# IN 4.0

## ADAPTATION OF INDUSTRY 4.0 MODEL TO THE NAVAL SECTOR

# Report on indicators for evaluating the growth of SMEs within IN 4.0 project

# Content

# 1 BACKGROUND

Driven by the Department of Industry, Commerce and Innovation of the Galician Regional Administration, the **Galician Naval Cluster Association (ACLUNAGA)** was established in 1999 as a dynamic tool and point of meeting between all entrepreneurs and agents in this sector.

**It is the only specific business association in the naval sector in Galicia and it was the second group of companies created within the Spanish naval sector as a "cluster"**.

Since its inception, **ACLUNAGA's objectives have focused on technological improvement and research**, **productive sophistication and efficiency improvements as well as new design methods for production and quality, training and organization**.

**ACLUNAGA has been working to further diversify into new and high technological content sectors**, while the Cluster has established itself as the first and main meeting point of all the stakeholders participating in the naval building sector.

Its mission is focused on improving competitiveness and promoting development of the companies that make up the Galician naval sector, establishing a consensus among the protagonists on the challenges they face, goals and strategies for overcome them and the priority actions to be carried out by the companies and the cluster, with the support and involvement of the rest of the agents that influence this sector (Administration, University, Unions, Sector Associations, etc.).

To fulfil this mission, ACLUNAGA develops a wide number of activities and provides a remarkable catalogue of services, including participation in European projects to enhance the competitive improvement of its member companies together with other prominent partners.

One of the initiatives in which ACLUNAGA is currently participating is **the project "IN4.0: Adaptation of the Model of Industry 4.0 to the Shipbuilding Sector"**, belonging to the 1st call of **INTERREG Atlantic Area** and which has as an objective to improve the competitiveness of companies in the naval sector through their adaptation to the production model that represents the 4.0 Industry, guaranteeing the continuity of the sector in a market increasingly demanding, in which innovation is a key factor of strategic positioning.

To do this, within the framework of the project, multiple activities will be carried out:

- The main barriers that prevent the sector to adapt its business model will be diagnosed.
- The degree of maturation of the existing technologies that can be implanted in SMEs will be determined.
- Work organization systems will be defined.
- Sector personnel will be trained to move towards 4.0.
- Innovative strategies will be designed to save costs in the implementation of technologies.
- New marketing methods will be detected.
- And the innovations designed in IN 4.0 will be implemented in SMEs selected from the participating regions.

Within this initiative, **ACLUNAGA is responsible for executing different work packages**; **one of them focuses on the "Preparation of a report about indicators to evaluate the SMEs growth"**.

# 2 PROCESS OF IDENTIFICATION AND ORDERING

Based on the **previous documentation available and making a deep and meticulous identification work, selection, collection and analysis of information on the subject**, the team of people working on this subject proceed with the identification of **both qualitative and quantitative indicators** to assess the growth experienced by an SMEs due to the application of 4.0 technologies. In this sense, **the following technologies were considered**:

A. Big Data
B. Robotics
C. Simulation
D. Integration Systems
E. Internet of Things (IoT)
F. Cloud
G. Additive Manufacturing
H. Cybersecurity
I. Augmented and Virtual Reality

An individualized analysis on the possible effects (advantages or benefits that implantation of each of these technologies could suppose for SMEs) was carried out, to subsequently proceed to its joint analysis, so that overlap removal could be carried out, its organization by areas...

Starting from a preliminary catalogue, it was made a work of assessment, prioritization and selection of the 50 indicators that better fit to assess the possible growth of a SME due to the application of 4.0 technologies, taking into account that **an indicator should be a "specific, observable and measurable characteristic that can be used to show the changes and progress being made towards the achievement of a specific result"**.

## 2.1 TECHNOLOGIES

The Galician Institute for Economic Promotion (Igape) has recently made studies about opportunities related to the 4.0 Industry technologies for the Galician main and strategic sectors, where naval sector was included. Focusing on that analysis, the **possible applications of these technologies** can be found.

### 2.1.1 BIG DATA

Regarding the application of these technologies in the naval sector, most of the solutions existing or planned focus on data analysis in functional ships, with application for preventive detection of machinery failures or for the optimization, for example, of routes. The Japanese Institute of Technology Monohakobi states that the combination of IoT technologies for mass data collection with a "big data" infrastructure can provide various benefits for both, the ship owner and operator, and the ship builder.

Among the use cases contemplated, the most remarkable ones are **optimization of new designs or tasks of maintenance, where predictive maintenance techniques could be applied to the machinery**, for example, with the aim of detecting possible problems to correct them in new productions.

The Royal Institution of Naval Architects from United Kingdom has studied the application of the 3V model to shipbuilding sector, identifying the following associations:

- <u>Volume</u>: a large volume of data is generated within the shipyards, many of them not collected electronically at this time, but have not yet been catalogued. The compilation of this information, in addition to its analysis, would allow better business decisions to be made together with improvements in production and project planning.

- Speed: ship construction projects are more durable compared to other production activities; however, time and resource constraints are important, so speed in processing large volumes of data is crucial, especially if it is necessary to face unforeseen changes in production.

- Variety: the type of data to be collected in a shipyard is very varied at all levels. The nonexistence of methods for the organization and cataloguing of all this data is one of the main challenges to solve in order to enter all this information on big data platforms.

In Galicia, Navantia has a Preditec Condition Based Maintenance (SMBC) system. This system, focused on predictive maintenance**, uses machine learning algorithms and data analysis techniques to identify the right time to repair a machine**.

The **main applications of "big data" identified** for the naval sector are summarized below:

1. **Demand forecasting**. Both information about customer-market (buying trends, new products, suppliers…) and information processing tools are available for demand forecasting.

2. **Competitiveness factors**. Market, customer, products and competition knowledge. Outer information (customer satisfaction, competition...) is available and can be exploited to analyse competitiveness factors.

3. **Knowledge about productive process**. To exploit production data (cycle time, machine stops, the resources available and their quality...) is possible to improve its management.

4. **Predictive maintenance**. CMMS for maintenance data can be exploited to improve it.

### 2.1.2 ROBOTICS

According to the second Industrial Technological Foresight report carried out by INNOVAMAR (Technological Institute Foundation for the Development of Maritime Industries), in its section "Technological Future on the Horizon 2020", **manufacturing efficiency is considered a key point of great impact for the development of the naval sector**, foreseeing the introduction of intelligent systems throughout the production process, from the design of the ship to its final delivery. The need to incorporate CIM systems that integrate various software such as design / production databases and intelligent CAD / CAM systems is also discussed.

**Robotic solutions** (for sheet metal forming, non-contact three-dimensional measurement, welding, etc.) **require a heavy investment**, in general, that most of the small and medium-sized Galician shipyards cannot afford, and **whose economic return is unknown in most cases**. An example of a robotic shipyard is the Meyer Werft in Germany.

As main **advantages provided by modern automated flexible manufacturing systems**, in welding and assembly operations, the following are highlighted:

- **Increased productivity in key stages of the manufacture of a ship**, such as the union of pre-panels and micro-panels and blocks or structures, which enables faster delivery times.

- **Significant reduction of grinding operations** (zero defect trend) which means savings in production costs and manufacturing time.

- **Significant savings in raw materials**: greater efficiency in the use of materials, consumables, welding, etc.

- **Greater versatility in the manufacture of naval parts and components**, by having a system easily reconfigurable, compared to previous generation automations.

- **Decreased risks associated with manual welding** (presence of fumes, UV radiation, metal projections, etc.).

Other KBS (Knowledge Based Systems) techniques have been proposed in the industrial field. Thus, for example, a KBS has been developed for the design of a tube bending process that integrates knowledge of the mechanical tube bending process and the experience of the operators. This KBS can help engineers select the tube bending method, design the bending tools, and select optimal bending parameters. Selected methods have also been developed in expert systems to select welding materials from steels.

The **main applications of "robotics" identified** for the naval sector are summarized below:

1. **Automation**. There are operations / tasks in the productive process that are likely to be automated due to their nature (repetitive, high quality demanding, high physical effort demanding…). Automation can drive to improvements in production rate, quality, costs…

2. **Real time process data generation**. There are automatised elements in the line which collect information / data from the process that can be used to improve it.

3. **Labour risks' reduction**. Due to automatization of the productive operations / tasks, there can be improvements in labour conditions.

4. **Enabling other possibilities**. By entering automatized processes, new technologies for industrial processes and project types can be enabled.

### 2.1.3 SIMULATION

An example is the German shipyard Flensburger Shipyard (FSG), which has actively introduced **various types of simulation tools into its production tasks**. In this case, and **due to the inherent characteristics of the manufacturing model followed by the shipyard** (specific customer projects), **continuous production planning becomes particularly important**. FSG has been collaborating with Siemens and other entities such as TU Delft since 2000 to develop a simulation toolkit, Simulation Toolkit Shipbuilding (STS), based on Siemens product lifecycle management software. The incorporation of this tool in FSG covering parts of the planning, design process and current state of production, **has led the company to increase its productivity in the last 15 years by 140%, with an average of 20 days in pre-production, a 25% reduction in working hours for ship equipment and savings of 3,000 working hours with simulations of the construction of the ship's hull**. All this through the application of these simulation tools to various activities:

- **Simulation of component and profile manufacturing**. The main objective of this simulation module is to ensure the delivery of the parts at minimum cost.

