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INDUSTRY 4.0: Analysis of the economic impact of AR devices inside PRIMA INDUSTRIE

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INDEX

Abstract

The main topic of this work is the Augmented Reality inside the company Prima Industria.

The first part is an introduction to The Fourth Industrial Revolution called 'Industry 4.0' and all its main features. The description is realized through a detailed analysis on the nine pillars that are the roots of this movement and all the positive and negative aspects that it brings.

Relevant space in the thesis is given to the Fourth Revolution, inside Prima Industrie, the reasons that convinced PI in starting this project, and all the economic advantages that offering a service like this could bring to the company. After a brief overview on all the activities related to the Industry 4.0, there is an analysis that underlines what could be the economic profit in dispensing a service as AR devices to customers.

In the end of all the analysis, what is clear is that the Fourth Industrial Revolution is a very important change all around the world of the production plants, since it improves the production process and reduce the time of downtime. However, even if these devices gives a huge advantage, they have some limits, such as the bandwidth, the prolonged exposition for employees to a technological device, or the fact that they should open their mind to concepts that are completely different compare before.

Although there are several obstacles to the spread of AR devices, looking at the future, what it is clear is that their usage could bring only economic benefits and also in the way firms manage the entire process.

CHAPTER 1

DESCRIPTION OF INDUSTRY 4.0: NINE PILLARS AND ANALYSIS OF THE AUGMENTED REALITY

1.1 Origin on The Industry 4.0

The term Industry 4.0 stands for the fourth industrial revolution, which is defined as the new level of organization and control over the entire value chain of the life cycle of the life cycle of products; it is oriented towards individualized customer requirements. The central purpose of Industry 4.0 is to cope with the different customers' need that affect fields such as research and development, manufacturing commissioning, order management, and so on. As we said in the beginning this new trend is considered the fourth industrial revolution, in fact, it is the result of a long process of innovation and improvements in different fields. We can summarize in the following way the previous revolutions:

- First Revolution → from 1784 to middle 19th century which was more focused on the water and steam-powered mechanical manufacturing;

- Second Revolution → from late 19th century until 1970s which was on the electrical powered mass production based on the division of labor (assembly line);
- Third Revolution → from 1970s until today there is the third revolution where the electronics and information technology drive new levels of automation of complex tasks;
- Fourth Revolution → from today we have the Industry 4.0, which is about sensor technology, interconnectivity and data analysis, mass customization, integration of value chains and greater efficiency.

  This definition was adopted the first time during the biggest meeting for the industrial technologies at the Hannover fair in 2011 in Germany. The paradigm of Industry 4.0 is that in the future, machines will contain all the useful information for production, but more important these machines will become the central point of the production process, since they will be able to coordinate themselves and with users. In a few words, the main aim if this revolution is to convert the regular machines to self-aware and self-learning machine to improve their overall performance and maintenance management with the surrounding interaction. Industry 4.0 has the goal of constructing an open, smart manufacturing platform for industrial-networked information application, real time monitoring, tracking the status and positions of product as well as to hold the instructions to control production processes.

  The central points of Industry 4.0 are data, information and how they are exploited using digital technologies to connect, innovate and govern the entire value chain in the manufacturing sectors. However, focusing only on digital bases poses limits, because this revolution is not composed by a single technology, as happened in the

previous industrial revolutions. This time, it comes from the convergence of different technological phenomena that see the intersection between the digital world, the studies on materials, artificial intelligence, people, objects and communities that interact with each other in a sudden way, giving rise to new tools and opening up new possibilities.

Different aspects support the huge growth of this phenomenon:

- The availability of more advanced technologies, which are reliable and less expensive;
- The reduction in cost for planning and development;
- Higher availability of information and data with sources outside the process;
- The possibility of translating typical process of human beings e the workers' capabilities in automatic processes → Artificial Intelligence.

It is important to keep in mind that all these technologies linked to Industry 4.0 have a modular architecture, so they can satisfy requirements of companies even if they vary from one company to another one.

1.2 Main features of Industry 4.0: Smart Factory

The main turning point of the Industry 4.0 is the concept of smart factory. It represents a company with an high level of know-how, characterized by an high level of automation, integration of systems cyber-physics in the industrial system and also in the communication between machines; from the digitalization and information of the entire industrial process to optimize the process itself. The principal aim of all

this is the reduction of costs (energy costs, maintenance costs, down time, etc…), as the name suggests, the smart factory is an efficient company.

The smart factory enables a huge customization of the product according the customers' requirements, higher energy and economic efficiency, faster decision maker process thanks to the availability of information that gives the possibility to the machine of taking autonomous and predictive decisions. Smart factories and more in general Industry 4.0 will bring some changes:

- Increased flexibility in production → automation of the production process, the transmission of data about a product as it passes through the manufacturing chain, and the use of configurable robots means that a variety of different products can be produced in the same production facility;
- Mass customization → it will allow the production of small lots due to the ability to rapidly configure machines to adapt to customer-supplied specifications and additive manufacturing. This flexibility encourage also innovation since prototypes or new products can be produced quickly without complicated re-tooling or the setup of new production lines;
- Increment in the production's speed → digital designs and the virtual modeling of manufacturing processes can reduce the time between the design of a product and its delivery (data-driven supply chains can speed up the manufacturing process by an estimated 120 % in terms of time needed to deliver orders and by 70 % in time to get products to market;
- Increment in product quality → data from sensors can be used to monitor every piece produced rather than using sampling to detect errors, and error-correcting machinery

can adjust production processes in real time; the rise in quality plays an important role in reducing costs and hence increasing competitiveness: the top 100 European manufacturers could save an estimated €160 billion in the costs of scrapping or reworking defective products if they could eliminate all defects;

- Increment of productivity → by using advanced analytics in predictive maintenance programs, manufacturing companies can avoid machine failures on the factory floor and cut downtime by an estimated 50% and increase production by 20%; some companies will be able to set up 'lights out' factories where automated robots continue production without light or heat after staff has gone home, human workers can be used more effectively, for those tasks for which they are really essential (For example, in the Netherlands, Philips produces electric razors in a 'dark factory' with 128 robots and just nine workers, who provide quality assurance);
- Higher involvement of customers in the design process → the location of some manufacturing operations may also be close to the customer: if manufacturing is largely automated, it does not need to be 'off-shored' or located in distant countries with low labor (but high transport) costs, European companies may decide to bring some manufacturing capacity back to Europe ('re-shore'), or to establish new plants in Europe rather than abroad;
- Changes in business models → rather than exclusively competing on cost, European companies can compete on the basis of innovation (the ability to deliver a new product rapidly), on the ability to produce customer-driven customized designs (through configurable factories), or on quality (the reduction of faults due to automation and control). Some companies may take advantage of the data created as

'smart' products are created and used, and adopt business models based on selling services not products.

1.3 How Industry 4.0 affects companies and the employment market

All companies operating in the scenario of the fourth revolution, adopt interconnected machines, they are able to exchange information, do self-diagnosis and the preventive maintenance. According some studies carried out by GE Digital (the leading software company for the Industrial Internet), in collaboration with the society of research Vanson Bourne, the maintenance of machine by machines themselves, thanks to the IoT, will overcome that one carried out by humans within the 2020, in terms of quality, capacity and velocity. The progress brought by the technological evolution will give the possibility to companies of adopting better measures to prevent down times, and customizing products according the customers' requirements. Robots will work with humans, and from the latter learn how working; the entire process will be analyzed in a virtual way, so every step could be implemented before the real production, as a result of this we have smart factories that reduce production costs.

As concern consequence of Industry 4.0 on employment, it is important to analyze how activities of workers will change, and which activities will disappear. According a research: "The Future of the jobs" presented in the World Economic Forum 2016, is clear that there will be an increase of employment of 2 million, but in the same time, there will be a reduction of 7 million, with a total result of minus 5 million of employment (in Italy for instance the situation remains constant). The greater loss

is located in the administrative and production area: respectively 4.8 and 1.6 million of positions, these position are covered mainly by unskilled workers. According studies these losses will be compensated with the finance, management, informatics and engineering sectors, which are skilled ones. What is clear from these numbers is that from the next years the skills that an employee should have are: problem solving, creativity and a huge predisposition for the technological and informatics solutions.

1.4 Real example of quantitative impact of the Fourth Industrial Revolution

In order to analyze analytically the positive effects of the fourth wave of technological advancement in Germany, we should divide four main areas.

The first area is the Productivity. During the next five or ten years, the Industry 4.0 will meet more companies increasing the productivity across all German manufacturing sectors by € 90 billion to € 150 billion. Improvements in productivity on conversion costs, which exclude the cost of materials, will range from 15 to 25 percentage (All these data are taken from the Harvard Business Review-A Manager's Guide to Augmented Reality). Whenever the material costs are factored in, productivity gains of 5 to 8 percentage will be reached. Of course these results could be different according the industry that we are analyzing. Industrial-component manufacturers stand to achieve some of the biggest productivity improvements, we are talking about 20 to 30 percentage, and for example the automotive companies

can expect increases of 10 to 20 percent. In order to better understand what we said,

we can have a look on the next Exhibits.

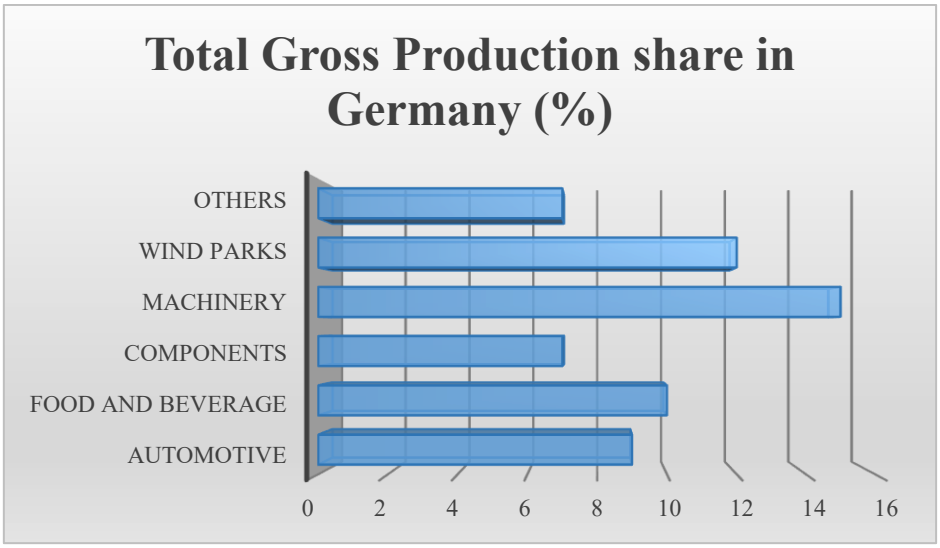

EXHIBIT 1. Gross Production share in Germany (%).

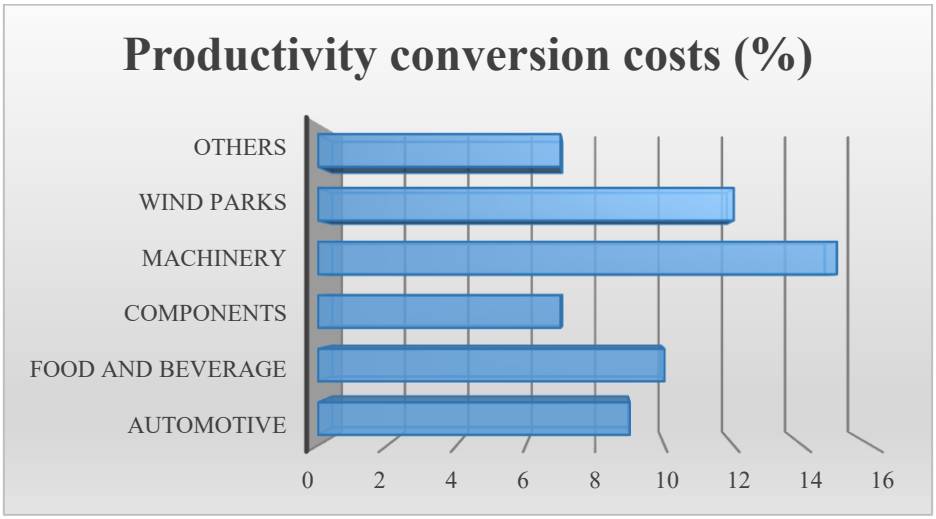

EXHIBIT 2. Productivity conversion costs (%).

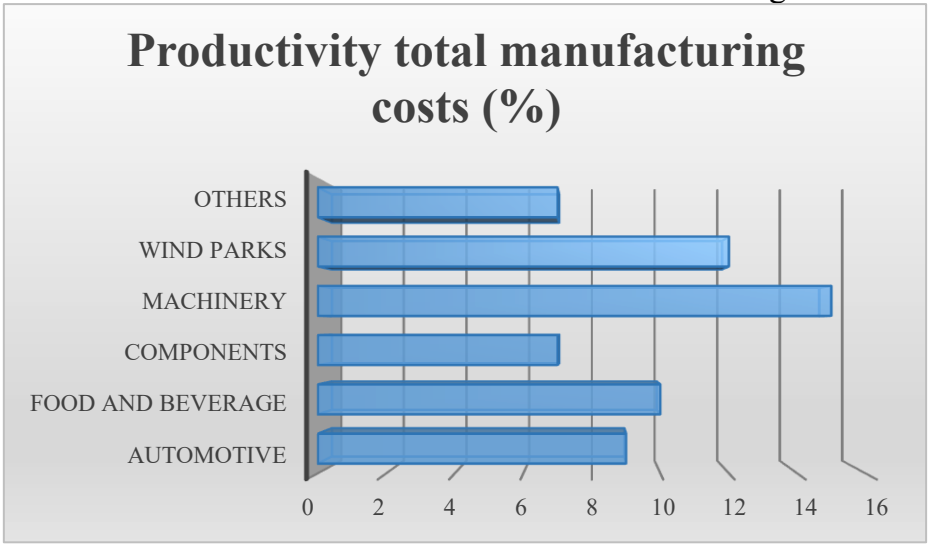

EXHIBIT 3. Productivity total manufacturing costs (%).

The second area of analysis is the Revenue Growth, manufacturers demand for enhanced equipment and new data applications, as well as consumer demand for a wider variety of increasingly customized products, will drive additional revenues growth of about € 30 billion a year, or roughly 1 percent of Germany's Gross Domestic Product (GDP).

The third area is about Employment, according some analysis of the impact of the Industry 4.0 in the German manufacturing there will be an increase of 6 percent during the next 10 years, and the demand for employees in the mechanical sector (engineering sector mat rise even more) by as much as 10 percent during the same period. However, different skills will be required, in a few time, the trend toward greater automation will move some of the often low-skilled laborers who has to perform simple and repetitive tasks. At the same time, the growing use of software, connectivity, and analytics will increase the demand for employees with experience in software development and IT technologies, such as mechatronics experts with

software skills. (Mechatronics is a field of engineering that comprises multiple engineering disciplines). This competency transformation is one of the key challenges of the future. All the analysis on the level of employment is resumed in the following Exhibit.

