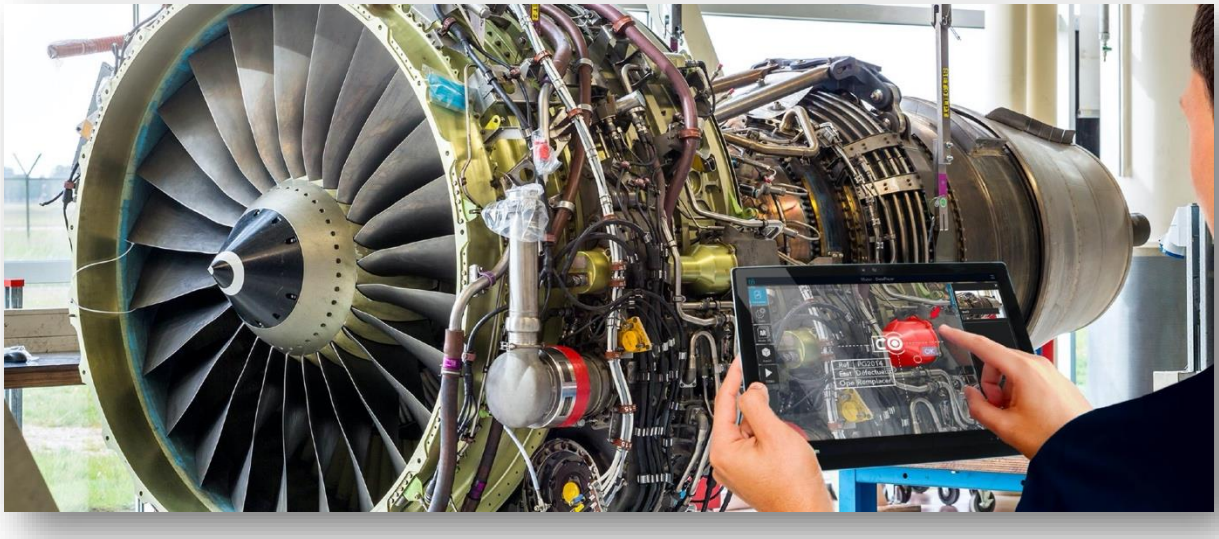
# AUGMENTED REALITY: AN IMPLEMENTATION STRATEGY FOR INDUSTRY 4.0

TESI DI LAUREA



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# AUGMENTED REALITY: AN IMPLEMENTATION STRATEGY FOR INDUSTRY 4.0

## Thesis supported by


## Mr. Karthigan VIJEYAKUMAR


To obtain the Scientific Master in Industrial Production Engineering and Technological Innovation

Under the direction of Mrs. ATZENI
Professor of Innovative Production Systems

# FOREWORD

This master thesis is the culmination of my higher education career. It has been written in order to fulfil the requirements for the Industrial Production Diploma of the Politecnico di Torino. I am presenting this thesis in order to obtain my Scientific Master's Degree in Industrial Production Engineering and Innovation.

"AUGMENTED REALITY: AN IMPLEMENTATION STRATEGY FOR INDUSTRY 4.0", is presented to you in accordance with the knowledge I accumulated during my university training and in particular the personal experience I gained during my final year internship as a business engineer at Diota, a startup selling 4.0 solutions for industry using Augmented Reality, 3D Interactive and Vision technologies, in the aeronautical capital Toulouse (France) as a business engineer. Air France, Airbus, Thales Alenia Space, Dassault Aviation, Volkswagen, Safran, Renault trust Diota. This thesis was questioning various themes: the risk of error, work assistance, the use of augmented reality and the place of robots in industry. The process of researching and writing this thesis began in February 2020.

The research was complex, but it allowed me to answer the problem in detail. Fortunately, my internship tutor, Mr Pierre Bareau, and the entire Diota marketing team were available and were able to answer my questions. I would like to thank my thesis director, Mrs ATZENI, for her excellent advice on the completion of my thesis writing plan. I would also like to express my gratitude to all the people who agreed to participate in the surveys and to all my colleagues at Diota for their cooperation. Discussing my research ideas with them was very rewarding.