- **Pre-production simulation**. It allows knowing in advance specific dates and sequences or the number of workers that will need to be assigned to complete the project in a certain period of time.

- **Simulation of assembly of sections and blocks**. The simulation is carried out during the validation and implementation stages, considering the various existing assembly processes or the available space.

- **Simulation and planning of painting**. The planning of the painting of each of the ship's blocks is made possible through these tools, obtaining completion dates, possible delays depending on the structure of the components, current state of construction, etc.

- **Simulation of the construction of the hull**. It focuses on the necessary planning of the operators and the processes necessary to carry out this task.

- **Simulation of internal logistics**. Since FSG is a shipyard with a reduced capacity to store ship blocks, this module is responsible for correctly planning the space available for it, based on current production and future manufacturing orders.

The **main applications of "simulation" identified** for the naval sector are summarized below:

1. **Knowledge in productive process**. Simulation can give information about the limits of the production process, about "what happens if…", about times, organization… management.

2. **Time optimization**. Due to the complexity of the process, it is necessary to make many machine tunings, settings, etc., which slow down the whole process. Simulation can contribute to a better configuration and a better decision making.

3. **Production costs optimization**. Simulation can help to optimize the consumption of tooling, raw materials and other consumables, which have a significant effect on the production costs.

4. **Predictive maintenance fulfilment**. Simulation can help to reduce breakdowns that happen due to incorrect maintenance. It also helps to program maintenance stops in the production lines.

#### 2.1.4 INTEGRATION SYSTEMS

Shipbuilding is a **complex process that typically involves multiple companies during a long period of time** - usually more than a year. In addition, the manufacturing process of a ship it is usually characterized by being a **dynamic manufacturing process that involves a good number of modifications from initial design to final tuning**. Therefore, **it is of great interest the possibility to manage these changes and integrate them efficiently during manufacturing**. **This is achieved with product data management (PDM) systems**. These systems allow to control changes, adapt the successive processes according to the changes that take place and reuse the design in new constructions. In this sense, management systems have already been specifically developed, such as the NUPAS - CADMATIC, which try to solve the problems of integration in the naval sector.

The main limitation of the commercial systems presented nowadays is that they offer a proprietary solution that limits its massive use in the sector. An alternative is based on the use of standards in the data generation and management process. In this line, a recent work that proposes the transfer of the civil construction standard, BIM, to the naval sector has been presented.

To replace non-repetitive manual manufacturing processes with very high cycle times (forming, welding, etc.), in addition to automation, **it is necessary to develop decision support systems (DSS)**, widely implemented in other industrial sectors and with some applications in the naval sector. They are interactive information systems in an interactive, flexible and adaptable computer, **specially developed to support the solution of an unstructured management problem to improve decision-making**. It uses data, provides a simple and friendly interface, and allows decision-making in the situation analysis itself.

The **main applications of "integration systems" identified** for the naval sector are summarized below:

1. **Real time vision of the business areas**. Having a global vision of the different business areas has an impact on better decision making, better understanding, better crisis response, etc.

2. **Interactivity between business areas**. Integration systems can provide real time interactivity between different business areas, what can help to optimize different processes.

3. **Improve communication and decision making**. The quality / fluency of vertical communication impacts on decision making.

4. **Propagation of new technologies and their application**. Integration systems can help to get value from other technologies adopted in different business areas and to share information generated all through the organization.

### 2.1.5 INTERNET OF THINGS (IOT)

Although IoT will have less influence on the competitiveness of the naval sector than in other sectors, **the implementation of IoT in the naval industry will have a deep impact on how companies produce, sell, relate to their value chain and to customers and offer and capture value**.

Regarding the application of IoT technologies in the shipbuilding sector, the application in the process of manufacturing of various sensor and communication technologies is currently a trend with the goal of reaching the existence of the so-called connected ship. Hyundai Heavy Industries has reached an agreement with Accenture for the creation of the OceanLink platform to provide solutions of connectivity to ships that allow obtaining different types of information to perform an analysis of data, predictive maintenance and other activities.

There are also **various products focused on the maintenance of ships and their machinery**. LAROS is an innovative, patented platform that enables parameter monitoring and analysis in boats operated remotely. Collects, processes and transmits data in real time on any kind of ship, sending them to the central administration through a network of smart and wireless sensors**. It provides a complete solution for diagnosis, prognosis and early warnings**. Likewise, AMOS Project is a **software for planning strategies of maintenance, monitoring of the general behaviour of the vessels and location of replacement parts**. It offers maintenance based on real operating conditions, allowing to prevent problems instead of reacting to failures.

In the Galician community, tests have been carried out at the Paulino Freire shipyards for the implementation of **wireless monitoring networks for dangerous parameters for workers**, such as the presence of toxic gases. Also focused on the protection and safety of the worker, it can be highlighted the wearable solution from Intel and Honeywell that allows monitoring the heart rate and activity of workers, as well as making it possible to detect abnormal dangerous values. This is another example on how IoT can help other 4.0 industry technologies – augmented reality, for example - to provide solutions.

The **main applications of "IoT" identified** for the naval sector are summarized below:

1. **Real time machine status**. IoT allows to collect data to manage probabilities of breakdowns, planning maintenance stops and other stops affecting to processes and their efficiency.

2. **Control of Production parameters**. Having real time production parameters affects the global functioning of production. IoT allows to collect data and having early warnings about machinery, processes and quality parameters in products.

3. **Traceability**. Linkage of quality results (NOK/OK or defects) with process parameters. Tracking per unit to optimize process parameters. To use per unit tracking to adjust process parameters to each unit. This is very important both for the process improvement / optimization and for the product improvement / optimization.

### 2.1.6 CLOUD

Surveys made in the Galician Naval Sector show that 91% of the **companies in the sector have the information stored on their own servers**, and the cases in which the cloud is used are limited only to email, not as a support and information system for the production process, integrated in the value chain.

The reasons for “no confidence” in the cloud are inherent to the sector, very traditional and highly resistant to change. Furthermore, **companies that work for the military sector cannot work in the cloud**, which is imposed for security reasons.

Another significant fact is that, since **processes are usually manual**, the way to collect information from them is, in almost all cases, manual, and in those cases that have management systems, this information is entered, also, manually, in these systems.

The **main applications of “cloud” technologies identified** for the naval sector are summarized below:

1. **Computational capacity**. The entire value chain has growing demands, in terms of computational capacity / power, as all these technologies are being adopted. Cloud computing offers great scalability.

2. **New software / services acquisition**. Commercial software tends to move to software as a service business model. Cloud computing is in the base of these business models.

3. **Remote working**. Jobs are increasingly moving to a remote working model. At the same time, remote collaborations are increasingly used. Cloud tools are in the base of these trends.

4. **Flexibility**. Flexible computational capacity according to the needs. Cloud computing is scalable and fits perfectly to a flexible "pay per use" model.

### 2.1.7 ADDITIVE MANUFACTURING

Within the **additive manufacturing of metallic materials**, different projects have been carried out for the manufacture by laser cladding of reinforcements on 15mm thick carbon steel sheets, as an alternative process to MIG / MAG welding of such reinforcements. But, nowadays, in this kind of large parts, the manufacturing process is not profitable.

On the other hand, **in repair and maintenance of naval components, 3D printing on polymeric materials has a wide range of possibilities**, as in other industrial sectors, **due to the precision, speed and little deformation of parts in their repairment**.

The **main applications of "additive manufacturing" technologies identified** for the naval sector are summarized below:

1. **Agile prototyping**. Additive manufacturing enables the capacity to fabricate prototypes for different business areas (design, productions, sales, …), having many advantages in the process of design and innovation for the SMEs.

2. **Reducing parts number in the assembly**. Additive manufacturing enables the possibility of simplification, as conventional manufacturing technologies limitations usually drive to products composed of many elements.

3. **Product and production optimization**. Additive manufacturing enables as many different geometries as you can imagine. This capability allows both a product and production optimization.

4. **Repairing parts**. Additive manufacturing makes possible to repair parts due to defects, accidents, as a service…

### 2.1.8 CYBERSECURITY

Cybersecurity is increasingly necessary and increasingly difficult, in a tremendously connected world both, horizontally and vertically. Aspects of **robustness and comprehensive security of ICT systems** are vital for the normal operation of systems against attacks or failures of services and infrastructures:

- Design technologies for secure systems.
- Cybersecurity technologies.
- Algorithmics, encryption and control.

In general, these solutions are incorporated as standard in products of companies with other types of technologies (IoT, Big Data, Cloud, etc.) to provide data confidentiality, permission management, and user or privacy roles, among others. problems. On the other hand, there are also solutions dedicated especially to this field with applications as diverse as product quality control, perimeter security systems and IDS or ICT tools for managing occupational risks and physical security.

The **main applications of "cybersecurity" technologies identified** for the naval sector are summarized below:

1. **Server shutdowns**. Server and services shutdowns affect company's operating. Cybersecurity should help to minimize this happening.

2. **Cloud services**. Services / tasks developed in the cloud are usually perceived as less secure. Cybersecurity technologies should help to minimize risks.

3. **Fast software upgrades, multiplatform applications**. Cybersecurity should guarantee security and integrate with these trends.

4. **Safe files transferring**. File transferring with customers and other stakeholders is crucial and must be secure. Cybersecurity has an important role in this matter.