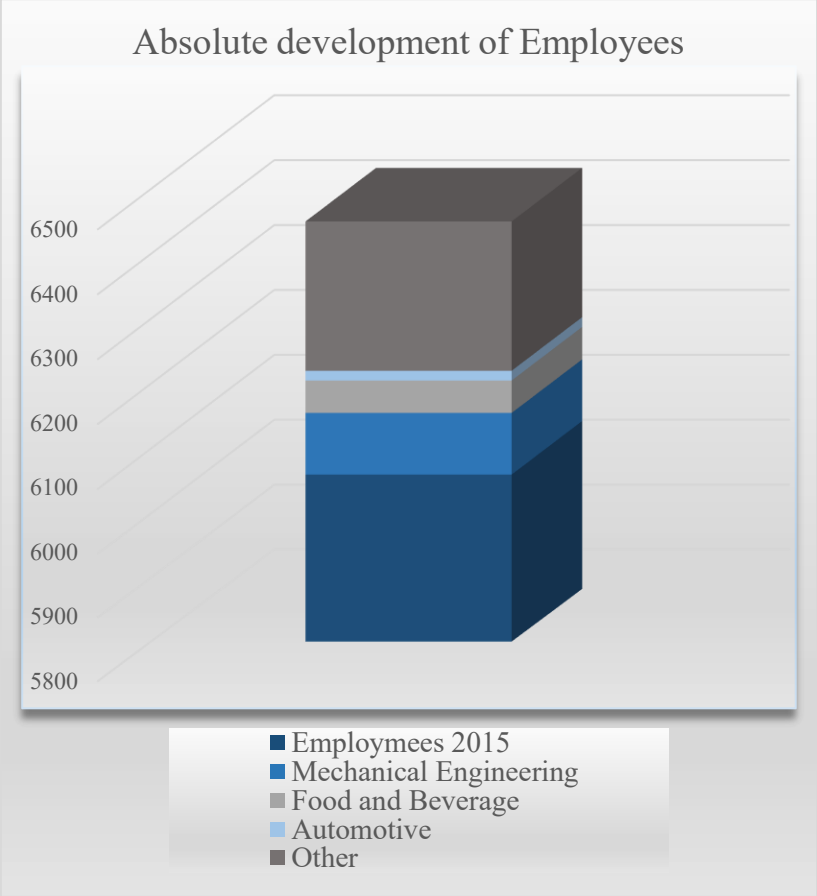

EXHIBIT 4. Absolute development of Employees.

By the graph is clear that we start with an employment in the 2015 equal to 6060 thousands of employees, and in the end of the 2025, we'll have 6450 thousand of employee, with a total increment of 6 %. But if we want to talk about the relative increment of employment for each category, we can analyze the following table.

TABLE 1. Relative development if employment.

Industry	2015-2025 CAGR (%)
Mechanical Engineering	0.9
Food and Beverage	0.7
Automotive	0.2
Other	0.6

Of course in order to reach these results, a significant shift in the skills should be done, since the activities required are more complex.

The last area is represented by the Investments, the adaptation of production processes to incorporate the Industry 4.0 will require that German producers invest about € 250 billion during the next ten years (about 1 to 1.5 percent of manufacturers' revenues).

Therefore, by the virtue of what we said about the German situation is clear that there will be a positive potential impact on the manufacturing sector, and in turn in all sectors that are linked to this.

1.5 ***Nine Pillars of Industry 4.0***

The main aim of the Industry 4.0 is transforming the manufacturing process into fully digitalized and intelligent one, in order to reach this purpose, this revolution has four main drivers that are: Internet of Things (IoT), Industrial Internet of Things (IIoT), cloud based manufacturing and smart manufacturing.

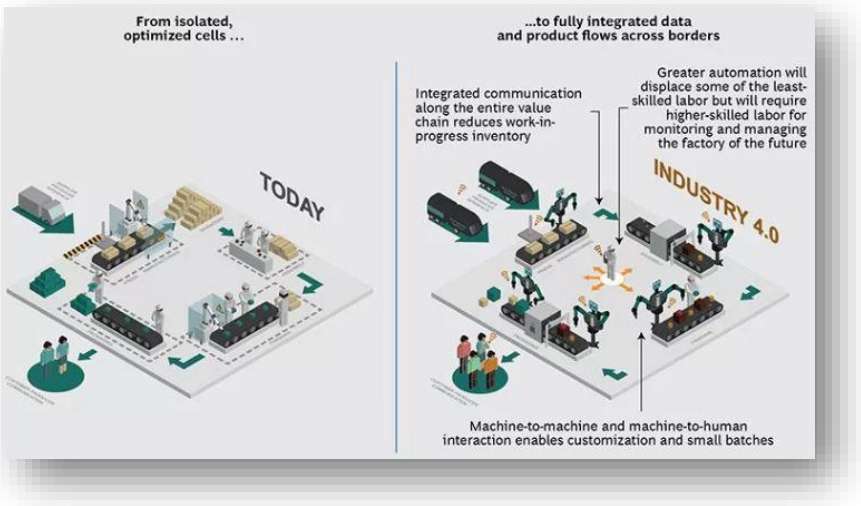

EXHIBIT 5. Change in the traditional Manufacturing Relationship.

Moreover, important aspects of this movement are the nine pillars that will transform isolated and optimized cells production into a fully integrated, automated production flow. This could bring important changes among relationship between suppliers, customers, producers, as well as between humans and machine. Below there is a representation of all the pillars.

EXHIBIT 6. Nine technologies that will transform the Industrial Production.

Let's start to talk about the first pillar: Big Data and Analytics. The activity of collection and evaluation of data from different sources production equipment and system as well as enterprise and customer-management system will become a standard to support a real time decision making. According to Forrester's definition (Forrester works with business and technology leaders to develop customer-obsessed strategies that drive growth), we can see in Big Data four dimensions: Volume of Data, Variety of Data, Velocity of generation of new data analysis and finally Value of Data. The data analysis on past processes or down time gives the possibility to find out threats that could occur in future processes, and also forecast issues, as well as various solutions to stop that from occurring again and again in the industry.

Autonomous Robots represent the second pillar. Many industries for a long time adopted robotics to perform complicate tasks, but the latter are having an evolution even more useful. They are becoming more flexible, autonomous and cooperative; moreover, they can interact between themselves and with humans, and they can even learn by them. An autonomous robot performs more complex production tasks obtaining a more precise result, an ensuring an high level of safety, flexibility, versatility and collaboration. These new machines will cost less and have a higher range of capabilities than that one used in manufacturing today. Below there is a table with a short list of robots used in some companies.

TABLE 2. Autonomous Robots used in different industries.

Sr.no	Name of Robot	Company	Function of Robot
1	Kuka LBR iiwa	Kuka	Lightweight robot for sensitive industrial tasks
2	Baxter	Rethink Robotics	Interactive production robot for packaging purpose
3	BioRob Arm	Bionic robotics	Use in close proximity with humans
4	Roberta	Gomtec	6-Axis industrial robot used for flexible and efficient automation

Then we have the third pillar: simulation. This instrument will be used more extensively in plant operations to increase real time data in order to shape the real world in a virtual model. This model can include machines, products and humans, in

doing so there will be not only a reduction in time and setup of machines but also an increase of production quality. Moreover, it could reduce the production failures during the start-up phase. 2D and 3D simulation can be created for virtual commissioning and for virtual simulation of cycle time, energy consumption or ergonomic aspects of a production facility. For example, Siemens and a German machine-tool vendor developed in a virtual machine that can simulate the machining of parts using data from the physical machine. This could ensure a reduction of the 80 % as regard the setup time for the machining process.

The fourth pillar is the Horizontal and Vertical System Integration. Nowadays most of IT systems are not so well integrated, so neither companies, suppliers and customers nor entire departments such as engineering, production or service, are not closely connected. However, with the help of the Fourth Revolution, companies, department, functions and capabilities will become much more cohesive, such as relationships between companies, and also the migration of data between them. Basically we have three dimension of integration: horizontal integration across the entire value creation network, vertical integration and networked manufacturing systems, end-to-end engineering across the entire product life cycle. An example, Dassault Systemes and BoostAereoSpace launched a platform to collaborate for the European aerospace and defense industry. The platform: AirDesign, serves as a common workspace to design and manufacturing collaboration and it is available as a service on a private cloud. It manages the complex task of exchanging product and production data among multiple partners.

Next pillar is the Industrial Internet of Things. With this term, we indicate the worldwide network of interconnected and uniform addressed objects that communicate through a standard protocol. When we say Internet of Things (IoT), we indicate also: Internet of Everything (IoE) which consists in Internet of Service (IoS), Internet of Manufacturing Services (IoMS) and Internet of People (IoP). The key elements of IoT are:

- Context → It refers to the change of advanced object interaction with an existing environment and immediate response if anything changes;
- Omnipresence → It provides information of location, physical or atmospheric conditions of an object;
- Optimization → It demonstrates that today's objects are more than just connection to network of human operators at human-machine interface.

Software and data are the key elements for intelligent planning and control of machines and factories of the future. An example, in the case of storage in a warehouse, intelligent shelving and pallets will become the driving force of modern inventory management, in respect of the carriage, tracking and tracing of goods, the process become faster, safer and more precise.

Sixth pillar is the Cyber security and Cyber Physical System (CPS). CPS becomes fundamental to protect critical industrial systems and manufacturing lines from cyber security threats, because of the increment of connectivity and use of standard communication protocols. Consequently, secure and reliable communications as well as sophisticated identity and access management of machines and users are essential. The quality of information required for planning, optimization and

operation of manufacturing systems, could be implemented by a strong connection of the physical, the service and the digital world. The term CPS is defined as systems where natural and human made systems (physical space) are closely integrated with computation, communication and control systems (cyber space). The main characteristics of CPS are: decentralization and autonomous behavior of the production process. The CPS is very important and useful in a company since a proper use sensors in CPS could find out the failure occurring in machines and automatically prepare for fault repair actions on CPS. In addition, it finds the optimum utilization of each workstation with the help of cycle time required for the operation performed on that station.

Seventh pillar is the cloud. Companies already were using cloud database for some enterprise and analytics application, but with the advent of Industry 4.0, more production-related undertakings will require increased data sharing across sites and company boundaries. In the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. The result, machine data and functionality will increasingly, be deployed to the cloud, enabling more data-driven services for production system. Even systems that monitor and control processes may become cloud based.

Another pillar is the Additive Manufacturing. Companies have just started to adopt the additive manufacturing, such as 3-D printing, which are used mostly to prototype and produce individual components. With Industry 4.0, these additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs.

High-performance, decentralized additive manufacturing systems will reduce transport distances and stock on hand.

The last pillar is Augmented Reality. Augmented-reality-based systems support different services, such as part selection in a warehouse and repair processes by sending instructions over mobile devices. These systems are currently in their infancy, but in the future, companies will make much larger usage of augmented reality in order to provide workers with real-time information to improve decision making and work procedures. For example, workers may receive repair instructions on how to replace a particular part as they are looking at the actual system needing it. This information may be displayed directly in workers' field of sight using devices such as augmented-reality glasses. Another application is virtual training, for instance, Siemens has developed a virtual plant-operator training module for its Comos software that uses a realistic data-based 3-D environment with augmented-reality glasses to train plant personnel to handle emergencies. In this virtual world, operators can learn to interact with machines by clicking on a cyber-representation. They also can change parameters and retrieve operational data and maintenance instructions.

1.6 ***Main Challenges for Industry 4.0***

In the future companies and industries will apply principles of Industry 4.0 at different rate and in different ways. Industries that require an high level of flexibility such as automotive or beverage and food sector, will benefit from a greater degree

of flexibility that can generate productivity gains, instead those industries that require an high level of quality will have a benefit from the data-analytics-driven improvements that reduce error rates. All countries characterized by an high level of cost skilled labor will be able to gain an advantage from the higher degree of automation combined with the increased demand for more highly skilled labor.

However, the spread of principles on Industry 4.0 could have some problems or better could face some challenges. In particular, we have:

- Investment and change → building a complex value network that can produce and distribute products in a flexible fashion means that companies leader in a particular market have to accept to change partner with other companies, we are not talking about suppliers and distributors of a product, but technology companies and infrastructure suppliers such as telecoms and internet service provider. To cope with this revolution huge investments are required;
- Data ownership and security → an essential element of this revolution is the huge amount of data that are important in order to customize products for clients and make more efficient the production, without any waste of time or costs. In this scenario is very important that companies that own these information manage data in a proper way, they have to prevent third party from using in an illegal way those information for their own interests. The necessary step, useful to ensure competitiveness, is building a set of rules on privacy, data storage and copyright, that balance trust and data protection;

- Legal issues → the concept of advanced manufacturing brings some legal questions such as employee supervision, product liability and intellectual property. Some statements are:

    a. Data coming from a "smart glove" that has the aim of guiding and recording movements of workers might be used to monitor or evaluated employee;

    b. If an autonomous manufacturing system that links different value networks produces a defective or dangerous product, how should the courts determine who is responsible in the network?

    c. If a customer requires am individualized product, who should own the intellectual property right to design that product?

- Standards → this element is important to ensure the exchange of data between machines, systems and software within a networked value chain. In case in which data and communication protocols are proprietary or only recognized nationally, only the equipment of one company or group of companies will be compatible, so the competition will suffer, and costs will increase. An essential element of the Industry 4.0 spread is the process of harmonization that means trying to find a common path between different countries in order to reach a sort of interoperability. In doing so, independent, commonly agreed, international standard communication protocols, data formats and interfaces are essential;

- Employment and skills development → with the revolution in manufacturing sector, the role of employees shift from a manual labor to a programming and control of high performance machines, so the risk of having low skill levels is becoming higher,

unless they are retrained. On the other hand, workers with the propensity to principles brought by the Industry 4.0, can have the possibility to find a greater autonomy, a more interesting and less heavy work. Employer need personnel with creativity and decision-making skills as well as technical and ICT expertise.

1.7 Augmented Reality and its applications

The exact definition of Augmented Reality (AR) is: "An enhanced version of reality where live direct or indirect views of physical real-world environments are augmented with superimposed computer-generated images over a user's view of the real-world, thus enhancing one's current perception of reality".

