use of emerging capabilities and technologies in new products and processes, the integration of advanced materials into higher added-value solutions and improved processes, and the efficiency and sustainability of resources and integration of high added-value services.
In recent years, the Basque Government has defined its RIS3 Smart Specialisation Strategy which marks, among other elements, areas of productive specialisation within the industrial network and technological capabilities of the Basque Country. One of these areas is Advanced Manufacturing, and as a result the Basque Government has developed a specific strategy, Basque Industry 4.0.

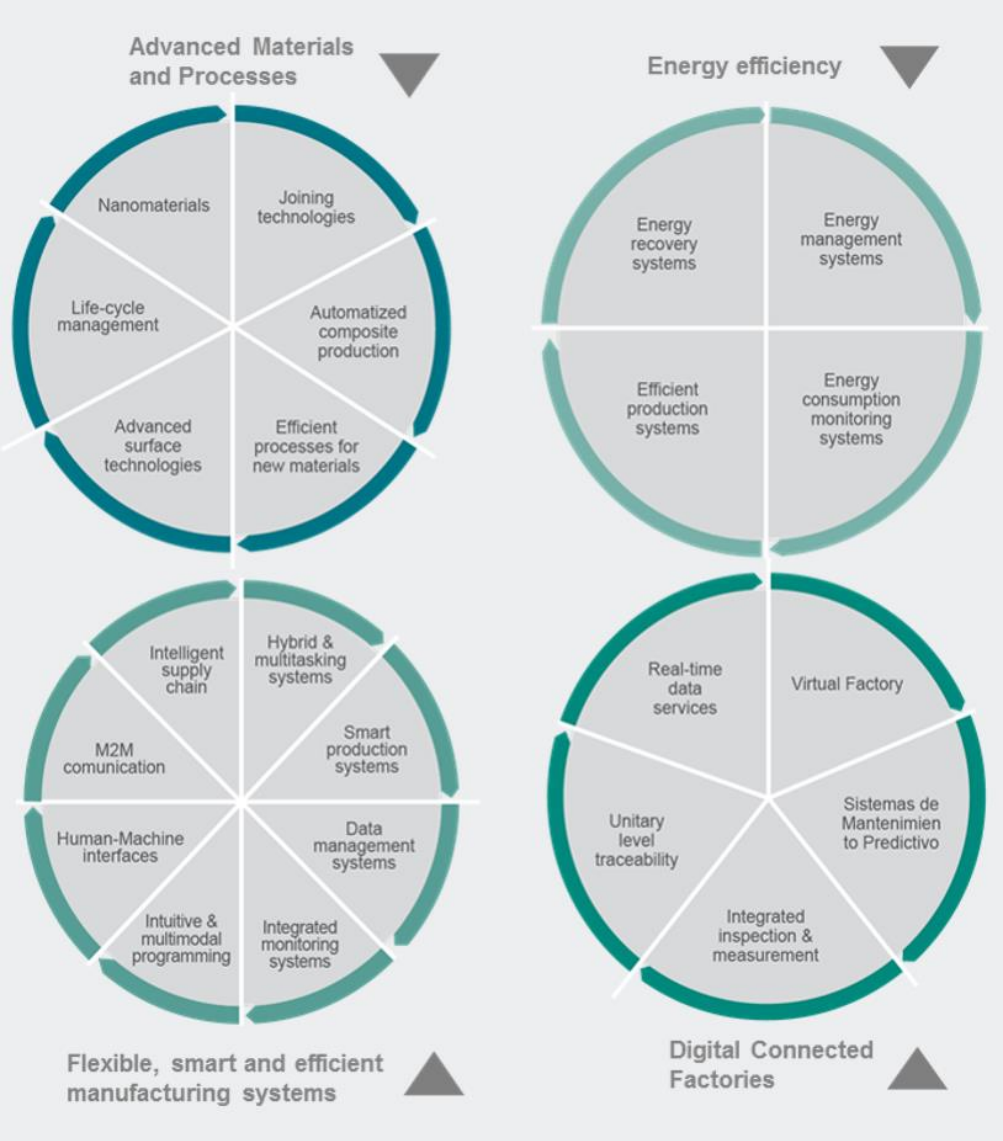
The construction of a territorial strategy requires not only scientific and technological knowledge, but also knowledge of markets and entrepreneurial skills. In short, this territorial strategy is the result of a

participatory process which includes local government, the business community, the world of academia and know-how, and civil society. This is how the Advanced Manufacturing Strategy has been built, to promote the positioning and leadership of the Basque Country as an industry-based economy, using the momentum of knowledge-intensive manufacturing.

The priority of this strategy is to contribute to the creation of new products, the incorporation of new materials and the improvement of manufacturing processes in specialised sectors.

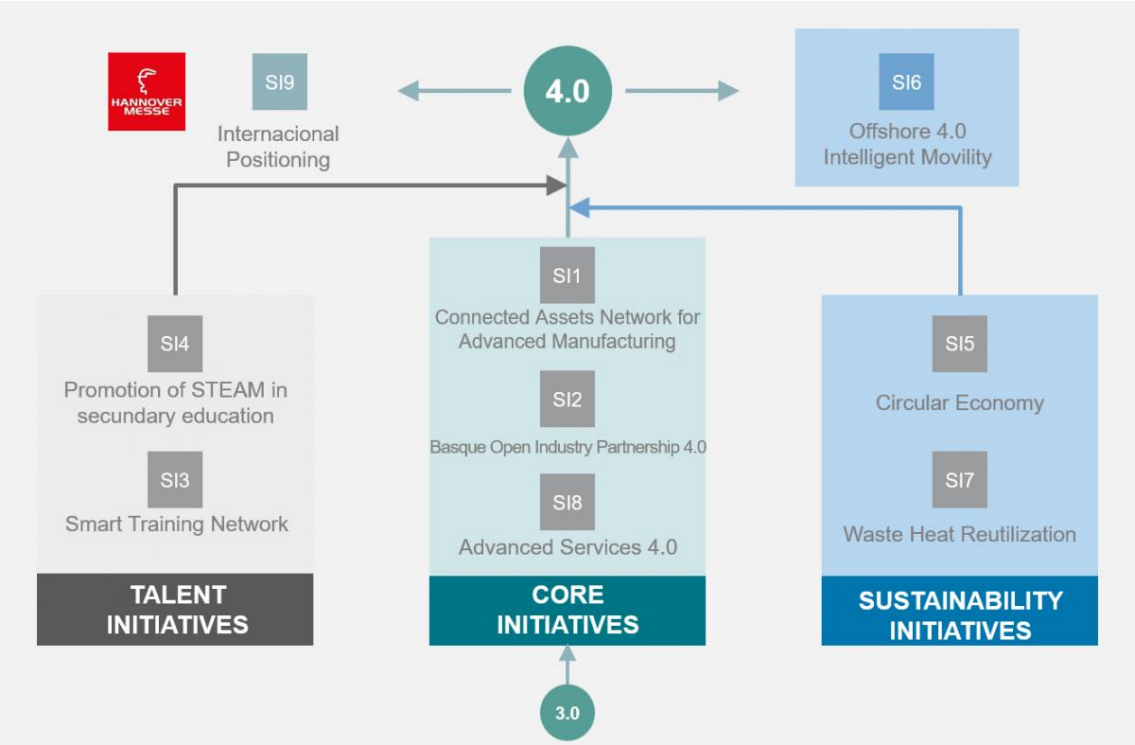
The implementation of the Advanced Manufacturing Strategy is being carried out through a space for public-private partnership called the “Basque Industry 4.0” Advanced Manufacturing Pilot Group, which was launched in June 2015.