### 2.1.9 AUGMENTED AND VIRTUAL REALITY

The development of advanced solutions to support shipbuilding, which **allow to guide the operator in the process of installation and assembly of machinery and equipment, as well as give support in the inspection / supervision in the different phases of construction, provides flexibility to small shipyards and / or auxiliary industry**, improving their response time to face new designs of more complex ships - with high added value -, in very short production series.

**Augmented reality allows the superimposition of virtual information** - plans, models, instructions— **in a real environment**. It is a technology that has experienced very rapid growth in recent years. The most widespread application of this technology is focused on the world of leisure. There are a large number of games based on augmented reality on the market, as well as applications related to tourism, restaurants, shopping, etc. This technology has also reached the naval sector. Thus, the large European companies dedicated to development of advanced software solutions applied to the naval sector, such as AVEVA or the Spanish SENER, are marketing **immersive virtual reality systems (CAVE) as tools for simulation and training of operations by operators**. These systems propose a solution based on the use of immersive caves adjusted to a specific space.

**This solution improves the ability to execute assembly operations by enabling training operator preview in a simulated environment**. However, it has the limitation of requiring the use of a specific room for its execution. A low-cost alternative to the use of immersive caves is the development of mobile devices that allow to carry out design, training and on-site assistance tasks. So, big shipyards like STX have started working with wearable devices (google glasses type) to assist with instructions in the assembly tasks of armament and naval rating systems.

An innovative proposal in the Japanese shipyards of Mitsui Engineering is working on collaboration with the Japan Ship Research Association to apply artificial vision techniques fused on information obtained from accelerometers positioned on workers and RFID tags that allow detect the activities of operators. This will allow optimizing work processes and reconfiguring the positions of the machinery and tools according to the detected needs.

Iwamoto establishes an interactive technological support that helps inexperienced operators to execute certain tasks. This technology is applied in the manual forming of sheets by heat lines. The author develops an image capture strategy to instruct the operator about his position, posture and speed.

Currently, the industry begins to incorporate other more advanced technologies such as wearables or augmented and virtual reality, which revolve around the concept of "Operator 4.0". **In the industry of the future it is necessary that human-machine interaction is faster, easier and more efficient**. **The new HMI devices, which deliver the most critical process data more easily and quickly, will significantly improve decision making**.

The **main applications of “augmented and virtual reality” technologies identified** for the naval sector are summarized below:

1. **No-risk training in critical operations / tasks**. There are some critical tasks (core processes, "in process" maintenance, high cost parts…) that require knowledge and experience. Augmented and virtual reality technologies can help training those critical tasks with no risks for people.

2. **Per-unit control**. Per-unit control (process parameters, location…) could yield benefits in productive process, and augmented reality could help it happens.

3. **Expert remote support, in situ information, smart glasses**. Tasks that require expert knowledge and critical parameters will benefit from the use of augmented reality technologies.

4. **Warehouse management complexity**. Warehouse management complexity grade makes it a good candidate for the use of augmented reality, helping to optimize operations, reducing mistakes, giving real time information for decision-making…

## 2.2 INDICATORS PRIORITISATION



### 2.2.1 CRITERIA

After this review, a double input matrix was used to assess, for each indicator identified, the two following criteria:

- **Relevance**: in the sense that they are important to the intended purpose and serve for measurement. This criterion was weighed 60%.

- **Availability**: in the sense that obtaining it is feasible, simple, fast and complete, without obstacles or restrictions. This criterion was weighed 40%.

For each of that criteria it was defined a **valuation scale** as follows:

| Value | Meaning | |
|---|---|---|
| | Relevance (60%) | Availability (40%) |
| 1 | No relevant | Very difficult to obtain |
| 2 | Not much relevant | Difficult to obtain |
| 3 | Average relevance | Accessible |
| 4 | Relevant | Not difficult to obtain |
| 5 | Very relevant | Easy to obtain / commonly used data |

By using this prioritization criteria and ponderation, the 50 most suitable indicators to measure the impact of 4.0 technologies on the growth of SMEs in the naval sector were selected and ordered.

The next table shows the results of the analysis, valuation and ordering of the set of indicators, using the descripted methodology, criteria and weights:

| Indicators | Code | Relevance | Availability | Weighted average |
|---|---|---|---|---|
| Production costs per unit | 01.A.3.2 | 5 | 5 | 5 |
| Value added | 02.A.2.2 | 5 | 5 | 5 |
| General costs per Euro sold | 03.D.1.3 | 5 | 5 | 5 |
| Maintenance costs rate | 04.A.4.1 | 5 | 4 | 4,6 |
| Contribution margins | 05.A.1.3 | 5 | 4 | 4,6 |
| Fixed computational costs rate | 06.F.4.1 | 4 | 5 | 4,4 |
| Incomes in repairing parts rate | 07.G.4.1 | 4 | 5 | 4,4 |
| Sick leaves rate | 08.B.3.1 | 4 | 5 | 4,4 |
| Sales per employee | 09.D.1.2 | 4 | 5 | 4,4 |
| Units of repairing parts sold share | 10.G.4.2 | 4 | 5 | 4,4 |
| Labour costs per unit produced | 11.B.3.2 | 4 | 5 | 4,4 |
| Number of stock brakes / stock rotation index | 12.I.4.3 | 4 | 5 | 4,4 |
| Number of machinery failures per maintenance stop | 13.A.4.5 | 4 | 5 | 4,4 |
| Production time per unit | 14.A.3.1 | 5 | 3 | 4,2 |
| Production rate (units/hour) | 15.B.1.1 | 5 | 3 | 4,2 |
| Productivity (units/person) | 16.B.1.2 | 5 | 3 | 4,2 |
| Rate of human mistakes in critical operations / tasks | 17.I.1.1 | 5 | 3 | 4,2 |
| Labour risk perception | 18.B.3.3 | 5 | 3 | 4,2 |
| Assembly costs per product assembled | 19.G.2.1 | 4 | 4 | 4 |
| Lifetime of equipment | 20.E.1.3 | 4 | 4 | 4 |
| Success rate in commercial proposals | 21.A.1.1 | 5 | 2 | 3,8 |
| Software & SAAS costs rate | 22.F.2.1 | 3 | 5 | 3,8 |
| Remote working jobs rate | 23.F.3.1 | 3 | 5 | 3,8 |
| Number of machinery maintenance stops | 24.A.4.4 | 3 | 5 | 3,8 |
| Number of stops in production process for training | 25.I.1.4 | 3 | 5 | 3,8 |

| Indicators | Code | Relevance | Availability | Weighted average |
|---|---|---|---|---|
| Time of stops in production process for training rate | 26.I.1.5 | 3 | 5 | 3,8 |
| Nonconformity products rate | 27.A.3.5 | 4 | 3 | 3,6 |
| Number of brakedowns per unit | 28.C.4.1 | 4 | 3 | 3,6 |
| R&D costs per product developed | 29.G.1.1 | 4 | 3 | 3,6 |
| Rate of product failures | 30.G.3.1 | 4 | 3 | 3,6 |
| Warehouse management time per operation | 31.I.4.1 | 4 | 3 | 3,6 |
| Costs of maintenance per unit produced | 32.A.4.3 | 4 | 3 | 3,6 |
| Improvement perception with integration systems | 33.D.1.4 | 4 | 3 | 3,6 |
| Maintenance time rate | 34.A.4.2 | 3 | 4 | 3,4 |
| Infrastructure costs per employee | 35.F.3.2 | 3 | 4 | 3,4 |
| Guaranty costs per product sold | 36.G.3.2 | 3 | 4 | 3,4 |
| Cybersecurity costs per job | 37.F.3.3 | 3 | 4 | 3,4 |
| Number of human mistakes per person | 38.D.1.1 | 4 | 2 | 3,2 |
| Market perception for innovation products | 39.A.1.2 | 4 | 2 | 3,2 |
| Costs of human mistakes in critical operations/tasks per mistake | 40.I.1.2 | 4 | 2 | 3,2 |
| Warehouse costs per operation | 41.I.4.4 | 4 | 2 | 3,2 |
| Number of server shutdowns | 42.H.1.1 | 3 | 3 | 3 |
| Number of cloud services shutdowns | 43.H.2.1 | 3 | 3 | 3 |
| Assembly time rate per product | 44.G.2.2 | 3 | 3 | 3 |
| Rate of warehouse management human mistakes per operation | 45.I.4.2 | 3 | 3 | 3 |
| Market share | 46.A.2.1 | 3 | 2 | 2,6 |
| Computational capacity costs rate | 47.F.1.1 | 3 | 2 | 2,6 |
| R&D time per product developed (time to market) | 48.G.1.2 | 3 | 2 | 2,6 |
| Costs of server shutdowns | 49.H.1.2 | 3 | 1 | 2,2 |
| Costs of cloud services shutdowns | 50.H.2.2 | 3 | 1 | 2,2 |