Nowadays our society is going towards Industry 4.0, and there is a huge proliferation of IoT technologies and digital information in everyday life, not only in manufacturing, digital components sectors. In general we could say that AR is a set of technologies that superimposes digital data and images on the physical world, though still in its initial step of creation and development, AR with the time will be more spread within the companies; according to one estimate, spending on AR technology will hit $ 60 billion in 2020. There are different fields of application of AR technology, from university to social enterprises, in a few years it will change the way in which we take decisions and interact with the physical world, also the way in which companies serve customers, train employee, design and create product, how they manage their value chain or how competing in the market. In a few words,

AR will become the new interface between humans and machines, combining the digital and physical world.

There are different application of AR, not only in the manufacturing sector, but let's think about the markerless augmented reality (Location Based), as shown in the Exhibit 7, it relies on pegging the AR object to a specific place using GPS or digital compass. Essentially what Pokémon Go does, this type of AR doesn't rely on a trigger. The AR object appears when we point our device at a specific location. This form of AR will soon be omnipresent and has tons of applications–especially for mapping.

EXHIBIT 7. Markerless augmented reality (Location Based).

The second type of AR is the Marker Based Augmented Reality, it works more or less as the first one, but in this case our device, that could be a phone or a table should identify a sign, a QR code, or even a 3D object, such as in the Exhibit 8.

EXHIBIT 8. Marker Based Augmented Reality.

The third type of AR is the Projection Based Augmented Reality, it consists in the projection of tridimensional figure that has the aim of simplifying production or also training to employee, or it could integrate the technologies present in the enterprise with the aim of standardize processes and establish a high level of quality. An example is shown in the Exhibit 9.

EXHIBIT 9. Projection Based Augmented Reality.

The last type of AR is the Superimposition Based Augmented Reality. It uses object recognition in order to replace an entire object or a part of it with an augmented view, a clear example is shown in the following Exhibit 10. This is what occurs normally in Ikea devices, where we can plan the organization of our living room without move one single object. Also in the manufacturing sector this type of AR is beneficial, for example while designing plants and production line layouts.

EXHIBIT 10. Superimposition Based Augmented Reality.

1.7.1 How Augmented Reality works

AR starts with a camera which is a well equipped device (such as mobile phone, tablet or smart glasses), loaded with AR software. Whenever a user points the device and look the object, the tool recognizes it through computer vision technology, which analyzes the video stream. The instrument utilized, then download information from the cloud, so what users see is in part real and in part virtual. The essential difference is that we are passing from a 2D page on a screen , to a 3D experience superimposed on the object. AR gives the possibility to have a look to data in real time, and control them with touchscreen, voice or gesture. For example, an operator could stop the production by simply saying the word stop. Employee could simply interact with

robots through the AR technology, and this gives the possibility to control the machines' performance.

As the user moves, the size and orientation of AR display automatically adjust to the shifting context, new graphical or text information comes into view while other information passes out of view. In industrial settings, users in different roles, such as a machine operator and a maintenance technician, can look at the same object but be presented with different AR experiences that are tailored to their needs. The 3D model (the object's digital twin), that is located in the cloud is created either by using computer-aided design, usually during product development, or by using technology that digitalizes physical objects. The twin then collects information from the product, business system and external sources to reflect the product's current reality. It is the vehicle through which the AR software accurately places and scales up-to-date information on the objects.

Below there is a picture that illustrate the way in which this technology works.

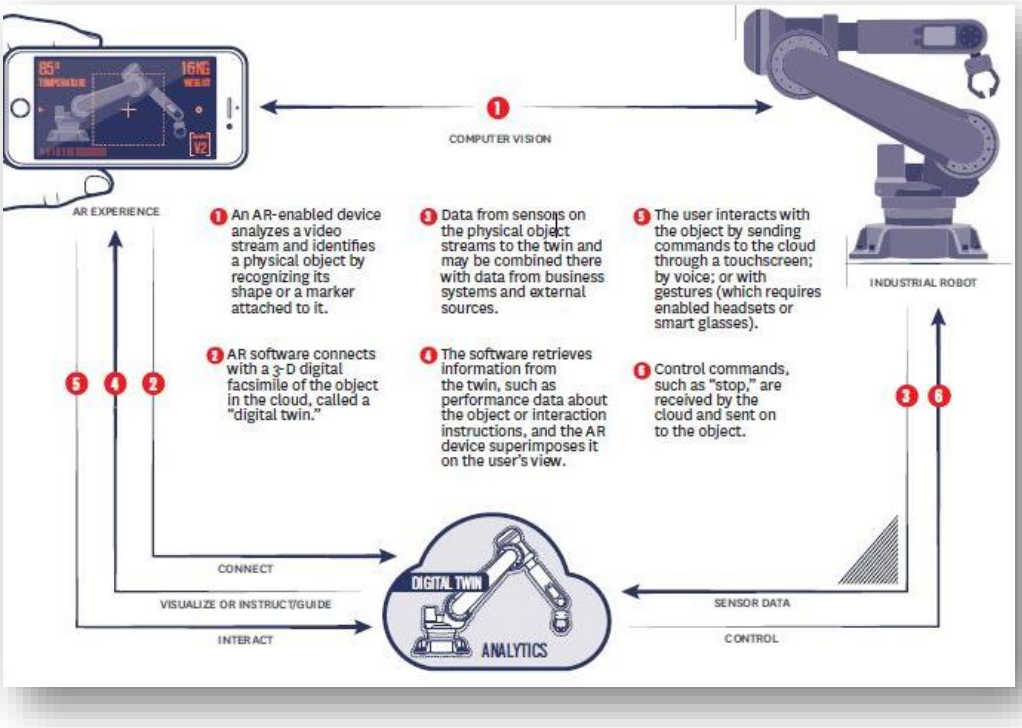

EXHIBIT 11. Schema on how work the Augmented Reality

1.7.2 ***Key Capabilities of Augmented Reality***

The huge spread of Smart Connected Products in homes, workplaces and factories allow users to monitor product operations and all conditions continuously and in real time, control and customize product operations remotely, and optimize product performance using real-time data. On this technology we can individuate three key capabilities: visualize, instruct and guide, and finally interact.

Let's start with the first one, "visualize", AR gives the possibility of having more details on the product that otherwise we can not collect by simple observation. An application of this option is represented by a medical device adopted by the AccVein,

which is able to converts the heat signature of a patient's veins into an image that is superimpose on his skin, making veins more easier for clinicians to locate. This improves the success rate of blood draws and other vascular procedures, AR more than triples the likelihood of a successful needle stick on the first try and reduces the need for "escalations" by 45%.

The second element is instruct and guide, AR is already redefining instructions, training and coaching, these critical functions are labor and cost intensive. As regard the training activity we have different issues in the traditional models, written instructions are frequently difficult to follow and time consuming, but also standard instructional videos aren't interactive and can't adapt to individual learnings needs. Another problem is represented by in person teaching, since it is expensive, and requires that students and teachers should meet in an agreed place also for more than one time. AR addresses those issues by providing real-time, on-site, step-by-step visual guidance on tasks such as product assembly, machine operation, and warehouse picking. At Boeing, AR training had a huge impact on the productivity and quality of complex aircraft manufacturing procedures. According to one Boeing study, AR was used to guide trainees through the 50 steps required to assemble an aircraft wing section involving 30 parts. In order to understand better these benefits it is helpful the video visible in the following link: https://www.youtube.com/watch?time_continue=155&v=qTblKJjTadQ. The next Exhibit gives us an idea on the work of Boeing's employees, and how AR makes more easy their taks.

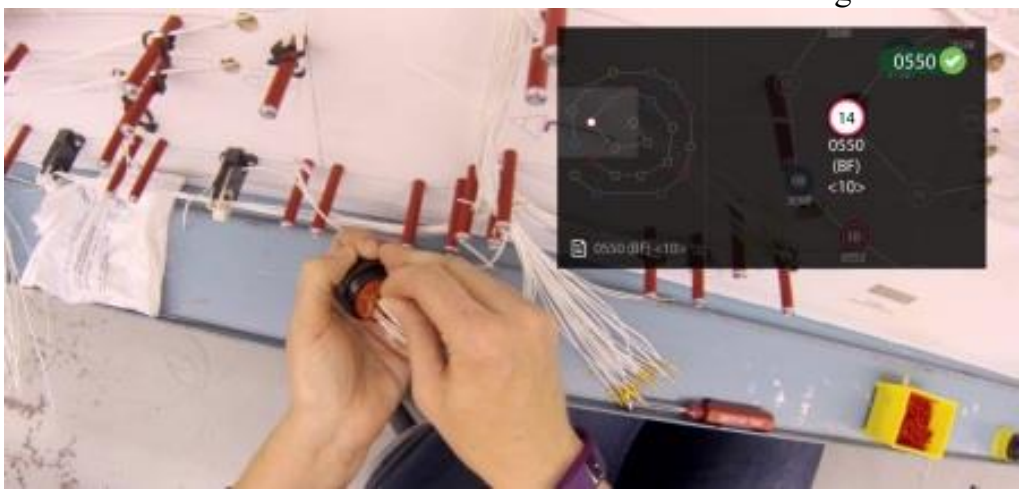

EXHIBIT 12. Boeing's employee.

With the help of AR, trainees completed the work in 35% less time than trainees using traditional 2-D drawings and documentation. Moreover, the number of trainees with little or no experience who could perform the operation correctly the first time increased by 90%. The power of AR stays also in the ability of transmit what on-site user is seeing to a remote expert, that can give his contribution in a real time, since this device put the expert on the side of the user, does not matter their localization.in doing so the expert could also give his instructions interacting with the tech's view. The result is a reduction of costs since the technicians do not have to visit so frequently the plant since it could easily solve the problem staying in his office.

The third essential capability is "interaction", traditionally in the manufacturing sector people adopted instruments such as buttons, knobs, and more recently touch-screens to interact with products. With the spread of Smart Connected Products, apps on mobile devices have replaced physical controls and given the possibility to users to operate remotely. AR takes the user interface to a completely new level. A virtual control panel can be superimposed directly on the product and operated using an AR

headset, hand gestures, and voice commands. An example of this functionality is Wemo company, which produces punching and bending machines: https://www.youtube.com/watch?v=ZiNsjslN1o4. In order to understand how it works we can simply look at the next Exhibit, where an employee is carrying out his activity with the help of the AR technology. (in doing so we have a reduction of failures up to the 90 %, and the operating efficiency increases by 30 %).

EXHIBIT 13. WEMO employee and his Hololens.

In a short time users will be able to gaze at or point to a product in order to open a new virtual interface and operate with that, moreover a worker could walk along the production line and analyze the parameter of productivity or performance and modify some values in order to increase the efficiency without touching the machine. Another surprising achievement is the possibility to manage the interface with vocal command or gestures or even with another smart product. The technologies

underpinning these capabilities are still emerging, but the accuracy of voice commands in noisy environments is improving, and advances in gesture and gaze tracking have been rapid.

1.7.3 Relationship between Augmented Reality and Virtual Reality

A complementary but different technology from AR is the Virtual Reality, the substantial difference is that while AR superimposes a virtual imagine on a physical world, VR replace completely the physical world with a scenario that is created by the computer itself. The VR finds its application in different fields from the entertainment purpose to training; it is extremely useful when contexts are hazardous or remote. Someway, VR adds another capability that is simulate, since it reproduces the reality through holograms.

EXHIBIT 14. Miligram's Reality-Virtual Continuum (1994).

Often AR and VR could be used together in order to transcend distance, time and scale, moreover bringing people together in a shared virtual environment could increase comprehension, teamwork, communication and decision making. An

example of what we said before is a virtual reality were engineers or scholars coming from different parts of the world could collaborate in real time with the help of holograms. In particular they can walk in this "reality" and refine design details such as the position of the steering wheel, or the angle of the dashboard and so on.

1.7.4 ***Value created by Augmented Reality***

AR creates business value in two main ways, the first is represented by becoming part of the product itself, the second is creating value in the different stages of the value chain, in particular: manufacturing, marketing and sales, after-sales service, logistics and other fields. Let's start with the analysis of the main fields:

- AR as a product feature → this instrument is very often used to create a better user interface and ergonomics, especially when products themselves started to transmit (real time) information. Smart glasses represent an application, through which a user can see an AR display on a product enabled to communicate with them. For instance if a user looks at a kitchen oven with smart glasses, she might see a virtual display that shows the baking temperature, the remaining minutes on the timer or the recipe that she is following. The AR interface is purely software based and delivered by the cloud, so it could be customized, and these increments have low costs;

- AR and the value chain → the positive effects of AR can be seen in different stages of value chain, in some more than in others, but let's start the analysis:

    a. Product development → for years engineers worked with tridimensional models (CAD) displayed in a 2D display on the computer, now AR gives the

possibility of superimposing holograms on physical world, giving the possibility to engineers of analyzing the reality and improving the design. AR is able also to superimpose CAD models on physical prototype, to compare how well they match, this is a technique that is used by Volkswagen. In doing so, there is an improvement in the accuracy of the quality assurance process. In few years, AR will enable devices such as phone and smart glasses, with their cameras, accelerometers, GPS and other types of sensors to inform product design by exposing where, when and how. AR interface is becoming an important source of data;

b. Manufacturing → in manufacturing very often we can find a lot of steps, sometimes also quite difficult to perform, so AR could be helpful in delivering the right information in the right moment, at the right employee in order to reduce down time and increase efficiency. In manufacturing, AR could also keep track of all information deriving from the line production, in so doing it could help maintenance technicians in understanding problems, and to ask to factory workers to do proactive maintenance that could prevent down time;

c. Logistics → warehouse operations cover the 20 % of logistic costs, and picking items from shelves represent the 65 % of warehouse costs. In many plants, employee works with paper in order to check all materials, but this implies waste of time and mistakes. Lots of logistic companies such as DHL are using AR for the picking process, this type of instructions direct workers to the location of each product, and once he is there, it suggests the best path to the next product. This method adopted by DHL leads to a gain of 25 %.

Another example is given by Intel which adopted this method and thanks to it, was able to save the 29 % of the picking time, with error rates falling near to zero;

d. Marketing and Sales → AR is completely redefine concepts of showroom and product demonstration, transforming them in a customer experience, in this way clients could have an experience with the product, before of buying them, they could be more confident about their purchaser decisions, and greater satisfaction. AR is particularly valuable whenever the product could be configured with different options, since there could be a demonstration on how machine could work if we put different options, or how the product become if we select different colors. AR is more powerful in the e-commerce sector since it gives the possibility to clients of creating holograms of product that they are going to buy. A famous example is IKEA which offers libraries with thousands of 3D product images and app that integrate them into a view of an actual room, giving the possibility to the customer to look how that particular furniture or décor will look in their homes. If on one hand this instrument gives the possibility to project object in homes, on the other hand, this is a way for IKEA to collect data on client's preferences, so they can exploit these information sending email to customers according their principal interests;

e. After-sales service → this is a field where AR could give its maximum expression, in fact one possible application is that this technology could predict that the machine will have a downtime within one month, allowing the tech to preempt the problem

for the customer by replacing it immediately. At KPN, an European telecommunications service provider, engineers on field, conduct remote or on-site repairs, using AR smart glasses to see a product's service-history data, diagnostics and location-based information dashboards. These AR displays help them in making better decision about how solving problems, in doing so they save 11 % in overall costs for service teams, moreover, a 17 % decrease in work-error rates and higher repair quality.