During the first year of the Pilot Group established to implement the “Basque Industry 4.0” Advanced Manufacturing Strategy, the public-private Working Group, composed of clusters and technological actors, it analysed and prioritised the technological requirements of each sector. The number of sectors consulted to perform the analysis represents approximately 60% of the Basque manufacturing industry. From these requirements, those with a greater industrial and multisectoral impact were identified, 4 technological areas, broken down into 23 key technologies, with the Basque strategy favouring the 10 with the highest demand and the greatest industrial priority.



STRATEGIC INItIATIVES

Nine Strategic Initiatives have been identified that are capable of transitioning the Basque industrial framework into “Industry 4.0”:



SI1: Connected Assets Network for Advanced Manufacturing

The aim is to create a "distributed and connected factory" structure as a platform for launching Pilot Project (PP) initiatives, with the involvement of Industry, Research Centres and the University.

SI2: Basque Open Industry Partnership

Its aim is to build an environment/platform based on Open Collaborative Innovation, making us a leading industrial region whose economic structure is mostly formed by SMEs.

SI3: Smart Training Network

“Vocational Training Hubs, Lehia 4.0” is a measure aimed at specialising vocational training students to meet the priorities of the Advanced Manufacturing Strategy

SI4: Promotion of STEAM in secondary education

STEAM (Science, Technology, Engineering, Arts and Maths) is a learning model based on the integrated teaching of these 5 disciplines with an interdisciplinary and applied approach to promote an interest in scientific and technological careers at an early age.

SI5: Circular Economy

This consists of establishing and implementing business, management and technology models that allow us to move towards a circular socioeconomic model, where the development of advanced manufacturing in the Basque Country is not linked to the consumption of resources.

SI6: Offshore 4.0

Consolidating the technological and commercial positioning of Basque companies in markets that demand high quality and reliability at competitive costs, e.g. “oil & gas” and renewable energies in offshore environments, by building a product testing and validation infrastructure for the offshore environment located in the BIMEP.

SI7: Waste Heat Reutilization

Aimed at helping to ensure a more energy-efficient industry by using the residual heat from manufacturing processes.

SI8: Advanced Services 4.0

Its aim is to develop strategic projects (advanced hardware, software platform, business models and demonstrators) that enable these advanced services to be created, visibly and measurably reflected both in the laboratory and in the companies that initially implement them.

SI9: International Positioning

Its aim is to help to make Basque industry more competitive compared to other global industries.

BIND 4.0. Basque Acceleration Programme

Bind 4.0 is a public-private acceleration programme takes place in the Basque Country. The collaborating companies can take on new talent and technology by selecting and contracting startups in the field of Industry 4.0 that are in their early stages and that meet the profile defined by the company.

Startups have the opportunity to obtain a real contract with a related industrial company in Industry 4.0

Drivers an barriers towards the adoption of 4.0 technologies

IRELAND

Naval national sector context and challenges in Ireland

Sectorial: Companies involved in the marine manufacturing sector in Ireland are located throughout the island but small clusters can be found in coastal areas of Donegal, Galway & Cork. Altough small the sector provides a vital source of employment in remote coastal communities.

Economical: Total GVA generated in 2014 was €65 million. Turnover decreased between 2012 -2014 by 39% with a 98% increase in GVA in the same period. This suggests an increase in efficiency within the sector.

Social: The Irish navel sector consisting almost entirely of SMEs many of which are located in remote coastal communities, struggles to attract skilled labour due to the 'brain drain' often associated with remote communities. Young people move to urban areas to access third level education and the majority of these people do not return.

Technological: The Irish government produced integreated marine plan 'Harnessing Our Ocean Wealth' produced in 2012 sets out actions in several key areas including infrastructure and research, knowledge & technological innovation. However within these sections very little attention is devoted to the naval sector other than recognition of its socio economic importance to rural & coastal communities. At present the sector is predominantly traditional – with the levels of technological innovation and R&D diffusion being tied to the goals of companies and their openness to innovation. Some firms are showing examples of best in class technologies which are the envy of Europe. This makes these firms extremely competitive. Examples include SeaQuest Fish Pumps which are regarded as the best pumps on the market for the delivery of catch and EireComposites who currently supply Airbus but due to the lightweight nature of composites are seeking to enter the ship building market.

Competition: The main competitors of companies operating in the naval sector in Ireland are in Asia. There are opportunities however to develop economic activity in the area of super yacht design & construction since firms in Ireland have access to highly trained talent which is not available in Asia. A real opportunity exists to carve out this niche market for Europe. Another element of future importance is Safe Green Ship Recycling – legislation is going to change regarding recycling and make manufacturers more responsible for the entire life cycle of a ship. This legislation may transition the current use of Asia as the place of choice for this work to more reliable areas of the globe with safety policies in place etc.

Existence of national approach dedicated to 4.0? Which national definition of 4.0?

Ireland is considered a front runner in the Rolan Berger (2015) Industry 4.0 Readiness Index. This was calculated by measuring Industrial excellence & combining with value network. Industrial excellence was calculated by evaluating process sophistication, degree of automation, workforce readiness, and

innovation intensity. Value network was calculated by evaluating high value added, industry openness, innovation network and internet sophistication. There is no data available however specifically on the naval sector in this regard.

IBEC – Ireland's Business & Employers' Confederation is Ireland's largest lobby group. It lobbies government, policy makers and other key stakeholders nationally and internationally to shape business conditions and drive economic growth. Their Manufacturing Ireland Strategy aims to drive Ireland's reputation in advanced manufacturing focuses on 4 key pillars: Maufacturing for competitiveness, Partnering for future growth, skills for the 21st century workforce & factory of the future.

1. Manufacturing for Competitiveness (research and innovation, better regulation, utility costs, funding & investment, regional development, extending global reach.)
2. Partnering for future growth (partnering for collaboration, lean manufacturing.)
3. Skills for the 21st Century (Education, trainng & funding for tomorrow, promoting STEM)
4. Factory of the future (Technology & Security)

The Marine Institute's National Marine Research & Innovation Strategy 2017 -2021 was identified as a key enabling action in the Ireland's integrated marine plan 'Harnessing Our Ocean Wealth'. It provides a framework for research funders to assess the impact and likely return to the state from research investment in marine related research themes. It identifies advanced technologies as one of its key research themes. It recommends that the key focus for funding in this area should be on:

1. Supporting and incentivising collaborative research between ICT and marine-focused research centres, including effective and sustainable interinstitutional research collaborations.
2. Establishing a research programme of scale in Ireland in the Marine ICT field, which will attract international interest from researchers and industry to utilise Ireland's research infrastructures for joint marine and ICT research.
3. Centre the research programme on a world-leading research infrastructure that can provide Ireland with a competitive advantage to secure further international investment, for example in maritime surveillance or ocean observation systems.
4. Developing active partnerships and collaborations with industry.