### 2.2.3 MATRIX TECHNOLOGIES / IMPACTS



| Technology | | Positive Impact (PI) |
|---|---|---|
| A | Big Data | 1. Demand forecasting. Both information about customer-market (buying trends, new products, suppliers…) and information processing tools are available for demand forecasting. |
| | | 2. Competitiveness factors. Market, customer, products and competition knowledge. Outer information (customer satisfaction, competition...) is available and can be exploited to analyse competitiveness factors. |
| | | 3. Knowledge about productive process. To exploit production data (cycle time, machine stops, the resources available and their quality...) is possible to improve its management. |
| | | 4. Predictive maintenance. CMMS for maintenance data can be exploited to improve it. |
| B | Robotics | 1. Automation. There are operations / tasks in the productive process that are likely to be automated due to their nature (repetitive, high quality demanding, high physical effort demanding…). Automation can drive to improvements in production rate, quality, costs… |
| | | 2. Real time process data generation. There are automatised elements in the line which collect information / data from the process that can be used to improve it. |
| | | 3. Labour risks' reduction. Due to automatization of the productive operations / tasks, there can be improvements in labour conditions. |
| | | 4. Enabling other possibilities. By entering automatized processes, new technologies for industrial processes and project types can be enabled. |

| Technology | | Positive Impact (PI) |
|---|---|---|
| C | Simulation | 1. Knowledge in productive process. Simulation can give information about the limits of the production process, about "what happens if…", about times, organization… management. |
| | | 2. Time optimization. Due to the complexity of the process, it is necessary to make many machine tunings, settings, etc., which slow down the whole process. Simulation can contribute to a better configuration and a better decision making. |
| | | 3. Production costs optimization. Simulation can help to optimize the consumption of tooling, raw materials and other consumables, which have a significant effect on the production costs. |
| | | 4. Predictive maintenance fulfilment. Simulation can help to reduce breakdowns that happen due to incorrect maintenance. It also helps to program maintenance stops in the production lines. |
| D | Integration Systems | 1. Real time vision of the business areas. Having a global vision of the different business areas has an impact on better decision making, better understanding, better crisis response, etc. |
| | | 2. Interactivity between business areas. Integration systems can provide real time interactivity between different business areas, what can help to optimize different processes. |
| | | 3. Improve communication and decision making. The quality / fluency of vertical communication impacts on decision making. |
| | | 4. Propagation of new technologies and their application. Integration systems can help to get value from other technologies adopted in different business areas and to share information generated all through the organization. |

| Technology | | Positive Impact (PI) |
|---|---|---|
| E | Internet of Things (IoT) | 1. Real time machine status. IoT allows to collect data to manage probabilities of breakdowns, planning maintenance stops and other stops affecting to processes and their efficiency. |
| | | 2. Control of Production parameters. Having real time production parameters affects the global functioning of production. IoT allows to collect data and having early warnings about machinery, processes and quality parameters in products. |
| | | 3. Traceability. Linkage of quality results (NOK/OK or defects) with process parameters. Tracking per unit to optimize process parameters. To use per unit tracking to adjust process parameters to each unit. This is very important both for the process improvement / optimization and for the product improvement / optimization. |
| F | Cloud | 1. Computational capacity. The entire value chain has growing demands, in terms of computational capacity / power, as all these technologies are being adopted. Cloud computing offers great scalability. |
| | | 2. New software / services acquisition. Commercial software tends to move to software as a service business model. Cloud computing is in the base of these business models. |
| | | 3. Remote working. Jobs are increasingly moving to a remote working model. At the same time, remote collaborations are increasingly used. Cloud tools are in the base of these trends. |
| | | 4. Flexibility. Flexible computational capacity according to the needs. Cloud computing is scalable and fits perfectly to a flexible “pay per use” model. |

| Technology | | Positive Impact (PI) |
|---|---|---|
| G | Additive Manufacturing | 1. Agile prototyping. Additive manufacturing enables the capacity to fabricate prototypes for different business areas (design, productions, sales, …), having many advantages in the process of design and innovation for the SMEs. |
| | | 2. Reducing parts number in the assembly. Additive manufacturing enables the possibility of simplification, as conventional manufacturing technologies limitations usually drive to products composed of many elements. |
| | | 3. Product and production optimization. Additive manufacturing enables as many different geometries as you can imagine. This capability allows both a product and production optimization. |
| | | 4. Repairing parts. Additive manufacturing makes possible to repair parts due to defects, accidents, as a service… |
| H | Cybersecurity | 1. Server shutdowns. Server and services shutdowns affect company's operating. Cybersecurity should help to minimize this happening. |
| | | 2. Cloud services. Services / tasks developed in the cloud are usually perceived as less secure. Cybersecurity technologies should help to minimize risks. |
| | | 3. Fast software upgrades, multiplatform applications. Cybersecurity should guarantee security and integrate with these trends. |
| | | 4. Safe files transferring. File transferring with customers and other stakeholders is crucial and must be secure. Cybersecurity has an important role in this matter. |

| Technology | | Positive Impact (PI) |
| --- | --- | --- |
| I | Augmented and Virtual Reality | 1. No-risk training in critical operations / tasks. There are some critical tasks (core processes, "in process" maintenance, high cost parts…) that require knowledge and experience. Augmented and virtual reality technologies can help training those critical tasks with no risks for people. |
| | | 2. Per-unit control. Per-unit control (process parameters, location…) could yield benefits in productive process, and augmented reality could help it happens. |
| | | 3. Expert remote support, in situ information, smart glasses. Tasks that require expert knowledge and critical parameters will benefit from the use of augmented reality technologies. |
| | | 4. Warehouse management complexity. Warehouse management complexity grade makes it a good candidate for the use of augmented reality, helping to optimize operations, reducing mistakes, giving real time information for decision-making… |

## 2.2.4 MATRIX TECHNOLOGIES / INDICATORS

| Technology | | Indicator (I1) | I2 | I3 | I4 | I5 |
|---|---|---|---|---|---|---|
| A | Big Data | Success rate in commercial proposals. | Market perception for innovation products | Contribution margins | | |
| | | Market share. | Value added. | | | |
| | | Production time per unit | Production costs per unit | Nonconformity products rate | | |
| | | Maintenance costs rate | Maintenance time rate | Costs of maintenance per unit produced | Number of machinery maintenance stops | Number of machinery failures per maintenance stop |
| B | Robotics | Production rate (units/hour) | Productivity (units/person) | Nonconformity products rate | | |
| | | Nonconformity products rate | Production costs per unit | Production time per unit | | |
| | | Sick leaves rate | Labour costs per unit produced | Labour risk perception | | |
| | | | | | | |
| C | Simulation | Production costs per unit | Nonconformity products. | | | |
| | | Production time per unit | Maintenance costs rate | Maintenance time rate | | |
| | | Production costs per unit | | | | |
| | | Number of brakedowns per unit | Production time per unit | Costs of maintenance per unit produced | Number of machinery maintenance stops | Number of machinery failures per maintenance stop |
| D | Integration Systems | Number of human mistakes per person | Sales per employee | General costs per Euro sold | Improvement perception with integration systems | |
| | | Number of human mistakes per person | Sales per employee | General costs per Euro sold | Improvement perception with integration systems | |
| | | Number of human mistakes per person | Sales per employee | General costs per Euro sold | Improvement perception with integration systems | |
| | | Number of human mistakes per person | Sales per employee | General costs per Euro sold | Improvement perception with integration systems | |

| | Technology | Indicator (I1) | I2 | I3 | I4 | I5 |
|---|---|---|---|---|---|---|
| E | Internet of Things (IoT) | Maintenance costs rate | Maintenance time rate | Lifetime of equipment | Number of machinery maintenance stops | Number of machinery failures per maintenance stop |
| | | Production costs per unit | Nonconformity products rate | | | |
| | | Nonconformity products rate | Production costs per unit | | | |
| F | Cloud | Computational capacity costs rate | | | | |
| | | Software & SAAS costs rate | | | | |
| | | Remote working jobs rate | Infrastructure costs per employee | Cibersecurity costs per job | | |
| | | Fixed computational costs rate | | | | |
| G | Additive Manufacturing | R&D costs per product developed | R&D time per product developed (time to market) | | | |
| | | Assembly costs per product assembled | Assembly time rate per product | Rate of product failures | Guaranty costs per product sold | |
| | | Rate of product failures | Guaranty costs per product sold | | | |
| | | Incomes in repairing parts rate | Units of repairing parts sold share | | | |
| H | Cybersecurity | Number of server shutdowns | Costs of server shutdowns | | | |
| | | Number of cloud services shutdowns | Costs of cloud services shutdowns | | | |
| | | | | | | |
| | | | | | | |
| I | Augmented and Virtual Reality | Rate of human mistakes in critical operations / tasks | Costs of human mistakes in critical operations/tasks per mistake | Sick leaves rate | Number of stops in production process for training | Time of stops in production process for training rate |
| | | Nonconformity products rate | Production costs per unit | | | |
| | | Rate of human mistakes in critical operations / tasks | Nonconformity products rate | Production time per unit | Production costs per unit | |
| | | Warehouse management time per operation | Rate of warehouse management human mistakes per operation | Number of stock brakes / stock rotation index | Warehouse costs per operation | |

# 3 DEFINITION OF THE RESULTING INDICATORS

The following tables content a set of 50 indicators to evaluate the SMEs growth with the adoption of 4.0 industry technologies. This set of indicators is the one resulting from the use of both criteria of prioritisation (relevance and availability).