1.7.5 Augmented Reality in the real World

In this section, some graphs will explain in a quantitative way, what are the main industries where AR will have an huge diffusion, and where it will play a central role in different steps of the value chain. Let's start with analyzing who will invest more in AR in the future, this graph gives an idea in percentage about how much in the single industry will be invested in AR. These data come from a survey of Pwc 2017 Global Ditigal IQ Survey, taken by 2216 business and it executives from 53 countries.

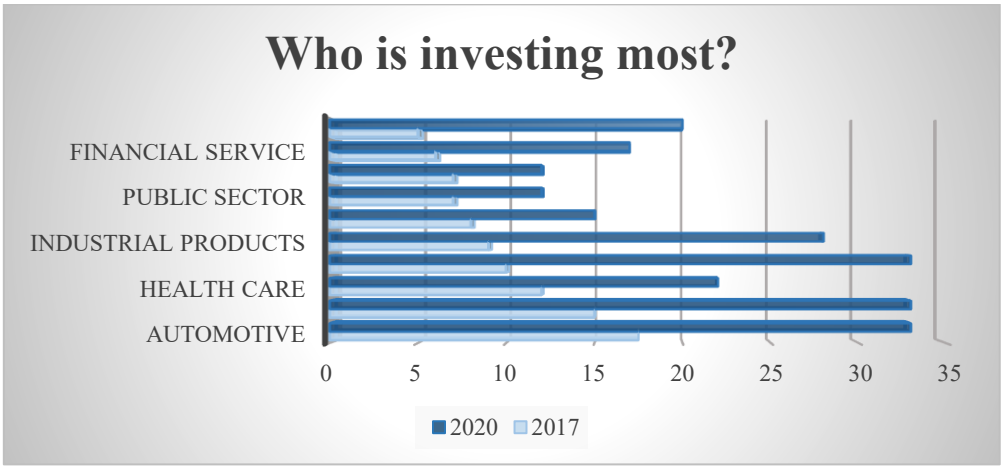

EXHIBIT 15. Comparison of investments between 2017 and 2020.

In order to analyze the graph, what is important to see, in not the absolute value of the investment in a particular sector, since could be that one needs more this technology with respect another one, what is relevant is analyzing the increment of investment from 2017 to 2020. For example, the industry of hospitality & leisure, invest much more less than the automotive one, but in both cases, from 2017 to 2020 we have an increment of the 15 % of investments more or less. Just a little bit more in the Technology & telecom sector where we find an increment of the 20 %, but the best result is achieved by the retail & consumer industry, where we have more than 20 % of increase in investments. This result is quite normal since we should think that AR technology could be exploited more by enterprises involved in the production and sales of good, especially if these products have several options and features, and more in general have a high level of customization. The lower increment in AR investments are registered in the energy and mining sector, and the public one.

Now, let's move to the percentage of surveyed developers creating AR experiences in each use category, this is explained well in the next exhibit.

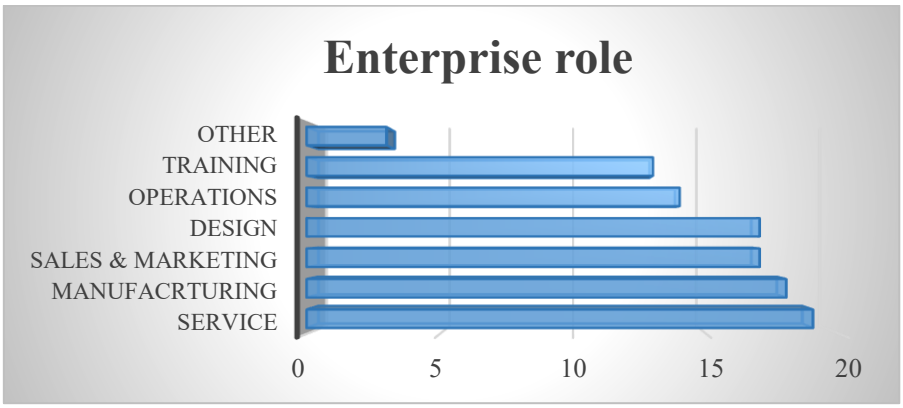

EXHIBIT 16. Distribution of developers creating AR.

Let's analyze for each category which kind of device could be created:

- Other → surgical guidance, and quality assurance of building;
- Training → job-specific training, safety and security training and coaching;
- Operations → heads-up displays, digital product controls, augmented operator manuals;
- Design → collaborative engineering, inspections of digital prototype;
- Sales & Marketing → product displays & demos, augmented advertising, optimization of retail space;
- Manufacturing → quality assurance, assembly instructions, performance dashboards;
- Service → manuals and instructions, service inspections, remote experts guidance, customer self-service.

From the graph it is clear that the sectors with higher presence of employees involved in the analysis and development of AR are service, manufacturing sales & marketing and design. This result is in line also with the previous graph since evidences show that the main purpose of this technology is trying to give a broader user experience, so sector such as services or marketing have the possibility to exploit all these potentiality, especially if we are talking about the automotive sector, retail or

technological one. Another important application of AR is in manufacturing since it improves workers performances by completely eliminating (or taking close to zero) errors, moreover it increase the quality of products.

According the International Data Corporation, in the future there will be an exponential increment of investments in AR, as is shown in the following Exhibit.

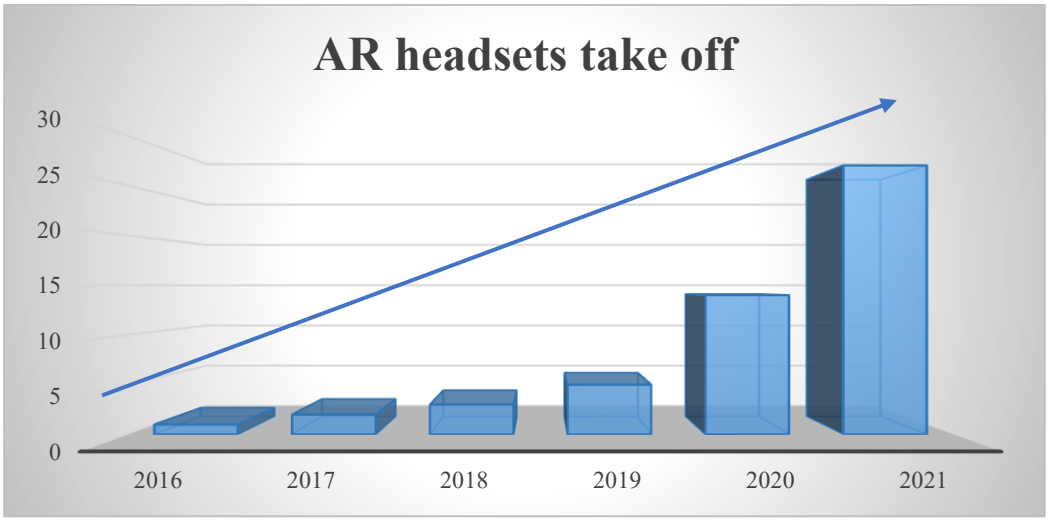

EXHIBIT 17. Projected growth in augmented reality headset unit shipments worldwide (in million).

This graph tell us how investments in AR starting from 2016 to 2021 will have a huge increment, so it is clear that now we are in the first stages of the development of this technology, so could be a good strategy for a company entering in this market now.

Last graph of our analysis is the percentage of respondents citing each reason as the primary goal of their AR development program, as is shown in the next exhibit.

EXHIBIT 18. Percentage displaying the main of AR's purpose.

By the analysis results that the high quality in manufacturing is the principal purpose of AR, and again, this result is in line with the previous graphs since in automotive industry, in particular in the manufacturing sector, the quality of product is very important in order to decrease the number of defects, and improve the efficiency. Other important purposes of AR, are sales revenue and shortened development cycle. Followed by training methods and end-user experience.

CHAPTER 2

AUGMENTED REALITY AND INDUSTRY 4.0 IN PRIMA INDUSTRIE AND MAIN COMPETITORS

2.1 Prima Industrie

Prima Industrie leads a Group leader in the development, production and marketing of laser systems for industrial applications, and machines for sheet metal processing, as well as industrial electronics and laser sources.

EXHIBIT 19. Machine produced by PI and an example of object produced by those machines.

PI is listed on the stock exchange market since 1999, with almost 40 years of experience, the Group has produced about 12,000 machines installed in more than 80 countries and is among the world's leading manufacturers in its reference market.

PI is divided in two divisions:

- Prima Power (PP), which develops, manufactures and markets laser and sheet metal working machines: 2D and 3D laser machines, laser-drilling systems, punching machines and combined systems, bending and paneling machines;

- Prima Electro (PE), which develops, manufactures and markets embedded electronics, motion control and CNC, high power laser sources.

2.2 Industry 4.0 in Prima Industrie

Prima Industrie has a huge confidence with progress and innovation; in fact, the company pioneered many laser and sheet metal technologies over the last four decades. PI has a forward-looking approach, and this is its key success factor that ensures to the company to remain the forefront of technology.

Inside Prima Power there are a lot of technological instruments that derive from the big movement of Industry 4.0, the field of applications are: digital, data-driven manufacturing and service. Machines and production lines are more and more interconnected and sensorized, moreover the technologies are becoming more integrated into systems, capable of producing ready parts from blanks in full autonomy. Additive manufacturing with its potentials, is changing the word, and PP is ready for this change by strongly investing also in this area.

PP invested between 5 % and 6% of its revenues in R&D, it collaborates with major universities and research centers, and participate in important European research projects, often as coordinators. The main success factors of PP are employees, about 15 % of the staff is dedicated to the research and development of new ideas which will shape the future of their technologies.

Between the instruments of Industry 4.0 used by Prima Power we can find: national plan of Industry 4.0 and hyper-depreciation; fleet manager; predictive maintenance and Augmented Reality.

2.2.1 National plan of Industry 4.0 and hyper-depreciation

The fourth industrial revolution has a big impact on several companies, we have different benefits in several fields such as production, efficiency and reduction of maintenance costs. Main goals of national plan of Industry 4.0 are: incenting companies' investments in technologies and increasing competitiveness; increasing expenses of companies in research and developments and innovation; strengthen finance to support industry 4.0 and start-ups.

Even for 2018, super-profitability is a certainty which allows entrepreneurs to benefit from a 250% amortization bonus on the purchase of assets like high digitization instruments. The purchase must be made by 31 December 2018, with payment of a 20 % deposit at least. The asset has to be delivered before 31 December 2019. On the purchase of intangible assets, the amortization is 140%. The incentive regards all companies operating in mechatronics, robotics, big data, internet of things, information security, nanotechnologies, 3D printing, development of smart materials, and concerns investments in technology, systems designed to optimize energy consumption, agrifood.

This depreciation is applied to three categories of assets:

- Material assets: instrumental assets, systems that should ensure a good level of quality and advices that help the iteration between man and machine;
- Immaterial assets: licenses, software, systems only if acquired with the product and fundamental for the correct functioning of all product of material assets;
- Interconnected assets.

The beneficiares of these incentives are all Italian companies (with a tax office in Italy, even with an operating headquarters outside Italy) of all types (srl, spa, sas, snc) and of all economic sectors, with the exception of companies that apply the new regime.

In general, we have some compulsory features that assets must have:

- Control by means of CNC and / or PLC (see note 1 below);
- Interconnection with computer systems at the factory;
- Integration with the logistics system of the factory and / or other machines;
- Simple and intuitive human machine interface (see note 2 below);
- Compliance with the latest safety standards.

In addition, machines should have at least two of these three elements:

1. Remote maintenance and / or remote diagnosis and / or remote control systems;
2. Continuous monitoring of working conditions and process parameters by means of appropriate sensor sets and adaptability to process drifts;

3. Characteristics of integration between the physical machine and / or the plant with the modeling and / or the simulation of one's own behavior in the development of the process (cyber-physical system).

In particular, Prima Power adopts conditions 1 and 2 of the previous list. Below there is a table that could describe better the compulsory and additional features in PP and in each product of the company.

TABLE 3. Product-features

	Compulsory features					Additional features	
	CNC/PLC	Connection informative systems	Int. logistic system and other machines	HMI intuitive	Safety	Remote maintenance or remote diagnosis or remote control systems	Monitoring
Laser 2D	√	√	√	√	√	√	√
Laser	√	√	√	√	√	√	√
Punch	√	√	√	√	√	√	√
Combi Shear	√	√	√	√	√	√	√
Combi Laser	√	√	√	√	√	√	√

Panel Bender	√	√	√	√	√	√	√
Press Brakes	√	√	√	√	√	√	√
Night Train	√	√	√	√	√	√	√
Combo FMS	√	√	√	√	√	√	√
Combo Tower Laser	√	√	√	√	√	√	√

In order to obtain the benefits deriving from the depreciation, a company can acquire material or immaterial assets, from 1st January 2018 until the 31st December 2018, and it should issue an order and pay a down payment higher than 20 % within the 31st December 2018 and put the good into operation within the 31st December 2019. Finally the company should prepare a documentation demonstrating that:

- It has all the technical features that are required by the law;
- It is interconnected to the system that manages the production or to the supply network.

2.2.2 ***Fleet manager (IIOT) and predictive maintenance***

For over 100 years, most of the companies specializing in sheet metal processing have operated on these principles as regard the diagnostic and maintenance of machines:

1. The machine stops;
2. The service team identifies the problem and goes to the customer to solve the problem on the spot;
3. The machine starts working again.

Today, in the era of Industry 4.0 Prima Power offers customers a forefront technology: the Remote Care service. The normal steps of maintenance forecast an unexpected interruption of production, instead Remote Care tries to analyze in a proactive way machine performances, it ensures the efficiency in production, helps in the reduction of interruptions not programmed and reduce the time for maintenance. Remote Care is a powerful tool that maximizes machine uptime and production efficiency.