Hopefully you enjoy your reading.

Karthigan Vijeyakumar

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# **CHAPTER 1:** AUGMENTED REALITY: INTEGRATION INTO SOCIETY

## 1. Introduction of Augmented Reality

Augmented reality is a 2D or 3D technology that consists in integrating virtual elements in real time within a real environment. These elements can be objects or data, readable from a touch tablet, a pair of glasses or a display system among others. To give a technical justification, the augmented reality becomes possible through a synchronization of the real and the virtual being made from geolocation and sensors that locate us and then adapt our movements to the display. Augmented reality is a recent technology since the first augmented reality system was designed in 1968 by Ivan Sutherland at Boston University. It was connected to the computer by an articulated arm, hence its nickname at the time: Sword of Damocles.

The fields of application of augmented reality are diverse like video games or medicine but the industry gains the majority because it is notably the sector that is most dedicated to training. Indeed, training is a crucial step in a company whatever its size and augmented reality facilitates it: it allows operators to learn new procedures in real conditions, then let's say that it is always much faster to learn with animations than with instruction books.

In this chapter we will take a look on the evolution of augmented reality in history and on the other hand we will see in which way it’s integrated into society.

## 2. Augmented Reality: Technology And Evolution

Augmented reality has more than 40 years of history.

# 1968

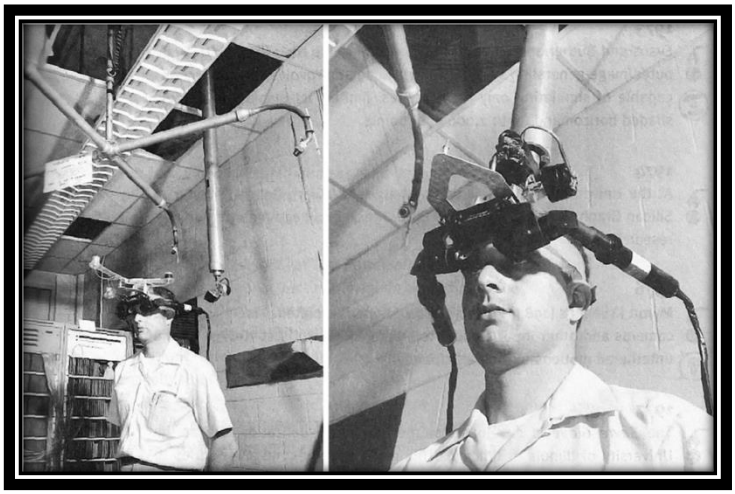
The Sword of Damocles experiment consists in displaying a 3D cube through the lenses: a computer recalculates the image and the angle of view in order to follow the user's head movements. This device lays the foundations of augmented reality.

*"Sword of Damocles" (artefacto-ar)*

Its inventor, the scientist Suntherland, explained the project:

*"The fundamental idea behind this three-dimensional device is to offer the user a personal image that changes when he moves. The image must change exactly in the same way as the image of a real object changes when the user moves his head".*

*("A head-mounted three-dimensional display" Ivan E. Sutherland)*



The tools used are two motion sensors, one mechanical and the other ultrasonic, to measure the position of your head and modify the image according to its movement.

*« Demo of Sword of Damocles » (ulyces)*

# 1970’s - 1980’s


*“HUD” (artefacto-ar)*

HUD (Head-up Displays) systems, especially in the army, were developed in the 80s. This device requires certain details to be viewed via a tiny translucent panel, positioned in the pilot/driver field of view. It uses augmented reality to designate a technology. Initially, it was planned for military use. It is usually used nowadays in different automobiles, such as race cars. Among other factors, while driving a vehicle, attention is often needed to prevent potential accidents. It is also necessary, however, to track the dashboard from time to time to know the vehicle's status.