| Production costs per unit | | | CODE | 01.A.3.2 |
|---|---|---|---|---|
| **AIM** | **To show the impact of big data, robotics, simulation, IoT and Augmented and Virtual Reality on the better manage of the production process.** | | | |
| **TECHNOLOGIES** | A, B, C, E, I | **KIND** | Effect / quantitative. | |
| **DESCRIPTION** | This indicator shows the impact of "**A – big data**" applied to improve knowledge about productive process, "**B – robotics**" for real time process data generation, "**C – simulation**" to improve knowledge in productive process and for tooling, raw material, etc., optimization, "**E – IoT**" for the control of production parameters, linkage of quality results (NOK/OK or defects) with process parameters and tracking per unit to optimize process parameters, and "**I - Augmented and Virtual Reality**" for per-unit control: process parameters, location… and expert remote support, in situ information, smart glasses. All these technologies should influence the "production costs per unit", coming in a better performance of the indicator.<br>"**Production costs per unit**" should be stated as the division of the sum of all the production costs and the number of products made.<br>It should show a **decreasing** evolution. | | | |
| **PERIODICITY** | Biannual | | | |
| **RELEVANCE** | 5 | **AVAILABILITY** | 5 | |

| Value added | | | CODE | 02.A.2.2 |
|---|---|---|---|---|
| AIM | **To show the impact of big data on the knowledge SMEs use from market.** | | | |
| TECHNOLOGIES | A | KIND | Effect / quantitative. | |
| DESCRIPTION | "Value added" aims to show the effect of "A – big data" on market, customer, products and competition knowledge. As long as the SME knowledge on all of these dimensions increases, the better its strategy will be.<br>"**Value added**" should be stated as a difference between selling prices and production costs. It can be expressed in Euros (gross – turnover minus production costs) or Euros per unit.<br>It should show an **increasing** evolution with the use of big data technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 5 | AVAILABILITY | 5 | |

| General costs per Euro sold | | | CODE | 03.D.1.3 |
|---|---|---|---|---|
| AIM | **To show the impact of integration systems technologies on the costs structures of the SMEs.** | | | |
| TECHNOLOGIES | D | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**D – integration systems**" on the costs structures of the SMEs, as integration systems produce general synergies difficult to assess in very specific factors.<br>"**General costs per Euro sold**" should be stated as a division between the sum of costs other than production costs and the turnover for one year. It should be expressed in Euros per Euro sold, but it could be expressed as a percentage. This indicator is configured to show the impact of integration systems out of the production process (we have many other indicators for the production process).<br>Its value should **decrease**, in long term scope, with the adoption of integration systems. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 5 | AVAILABILITY | 5 | |

| Maintenance costs rate | | | CODE | 04.A.4.1 |
|---|---|---|---|---|
| **AIM** | **To show the impact of big data, simulation and IoT in maintenance performance.** | | | |
| **TECHNOLOGIES** | A, C, E | **KIND** | Effect / quantitative. | |
| **DESCRIPTION** | This indicator tries to show the impact in maintenance performance of "**A - big data",** applied to predictive maintenance, using CMMS, "**C – simulation**", applied to the complexity of the production process, and "**E - IoT**", applied to real time machine status, breakdowns, maintenance stops and other stops affecting to the process and its efficiency. The improvement should show a better performance in the "maintenance costs rate" of the SMEs.<br>"**Maintenance costs rate**" must be stated as a division between the sum of every maintenance contract or "in-house" costs related to capital goods for one year and the total value of those capital goods. It could be expressed as a percentage per year.<br>It should show a **decreasing** evolution. | | | |
| **PERIODICITY** | Annual. | | | |
| **RELEVANCE** | 5 | **AVAILABILITY** | 4 | |

| Contribution margins | | | CODE | 05.A.1.3 |
|---|---|---|---|---|
| **AIM** | **To show the impact of big data technologies on decision making and** | | | |
| **TECHNOLOGIES** | A | **KIND** | Effect / quantitative. | |
| **DESCRIPTION** | This indicator aims to show the impact of "**A – big data**" technologies on the better knowledge of markets and customers, what is connected to better decision making. All this information should help to define better strategies, better fitted products, etc. and lead to better contribution margins.<br>"**Contribution margins**" should be stated as a division between the difference between the selling price per unit and the sum of the variable costs per unit, and the selling price per unit. It should be stated as a percentage of the selling price.<br>Its value should **increase** with the adoption of big data technologies, but the effect could not be a short-term one. | | | |
| **PERIODICITY** | Annual | | | |
| **RELEVANCE** | 5 | **AVAILABILITY** | 4 | |

| Fixed computational costs rate | | | CODE | 06.F.4.1 |
|---|---|---|---|---|
| AIM | **To show the impact of cloud technologies on fixed costs of the SMEs.** | | | |
| TECHNOLOGIES | F | KIND | Effect / quantitative. | |
| DESCRIPTION | One of the benefits from "**F – cloud**" technologies is their capacity to turn fixed costs and investments into variable costs (flexible computational capacity according to the needs). By their introduction, SMEs could turn annual costs of licenses and hardware investments into SAAS costs or a "pay per use" model.<br>"**Fixed computational costs rate**" should be stated as a division between the sum of hardware amortizations and fixed software licences and the sum of all computational costs in the company. It could be expressed as a percentage.<br>It should show a **decreasing** evolution. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Incomes in repairing parts rate | | | CODE | 07.G.4.1 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing on the repairing pats business line.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | "Incomes in repairing parts rate" aims to show the effect of "**G – additive manufacturing**" on being able to repair parts because of defects, accidents… as a service. These technologies could enable a new business line in SMEs or make it more competitive in the ones that already had it.<br>"**Incomes in repairing parts rate**" should be stated as a division between the sum of incomes coming from repairing parts and the global turnover. It could be expressed as a percentage.<br>It should show an **increasing** evolution with the use of additive manufacturing technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Sick leaves rate | | CODE | 08.B.3.1 |
|---|---|---|---|
| AIM | **To show the impact of robotics and augmented and virtual reality technologies on leaves caused by risky labour conditions.** | | |
| TECHNOLOGIES | B, I | KIND | Effect / quantitative. |
| DESCRIPTION | This indicator aims to show the impact in labour risks of "**B – robotics**" in risky labour conditions and "**I - augmented and virtual reality**" as helping tools to train and offer information to reduce risks in labour conditions.<br>"**Sick leaves rate**" should be stated as a division between the number of sick leaves in production process (because of risky conditions) and the total number of sick leaves. It could be expressed as a percentage.<br>It should show a **decreasing** evolution with the use of these technologies. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 4 | AVAILABILITY | 5 |

| Sales per employee | | CODE | 09.D.1.2 |
|---|---|---|---|
| AIM | **To show the impact of integration systems on the global productivity.** | | |
| TECHNOLOGIES | D | KIND | Effect / quantitative. |
| DESCRIPTION | This indicator aims to measure the impact of "**D – integration systems**" in global productivity of people. Real time vision, global vision, interactivity, improved communication between business areas… should have an impact on a better decision making, better understanding, better crisis response, etc., and on the propagation of the benefits from each technology implemented.<br>"**Sales per employee**" should be stated as a division of sales and the total number of employees. It should be expressed in Euros per person.<br>It should show an **increasing** evolution with the use of these technologies. It has to be said that many other factors could affect this indicator, so it has to be carefully analysed. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 4 | AVAILABILITY | 5 |

| Units of repairing parts sold share | | | CODE | 10.G.4.2 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing on the SMEs businesses by the introduction of new possibilities.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This ratio aims to show the effect of "**G – additive manufacturing**" on the product and production optimization. As a consequence of the introduction of these technologies, parts that couldn't, now can be repaired; so, these technologies enable a new business line.<br>"**Units of repairing parts sold share**" should be stated as a division between the sum of units of repairing parts sold and the whole sum of units sold (repairing parts and new ones). It should be considered the nature of parts to compare units (both small and high value units are counting the same in this ratio).<br>It should show an **increasing** evolution with the introduction of additive manufacturing technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Labour costs per unit produced | | | CODE | 11.B.3.2 |
|---|---|---|---|---|
| AIM | **To show the impact of robotics on the labour costs of SMEs.** | | | |
| TECHNOLOGIES | B | KIND | Effect / quantitative. | |
| DESCRIPTION | The aim of this indicator is to show the impact of "**B – robotics**" technologies on the labour costs of the SMEs.<br>"**Labour costs per unit produced**" should be stated as a division between the labour costs in the production process and the number of units produced for one year. It should be expressed in Euros per unit made. Of course, this indicator shouldn't be taken into account on its own, because any human job elimination will drive to lower labour costs, but it gives information about the impact of robotics in the SMEs. It should be analysed together with "Sick leaves rate" and "Labour risks perception".<br>Its value should **decrease** with the adoption of robotics technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Number of stock brakes / stock rotation index | | | CODE | 12.I.4.3 |
|---|---|---|---|---|
| AIM | **To show the impact of augmented and virtual reality technologies on warehouse management.** | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**I – augmented and virtual reality**" technologies on warehouse management, as these technologies should help to predict this happening though supplies consumption in different scenarios, giving warnings, etc.<br>"**Number of stock brakes / stock rotation index**" should be stated as a division between the number of stock brakes in one year and the stock rotation index, calculated as a division between sales (at costs prices) and the medium stock of the period. The resulting value could be stated as a percentage. This indicator should not be difficult to be stated.<br>Its value should **decrease** with augmented and virtual reality technologies adoption. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Number of machinery failures per maintenance stop | | | CODE | 13.A.4.5 |
|---|---|---|---|---|
| AIM | | | | |
| TECHNOLOGIES | A, C, E | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**A – big data**", "**C – simulation**" and "**E – IoT**" technologies on machinery maintenance. Using these technologies, the number of machinery failures should be reduced.<br>"**Number of machinery failures per maintenance stop**" per year should be stated as a division between the sum of these machinery failures and the sum of maintenance stops. This indicator should be analysed together with other indicators aiming to show the effect of these technologies on machinery lifetime and its predictive maintenance. It could be expressed as a percentage.<br>It should show a **decreasing** evolution with the adoption of these technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 5 | |