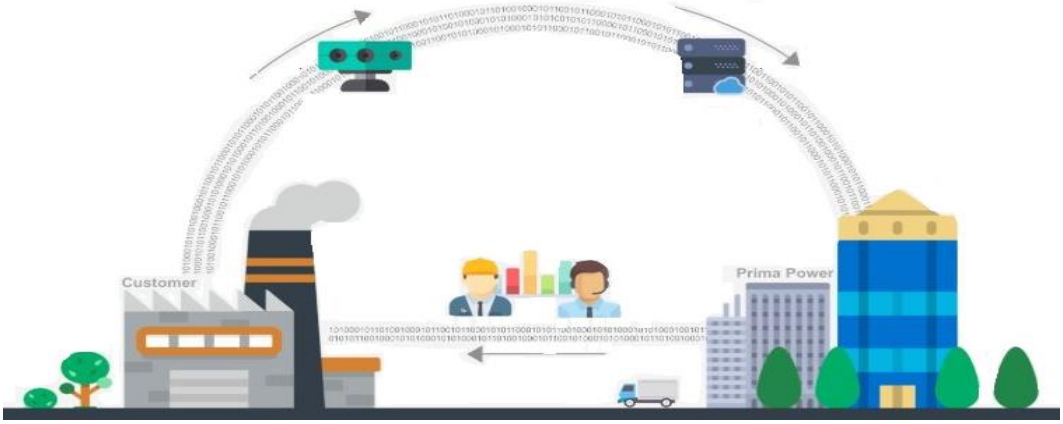

EXHIBIT 20. Remote Care: PP turns machine-generated data into the valuable insights for their customers.

In the first part of the figure, the remote connectivity is shown; the remote access is achieved through a device in the customer's machine, which creates a secure VPN-connection. The second step is about data security where collected data machine data is stored secure cloud service. Remote Machine Care built-in firewall add extra security. Last step between PP and customer is Data analytics; here collected data is used to produce efficiency reports. PP specialists analyze material, make a summary and recommend actions for improving overall efficiency of the manufacturing process.

In order to have an overall impression on what are the main benefit of Remote Care, we can have a look at the following representation.

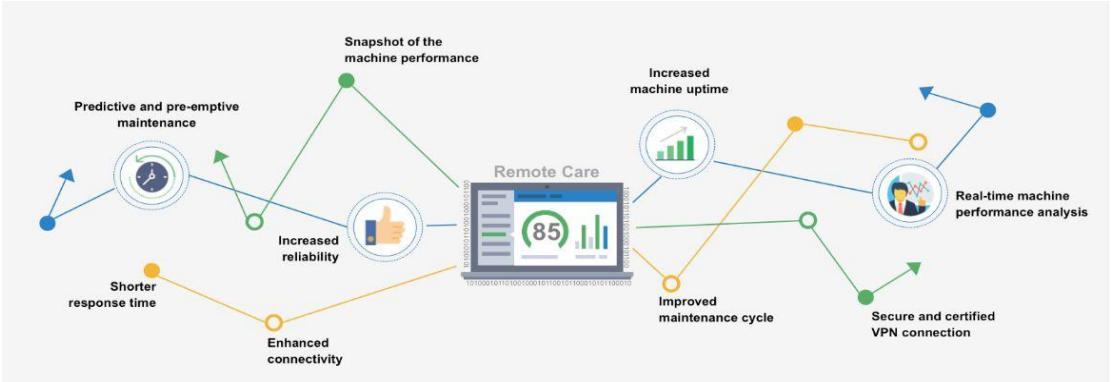

EXHIBIT 21. Benefit of Remote Care at a glance.

Remote Care monitors the condition of the machine, plans maintenance and speeds up troubleshooting. The remote monitoring system collects machine data, records the history of operations and saves data on component usage and alarms in the Prima

Power database. The collected data are used to produce efficiency reports that include an analysis of machine downtime, alarms and machine condition. Upon request, Prima Power specialists can analyze the material, summarize it and suggest actions to improve the overall efficiency of the production process. With Remote Care clients could get an overview of the current condition of the individual machines and of the production as a whole. Remote Care enables a direct online contact between Prima Power and the customer's production technology, providing quick access to the machine's condition and speeding up remote assistance. An image is better than a thousand words and Remote Care has a live video monitoring function of the machine. In this way, for example, a damaged component can be seen directly and the correct replacement part can be ordered without delay. In case of problems, the customer is contacted in time to prevent work on the machine.

PP offers three types of package of Remote Care: Basic, Standard and Premium; clients could choose the package that better satisfy their needs, and once they made their choice, they could easily change ne package with another one. The goal of PP is giving the best service experience to customers, according their needs. The Exhibit below could better show the three packages.

EXHIBIT 22. Remote Care packages and relative options.

Data security and confidentiality are very important for Prima Power. Remote access to the machine is obtained through a device installed in the customer's machine that creates a secure VPN connection between the customer's machine and Prima Power. The data collected by the machine is stored on a secure cloud server and their security policies guarantee that access to the machine is only possible to certified personnel. The integrated firewall in Remote Care further increases security. The following exhibit is a clear representation of how data are stored and treated inside PP.

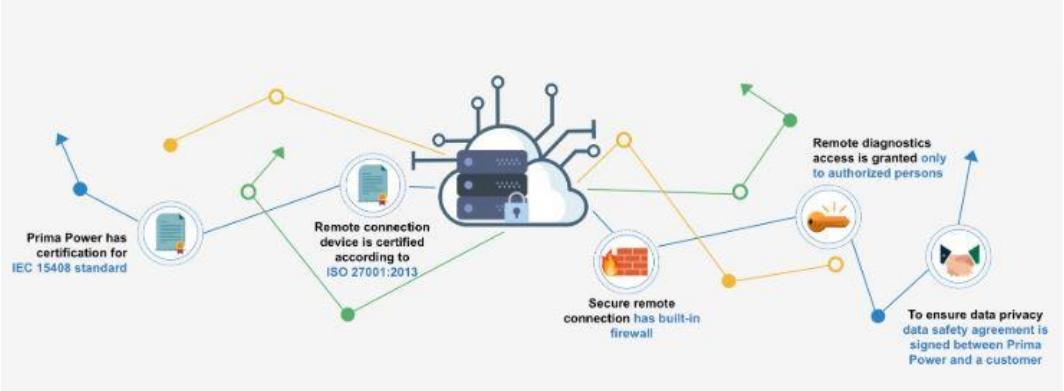

EXHIBIT 23. Security policy ensuring data privacy.

As regard the predictive maintenance, it is based on the analysis of data in order to prevent a future down time before that it occurs, a variation in the normal functioning of machine is an alarm for an eventual problem. In PP this type of maintenance is based on the result obtained from Remote Care, but at the moment there are no enough information for predictive, but enough for preventive (that has been done since years).

2.2.3 Augmented Reality

Lately PP decided to adopt an important technology: Augmented Reality. In the previous chapter, it has already been described the main features of AR, its possible benefits to the company and employees themselves. However, the real question is why PP decided to adopt AR technology in this moment, and if PP is personally carrying out analysis on AR technology or it is outsourcing the activity.

In order to answer these questions it is crucial to remember that AR is a new technology and part of the Industry 4.0. Therefore, below it has been reports a short description of the life cycle of a technological instrument as is shown in the following Exhibit 23. On the horizontal axis we can find the time, instead on the vertical one we have the units of product that are sold in the market.

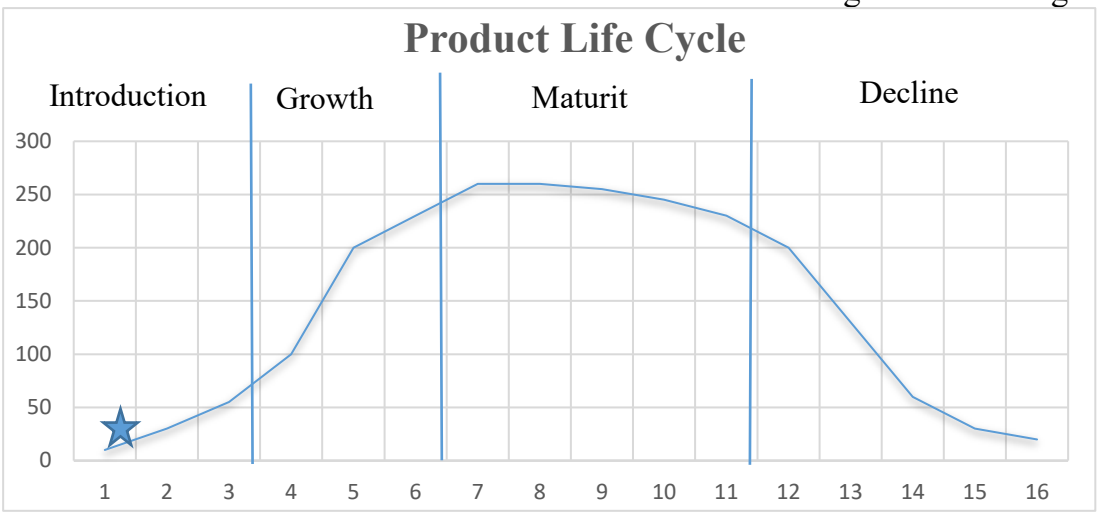

EXHIBIT 24. Product Life Cycle.

From this graph, it is possible to individuate four stages of the evolution of a technological product:

- Introduction → an initial phase, where there is the introduction of the product in the market, so the volume of sales is not so high since the product is quite new, so customers do not even know that there is a new product in the market;
- Growth → in this phase there is an increment in sales since everyone wants this new product due to an higher awareness in the market;
- Maturity → period of equilibrium in sales where they are quite stable;
- Decline →last phase where the product is already obsolete, so less customers will buy it from the market.

From this graph is clear that AR is located in the first stage (look at the star), just like studies of Jon Roland say, so in a few months the volume of sales should presumably

have a huge increment. Given the current predicted timing, PP thought it was a smart decision to invest in this technology just before the phase of growth.

In order to analyze better the actual situation of the market, we can also analyze other three parameters that are shown in next exhibits.

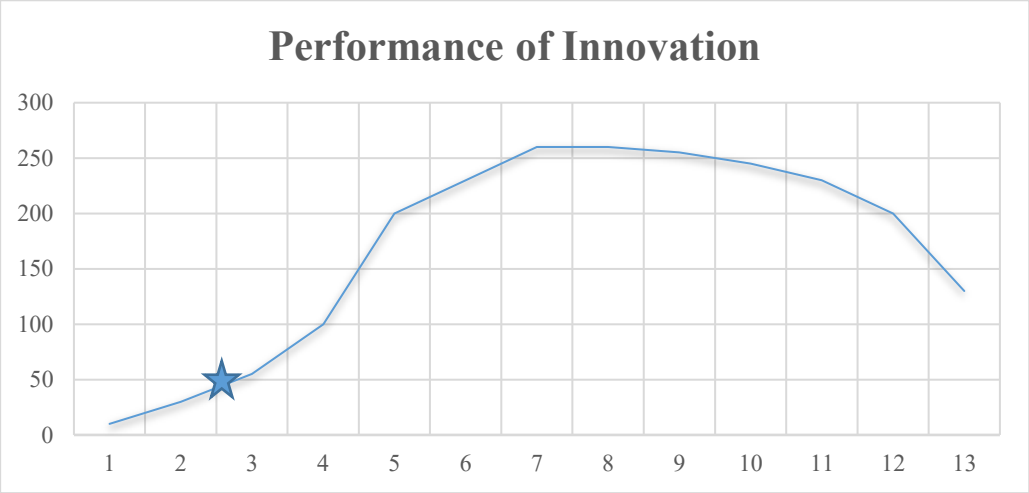

EXHIBIT 25. Performance of Innovation.

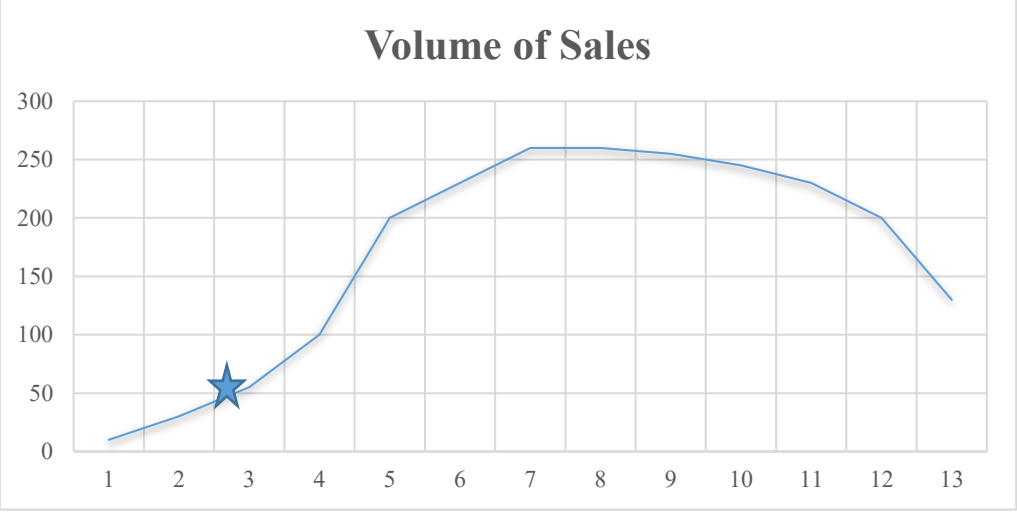

EXHIBIT 26. Volume of Sales.

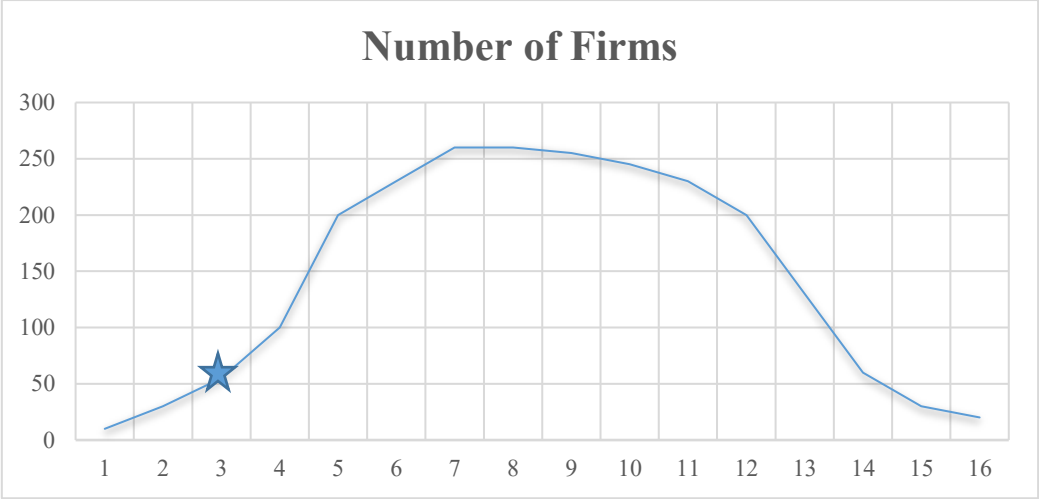

EXHIBIT 27. Number of Sales

Looking together these three graphs we can see that in the phase of introduction in the market of the product, we have an increasing level of performance and volume of sales. In this moment the number of firms is quite huge since this is a new market, so all companies have interest in entering in it and start this new business.