Drivers and barriers towards the adoption of 4.0 Technologies

- ***What are the drivers of the implementation of 4.0 techno in the industries?***
  - International competition pushes companies to increase the added value of their product
  - through new technologies and services.
  - Companies continually seek greater efficiency & cost reduction and drive for increasing profits

- Businesses need to keep innovating to ensure their competitive advantage, sustainability & growth
- Companies need to meet the customer expectation of always on, instant availability, high quality, environmentally friendly, intelligent products

- ***What are the barriers of the implementation of 4.0 techno in the industries?***
  - Lack of digital culture and training amongst staff within the organisations
  - Legacy IT systems in need of overhaul and upgrading within companies
  - Difficulty in attracting digital native employees to remote coastal locations
  - Uncertainty around issues relatin to cyber security with increasing digitisation
  - High financial investment requirements
  - Uncertainty with regard to cost/benefit ratio
  - Lack of a clear digital operations vusion and leadership from top management
  - Business partners unable to collaboratate around digital solutions – diverse levels and digital abilities and adoption between companies along the supply chain
  - Concerns over loss of control over a company's intellectual property
  - Lack of digital standards, norms and certification.

- ***Suggestions for the adoption of 4.0 technologies (strategic actions):***
  - Provide formal cluster organisation type support for SMEs in the naval sector. This is particularly important for this sector in particular in Ireland given the size, structure and location of the naval sector (smaller companies, located in rural coastal locations). The development of formal cluster support can help these SMEs to overcome the barriers they face as a result and build the contribution of these sector to Irelands socio economic wellbeing.
  - Development of Industry 4.0 training & support programme for SMEs in naval sector to include
  - Facilitate the development of a shared Naval 4.0 visions for SMEs in this sector so everyone is working towards a shared goal capable of enabling efficient interaction along the supply chain
  - Determine skills requirements and methods to attain these
  - Use collaborative pilot projects to test proof of concept
  - Grow connections, collaboration and integration with naval clusters outside of Ireland

Do you have any stand out example or success stories of a successful implementation of 4.0 technologies in naval industries?

ÉireComposites are currently active in the aerospace, renewables, services & R&D space. They have some of the most advanced equipment in composite processing. They are currently exploring the shipbuilding and ship-repair sector through their SEABOAT initiative. The SEABOA concept will tackle inherent issues in the recreational boat manufacturing industry, with a particular focus on addressing outdated, inefficient, costly and environmentally inferior hull manufacturing processes that will not meet new legislation. SEABOAT will deliver significant positive impacts in terms of industry/EU competitiveness, scalable company growth in revenue & jobs and a wide array of performance & environmental benefits.

This will be achieved by commercialisation of the Composite Powder Epoxy Technology (C-PET) manufacturing process within the recreational boat manufacturing segment and by introducting a revolutionary E-Boat design incorporating the CPET manufactured hull into the market.

Due to the lightweight nature of its composites, its adoption of new technologies and experience in R&D, they are seeking to address the following objectives:

- Reduce the cost of boat hull manufacturing by 30%.
- Reduce the weight of boat hulls by 45%.
- Manufacture 8m boat hull using manufacturing technology that avoids the emission of harmful VOC's.
- Demonstrate that boats can be powered from clean, renewable electricity instead of fuel-powered internal combustion engines thereby eliminating the use of hydrocarbon-based fuels, which will massively reduce the carbon footprint and pollution from boat operations.

UNITED KINGDOM

Naval national sector context and challenges in the UK

Sectorial: The UK has a great maritime history and today boasts the largest maritime sector in Europe. UK's expertise in maritime systems, equipment, design, manufacturing, engineering and naval architecture is recognised internationally.

The UK is the fourth largest shipbuilder in Europe and the third largest in boatbuilding. This important sector directly employs nearly 90,000 people across the UK. It is a sector that is thriving, with plans to grow even stronger in the years ahead, building on competitive strengths that have been developed over many years.

The industry spans six subsectors that include: ship building and repairs; marine equipment; marine renewable energy servicing; leisure and small commercial; marine science; and marine consultancy.

Economical: The UK's marine sector is an important part of the economy with £19billion gross value-added contribution to GDP and employing over 360,000 people*, many of them in highly skilled roles. The UK is a high wage economy and so is outpriced by low wage economies (For instance BRIC economies)

The UK's position as a provider to global customers is enhanced by having time zone where the business day overlaps with the Americas, Europe and Asia.

UK is a major exporter on:

- Marine equipment – 4th in Europe.
- Repairs and refit –6th in Europe
- Superyacht manufacture - 2 shipyards in the global top 5

However, there is an uncertainty on the market due to Brexit.

Social: Government and industry are committed to investing in the next generation of maritime professionals, and capitalising on every opportunity the market provides, by building capacity and taking an innovative approach to training, for roles at sea and ashore. The UK recognises the importance of transferable skills and the essential role seafarers play when they return from sea to shore-based.

Technological: UK anticipated its future evolution in the 'Uk marine industry technology Roadmap 2015'. The roadmap was defined at 2015 as a result of five one-day workshops to assist the UK Marine Industries Alliance to identify the priorities of the industry, the key opportunities in which industry and govermeent should invest and map the key technical capabilitities that need to be developed.
Numerous technologies mentioned in the report can be classified as industry 4.0 technologies. According with the roadmap the industry aims to :

- work closely with a number of organisations including the Knowledge Transfer Network to engage further with adjacent sectors, maritime industries and regulators to facilitate the cross-fertilisation of technology
- collaborate on programs with aerospace and automotive industries on common themes including manufacturing techniques and use of composites
- engage with the standards and regulatory bodies to accelerate acceptance and adoption of innovation that underpins the UK Marine Industries Technology Roadmap

Competition: The European yards are the mayor competitors. In the leisure sector, the main competitor is Germany.

4.0 national approach

The Made Smarter Review (previously referred to as the Industrial Digitalisation review),which was announced by UK government in the Industrial Strategy Green Paper in January 2017 defines Industrial degitalisation as the application of digital tools and technologies to the value chains of businesses who make things (e.g. in the automotive and construction industries) or are otherwise operationally asset intensive (e.g. power grids and wind farms). These technologies enable the physical and digital worlds to be merged, and can bring significant enhancements to performance and productivity.
Within the key technologies identified are the following:

- Robotics and process control automation
- Industrial Internet of Things
- Additive manufacturing e.g. 3D printing
- Augmented and Virtual Reality
- Simulation
- Data and systems integration
- Big data and analytics
- Industrial security
- Cognitive computing and artificial intelligence
- Mobility and wereables
- Cloud based platforms

Drivers and barriers towards the adoption of 4.0 Technologies

- ***What are the drivers of the implementation of 4.0 techno in the industries?***
  - International competition pushes companies to increase the added value of their product through new technologies and services.
  - Better integration of the vertical and horizontal value chains. Operational opportunity.
  - Economical drivers