| Production time per unit | | | CODE | 14.A.3.1 |
|---|---|---|---|---|
| AIM | **To show the impact of big data applied to the production process.** | | | |
| TECHNOLOGIES | A, B, C, I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator tries to show the impact of "**A - big data**" applied to improve knowledge about the productive process (cycle time, machine stops, resources…) of the SMEs. It also shows the impact of "**B – robotics**" - real time process data generation. There are automatize elements in the production line which collect information / data from the process – in the production process, "**C – simulation**" - costs reduction due to machine tunnings, settings, etc. Due to the complexity of the processs, it is necessary to make many machine tunnings, settings, etc., which slow down the whole process; simulation has an impact in predictive maintenance fulfilment. Breakdowns that happen due to incorrect maintenance also have an impact in the production process - , and "**I - Aumented and Virtual Reality**" - expert remote support, in situ information, smart glasses. Tasks that require expert knowledge and critical parameters should benefit from these technologies, so they should have an effect in "production time per unit". This improvement should show a better performance in the production time per unit.<br>"**Production time**" must be stated as a division between time necessary for the whole production process and number of products made. It should be expressed in time units (hours, minutes… depending on the good made) per product made.<br>It should show a **decreasing** evolution (savings in time per unit). | | | |
| PERIODICITY | Biannual. | | | |
| RELEVANCE | 5 | AVAILABILITY | 3 | |

| Production rate (units/hour) | | | CODE | 15.B.1.1 |
|---|---|---|---|---|
| AIM | **To show the impact of robotics in the productivity of SMEs.** | | | |
| TECHNOLOGIES | B | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator tries to show the impact of "**B - robotics"** applied to improvements in production rate, repetitiveness, quality, costs… There are operations / tasks in the productive process that are likely to be automated due to their nature (repetitive, high quality demanding, high physical effort demanding…). This improvement should show a better performance in the "production rate" of the SMEs.<br>"**Production rate**" must be stated as the division of units made and hours used in the production process for those units, and should be expressed in units/h.<br>It should show an **increasing** evolution. | | | |
| PERIODICITY | Biannual. | | | |
| RELEVANCE | 5 | AVAILABILITY | 3 | |

| Productivity (units/person) | | | CODE | 16.B.1.2 |
|---|---|---|---|---|
| AIM | **To show the effect of robotics in people's productivity.** | | | |
| TECHNOLOGIES | B | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator shows the impact of "**B – robotics**" - improvements in production rate, repetitiveness, costs… There are operations / tasks in the productive process that are likely to be automated due to their nature (repetitive, high physical effort demanding…). The use of these technologies should come in better performance of "Productivity (units/person)".<br>"**Productivity (units/person)**" should be stated as the division between the number of products made and the number of people working on the production process.<br>It should show an **increasing** evolution. | | | |
| PERIODICITY | Biannual. | | | |
| RELEVANCE | 5 | AVAILABILITY | 3 | |

| Rate of human mistakes in critical operations / tasks | | | CODE | 17.I.1.1 |
|---|---|---|---|---|
| AIM | **To show the impact of augmented and virtual reality on critical operations / tasks.** | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator shows the effect of "I - augmented and virtual reality" in critical operations / tasks, as these technologies allow to train these operations with no risk and can help to prevent and to avoid problems by giving real time information. These technologies are of special interest also in operations that require expert knowledge and critical parameters.<br>"**Rate of human mistakes in critical operations / tasks**" should be stated as a division between the number of these mistakes taking place in half a year, for example, and the total number of these operations in the same period. It could also be expressed as a percentage.<br>It should show a **decreasing** evolution with the use of these technologies. | | | |
| PERIODICITY | Biannual | | | |
| RELEVANCE | 5 | AVAILABILITY | 3 | |

| Labour risk perception | | | CODE | 18.B.3.3 |
|---|---|---|---|---|
| AIM | **To show the impact of robotics technologies on labour risk and its perception.** | | | |
| TECHNOLOGIES | | KIND | Effect / qualitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**B – robotics**" technologies on labour risk and its perception, as these technologies can help or substitute people in risky processes.<br>"**Labour risk perception**" is a quality indicator that should be included in a work climate survey. Results of this annual survey should be analysed. It could be asked in a 1 to 5 degrees, where 1 would be the minimum one and 5 the maximum. Then, the average value should be calculated.<br>It should show a **decreasing** evolution with the adoption of robotics technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 5 | AVAILABILITY | 3 | |

| Assembly costs per product assembled | | | CODE | 19.G.2.1 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing technologies on the assembly process.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**G – additive manufacturing**" in the complexity of production processes and products. Additive manufacturing should help in reducing parts number in the assembly process.<br>"**Assembly costs / product**" should be stated as the division between the sum of assembly costs and the number of products assembled. It must be expressed in Euros / unit.<br>It should show a **decreasing** evolution with the use of additive manufacturing technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 4 | |

| Lifetime of equipment | | | CODE | 20.E.1.3 |
|---|---|---|---|---|
| AIM | **To show the impact of IoT technologies on the lifetime of capital equipment.** | | | |
| TECHNOLOGIES | E | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**E - IoT**" technologies on the lifetime of capital equipment, as real-time data and its analysis should help to instantly detect misfunctioning and drive to a predictive, early and better maintenance. These IoT technologies should be used in combination with big data, simulation or even integration systems technologies to take advantage of them.<br>"**Lifetime of equipment**" should be stated as the real time that machinery works in good and competitive conditions (technological obsolescence must be considered), usually expressed in years. It could be stated as a mean of "lifetime" of each equipment, or just related to critical or great value equipment. It is not easy to reach to an exact value. Values should be compared with historical ones.<br>Its value should **increase** with the adoption of IoT technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 4 | |

| Success rate in commercial proposals | | | CODE | 21.A.1.1 |
|---|---|---|---|---|
| AIM | **To show the impact of big data applied to the better knowledge of competitive factors in the marketing performance.** | | | |
| TECHNOLOGIES | A | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator tries to show the impact of "**A - big data**" applied to improve knowledge about the different competitive factors (knowledge about customers, competitors, trends…) of the SMEs. This indicator applies to every technology that applies to the most relevant competitive factors. This improvement should show a better performance in the conversion rate of opportunities.<br>"**Success rate in commercial proposals**" must be stated as a division between units of commercial operations confirmed and commercial proposals. It could be expressed as a percentage.<br>It should show an **increasing** evolution. | | | |
| PERIODICITY | Annual. | | | |
| RELEVANCE | 5 | AVAILABILITY | 2 | |

| Software & SAAS costs rate | | | CODE | 22.F.2.1 |
|---|---|---|---|---|
| AIM | **To show the impact of cloud technologies on the costs of software for the SMEs.** | | | |
| TECHNOLOGIES | F | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "F – cloud" technologies on the costs of software and its services, besides other benefits (efficiency – pay per use -, cybersecurity, actualization/obsolescence…).<br>"**Sofware & SAAS costs rate**" should be stated as the division between the costs of software licenses paid by the SME and turnover in Euros. This rate could be expressed as a percentage.<br>It should show a **stable** (software and SAAS needs are growing) **or decreasing** evolution. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 5 | |

| Remote working jobs rate | | | CODE | 23.F.3.1 |
|---|---|---|---|---|
| **AIM** | **To complement other indicators to explain the impact of cloud technologies on remote working jobs.** | | | |
| **TECHNOLOGIES** | F | **KIND** | Effect / quantitative. | |
| **DESCRIPTION** | This indicator aims to show the effect of "**F – cloud**" technologies in facilitating remote working jobs. It complements information with other indicators.<br>"**Remote working jobs rate**" should be stated as a division between the number of remote working jobs and the total number of jobs. It could be expressed as a percentage.<br>It should show an **increasing** evolution. | | | |
| **PERIODICITY** | Annual | | | |
| **RELEVANCE** | 3 | **AVAILABILITY** | 5 | |

| Number of machinery maintenance stops | | | CODE | 24.A.4.4 |
|---|---|---|---|---|
| **AIM** | **To show the impact of big data, simulation and IoT technologies on machinery maintenance.** | | | |
| **TECHNOLOGIES** | A, C, E | **KIND** | Effect / quantitative. | |
| **DESCRIPTION** | This indicator aims to show the effect of "**A – big data**", "**C – simulation**" and "**E – IoT**" technologies on machinery maintenance. Using these technologies, the number of machinery maintenance stops should be optimized.<br>"**Number of machinery maintenance stops**" per year should be stated as a sum of these maintenance stops. This indicator should be analysed together with other indicators aiming to show the effect of these technologies on machinery lifetime and its predictive maintenance.<br>It should show a **decreasing** evolution with the adoption of these technologies. | | | |
| **PERIODICITY** | Annual | | | |
| **RELEVANCE** | 3 | **AVAILABILITY** | 5 | |

| Number of stops in production process for training | | | CODE | 25.I.1.4 |
|---|---|---|---|---|
| AIM | | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | The aim of this indicator is to show the effect of "**I – augmented and virtual reality**" technologies on the production process. These technologies should help to reduce and minimize stops in production process for training, as they can reproduce virtual environments to make the training process as realistic as possible.<br>"**Number of stops in production process for training**" should be stated as a sum of this kind of stops happening during the year.<br>It should show a **decreasing** evolution with the use of augmented and virtual reality. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 5 | |