With the time we have an increase in the performance since the product become more know and common between customers; this is demonstrated by the fact that volume of sales increases such as the numbers of firms in the market.

In this moment we reach the peak in the number of firms, since with the time the volume of sales is quite constant; as regard the rate of innovation is quite high.

In each graph the star indicates the position of PP, this means that we are in the first stage of AR implementation, so for PP is more convenient invest now in this

technology in order to be an innovator. AR is in the first stages of its life cycle and according to the forecast in the future years there will be a huge increment in benefits.

The second point that we should analyze is who is carrying out all the analysis and works related to the project. AR inside PP is developed in the contest of a project EU h2020 Serena (https://www.serena-project.eu/project/). In the specific both in Italy and Finland, there are two different projects that are implemented simultaneously. The activity is performed inside PP with the help of external consultants. External activities mainly concern intrinsic aspects of AR technology, such as the development of 3D animations and interaction with them. Due to the short time to market, PP wants to maintain the core business of the company (i.e. technology for the production of sheet metal). In short terms, the collaboration with external entities appears to PP the best and profitable decision.

Over time companies very often face difficult decision about the scope of their activities to perform in house, or in case these them should be performed in a collaboration with someone, it is important the selection on our partners. In our case externalize an activity ensure the possibility of achieving the goal at a faster rate with lower risks.

The collaboration on a development project could give a series of advantages for firms, first of all the collaboration ensures necessary skills or resources more quickly than developing them in-house, these capabilities with the time may be acquired by the company, but only in a second moment, and so it could be too late.

A second advantage in the outsourcing is the high level of flexibility, and this is a crucial point in this fields with rapid technological evolutions, in doing so the life cycle of product become shorter and innovation drives changes in the market. When technology is processing rapidly, firms may seek to avoid committing themselves to fixed assets that could become obsolete in a few time.

Another strong point in the collaboration in that in doing so the company could learn something that otherwise alone was impossible to analyze and discover. In addition there is a considerable reduction in costs, since PP does not have to invest in the training for specialist in e.g. 3D animation, and since the project is currently a pilot there are concerns about the actual adoption of this technology. There might be ergonomic city problems, and other issue that may arise during development.

Finally, two companies decide to carry out together a project whenever this collaboration could facilitate the creation of a shared standard. Collaboration at the development stage can be an important way of ensuring cooperation in the commercialization stage of a technology.

If we want to answer the final question why PP adopt AR technology we can say simply that AR inside the company is supposed to make the job easier for technicians for offering a prompt service to customers, especially while performing complex/new service activities regarding maintenance in machines on the field. The target is to develop an Augmented Reality solution that will provide a guide for machine maintenance and a way for doing enhanced remote assistance.

2.2.4 *Case studies for the implementation of the Augmented Reality inside Prima Industrie*

For the implementation of the AR, Prima Industrie gets its inspiration from different companies that already adopt this technology inside their organization in order to optimize performances in maintenance and not only, also in the production.

One example is the experience of ThyssenKrupp, which adopts the Microsoft HoloLens (Device that will be explained in the chapter 2.3.2), for the maintenance of an elevator. The next video better explains how does the device works and could improve the performance of the employee: https://www.youtube.com/watch?v=8OWhGiyR4Ns.

Every days, millions of people drive elevators, so HoloLens device wants to overcome challenges related to their maintenance, which should be fast, easy and efficient. An expert engineer should make the maintenance, but very often, they can not move to the place every time there is a problem, for this reason the device gives the possibility of having a 3 D picture of the elevator, staying in their office. HoloLens gives the opportunity also of making a zoom in the area where there is the problem; another important aspect is that, the device gives a sort of history of the elevator, all available information regards its past or past downtimes.

A huge advantage in using the AR device is having both hands free, since the technicians does not have to check information on the laptop. During the maintenance, if the technicians has a problem, he could call an assistant who will see the same things that the operator does. In doing so, the problem is solved in less than 20 minutes, instead of the one or two hours required using the normal instruments.

Another example that was of inspiration for Prima Industrie is the case of AGCO, it is a US group based in Duluth, Georgia, quoted on the New York Stock Exchange. Founded in 1990, it has grown thanks to numerous acquisitions to the point of turning into the third group of tractors and agricultural machinery in the world. The device that it adopts is the Google Glass Enterprise. As the following video shows, https://www.youtube.com/watch?v=xIkPb4fsb54, the function of this device is assisting every step of the production, from assembly to warehouse logistics. The benefit that the glass give to the company is the reduction of over 30 % of time in inspection, and the 25 % of time in the production for low volume, high complexity assembles and the ability of training the staff is 300 % faster.

2.3 Possible AR Application in Prima Power

The AR device could be very useful for Prima Industrie in different fields, for example, it could be adopted for the maintenance, in particular as an instrument of service at customer premises. In this way the employee of Prima Industrie could help customers in solving their problem staying in his office without waste time. Another possible application is in the machine production, such as during the wiring or

assembly. Another relevant usage could be in the marketing, in fact the AR device could be useful for the designation of a production line at customer premises.

2.4 Serena Project

As we have already explained briefly in the previous paragraphs (paragraph 2.2.3), inside Prima Industrie, the implementation of the AR is carried out in the contest of the project EU h2020 Serena, in particular both in Italy and in Finland there are two projects that are developing simultaneously.

The growing complexity of modern engineering systems and manufacturing processes is an obstacle to concept and implement Intelligent Manufacturing Systems, and keep these systems operating at high levels of reliability. Additionally, the number of sensors and the amount of data gathered on the factory floor constantly increases. This opens the vision of truly connected production processes where all machinery data are accessible allowing easier maintenance of them in case of unexpected events.

The project so called Serena will build upon these needs for saving time and money inside the company, minimizing the costly production downtimes. The proposed solutions are covering the requirements for versatility, transferability, remote monitoring and control by:

- Plug-and-play cloud based communication platform for managing and monitoring the data processing remotely;

- Advanced IoT system and smart devices for data collection and monitoring of machinery conditions;
- Artificial intelligent methods for predictive maintenance and planning of maintenance and production activities;
- AR based technologies for supporting the human operator for maintenance activities and monitoring of the production machinery status.

Serena will work for improving the today's manufacturing facilities where process chain are rigid, production are optimized for one product only and there are standalone machine or devices and no standardized interfaces.

Below there is a picture that better explains the change in terms of time for the maintenance that the company could reach with the project Serena.

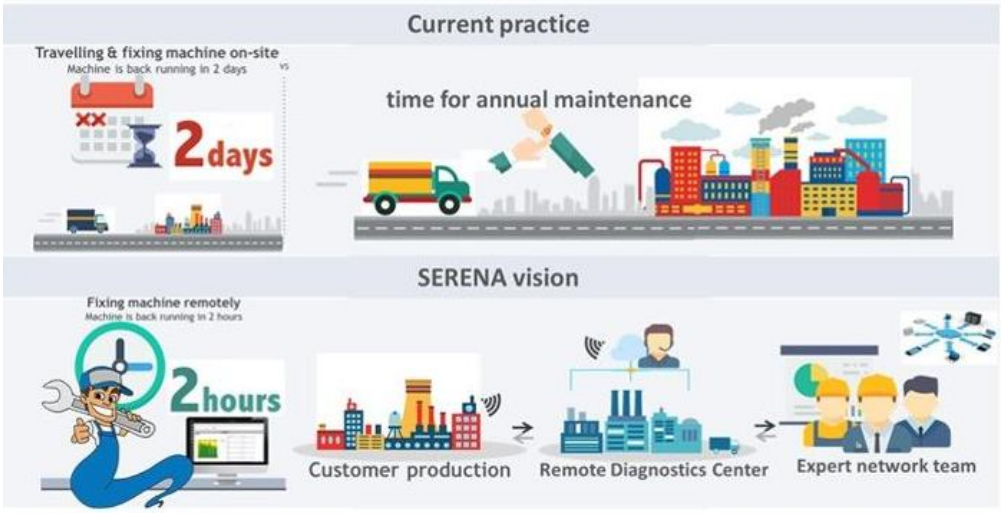

EXHIBIT 28. Difference between the current practice and the Serena vision.

The Serena vision is: "*To introduce a powerful platform to aid manufacturers in simplifying their maintenance burdens, by reducing costs, time and improving the productivity of their production processes*". In particular the system foresees to:

- Gather and process data from different devices and sensors within the factory by integrating a smart data collection device;
- Distinguish the 'smart data' from the 'big data'considering edge computing methods;
- Apply advanced data analytics, AI methods and hybrid methods considering physics model and data driven approaches for predicting potential failures and improve process related parameters;
- Allow remote access and data processing in cloudfor predicting maintenance actions;
- Enable easy-to-use interfaces for managing data and providing human operator support for machines status and maintenance guidance using AR devices
- Fully demonstrate in different applications (white goods, metrological engineering and elevators production) and investigate applicability in steel parts production industry (extended-demonstration activities) checking the link to other industries (automotive, aerospace etc.) showing the versatile character of the project.

2.4.1 Serena Objectives

Between the final objectives of this project, we can find:

- Enabling technology transfer and validation in different industrial sectors (white goods, metrological engineering, elevators production industries and steel parts production), by designing, applying, testing and quantifying SERENA technologies in terms of feasibility, adaptability, scalability and flexibility. As is shown in the next Exhibit;

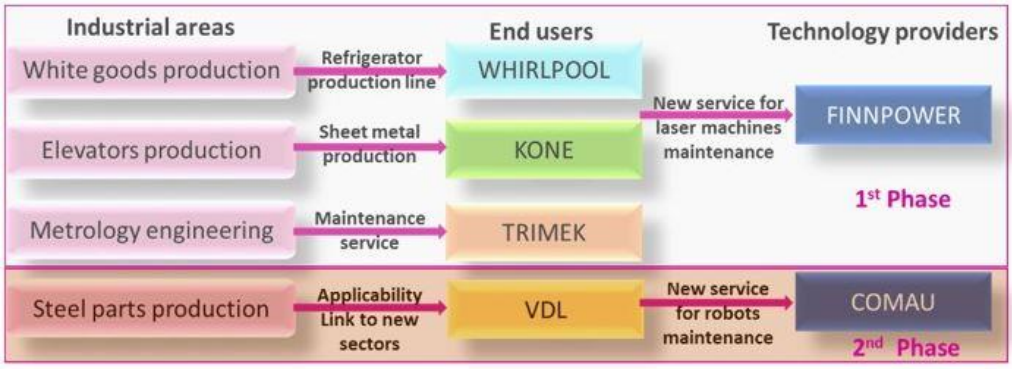

EXHIBIT 29. Representation of a Serena Objective.

- Enabling remote factory condition monitoring and control, derive and separate the 'smart data' from the 'big data' based on edge computing capabilities;

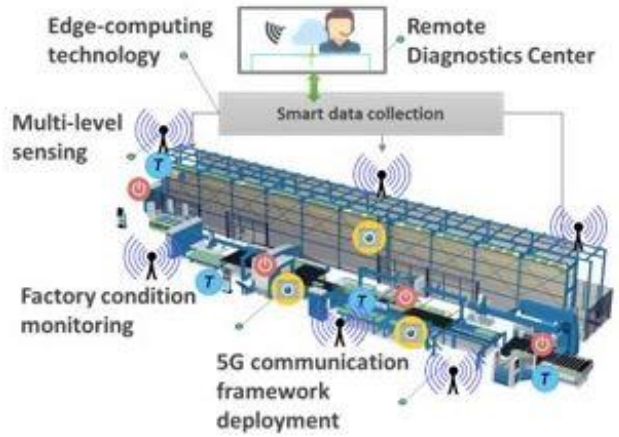

EXHIBIT 30. Representation of a smart data collection.

- Developing AI condition based techniques and planning of production and maintenance activities, by using AI methods for condition based monitoring and planning, hybrid methods (physics-models & data-driven approaches) for increased prediction accuracy;

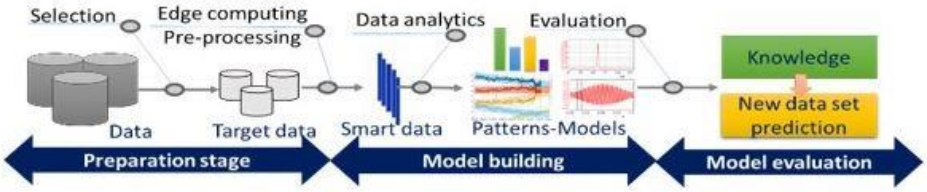

EXHIBIT 31. Schema on how the predictive maintenance accuracy will increase.

- Enabling AR-based tools for remote assistance and operator support, by introducing AR device for providing critical information or guidance to the maintenance personnel within the factory;

EXHIBIT 32. Schema on the functioning of AR devices.

- Plug-and-play concept for cloud-based platform enabling predictive diagnostics, by managing the data remotely, applying data analytics and predictive maintenance algorithms in a remote cloud and proposing corrective actions and guidance for maintenance in near real time and in the correct place within the factory.

EXHIBIT 33. Plug-and-play concept for cloud-based platform.

2.5 Companies that produce AR systems

Nowadays, an increasing number of firms starts to produce AR systems, even if this technology is a little bit far from the world of the IT. Of course the number of firms that are adopting this technology is continuously increasing thanks to the Pokemon Go app (which is a game for smartphone, but not only), or that one of Ikea, which provides high potentiality for the AR and its commercial use. More in general lots of companies that belong from the Silicon Valley are investing in this new technology for one reason above all the other: the promise of massive long-term growth.

According to an International Data Corporation report, the digital reality market will have a relevant growth, starting from $ 5,2 billion in the 2017 to more than $ 162 billion in the 2020. For any CEO of any company will be quite hard finding a billion-dollar industry with a value of the anticipated compound annual growth rate (CAGR) equal to 181,3 %, over a period of forecast that goes from 2015 to 2020 in any sector linked to the digital.

In the next paragraphs there will be some of the most important and well known producers of AR.

2.5.1 Apple Headset

One of the most know producer of AR is Apple, which is running both Augmented Reality and Virtual Reality scheduled for 2020.

Apple's augmented reality headset in the future will have a virtual reality capabilities built in; its name will be T288, and currently its production is scheduled for 2020. In Apple there are also projects as regard Augmented Reality which are maps or digital objects over impose on the real world, and Virtual reality, where users are immerse entirely in a digitally-generated environment. The tech giant is moving forward with an augmented reality headset that customers could find in store starting from 2020, so Apple will be able of realizing a reality until 2019. Apple seems more bullish as regard the Augmented Reality rather than the Virtual Reality; AR over impose virtual objects on the real world and can be used in different ways, including video games,

corporate settings and more, while VR places the user in a virtual world, completely removing them from the physical world.