- Enhance safety and increase realibility
- Regulation

- ***What are the barriers of the implementation of 4.0 techno in the industries?***
  - Lack of automated production process
  - SMEs: Lack of critical gain from the adoption of expensive 4.0 technologies such as robotics
  - Current workforce qualifications represents a barrier in terms of employee acceptance – fear and concerns due to lack of expertise on the technologies suggested by Industry 4.0 paradigms.
  - Implementation of I4.0 technologies into existing hierarchies is complex
  - Very low digitalisation of the industry conflicts with i4.0 paradigms (digitally based)
  - The conservatism of the marine sector and its peculiarities
  - The fragmentation of the sector, with some small companies under the umbrella of big players
  - Investment coming from private funding (shipowners) and not enough financial initiatives from goverment
  - Personalised and short series production

- **Suggestions for the adoption of 4.0 technologies (strategic actions):**
  - Mobilisation of various actors for a common reflexion on the sector
  - Raising SMEs awareness to operational and strategic challenges linked to digital transformation
  - Foster companies' cluster structuration and replication of digital projects
  - Share design means (shared platform for digital twin)
  - Centre of excellence to support clusters
  - Government-industry partnerships to support the adoption through marketing (awareness) and sponsorship of initiatives.
  - Single, industry-wide body for Industry 4.0 to unify and develop an Industry 4.0 strategy for the sector in terms of skills, technology and governance.
  - Introducing I4.0 paradigms maritime examples into primary

Do you have any stand out example or success stories of a successful implementation of 4.0 technologies in naval industries?
Strathclyde project with Rolls Royce in Autonomous vessels

- ***Free comments:***

The current focus of experimentation and implementation by companies is on energy efficiency and alternative fuels such as energy monitoring devices and engine hybridization. This reflects in the latest list of gov funded innovation projects

Other comments:

(1) Through our detailed research, two contrasting figures were highlighted for the number of people the marine industry employees in the United Kingdom. In "A Strategy for growth for the UK Marine Industries – UK Marine Industries Alliance" the figure of 90,000 is suggested, in contrast to this "UK Marine World Class Capability – UK Marine Industries Alliance" suggest a figure of greater than 360,000. The discrepancy between these two figures can be put down to people who are directly employed and indirectly employed within Marine Industry.

FRANCE – Brittany & Pays de la Loire

Naval national sector context and challenges in France

Sectorial: The French naval sector can be distinguished from other main French industrial sectors because of highly personalised and short production series. This explains the lack of automated production means; most technical tasks (welding, pipework etc.) are manually accomplished.

Economical: Naval industries produce complex products with high added value in a strongly competitive world. Sales prices are increasingly low and market delays are shortened.

Social: The French naval sector struggles to attract high added value competencies and therefor can lack skills. Manual work is not attractive to younger generation. The adoption of 4.0 technologies implies new competencies that need to be anticipated.

Technological: The French naval sector has not anticipated future evolution, as did the aerospace or automotive sectors for instance. 4.0 technologies are partially adopted through the value chain, creating a division between advanced companies (STX, Naval Group, H2X etc.) that own advanced production tools and the rest of the value chain.
This diversity of 4.0 technologies integration amongst the value chain creates difficulties to collaborate in-between companies.
One of the common challenges identified is the need to harmonise digital solution use for more integration, currently impeded by the large diversity of software used in the naval sector.

- *An important contrast exists between the "majors" indicated above (in particular Naval Group, STX ...) and the SME who took the part of a commitment in a step of development, this one being certainly on levels less important in terms of innovation, but the tools currently used and in a more and more systematic way undeniably contribute to securing the axes of diversification.*
- *The use of augmented virtual reality tools, as well as the more frequent use of 3D printer, allows this typology of companies to position themselves in markets with higher added value.*

Competition: The two major competitors for French yards are European

4.0 national approach

- ***Existence of national approach dedicated to 4.0? Which national definition of 4.0?***

The French alliance for Factory of the Future (Alliance pour l'industrie du future) is dedicated to industry 4.0 and has detailed its vision of industry 4.0 in 6 pillars:

1. Internet of things and industrial internet (sensors, data management, cyber security, RFID, big data etc.)

2. Advanced production technologies (high added value and eco-friendly process and material, highly functional steel, bio sourced materials, additive manufacturing, clean and energy efficient process, robotics, multi-functional machine, etc.)
3. New approach of Human at work, innovative management and organisation (zero-paper technologies, process optimisation, mobile application etc.)
4. Online factories and connected, piloted and optimised blocks (break free from siloed structure, simulation and modelling, 3D prototyping etc.)
5. Integrated customers/suppliers relationship (network through the value chain integrated conception, automated supply chain flow, etc.)
6. New economical and societal model, strategy and alliances (marketing break-through, investment capacity, technological alliances, internationalisation, agile companies, etc.).

With regards to naval sector, EMC2 is currently responsible for the development of a new roadmap for the naval sector competitiveness called “Smart Yard”, in collaboration with the Orientation council for research and Innovation in construction and naval activities (CORICAN).

With regard to the development of IN 4.0 industries, BPN is leading a working group within the NAVAL cluster aiming at the implementation of a model called "INDUSTRIAL RENEWAL", the latter having the infrastructure as a guide. multi modal port "allowing to develop a naval and maritime industry" proper and eco-friendly "

Drivers and barriers towards the adoption of 4.0 Technologies

- ***What are the drivers of the implementation of 4.0 techno in the industries?***
  - International competition pushes companies to increase the added value of their product through new technologies and services.

- ***What are the barriers of the implementation of 4.0 techno in the industries?***
  - Personalised and short series production
  - Lack of automated production process
  - SMEs: Lack of critical gain from the adoption of expensive 4.0 technologies such as robotics
  - *lack of "interface" staff between engineering and production to deploy and apply the digital models especially in production*
  - *skills in work preparation and flow management are insufficient in companies for an economical application of an innovative model*

- ***Suggestions for the adoption of 4.0 technologies (strategic actions):***

- Raising SMEs awareness to operational and strategic challenges linked to digital transformation
- Foster companies' cluster structuration and replication of digital projects
- Share design means (shared platform for digital twin)
- *Involve SME very upstream by demonstrating by simple and competitive proposals the interest they would have to integrate IN 4.0 in their industry*
- Mobilisation of various actors for a common reflexion on the sector

Do you have any stand out example or success stories of a successful implementation of 4.0 technologies in naval industries?

The development of the SHELTI BREIZH brand, in particular through the BPN RA "marketing" application, this brand concept which allowed to create groups of companies pooling their competence and with a goal , that to produce Innovative containers "navalized and offshore

7. ANNEXES

Annexe 1: Template distributed to all partners to gather information from each country

NAVAL 4.0

WP 4.1 State of the Art

WP 4.1 Objective: "Validate in all the regions the previous studies about the current situation of the companies of the naval sector in the countries and regions of AA, analysing aspects such as the degree of innovation or factors that causes a loss of competitiveness in the sector".