| Time of stops in production process for training rate | | | CODE | 26.I.1.5 |
|---|---|---|---|---|
| AIM | **To show the impact of augmented and virtual reality technologies on the production lines used for training.** | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | The aim of this indicator is to show the impact of "**I – augmented and virtual reality**" on the time that production process is stopped because of personnel training, as these technologies should allow to highly reproduce the whole production process in a realistic way, so that the trend should be for none stops at all.<br>"**Time of stops in production process for training rate**" should be stated as a division between time of stops in the production process and total time available of the production process in one year. It could be expressed as a percentage.<br>It should show a **decreasing** evolution with the use of augmented and virtual reality technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 5 | |

| Nonconformity products rate | | | CODE | 27.A.3.5 |
|---|---|---|---|---|
| AIM | **To show the impact of big data, robotics, IoT and augmented and virtual reality in the quality of the products.** | | | |
| TECHNOLOGIES | A, B, E | KIND | Effect / quantitative. | |
| DESCRIPTION | Knowledge provided by the following technologies should have an effect in the quality of the products. "**A - big data**" provides knowledge about productive process, to exploit production data (cycle time, machine stops...), the resources available and their quality. "**B – robotics**" provides improvements in production quality. There are operations / tasks in the productive process that are likely to be automated due to their nature (repetitive, high quality demanding, high physical effort demanding…), but also real time process data generation: there are elements that can be automatized which collect quality information / data from the process. "**E – IoT**" provides knowledge about real time machine status can affect to quality of the products. Control of Production parameters: having real time production parameters affects the global functioning of production. Linkage of quality results (NOK/OK or defects) with process parameters. Tracking per unit to optimize process parameters. "**I - augmented and virtual reality**" enables per-unit control: process parameters, location… Per-unit control could yield benefits in productive process. Expert remote support, in situ information, smart glasses. Tasks that require expert knowledge and critical parameters are susceptible to benefit from these technologies. The use of these technologies should come in lower values of "nonconformity products rate".<br>"**Nonconformity products rate**" should be stated as the division between the number of nonconformity products and the number of products made and could be expressed as a percentage.<br>It should show a **decreasing** evolution. | | | |
| PERIODICITY | Biannual. | | | |
| RELEVANCE | 4 | AVAILABILITY | 3 | |

| Number of breakdowns per unit | | | CODE | 28.C.4.1 |
|---|---|---|---|---|
| AIM | **To show the impact of simulation on predictive maintenance fulfilment.** | | | |
| TECHNOLOGIES | C | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to measure the effect of "**C – simulation**" for predictive maintenance fulfilment, tackling breakdowns that happen due to incorrect maintenance.<br>"**Number of breakdowns per unit**" should be stated as a division between the number of breakdowns and the number of products made.<br>It should show a **decreasing** evolution. | | | |
| PERIODICITY | Biannual | | | |
| RELEVANCE | 4 | AVAILABILITY | 3 | |

| R&D costs per product developed | | | CODE | 29.G.1.1 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing in R&D costs per product developed.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**G – additive manufacturing**" in the costs of innovation for SMEs. Agile prototyping, having the capacity to fabricate prototypes for different business areas (design, production, sales…) has important advantages in R&D costs savings.<br>"**R&D costs / product developed**" should be stated as the division between the whole R&D costs and the number of new products developed. It must be expressed in Euros / unit.<br>It should show a **decreasing** evolution. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 3 | |

| Rate of product failures | | | CODE | 30.G.3.1 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing technologies on product reliability.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**G – additive manufacturing**" in the quality of products made. Additive manufacturing should act in product quality/reliability through product and production optimization, reducing parts number…<br>"**Rate of product failures**" should be stated as the division between the sum of product failures per year and the number of products currently in the market. It could be broken down into many different rates (rate of product failures after 5 years, for example).<br>It should show a **decreasing** evolution with the use of additive manufacturing technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 3 | |

| Warehouse management time per operation | | | CODE | 31.I.4.1 |
|---|---|---|---|---|
| AIM | **To show the effect of augmented and virtual reality on warehouse management complexity.** | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator shows the effect of "**I - augmented and virtual reality**" in warehouse management complexity.<br>"**Warehouse management time per operation**" should be stated as a division between the total time used in warehouse management and the total number of operations made. It should be expressed in time units per operation.<br>It should show a **decreasing** evolution with the use of these technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 3 | |

| Costs of maintenance per unit produced | | CODE | 32.A.4.3 |
|---|---|---|---|
| AIM | **To show the impact of big data, simulation and IoT on the costs of maintenance due to predictive maintenance.** | | |
| TECHNOLOGIES | A, C, E | KIND | Effect / quantitative. |
| DESCRIPTION | This indicator aims to show the effect of "**A – big data**", "**C – simulation**" and "**E – IoT**" technologies on the performance of machinery, as these technologies can help to approach to the concept of predictive maintenance and its benefits.<br>"**Costs of maintenance per unit produced**" should be stated as a division between the sum of costs of maintenance and the number of units produced in one year. It should be expressed in Euros per unit. The effect should be analysed in the long term and together with other indicators, because "no maintenance" would drive to the lowest value of this indicator in short term basis. It should be expressed in Euros per unit made.<br>Its value should **decrease** with the adoption of these technologies. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 4 | AVAILABILITY | 3 |

| Improvement perception with integration systems | | CODE | 33.D.1.4 |
|---|---|---|---|
| AIM | **To show the impact of integration systems technologies on different factors.** | | |
| TECHNOLOGIES | D | KIND | Effect / qualitative. |
| DESCRIPTION | This indicator aims to show the impact of "**D – integration systems**" technologies on different job factors as efficiency in processes, communication improvement, decision making, etc.<br>"**Improvement perception with integration systems**" is a quality indicator that should be included in a work climate survey for as many factors as wanted. Results of this annual survey should be analysed. It could be asked in a 1 to 5 degrees, where 1 would be the minimum one and 5 the maximum. Then, the average value should be calculated for each factor.<br>It should show an **increasing** evolution with the adoption of robotics technologies. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 4 | AVAILABILITY | 3 |

| Maintenance time rate | | | CODE | 34.A.4.2 |
|---|---|---|---|---|
| AIM | **To show the impact of big data, simulation and IoT on the maintenance process.** | | | |
| TECHNOLOGIES | A, C, E | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact in the production process of "**A – big data**" for predictive maintenance, "**C – simulation**" for costs reduction due to machine tunnings, settings, etc., and "**E – IoT**" for real time machine status.<br>"**Maintenance time rate**" should be stated as a division between the sum of maintenance time and the sum of production time per year. It could be expressed as a percentage.<br>It should show a **decreasing** evolution with the use of these technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 4 | |

| Infrastructure costs per employee | | | CODE | 35.F.3.2 |
|---|---|---|---|---|
| AIM | **To show the impact of cloud technologies on the reduction of infrastructure costs.** | | | |
| TECHNOLOGIES | F | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**F – cloud**" technologies on the reduction of infrastructure costs. Thanks to cloud technologies, many workers are moving to remote working jobs. As far as this occurs, infrastructure costs should reduce. Cloud technologies are also moving hardware and software investments to contracting services.<br>"**Infrastructure costs per employee**" should be stated as a division between the sum of infrastructure costs and the total number of employees, per year. It should be expressed in Euros per employee.<br>It should show a **decreasing** evolution with these technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 4 | |

| Guaranty costs per product sold | | | CODE | 36.G.3.2 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing on the reliability of products.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This ratio aims to show the effect of "**G – additive manufacturing**" on the product and production optimization. As a consequence of the introduction of these technologies, products should have less parts, should be simpler and have higher reliability, so guaranty costs per product sold should decrease.<br>"**Guaranty costs per product sold**" should be stated as a division between the sum of guaranty costs and the number of products sold within guaranty life. It should be expressed in Euros per product.<br>It should show a **decreasing** evolution with the adoption of additive manufacturing. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 4 | |

| Cybersecurity costs per job | | | CODE | 37.F.3.3 |
|---|---|---|---|---|
| AIM | **To show the impact of cloud technologies on cybersecurity costs.** | | | |
| TECHNOLOGIES | F | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**F - cloud**" technologies on cybersecurity and its costs, as cloud technologies should be secured in origin, always and continuously updated and monitored.<br>"**Cybersecurity costs per job**" should be stated as a division between the sum of cybersecurity costs and the total number of jobs in the SME. To partially avoid the direct impact of the size of the SME, activity, etc., it is intended to express it in a "per job" basis. It should be expressed in Euros per job.<br>Its value should **decrease** with cloud technologies adoption. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 4 | |

| Number of human mistakes per person | | | CODE | 38.D.1.1 |
|---|---|---|---|---|
| AIM | **To show the effect of integration systems on human mistakes.** | | | |
| TECHNOLOGIES | D | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to measure the impact of "**D – integration systems**" to avoid human mistakes in operations. Real time vision of the business areas, having a global vision of the different business areas, interactivity between business areas, improved communication… should have an impact on a better decision making, better understanding, better crisis response, etc., and on the propagation of the benefits from each technology implemented.<br>"**Number of human mistakes per person**" should be stated as a division between the sum of every registered human mistake, as this concept is defined in the quality systems of the SMEs, and the total number of people working for the company.<br>It should show a **decreasing** evolution with these technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 2 | |