While there were past reports that states the activities of Apple on the augmented reality headset, the CEO, Tim Cook threw water on this idea recently, saying in an interview with "The Independent" that the technology itself does not exist to create an augmented reality glasses that would work in a proper way with an high level of quality. Moreover, Cook said that he is particularly concerned with the display technology that would be required to place virtual elements over the real world; what is clear is that in the next future products of Apple will transform the way in which we work, play, connect and learn.

Always in the interview at The Independent, Cook said that he does not want to be the first, but Apple want to be the best. Moreover, he said: "Now anything you would see on the market any time soon would not be something any of us would be satisfied with, nor do I think the vast majority of people would be satisfied."

2.5.2 Microsoft HoloLens

The second company of our analysis is Microsoft with its HoloLens, which can be used in the enterprise in order to help people in their job.

Microsoft HoloLens is better recognize under the name "Project Baraboo", it is a pair of mixed reality smart glasses, this instrument obtains a huge popularity since it is one of the first computer running the Windows

Holographic platform under the Windows 10 operating system. The HoloLens' ancestor is the Kinect, an add-on for Microsoft's Xbox gaming console that was introduced in the 2010. As regard the pre-production version of this technology and the development is planned in United States and Canada for a list price of $ 3000.

Asus and Samsung have extended an offer to Microsoft in order to help during the production phase of their own mixed-reality products. in October 12, 2016, Microsoft announced global expansion of HoloLens and publicized that this technology would be available for a preorder in Australia, Ireland, France, Germany, New Zealand and the Unite Kingdom.

As regard the design, HoloLens is a display unit mounted on the head and connected to an adjustable cushion inner band, which can incline HoloLens up and down, as well as back and forth. In order to wear the unit, the user fits HoloLens on their head, using an adjustment wheel in the back of the band useful to fix it around the crown, supporting and distributing the weight of the drive equally for convenience, before positioning the visor to the front of the eyes. Many sensor and related hardware, (including cameras and processors), are located in the front of the tool. The visor is colored, enclosed it there is a pair of transparent combine objectives; in the lower half are projected all the imagines. HoloLens must be calibrated to interpupillary distance (IPD), or usual user vision. Close the lower edges of the side, near the user's ears, there are a pair of small and red 3D audio speakers, the latter, differently from the normal audio system, don't obstruct external sounds, allowing the user to

listen to the virtual sounds, along with the environment. Moreover, using a function related to the head, the HoloLens generates binaural audio, which can simulate spatial effects, in doing so the effect for the user is virtually perceive and locate a sound, as if it is coming from a virtual point. Two buttons are located in the upper edge: above the left ear there is the button useful to regulate the brightness of the display, instead on the right one there is the button for the volume. The adjacent buttons have a concave and convex shape, in so doing the user could easily distinguish them by touch. Near the end of the left arm there is a power button and a row of five, small and individual LED nodes, the latter are used to show the battery status, and so they are useful to take under control the power, and to impose the power or standby mode. A USB 2.0 micro-B receptacle is located along the bottom edge and a 3.5 mm audio jack is located along the bottom edge of the right arm.

Below there are two pictures that could describe in a better way hoe HoloLens are structured.

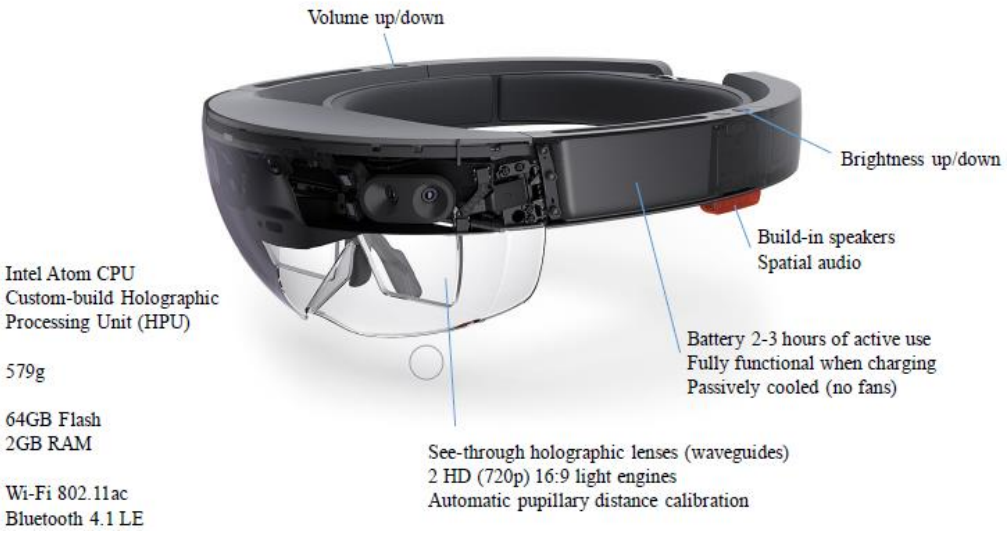

EXHIBIT 29. Picture n. 1 of HoloLens.

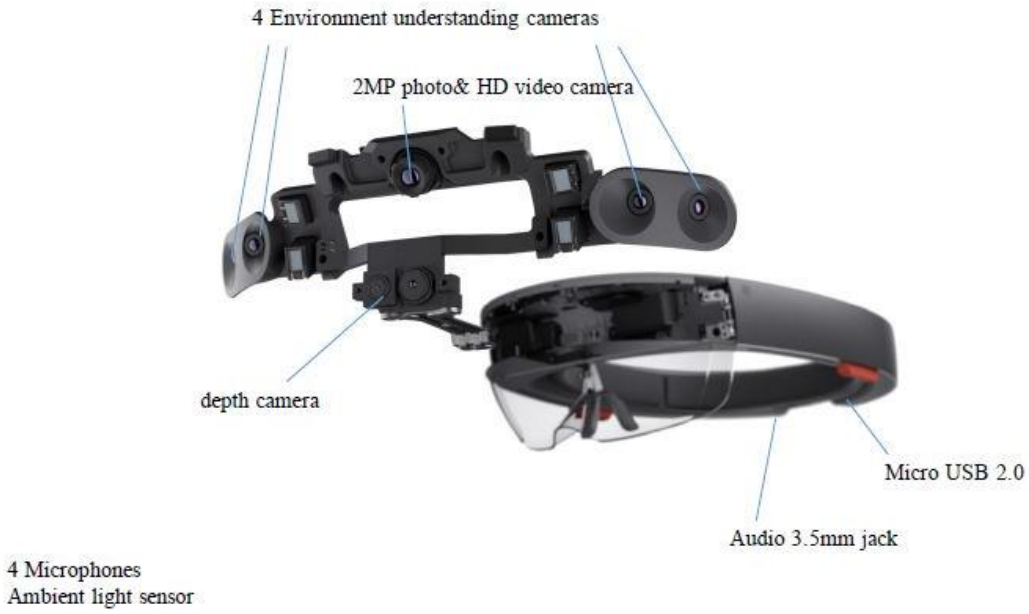

EXHIBIT 30. Picture n. 2 of HoloLens.

Thanks to the use of HPU, HoloLens adopts natural interface command: gaze, gesture and voice, sometimes referred to as "GGV" inputs. Between gaze commands, such as head tracking, allows the user to bring application focus to whatever the user is perceiving. All the elements, or whatever is present in our virtual display, are selected by simply using and air tap method, such as a click to an imaginary computer mouse, the tap could be held for a drag simulation to move an element, as well as voice commands for certain actions.

Virtual elements like windows or other elements could be located on physical objects within the environment, or can follow the user as he moves; title bars for application windows have a title on the left, and buttons for window management functions on the right.

As regard the possible use of HoloLens, there are different alternatives, between them we can find the remote instruction, so for instance if we have a problem, and we need a technicians, through this instrument we can solve immediately the damage. Another application is the 3D computer-aided Design, so we can design 3D virtual model in the physical environment. The most popular purpose is gaming, giving the possibility to the user to put himself in the game, let's imagine to the game Pokemon Go that obtain a huge consent between young and not only. HoloLens could be useful also when we want to decorate our home, so we can visualize how our room could appear. In the next link there is a video where there is a brief demonstration in how does this technology works, and different possible application of HoloLens: https://www.youtube.com/watch?v=qym11JnFQBM.

In the light of what we said about HoloLens, we can individuate positive and negative things. Starting from the pros, we have:

- The holographic communication is 100 % the future, no matter if it is for AR, VR or on any other devices;
- The quality of this setup is really good: full body, n gaps, good color and high quality.

As regard cons we find:

- The setup is quite expensive, since we could need a lot of computer in order to process all the information and project the imagine in the space;
- It also need a complicated positioning and calibrations;
- Urgent problem is the bandwidth needed for this quality;

- It requires good and even lighting;
- This system is not able to manage the presence of a mirror in the scene.

2.5.3 Epson: Moverio Pro BT-2000

Lately also Epson started to invest in the AR with an intelligent viewer, called Moverio Pro BT-2000, capable to solve complex activities in industrial fields in a fast and easy way; the cost of the tool in euro is 2013,00 €.

Moverio Pro BT-2000 is the innovative multimedia viewer that allows everyone to easily perform complex tasks in the professional field, making them faster and more intuitive thanks to the visual indications provided and the possibility of having your hands free.

This is a high-end device combines the hands-free binocular functionality of the current Moverio BT-200 smart glasses with a completely new and durable design. Thanks to the viewer, companies can enter a new dimension by offering employees in different locations the opportunity to see exactly what their interlocutors are seeing and receive visual assistance, as well as providing up-to-date support and training. This wearable viewer integrates stand-alone voice commands and allows the user to create user interface based in the recognition of head movements and gestures. Below there is a picture that could explain better how this device works, and how it could facilitate the tasks of employees.

EXHIBIT 31. Revolution in visual communication for today professionals.

Moverio Pro BT-2000 stands out for its practical and reliable design with IP54 protection level and it is therefore ideal for prolonged use in hard environment. In order to ensure an extremely addictive Augmented Reality experience, this device offers a qHD binocular display with transparent lenses, 3D functionality and a 5-megapixel stereo front camera with a three-dimensional depth sensor that detect the size and position of multiple objects in the space in relation to each other. The high-resolution 5-megapixel front-facing camera, at the center, allows technicians to share what they see, so they can assist with complex tasks by streaming or recording images and videos in HD.

Thanks to its particular design, and the possibility of replacing batteries, (even when they are hot), the viewer with Android operating system can be used for a long time without problems.

EXHIBIT 32. Model of Moverio Pro BT-2000-

In addition to GPS, the device integrates the Epson the Epson Inertial Measurements Unit (IMU), which consists of a high precision motion sensor with a margin of error much lower than traditional sensor. If the GPS signal is not received, the viewer is therefore able to precisely detect the movements of the wearer. The low-power WiFi and Bluetooth LE connectivity, combined with the beacons, ensure greater accuracy in indoor positioning.

EXHIBIT 33. Precise positioning also in a closed environment.

The intuitively arranged buttons, with easily recognizable shapes, can be pressed easily even when wearing protective gloves. The integrated ambient light sensor automatically adjusts the brightness of the display to ensure optimal visibility.

2.6 Companies that are adopting the AR technology: Trumpf

Nowadays an increasing number of companies are adopting the AR technology inside their companies in order to facilitate the production. One of them in Trumpf, the latter is a competitor of Prima Industrie; it offers systems for flexible sheet and tube processing in a very multifaceted application field: bending, punching, combined laser-punching processes, 2D and 3D cutting applications or laser welding. TRUMPF also provides all laser technologies relevant to additive manufacturing. Their machines work in a very efficient way, so that it is quite difficult finding a way to optimize the production.

One of the application of the AR regards the customer service, the following video could better describe in which way the smart glasses are used inside the company in order to optimize the production: https://vimeo.com/236497334. As the video shows, the technology will bring up the service level of the company, because the supplier could guide the customer (Trumpf employee) through a machine repair. In any moment the employee has a problem, he could call the supplier, who are a team of engineers always ready to give their help. Now the customer could wear the smart glasses device and put on the earphones; after that, the support team could see the same view of the worker. In doing so, the engineer could support the customer; the

former could also make photos during the call, and modify them, underlining what the worker should adjust, then this picture will be present in a box on the left. In this way, the support team of engineers could help the employee in solving every types of problems.

Another field where AR is used is the plant and production planning. For a big company it is very important evaluating the space requirements, when an investment on expensive machines should be done. This company, one of the leader in the sheet metal fabrication machinery, industrial laser and electronics, decided to adopt AR technology in order to study the customer's plant, in order to understand if the sales and installation of a machine is feasible or not. AR let customers to try before buy; the AR iPad app is developed exclusively for Trumpf and it can be used to place Trumpf machinery into any location at full-scale. The only thing that the customer should do is choosing an automation product and point the iPad to his desired location and it will appear on the screen to scale. To upgrade existing products just choose the matching mounting parts and they will upgrade themselves to the existing machinery. As well as the innovative tool for visualization, Trumpf also offer an app that gives sales teams the ability to allow for on-site facility planning, scrutiny of material flows and optimization of workflows by the customer.

CHAPTER 3

SWOT ANALYSIS OF THE AR AND THE VALUE CREATION INSIDE PRIMA INDUSTRIE THANKS TO THE AR

3.1 SWOT analysis of the AR device in Prima Industrie

In the following paragraph, we are going to make an analysis of the key points of the AR, and of the weakness, in a few words we are going to make a SWOT analysis on this device. For Prima Industrie is very important understand if the investment in this new device could be profitable, or if it has some weak point that could create problems in the future.

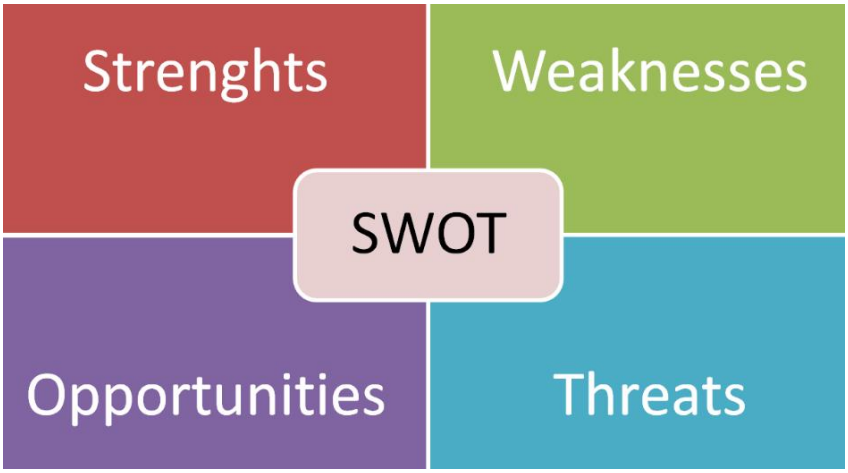

EXHIBIT 34. SWOT analysis.