- *Objective of this template: collect all the information regarding 4.0 technologies with regards to the naval sector in your regions of the Atlantic Area.*

- *Reminder: please provide a **first version by the end of March**; do not hesitate to contact me for any question.*

- *Guidelines for completion of the template:*
  - *This template has to be filled in with information from your country (thanks to existing literature and national studies), please identify the scope of the data you will provide (regional or national). If you do not have access to the information required please come back to me and explain the reason.*
  - *For inspiring purpose, you will find some answers from French data in the form, please do not consider this information as completely exhaustive and replace my answers by yours.*
  - *Do not hesitate to add other elements and information that may not appear in this template. This template was created from the information I collected regarding the French situation, it may not be completely adequate to your country situation.*

For any question or remark, do not hesitate to contact me: coline.fiquet@pole-emc2.fr Mob. : +33 (0)7 85 01 95 58

Literature review

Please fill in the table indicating your sources as per the provided template.

Naval sector State of the art

- **National Key Facts :**

Key actors (major players)	**Yard :** **Repair :** **Dismentling :** **Refit :** **Suppliers:**
Turnover in the country (M€)	Click here to add text
Number of employees	Click here to add text
Exportation (%)	Click here to add text
Number of SMEs	Click here to add text
Type of activity (Presence of each type of activity or not, please comment on the characteristics/importance in the national value chain).	
Engineering and conception	Cliquez ici pour taper du texte.
Production of part and component	Cliquez ici pour taper du texte.
Sub-assembly and pre assembly,	Cliquez ici pour taper du texte.
Assembly	Cliquez ici pour taper du texte.
Exploitation	Cliquez ici pour taper du texte.
Maintenance	Cliquez ici pour taper du texte.
National programs /initiative dedicated to research in naval industrial sectors. Please indicate their scope of activity and the website.	Click here to add text
Any other key facts you want to mention?	Click here to add text

- **Naval national sector context and challenges observed (Economical, social, technological, competition etc…):**

Sectorial:
Economical:
Social:

Technological:
Competition:.

4.0 national approach

- **Existence of national approach dedicated to 4.0? Which national definition of 4.0?**

Cliquez ici pour taper du texte.

EU parliament proposition for a definition of 4.0 industries[14] *:*

- information and communication technology (ICT)
- Cyber-physical systems that use ICTs to monitor and control physical processes and systems (sensors, robots, additive manufacturing)
- Network communications including wireless and internet technologies that serve to link machines, work products, systems and people, both within the manufacturing plant, and with suppliers and distributors;
- Simulation, modelling and virtualization in the design of products and the establishment of manufacturing processes
- Collection of vast quantities of data, and their analysis and exploitation, either immediately on the factory floor, or through big data analysis and cloud computing
- Greater ICT-Based support for human workers, including robots, augmented reality and intelligent tools

4.0 technologies in the Naval Sector

- **Situation/State of the art of use of 4.0 technologies in naval industries.**

- According to our studies, "Engineering and conception industries" and "Production and maintenance companies" should be distinguished in their use of 4.0 technologies as their needs might differ due to their specific work.

- French results are extracted from the report "digital and robotic use in the naval sector" done by the WAVESTONE consultancy office. The report studied the entire value chain and therefore cannot be directly representative of the SMEs. Information is to be confirmed by our survey.

- The following is a tentative list of 4.0 technologies: please fill in the "level of adoption" according to your national context and do not hesitate to add technologies and/or modify the tables. When preparing the final report, we will obviously take into account the survey's results.

[14] *Industry 4.0, Digitization for productivity and growth, Briefing, September 2015* :
http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf

Engineering & conception industries	
Technologies	**Level of adoption**
Design and simulation software	Choose an option
Rapid prototyping	Choose an option
PLM Tool (Product Lifecycle Management)	Choose an option
Digital mock-up	Choose an option
Project management software	Choose an option
Virtual reality	Choose an option
Augmented reality	Choose an option
Additive manufacturing	Choose an option
Internet of things	Choose an option
Collaborative design environment	Choose an option.
Mobile solution (application/remote access)	Choose an option
Cyber security	Choose an option
Click here to add text	Choose an option
Click here to add text	Choose an option
Click here to add text	Choose an option

Production and maintenance industries	
Technologies	**Level of adoption**
Machine tools	Choose an option
Computer-Assisted Maintenance Management and traceability solution	Choose an option
Manufacturing Execution System	Choose an option
Logistic flow simulation	Choose an option
PLM Tool (Product Lifecyle Management)	Choose an option
Digital mock-up	Choose an option
Project management software	Choose an option
Electronic document management & document sharing	Choose an option
Enterprise Resource Planning	Choose an option
Augmented reality	Choose an option
Collaborative robot	Choose an option
Additive manufacturing	Choose an option

Predictive maintenance	Choose an option
Internet of things	Choose an option
Mobile solution (application/remote access)	Choose an option
Cyber security	Choose an option
Factory/ yard digital twin	Choose an option
Click here to add text	Choose an option
Click here to add text	Choose an option
Clik here to add text	Choose an option

Drivers and barriers towards the adoption of 4.0 Technologies

- **What are the drivers of the implementation of 4.0 techno in the industries?**

Click here to add text

- **What are the barriers of the implementation of 4.0 techno in the industries?**

➢ Cliquez ici pour taper du texte.

- **Suggestions for the adoption of 4.0 technologies (strategic actions):**

➢ Click here to add text

- Do you have any stand out example or success stories of a successful implementation of 4.0 technologies in naval industries?

Click here to add text

- **Free comments:**

Feel free to add any comments necessary to understand the naval situation in your country

Annexe 2: Level of 4.0 technologies' adoption for each partner

Engineering & conception industries								
Technologies	**PT**	**UK**	**IE**	**ES - Galicia**	**ES - Basque Country**	**FR - Pays de la Loire**	**FR - Brittany**	**global**
Design and simulation software	3	3	2	2	3	3	2	2,6
Rapid prototyping	2	0	0	2	3	0	0	1,0
PLM Tool (Product Lifecycle Management)	1	1	2	1	1	2	2	1,4
Digital mock-up	3	3	2	0	3	2	2	2,1
Project management software	2	3	2	2	2	2	2	2,1
Virtual reality	1	0	2	1	1	3	2	1,4
Augmented reality	1	0	2	2	1	2	2	1,4
Additive manufacturing	0	0	2	1	1	1	2	0,7
Internet of things	2	1	2	1	1	1	2	1,3
Collaborative design environment	2	2	1	1	1	1	2	1,3
Mobile solution (application/remote access)	2	2	1	1	1	2	2	1,7
Cyber security	2	2	1	1	1	1	1	1,3
Laser survey							2	
3D model flow management							1	

Production and maintenance industries								
Technologies	**PT**	**UK**	**IE**	**ES - Galicia**	**ES - Basque**	**FR - PDL**	**FR - BR**	**Global**
Machine tools	1	2	3	2	2	3	3	2,3
Computer-Assisted Maintenance Management and traceability solution	2	0	2	1	1	2	2	1,4
Manufacturing Execution System	1	0	1	1	1	0	0	0,6
Logistic flow simulation	1	2	1	1	2	2	2	1,6
PLM Tool (Product Lifecyle Management)	1	2	2	1	1	2	2	1,6
Digital mock-up	1	2	2	0	1	2	2	1,4
Project management software	3	3	2	2	2	2	2	2,3
Electronic document management & document sharing	2	2	2	1	2	2	2	1,9
Enterprise Resource Planning	2	0	2	2	2	2	2	1,7
Augmented reality	1	0	2	1	1	2	2	1,3
Collaborative robot	1	0	2	1	1	2	2	1,3
Additive manufacturing	1	1	1	1	1	1	1	1,0
Predictive maintenance	1	0	1	1	2	1	1	1,0
Internet of things	1	0	1	1	1	1	1	0,9
Mobile solution (application/remote access)	2	0	2	2	2	2	2	1,7
Cyber security	3	2	1	1	1	1	1	1.4
Factory/ yard digital twin	1	0	2	0	1	2	2	1.1

Annexe 3: Questionnaire distributed to naval companies

4.0 technologies in Naval industries

Welcome to Naval 4.0 survey

This survey has been created in the framework of the European project Naval 4.0 which aims to promote the modernisation of the naval sector through the implementation of actions that help SMEs in their 4.0 transformation.
With this survey we wish to review the current situation of the implementation of the factory of the future (industry 4.0) in the Atlantic area's naval sector, and identify the barriers that prevent the integration of innovative solutions.