| Market perception for innovation products | | | CODE | 39.A.1.2 |
|---|---|---|---|---|
| AIM | **To show the impact of big data technologies on the marketing success of innovation products.** | | | |
| TECHNOLOGIES | A | KIND | Effect / qualitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**A – big data**" on the perception that market has for innovation products. As long as big data helps SMEs to understand competitive factors, it helps to guess right with innovation products.<br>"**Market perception for innovation products**" is a qualitative indicator that should be stated using survey techniques. It could be estimated indirectly through the market share of innovative products, time to get that market share… besides the efforts made on their promotion.<br>It should show an **increasing** evolution with the use of big data technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 2 | |

| Costs of human mistakes in critical operations/tasks per mistake | | | CODE | 40.I.1.2 |
|---|---|---|---|---|
| AIM | To show the impact of augmented and virtual reality technologies on human performance in critical operations/tasks. | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**I - augmented and virtual reality**" technologies on human performance in critical operations/tasks, as these technologies can help both in training and in real and real time operations. Once this kind of mistakes are identified, their cost should be estimated.<br>"**Costs of human mistakes in critical operations/tasks per mistake**" should be stated as a division between the sum of all the direct costs incurred because of human mistakes in critical operations/tasks plus all the indirect ones, and the sum of mistakes during the year. It should be expressed in Euros per mistake, to avoid the possible impact of the volume of activity in the number of mistakes occurred. The estimation of these costs would be easier in well-defined and developed quality systems.<br>It should show a **decreasing** evolution with the adoption of "I – augmented and virtual reality" technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 4 | AVAILABILITY | 2 | |

| Warehouse costs per operation | | CODE | 41.I.4.4 |
|---|---|---|---|
| AIM | **To show the impact of augmented and virtual reality on the efficiency of warehouse management.** | | |
| TECHNOLOGIES | | KIND | Effect / quantitative. |
| DESCRIPTION | One of the effects of the use of "**I – augmented and virtual reality**" technologies on warehouse management is its simplification, helping an agile decision making based on real time knowledge given to managers and operators. Augmented and virtual reality – in combination with other technologies like simulation… - can give scenario/probabilistic real time analysis, can show real time critical information, etc., simplifying warehouse management and minimizing the occurrence of mistakes. This should make an effect on the efficiency of operations.<br>"**Warehouse costs per operation**" should be stated as a division between the sum of all the direct and indirect costs involved in operations and the number of operations in one year. This disaggregation between direct and indirect costs is interesting for a subsequent analysis. It should be expressed in Euros per operation.<br>It should show a **decreasing** evolution with the use of augmented and virtual reality. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 4 | AVAILABILITY | 2 |

| Number of server shutdowns | | CODE | 42.H.1.1 |
|---|---|---|---|
| AIM | **To show the impact of cybersecurity on server performance.** | | |
| TECHNOLOGIES | H | KIND | Effect / quantitative. |
| DESCRIPTION | This indicator aims to show the effect of "**H – cybersecurity**" on server performance, having an impact on the normal operation of SMEs.<br>"**Number of server shutdowns**" should be stated as the sum of shutdowns taking place in one year, for example.<br>It should show a **decreasing** evolution with the use of cybersecurity technologies. | | |
| PERIODICITY | Annual | | |
| RELEVANCE | 3 | AVAILABILITY | 3 |

| Number of cloud services shutdowns | | | CODE | 43.H.2.1 |
|---|---|---|---|---|
| AIM | **To show the impact of cybersecurity on cloud services performance.** | | | |
| TECHNOLOGIES | H | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the effect of "**H – cybersecurity**" on cloud services performance, having an impact on the normal operation of SMEs.<br>"**Number of cloud services shutdowns**" should be stated as the sum of shutdowns taking place in one year, for example.<br>It should show a **decreasing** evolution with the use of cybersecurity technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 3 | |

| Assembly time rate per product | | | CODE | 44.G.2.2 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing on the assembly process.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**G – additive manufacturing**" on the assembly process. These technologies allow to reduce parts number, so it simplifies and shortens assembly process.<br>"**Assembly time rate**" should be stated as a division between the assembly time and the total production time per product. It should be expressed in time units per product.<br>It should show a **decreasing** evolution with the adoption of additive manufacturing. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 3 | |

| Rate of warehouse management human mistakes per operation | | | CODE | 45.I.4.2 |
|---|---|---|---|---|
| AIM | **To show the impact of augmented and virtual reality technologies on the occurrence of human mistakes in warehouse management.** | | | |
| TECHNOLOGIES | I | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**I – augmented and virtual reality**" technologies on the occurrence of human mistakes in warehouse management, as these technologies can help offering real time information that helps and assures the whole process.<br>"**Rate of warehouse management human mistakes per operation**" should be stated as a division between the sum of all these mistakes occurred during the year and the total number of operations, for example, to avoid the impact of the volume of activity in the evolution of this indicator. It could be stated as a percentage. The estimation of this rate would be easier in well-defined and developed quality systems.<br>It should show a **decreasing** evolution with the adoption of "I – augmented and virtual reality" technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 3 | |

| Market share | | | | CODE | 46.A.2.1 |
|---|---|---|---|---|---|
| AIM | **To show the impact of big data applied to the better knowledge of competitive factors in the market position of the SMEs.** | | | | |
| TECHNOLOGIES | A | KIND | Effect / quantitative. | | |
| DESCRIPTION | This indicator tries to show the impact of "**A-big data"** applied to improve knowledge about the different competitive factors (knowledge about customers, competitors, trends…) of the SMEs. This indicator applies to every technology that applies to the most relevant competitive factors.<br>"**Market share**" must be stated as a division between annual sales and market size, wherever the company operates. It could be expressed as a percentage.<br>It should show an **increasing** evolution. | | | | |
| PERIODICITY | Annual. | | | | |
| RELEVANCE | 3 | AVAILABILITY | 2 | | |

| Computational capacity costs rate | | | | CODE | 47.F.1.1 |
|---|---|---|---|---|---|
| AIM | **To show the impact of cloud technologies on the costs of computational capacity.** | | | | |
| TECHNOLOGIES | F | KIND | Effect / quantitative. | | |
| DESCRIPTION | This indicator aims to show the impact of "**F – cloud**" on computational capacity and its costs. The entire value chain of the SME requires growing computational capacity / power, and cloud technologies could provide it at much lower costs than "in-house" hardware, besides other benefits (efficiency – pay per use -, cybersecurity, obsolescence…).<br>"**Computational capacity costs rate**" should be stated as a division between the sum of all the costs related to the maintenance of computational capacity and turnover in Euros. It could be expressed as a percentage.<br>It should show a **stable** (computational capacity needed is growing) **or decreasing** evolution. | | | | |
| PERIODICITY | Annual | | | | |
| RELEVANCE | 3 | AVAILABILITY | 2 | | |

| R&D time per product developed (time to market) | | | CODE | 48.G.1.2 |
|---|---|---|---|---|
| AIM | **To show the impact of additive manufacturing on the time to market of new products.** | | | |
| TECHNOLOGIES | G | KIND | Effect / quantitative. | |
| DESCRIPTION | This indicator aims to show the impact of "**G – additive manufacturing**" on the R&D time to develop a new product, as it allows agile prototyping.<br>"R&D time per product developed" should consider the whole time since the R&D starts until the moment a new product reaches marketing conditions. There are many factors for an SME that affect this lapse of time; for example, nature of the product, standardization, budgeting, permissions... It should consider various products. It should be expressed in time units.<br>It should show a **decreasing** evolution with additive manufacturing. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 2 | |

| Costs of server shutdowns | | | CODE | 49.H.1.2 |
|---|---|---|---|---|
| AIM | **To show the impact of cybersecurity in SMEs businesses.** | | | |
| TECHNOLOGIES | H | KIND | Effect / quantitative. | |
| DESCRIPTION | The aim of this indicator is to show the effect of "**H – cybersecurity**" technologies on the activity of the SMEs, as it is growing their importance as TICs and connectivity are growing.<br>"**Costs of server shutdowns**" should be stated as a sum of all the direct costs that have to be paid to restore activity, fixed or variable, plus all indirect costs that have to be taken into account as a consequence of the stop in systems (sales, purchases, production orders, time…). It should be expressed in Euros per year. This indirect component is not easy to estimate.<br>It should show a **decreasing** evolution with the introduction of cybersecurity technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 1 | |

| Costs of cloud services shutdowns | | | CODE | 50.H.2.2 |
|---|---|---|---|---|
| AIM | To show the impact of cybersecurity in SMEs businesses. | | | |
| TECHNOLOGIES | H | KIND | Effect / quantitative. | |
| DESCRIPTION | The aim of this indicator is to show the effect of "**H – cybersecurity**" technologies on the activity of SMEs, by calculating the economic impact of cloud services shutdowns, as cybersecurity should help to protect systems from shutdowns derived from attacks.<br>"**Costs of cloud services shutdowns**" should be stated as a sum of all the direct costs that have to be paid to restore activity, fixed or variable, plus all indirect costs that have to be taken into account as a consequence of the stop in cloud services (sales, purchases, production orders, time…). It should be expressed in Euros per year. This indirect component is not easy to estimate.<br>It should show a **decreasing** evolution with the introduction of cybersecurity technologies. | | | |
| PERIODICITY | Annual | | | |
| RELEVANCE | 3 | AVAILABILITY | 1 | |

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## ADAPTATION OF INDUSTRY 4.0 MODEL TO THE NAVAL SECTOR

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