We started our analysis from the internal factors that makes so powerful these AR devices, so we are talking about the Strengths. The first one is the machine know how, so this means that the employee of Prima Industrie, or at least who is implementing the device, has knowledge on this technology, and how it could be adopted inside the company in order to maximize the time of production or maintenance, (according the scope of the device). Another strong point is the existing customer service structure that gives the possibility of savings time during the implementation of the device since some elements are already present inside the company; another important aspect is the presence inside PI, 3 D machine models that could make faster the development of the technology.

Next step for us was analyze all the external elements that could improve, or help our studies, we are talking about the future opportunities, such as offer a premium paid service or lower clients machine down time, or lower warranty service costs.

In our project, all threats and the weak points cover relevant importance. Inside PI, the study and analysis of the AR devices is in its first steps of development, so for this reason is crucial take in consideration all single element that could have a negative impact on the implementation. As regard the threat for the external environment we should imagine that a huge number of company is trying to carry out experiment on these device, so it is very easy for a competitors buying our product and through the reverse engineering understand the internal structure of our tool. Another possible problem is about the bandwidth, since the AR technology could be used mostly for a production plant, which is stabilized in the suburbs of the city where the dimension of the band as regard internet could represent a problem.

An internal problem that PI is analyzing is the know-how of the employee that have to use every days the device. The questions that It makes its self each day is: “Will our employees be able to manage this new device ?”.

PI is quite careful as regard the analysis of risks and benefits that this new device could bring to the company; in the next paragraph, we will examine what are the problems that we discover during the implementation of the device.

3.2 Problems of Augmented Reality devices

Whenever a company is carrying out an implementation related to innovative technology such as the AR, it should investigate which ones could be the possible problems that could arise during the different phases of the project. This is exactly what we did, analyzing the environment and the context where PI wanted to introduce the AR technology; trying to understand if this introduction was feasible or not, if some troubles could come to light.

We have already made the SWOT analysis, and from it is clear that AR devices could bring a huge advantage in the company, but it is important think about all the employee that will adopt that technology. Inside the company who will use the device will be all the employees hat are working in the production, but the question is: “will they be able to use that tool?” The answer is not so easy, since some workers are not able to use them, probability because their age, so they will need of some hours of training, this imply a cost for the company. Moreover, these glasses will be comfortable for the final users? It is true that with this instrument employee has free

hands so in doing so, he will have the possibility to work with both hands, but it is not healthy working for eight hours per day with a technological device, he will need a rest for his eyes. If we look at the long-term effects, the prolonged use of the device could cause problems to health of workers. Therefore, PI has to think about the availability of its employee to work in these conditions.

Another problem that came up is related to the battery of the device, since it is not connected with wires to a power supply, so it has an autonomy that could be lower than a worker's turn. If the employee has to change the battery each time (during his working turn), this could represent a down time where the production is stopped.

Finally, another problem is related to the dimension of the band for internet, very often AR devices need of a broadband connection, especially for the remote call. This could be a relevant issue, since normally a production plant is located in the suburbs of a city since it needs a huge space, but in those area the connection is not so strong, so they could not work properly.

3.3 Economic impact of the Augmented Reality inside Prima Power

Before investing in this new technology, inside Prima Power we made some analysis based on the costs that the company (client of Prima Power) will suffer in case of down time of machines in order to estimate the effect of the AR devices in the production. What is important understand is that in our analysis we tried to estimate the additional costs that all clients of PI could have during the production, and so if

for PI in convenient giving this additional service (AR devices). According to this estimation it is possible to estimate the possible price of the service.

In our specific case, the mockup of the AR products is made on the laser 2 D machines, to evaluate its value inside the company. The contractors, (which are companies with machines that cut pieces for other companies), have a costs of 80 €/h for each machine laser 2 D, one day of down time is equal to 1000 € of loss revenue. During our analysis, we tried to estimate the net loss profit that should be more or less equal:

- If the employee could work on other tasks during the down time:

(Daily revenues - direct costs [electricity + consumables (e.g. cutting gas) + daily value of maintenance] - daily amortization fee) * (1 – tax rate);

Eq. 1

- If the employee could not work on other tasks during the down time:

(Daily revenues - direct costs [electricity + labor + consumables (e.g. cutting gas) + daily value of maintenance] - daily amortization fee) * (1 – tax rate). Eq. 2

In order to compute the value of these two formulas, we need some information about the single voice. Let's start our analysis with the value of the daily amortization fee, which is given by considering the value of the amortization equal to 400 k€ spreads in 5 years, so in order to compute the daily value of the amortization we could do:

$$\frac{\frac{(Annual\ value\ of\ the\ machine)}{(Period\ of\ amortization)}}{(Work\ days\ in\ one\ year)} = \frac{\frac{400000\ €}{5\ years}}{250\ gg/year} = 320\ €/gg$$

Related to the machines there are some maintenance costs, this value depends on different factors which are considered sensible data, but its value is around 8 €/h, so if we are doing our calculation based on a shift of 8hours, we have a cost of 64 €.

The labor cost is ca. to 20 €/h, so in order to compute this loss, we should make a distinction in two cases, according to the fact that we can re-allocate this resource or not. In the first case, we can not consider the entire amount as a loss since if the worker could be reallocate in another task, we should talk about the 10 – 20 % of that value as a loss, in doing so we are talking about 3 €/h more or less. In the second case where the employee can not work somewhere else, we should consider an amount higher that 3 €/h, but not the entire value of 20 €. This because we should imagine that during his shift, the employee could work on the machine for at most 15 minutes, so by the virtue of what we said the loss is around 6 €/h. Each worker could have different work shifts, so each day we can have: a single work shift → 8 h/gg; 2 work shifts → 16 h/gg; 3 work shifts → 24 h/gg. For simplicity we'll consider a normal shift of 8 hours, so the daily loss will be respectively 24 €/gg and 48 €/gg.

An important source of cost is the value of the gas used in the cutting phase, in the specific PI adopts some gasses which has a cost of 10 €/h (this value was computed considering 20 m^3/h with a cost of 0,50 €/m^3), in addition the compressed air plus cooling water, which costs 3 -4 €/h. So if the shift is of 8 hours we will have:

$$(10 + 4)\ €/h * 8\ h = 112\ €.$$

Another cost that we should keep in mind is the cost of the electricity that depends on different factors. We made a short analysis, and it could change according to the location. However during the 2017 the cost of the electricity in Italy was of 0,2142 €/Kwh according to the next document where we found the information https://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=ten00117. The consumption of a machine with a laser (we are making our analysis on a model of laser 2 D- 3 D, for this we are talking of laser) is about 4 kW. To sum up, in order to consider the consumption of electricity we should consider:

10 kW (laser) + 18 kW (consumption of the tools of the machine with compressor and ventilator)

So the power of the machine is about 34 kW, in order to compute the consumption in quantitative terms of the power we should consider that 1 kW of power is equal to 1 kWh, if it is used in a constant way. Moreover, we should think that about the 15 % of the time, the machine will be in standby, and that the laser fiber during the standby consumes 0, so the final value of the consumption will be:

28 kWh * 8 h * (1-0,15) ~190 kWh/shift

Consumption per work shift -> 190 kWh/shift / 8 h/shift ~ 24 kWh

Then we should multiply the precedent result times the value in euro of each single kWh, so we will have.

190 kWh * 0,2142 €/Kwh = 41 €.

The last one was the cost of each single hour, if we consider a normal shift of 8 hours what we will obtain is 328 €.

Now we are ready to make the estimation of the net loss profit, which in our case will refer to a single machine 2 D in the case of contractor.

In order to simplify our calculation we can consider the cost related to one hour of work, since we can have different shifts, as we said before. For the cushioning we can consider 12 h/gg of utilization of the machine, so 12 times 80 € per hours are more or less 1000 €.

Therefore, when we want to compute the loss per hour we have:

(80 €/h – direct costs (24 kWh * 0,2142 [electricity] + 10 €/h [gas] + 4 €/h [air plus water] – direct cost [in the worst case we have 6 € otherwise 0] – amortization [320 €/gg / 12 h/gg]) * (1 – 0,48))

So according the two case that we are analyzing we will have a result of: 14,56 €/h (employee can not be allocate) or 17,68 €/h (employee can be allocate).

Obviously all the data are estimations, since they are based on data that could vary according different variables.

The following step is computing the daily loss of profit, so if we consider a work shift of 12 h/gg we will have:

- 14,56 €/h * 12 h/gg = 174,72 €; → ESTIMATION
- 17.68 €/h * 12 h/gg = 204,81 €. → ESTIMATION

As regard the loss of revenue, it will be equal to 80 €/h * 12 h/gg = 960 €.

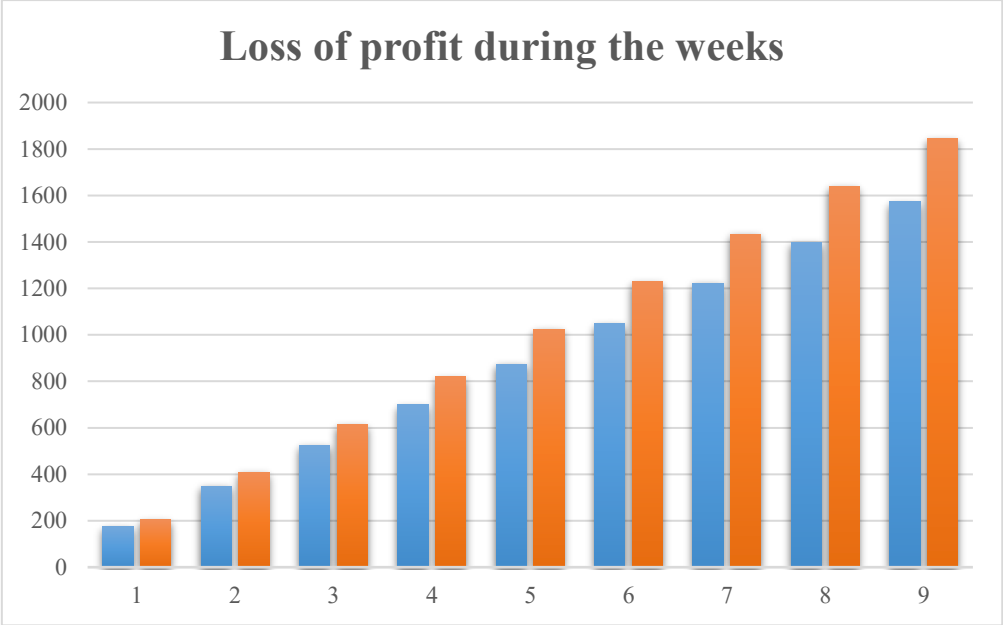

EXHIBIT 35. Trend of profit during the weeks.

By the graph is clear that with the time there is a cumulative increase of the loss profit for the clients, in the vertical axis there is the value of the cumulative daily loss, instead on the horizontal axis there is the time (days). In the graph are present two columns since the blue one refers to the first estimation, instead the orange one to the second one.

There are several positive aspects of the AR device, it is enough thinking that for a guy that work in the service, he needs less time to solve the problem. There is no the need of having an expert in each plant around the world, but it is enough having an employee with a low level of skills, that could wear the AR glasses and solve the problem. Therefore, if before to solve the problem the service department needed 3 days, now it is enough one or at most 2 days.

For the service department there is an increase of the efficiency of about 30 %, in order to support these data we can have a look to this link: https://www.youtube.com/watch?v=n5LhQqggGTE&feature=youtu.be.

Other advantages are related to the maintenance, so for instance for the technical change of the head for a laser machine, it arrives after 2 days instead of 3, moreover for each change it needs 8 hours instead of 12 hours. Therefore in total the machine is in down time for a period lower that 30 %.

By the virtue of what we said, we estimate an increase of the 30 % of the profit, or revenue using the AR. What is important to understand is that the profit or revenue will be of the client of the PI that will use the AR devices in the production, not of PI which produces machines. All these computations are relevant in order to estimate the price of this service.

If before the machine was in down time for 5 days, so 60 hours, now it decrease to 3-5 days, so 42 hours.

All the advantages will be more important in the case of a line of production, where the bottleneck of the laser could be higher. Let's suppose zero buffer of semifinished products, the damage will we worst and we could estimate this value in the following way:

(value of the production of one day-direct costs-daily amortization fee of the entire line) * (1- tax rate)

It is important to stress again the concept that all these calculation are estimation that give an idea on the benefits that the AR device could bring, but there are more

variables to keep in mind that very often are not considered since these data are considered sensible.

CONCLUSION

The Augmented Reality, with all the artificial intelligence devices shows a good perspective for the future, where the technology that up to some months ago seems something impossible, now it could have an important impact on the individual life and on the society more in general. Obviously, the process to reach the complete version is quite long, but nowadays, we are a good point.

The benefit that we can have from the AR devices are several, as this document explains, if the production became mainstream there will be a huge improvement in the maintenance activities. The interest for these devices in industrial fields is recognize under the name of Industry 4.0 that push for an innovation for process in the manufactory industry through digital instruments. The AR devices, in fact, has the ability to make faster e easy the tasks of workers; what we expect is an increase in investments, thanks to the "National Plan of Industry 4.0 2017–2020" created by the Italian Government. Another field of a company that could change is the marketing, since with the AR technology, the customer could be involved during the sales, and could have a better idea of what he is going to buy.

The more innovative device is the Smart glasses, this tool requires a great investment, so it is clear that who is able to produce them are all those companies that are quite established in the market and that have the possibility of investing a big amount of money. However, this does not exclude the possibility for small companies to enter in the market in a second moment. The AR devices, at the moment, has a cost quite high, and for this reason not all companies decide to invest in them. This technology

is in its initial steps of development, there is no a dominant design, so this means that several features could be implemented as for instance the duration of the battery, but despite this, it remains a promising product. It promise to overlap the physical world with the power of Internet (this potentiality is already recognize by companies as Google, Ikea, Apple, and so on).

If the usage of the smart glasses should have a huge spread, we will have several changes, in order to understand the entity of these changes, we can simply think about the role of the smartphone in our life. Of course, there will be changes in the communication, in the social iterations, in the information, the way in with companies will enter in contact with customers, all this lead to an usage of internet with higher speed.

Concluding, the purpose of this document was that one of giving an overall description of the Fourth Industrial Revolution, trying to describe its main features and its nine pillars: autonomous robots, simulations, horizontal and vertical system integration, the industrial internet of things, cybersecurity, the cloud, additive manufacturing, the augmented reality and big data and analytics. However, the main focus was on the Augmented Reality devices, describing what are the main important companies that produce them, and that adopt them. In order to give a real idea of the AR impact in the company, in the document there was also a brief analysis, inside Prima Industrie, of the possible costs that a down time could have, and so how much a company could save investing in this innovative technology.

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