We are interested in learning your opinion and gain from your experience. The result of this questionnaire will help us determine the level of advanced technologies adoption in the naval sector.

If you want more information, don't hesitate to visit the project website or contact me at coline.fiquet@pole-emc2.fr

You can always contact us if you wish to change or delete your personal data at communication@pole-emc2.fr

4.0 technologies in Naval industries

Entities information

* 1. Name of your company

* 2. Type of company:

- ◯ Micro enterprise (less than 10 employees)
- ◯ Small enterprise (10 to 49 employees)
- ◯ Are you part of a group ? If yes which one ?
- ◯ Medium-sized enterprise (50 to 249 employees)
- ◯ Large enterprise (250 or more employee)

* 3. Number of employee

* 4. Type of activity

- ◯ Maintenance
- ◯ Engineering and conception
- ◯ Production of part and component
- ◯ Other ?
- ◯ Sub-assembly and pre-assembly
- ◯ Assembly
- ◯ Exploitation

* 5. Turnover of your company in €?

- ◯ <20 000€
- ◯ 20 000€ to 50 000€
- ◯ 50 000€ to 100 000€
- ◯ 100 000€ to 10 Million €
- ◯ 10 to 100 Million €
- ◯ 100 Million € to 1Bn€
- ◯ >1Bn€

* 6. Location of your company (Country and region)

* 7. Do you agree to be contacted by the project partners? Do you want to receive more information on the project?

- ◯ Yes
- ◯ No

8. Your job function

9. E-mail:

10. Phone number

* 11. Do you agree to be mentioned in the final report of Naval 4.0 project ?

- ◯ Yes
- ◯ No

4.0 technologies in Naval industries

4.0 technologies

The following questions aim to investigate the impact that Industry 4.0 technologies could have in the maritime industry.
We consider that 4.0 technologies could be integrated in your product and services as well as in your production processes.

* 12. To what extent are you aware of Industry 4.0 technologies and are they being actively pursued? (From 1. to 5.)

1. Unaware of Industry 4.0 and it is not being actively pursued within the business	2.	3.	4.	5. Industry 4.0 technologies are well understood and solutions are being actively developed
○	○	○	○	○

* 13. To what extent have you allocated resources and budgets for the integration of 4.0 Technologies?

1. There is no budget or resource allocated in the pursuit of Industry 4.0 technology	2.	3.	4.	5. Resource and budget readily available from various funding sources both internally and externally
○	○	○	○	○

* 14. Have future skill requirements and training needs been identified for the successful adoption of Industry 4.0 technologies ?

1. Future skill requirements are not currently being investigated	2.	3.	4.	5. Skills and training requirements have been investigated and embedded into future business forecast
○	○	○	○	○

What channels are you exploring/exploiting to meet your current skills needs ?
E.g. Internal training, external training, recruitment, outsourcing...:

* 15. How would you rank your use of Industry 4.0 technologies ?

1. Minimum (You do not currently engage in 4.0 technologies)	2.	3.	4.	5. Visionnary (you develop or co-develop new solution to address specific issues encountered)
○	○	○	○	○

* 16. Within your business, what are your main sources of Identification for new technologies that might upgrade or revolutionize your business?

- ☐ Adopting new technologies in line with your supply chain
- ☐ Taking insight from existing technology providers
- ☐ Competition and partners analysis
- ☐ Other sectors' solution analysis
- ☐ Co-development with a partner
- ☐ Internal research / Adding new skills
- ☐ Participation in local ecosystem activities (cluster, business and networking association…)
- ☐ Trade fairs
- ☐ Other (please be precise)

* 17. What are your main drivers for adopting a 4.0 technology? Please choose the 3 most important options for your business.

- ☐ To solve a technical issue
- ☐ Reduce difficulty of task for operator or to improve ergonomics
- ☐ To reduce cost
- ☐ To become compliant with your partners'/clients' tools
- ☐ To create a differentiation strategy/aspect through the technology
- ☐ Offer new services/products
- ☐ To save production time
- ☐ Increase sells
- ☐ Other drivers ? Please be precise

* 18. What are your main barriers for adopting 4.0 technologies ? Please choose the 3 most important options for your business.

- ☐ Financing issues
- ☐ Lack of information regarding their Return on Investment
- ☐ Difficulties to evaluate priorities in your 4.0 strategy
- ☐ Lack of adoption of the technology from the operational/value chain side
- ☐ Poorly suited solutions
- ☐ Lack of internal expertise or special competences required
- ☐ Other barrier ? (please be precise)

* 19. What is the state of Implementation of these 4.0 technologies in your company ?

	I do not know	Our organisation have no interest in this technology	This is relevant to our business but we have not planned to implement it	The implementation of the technology is planned	Integration of the technology is in progress	It is already implemented and we have regular use of this technology
Design and simulation software	○	○	○	○	○	○
Rapid prototyping	○	○	○	○	○	○
PLM Tool (Product Lifecycle Management)	○	○	○	○	○	○
Digital mock-up	○	○	○	○	○	○
Project management software	○	○	○	○	○	○
Virtual reality	○	○	○	○	○	○
Augmented reality	○	○	○	○	○	○
Additive manufacturing	○	○	○	○	○	○
Internet of things	○	○	○	○	○	○
Collaborative design environment	○	○	○	○	○	○
Mobile solution (application/remote access)	○	○	○	○	○	○
Cyber security	○	○	○	○	○	○
Machine tools	○	○	○	○	○	○
Computer-Assisted Maintenance	○	○	○	○	○	○
Management and traceability solution	○	○	○	○	○	○
Manufacturing Execution System (computerized systems used in manufacturing, to track and document the transformation of raw materials to finished goods)	○	○	○	○	○	○
Logistic flow simulation	○	○	○	○	○	○
Electronic document management & document sharing	○	○	○	○	○	○
Enterprise Resource Planning	○	○	○	○	○	○
Collaborative robot	○	○	○	○	○	○
Predictive maintenance	○	○	○	○	○	○

	I do not know	Our organisation have no interest in this technology	This is relevant to our business but we have not planned to implement it	The implementation of the technology is planned	Integration of the technology is in progress	It is already implemented and we have regular use of this technology
Factory/ yard digital twin	○	○	○	○	○	○

Free comment

Literature review:

ACLUNAGA			
Title	**Author**	**Publication date**	**Description**
« Demographic Change & Skills Requirements in the European Shipbuilding & Ship Repair Industry »	Pieter´t Hart/ Dick Schotte /European Metalworker´s Federation / CESA (Community of European Shipyards Association)	2008	The study recommends looking for solutions regarding education and training as well as shortage of personnel in the sector due to demographic change. The main aim of this project is to identify the problem relating to demographic change in the European shipbuilding and repair industry with regard to skills requirements over the next years.
« La Digitalización y la Industria 4.0-Impacto industrial y laboral »	C.C.O.O. Industria	2017	The study approach us to the « Digital Transformation ». A new economy and, therefore a new type of work is announced by the robotization and the Big Data. How can affect the market´s competitiveness to the conditions of the work, the level of employment and the distribution of the income is addressed in this report.
« Study on Competitiveness of the European Shipbuilding Industry Within the Framework Contract of Sectorial Competitiveness Studies-ENTR/06/054 »	ECORYS, Research and Consulting.	2009	The report analyses the position of Europe within a global market, investigating the Competitiveness of the European Shipbuilding Industry. In order to ensure its long-term prosperity in a dynamic market.
Boletines informativos trimestrales de Construcción Naval	Ministerio de Industria, Comercio y Turismo. Gobierno de España.	2018	Quarterly newsletters published by the Spain´s government with information and data of the national Shipbuilding. Including shipyard´s order-books, deliveries, keel laying, etc.

Base de datos SABI (Sistema de Análisis de Balances Ibéricos)	Bureau Van Dijk	2018	Database that details financial information of more than 2.7 million companies in Spain and Portugal.
« Oportunidades Industria 4.0 en Galicia. Diagnóstico Sectorial : Naval »	Atiga Alliance	2018	Analysis of the Galician´s Shipbuilding and repair sector global situation and difficulties faced. New trends, changes within the ship building´s techniques and how the 4.0 shipyards will improve the competitiveness.
Portfolio of existing and developing technologies	AIMEN	2018	Technological centre dedicated to innovation within the metal industry. European reference in the provision of services for the industry in the field of materials and advanced manufacturing processes.
FMV			
RIS3 Smart Specialisation Strategy	Basque Goverment	2014	In the process of identifying vertical priorities, the basic document was the Science, Technology and Innovation Plan, PCTI-2020, which establishes a deliberate and explicit strategy of diversifying the Basque economy, based on three essential enabling technologies (biosciences, nanosciences and advanced manufacturing) and five priority markets (transport and mobility, digital world, science industry, ageing and health, and energy).
Basque Industry 4.0	Basque Goverment	2017	Basque Industry 4.0 is a move towards the incorporation of intelligent systems into production plants, the improved use of emerging capabilities and technologies in new products and processes, the integration of advanced materials into higher added-value solutions and improved processes, and the efficiency and sustainability of resources and integration of high added-value services
Propuesta de valoración de oportunidades para la transformación digital y fabricación avanzada del sector de la Construcción Naval del País Vasco - Plan de transformación 4.0 de los astilleros vascos	Sisteplant / Foro Marítimo Vasco	2018	The Astillero 4.0 plan is a document that includes advanced manufacturing technologies, new organizational and management models, training plans for people employed by the sector, as well as a digital transformation plan that will radically transform the traditional business throughout its value chain.

Esudio de importancia económica del sector maritimo en la economía del País Vasco	Bizilan	2017	This study mainly gathers information on economic data and employment in the Basque maritime sector
Bretagne Pôle Naval			
Auxnavalia +	Espagne / France / Portugal / UK /	2014	AUXNAVALIA PLUS is a project, funded by the ERDF in the Atlantic Area Operative
OCEANS 21	France Gican / BPN/ PMME/	2013 / 2015	Océans 21, porté par le Groupement des Industries de Construction et Activités Navales (GICAN) et soutenu par l'Etat via le Programme d'investissements d'avenir (PIA), a visé à renforcer la compétitivité des entreprises du secteur. Les thématiques de ce programme ont été le positionnement stratégique des PME/ETI, le développement international, le maintien et le développement des compétences clés et les coopérations innovation et performances industrielles entre acteurs de la filière.
LeaderSHIP 2015	DEFINING THE FUTURE OF THE EUROPEAN SHIPBUILDING AND SHIPREPAIR INDUSTRY	2005	The "LeaderSHIP 2015" initiative is the EU shipbuilding industry's response to the competitive challenges it is facing. It is designed to address all issues that are important for the future competitiveness of this industry sector.
MARNET	France IFREMER / Région Bretagne (BPN)	2014	Economy and social study - INTERREG : collect and analysis of socioeconomical marine data.
CESER	Brittany region	2014	Maritime economy in Brittany : change of perspective
CESER	Brittany region	2005	Maritime strategy in Brittany 2014-2020
CESER	Brittany region	2017	Brittany and sea at 2040 horizon
LeaderSHIP 2020 Initiative	European Commission	2005	LeaderSHIP 2020 Initiative : The new LeaderSHIP 2020 (1 MB) initiative was adopted in 2013, in response to the effects of the economic crisis on the shipbuilding sector.
CIT			
Industry 4.0: Building the Digital Enterprise Transportation & Logistics Key Findings	PWC	2016	A sub report of PWCs main global report on Industry 4.0, biggest worldwide survey of its kind. It explores the benefis of digitising horizontal & vertical value chains in companies.
Employment, Skills & Workforce Strategy for the Fourth Industrial Revolution	World Economic Forum	2016	Discusses the challeneges & opportunites faced by governments, business & individuals in adapting to Industry 4.0 focussing in particular on the future of jobs & skills & the industry gender gap

A study of the current & future skills requirements of the marine/maritime economy to 2020	Expert Group on Future Skills Needs (EGFSN)	2015	Report assesses the profile & diversity of the occupations & skills requirements of enterprises in marine economy & proposes recommendations to ensure the right skill base to meet the future needs.
Ireland's Ocean Economy	Socio Economic Marine Institute (SEMRU)	2017	A report on the performance of Ireland's ocean economy and its subsectors including shipping & maritime transport
Ireland's Competitiveness Challenge 2017	National Competitiveness Council	2017	Report on key competitiveness issues in the Irish economy and provides policy recommendations to tackle these issues- non sector specific
The supply chain for the ocean energy industry in Ireland	MRIA	2013	A discussion paper
Review of Engineering and Specialist Support Requirements for the Ocean Energy Sector	RPS	2009	
Assessment of Ports & Shipping Needs	SEAI	2011	Illustrates the demands made on these facilities by major wind energy projects
Industry 4.0: Are you Ready?	Deloitte	2018	
Irish Ports Offshore Renewable Energy Services	Irish Maritime Development Office (IMDO)		Summary of information on port infrastructure, facilities and management plans in relation to meeting requirements for marine renewable energy developers
Defence Paper Review	Irish Chamber of Shipping	2013	
Harnessing Our Ocean Wealth	Department of Agriculture, Food & the Marine	2012	An Integrated Marine Plan for Ireland highlights the potential benefits and economic impact the Blue Economy can have for Ireland. Sets out the Government's Vision, High-Level Goals, and Key 'Enabling' Actions to put in place the appropriate policy, governance and business climate to enable our marine potential to be realised
National Marine Research & Innovation Strategy 2017 -2021	The Marine Institute	2017	Sets out Ireland's Marine Research & Innovation Strategy to 2021. Identifies a number of trageted research themes including tranpsort & logisitics and advanced technologies.
Harnessing Our Ocean Wealth Review of Progress 2016	Department of Agriculture, Food & the Marine	2017	4th Review of Progress provides an update on key activities undertaken to the end of 2016 and focus for 2017.
Manufacturing Ireland: Manufacturing a Renaissance	IBEC	2016	Document outlining Manufacturing Ireland's campaign to drive Ireland's reputation in advanced manufacturing focuses on 4 key pillars: Maufacturing for competitiveness, Partnering for future growth, skills

			for the 21st century workforce & factory of the future.
Foro Oceano			
Analysis of National Initiatives for Digitising Industry : Portugal: Portugal indústria 4.0	Oscar Lazaro for European Commission	2017	Document with the Analysis by the expert Oscar Lazaro of the Portuguese National Strategy 'Portugal I4.0' made for the European Commission?
Portugal Industria 4.0 – Action Plan (Portuguese)	Portuguese Government: Ministry of Economy	2017	Action plan with the measures of Industry 4.0 Porgram. The Industry 4.0 Program is an initiative of the Portuguese Government with the main objective of accelerating the adoption of industry 4.0 by the business community.
HELM – PwC Economy of the Sea Barometer 8th Edition	PwC	2017	In the 8th edition of the HELM (LEME) in Portugal, PwC present a survey on "The Digital Revolution and the Economy of the Sea." The great majority of respondents believe that the digital revolution will impact greatly on the economy of the sea, pointing out, by segment, those themes of the digital revolution that will have the greatest impact.
The Satellite Account for the Sea (SAS)	INE (Statistics Portugal)	2016	Official Statistic on the Blue Economy in Portugal (2010-2013)
National Ocean Strategy 2013-2020	Portuguese Government: Ministry of the Sea	2013	The NOS2013-2020 presents a new model of development of ocean and coastal areas that will allow Portugal to meet the challenges for the promotion, growth and competitiveness of the maritime economy,
The 2018 Annual Economic Report on EU Blue Economy	DG Maritime Affairs and Fisheries, European Commission	2018	The Annual Report on the EU Blue Economy aims to describe the scope and size of the blue economy in the European Union. It will monitor developments in the EU blue economy annually and examine the drivers behind the trends.
The Ocean Economy in 2030	OCDE	2016	Study of OCDE on the prospects of the development of Ocean Economy in the World
Blueprint for sectoral cooperation on skills - Responding to skills mismatches at sectoral level	European Commission	2017	The Blueprint for Sectoral Cooperation on Skills is one of the ten Actions launched by the New Skills Agenda for Europe. It's a new framework for strategic cooperation to address short and medium-term skills needs in a given economic sector. One of the Six pilot sectors is Maritime Technology.
HSSMI & University of Strathclyde			
National Shipbuilding Strategy: The Future of Naval Shipbuilding in	Ministry of Defence	2017	Government vision and strategies in place to grow the Royal Navy fleet and support UK shipbuilding

the UK			
UK Marine Industries: Technology Roadmap	IfM: University of Cambridge	2015	Identification of future priorities, gaps, opportunities and capability needs in order to underpin the UK's marine growth strategy. This report provides the consolidated output of the series of four Marine Industries Technology Roadmap workshops that took place from February – April 2015.
The UK's Global Maritime Professional Services: Contribution and Trends.	Pricewaterhouse Coopers (PwC)	2016	Study of UK's maritime business service contribution (Accounting, consulting, education, finance, insurance, law, shipbroking)
Maritime Growth Study: Keeping the UK competitive in a global market	Department for Transport	2015	Compelling study of all aspects of the maritime sector. Assessing competitive positioning in the global market. Reviewing challenges and opportunities, identifying drivers and barriers to further growth. Lastly, making recommendations for both Government and Industry
International competitiveness of UK maritime sector (2015)	Department for Transport	2015	Analysis of the UK maritime sector at industry and supply chain level. this report compares sector's performance and drivers relative to international competitiveness Highlighting influencing factors, opportunities and challenges as well as providing indicators for future monitoring.
A strategy for growth for the UK Marine Industries	UK Marine Industries Alliance	2011	Outlook of the UK marine industry and strategy change delivery plan.
Global Marine Trend 2029	Lloyd's Register, QinetiQ, University of Southampton	2015	Identification of key global trends considering global drivers impacting the commercial and naval sectors. Anticipation of disruptive events that will generate change in the marine industry. The authors examinate three plausible scenarios , that separate out the possible actions in terms of international politics.
Global Marine Technology Trend 2030	Lloyd's Register, QinetiQ, University of Southampton	2015	Outline of the fundamental marine technology trends organisations can expect to see in the next 15 years, and their industry-wide impact in three interconnected sectors: Commercial shipping, Naval and Ocean space
Uk Marine World Class Capability	UK Trade and Investment	2014	Overview of the different individual marine engineering discplines that make up the United Kingdoms varied landscape
What Drives the Implementation of Industry 4.0? The Role of Opportunities and	Julian Marius Müller, Daniel Kiel and Kai-Ingo Voigt. Industrial engineering,	2018	Analysis of the hypotheses behind the drivers for implementation of Industry 4.0 in German industry sectors. However the analysis of the hypotheses, the drivers, the opportunities, the barriers, the challenges are broadly applicable. In combination with the above

Challenges in the Context of Sustainability	Friedich-Alexander-University Nurnberg, Germany.		literature give us teh confidence to apply these to the UK maritime industries
Pôle EMC2			
Études filières, Industrie du futur	Alliance pour l'Industrie du Future	2017	Study of the implementation of the factory of the future un 6 different sector, including naval.
Quantitative analysis of how EU Manufacturing companies currently use advances manufacturing and potential impact	Fraunhofer ISI, Karlsruhe, Germany	2014	This document is the deliverable #3 of the Project EASME/COSME/2014/014: "An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies".
An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies	European Commission; Henning Kroll, Giacomo Copani, Els Van de Velde, Magnus Simons, Djerdj Horvat, Angela Jäger, Annelies Wastyn, Golboo PourAbdollahian, Mika Naumanen	2016	This study on the 'analysis of drivers, barriers and readiness factors of EU companies for adopting AMT' identifies relevant steps and actions towards not only the development of better manufacturing technologies but also the uptake of industrial moderni-sation in a more general sense in a threefold manner.
Usage robotique et numérique dans la filière navale.	Wavestone	2016	Study on the use of robotic and digital tools in the Naval sector.
Guide pratique De l'usine du futur : Enjeux et panorama de solutions	Alliance pour l'Industrie du Future	2016	Practical guide for the factory of the future : challenge and an overview solution
Drivers and Barriers of EU Companies for Adopting Advanced Manufacturing Technologies	VTT, Helsinki, Finland and IDEA Consult, Brussels, Belgium	2016	This document is the deliverable #2 of the Project EASME/COSME/2014/014: "An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies".

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