In order to help drivers keep concentrated, specialists in augmented reality have built the Head up display or HUD. Before being what it is now, it is important to realize that the head-up display has already come a long way. It was used initially for fighter pilots. It therefore allowed them, but not only, to track their surroundings. They have used it to keep an eye on the data supplied by their separate on-board software. Indeed, for both navigation and weapons, the HUDs designed for fighter aircraft are extremely detailed. It is also worth remembering that this technology has been used for decades in military aviation.

*"HUD" (augmented reality)*

Heads-up displays started gaining a foothold in another industry in the 1970s: commercial aviation. However, only quite recently has the technology been broadly accepted. Currently, on the Airbus A380 and Boeing 787, HUD is regular equipment. In either case, in the accessibility sector, the implementation of the head-up display has been very sluggish. In reality, in 1988, it was first implemented. Just a few chosen luxury nameplates started to incorporate this feature in their separate versions at the period.

Head-up displays are also increasingly used in other industries, especially in the automobile industry. This encourages drivers to remain concentrated on the lane. It is good to note that in this specific market, the use of the head up display has risen almost exponentially. The first automotive maker to install this device in its vehicles was General Motors. And now, almost all the other manufacturers, including Nissan, BMW, Citroën, Mercedes-Benz, Toyota, etc., have introduced it in at least one variant in their line.


*"Head up display" (augmented reality)*

The Head Up Display is a quick and easy way to display important data in a less invasive and disruptive way. Therefore, it is not likely to block any user's vision.
In other terms, HUD applies to any display in front of the consumer which can be physically projected. Consequently, it is a projection device that transmits a strongly illuminated picture, video or display to a transparent surface. This surface may be a windshield or some other support in front of the consumer that can be mounted. The head-up monitor, of instance, removes the need for drivers to, for example, look away from the dashboard. It's real that, among other items, it only takes a fraction of a second to glance at the gauges on the dashboard. However, it is also very likely that, whilst on the road, this fleeting moment may be the source of an accident. That's when it gets to HUD.

They have used it to keep an eye on the data supplied by their separate on-board software. Indeed, for both navigation and weapons, the HUDs designed for fighter aircraft are extremely detailed.

*"EyeTap" (Steve Mann)*

# 1990’s

- **NASA’s HoloLens**

An augmented reality headset is now being built by NASA, foreshadowing what Microsoft HoloLens will be 30 years later. This tool helps operators to incorporate an overlay of knowledge about physical elements, which is lightweight but includes embedded computing. The light of day will have many more related ventures.

*“Augmented reality headset” (NASA)*

**The word 'augmented reality' was not invented until the 1990s.** Indeed, two Boeing workers, Tom Caudell and David Mizell, created a tool tailored for the group's employees employed on production lines. A layer of knowledge about some aspects of the chain was applied to this method, enabling a technological plan to be connected to the physical part. **NaviCam, the first augmented reality device capable of reading markers**, was created in 1994 by Rekimoto and Takashi, two scientists working at Sony Computer lab. Quite simple and quick, via a headset fitted with a HUD, it was possible to launch textual data that was grafted to the real world. By providing a very quick response time, the markers would later become the reference support for repairing simulated items in the actual world.

In order to execute an operation, markers are visual signals identified by the system. They may take the shape of a picture or a mark, but in order to maximize identification, they must primarily provide a high contrast. They are used as markers to repair a 3D part, crucial to the computer, via the camera. But due to the technical changes proposed by Apple and Google, the marks are likely to vanish.

- **Connected backpack**

In the late 90s, the first "mobile" form of augmented reality was created which needed a backpack linked to a computer. Heavy, cumbersome and dramatically reduced visualization tools were the whole issue. It was more like a project of exploration than a true instrument for the general public.
This prefigured, though, what smartphone augmented reality was going to become. The invention of cell phones, and more specifically smartphones, made it possible to miniaturize this form of device: camera, monitor and embedded computing made it possible to create fully mobile and applicable applications.

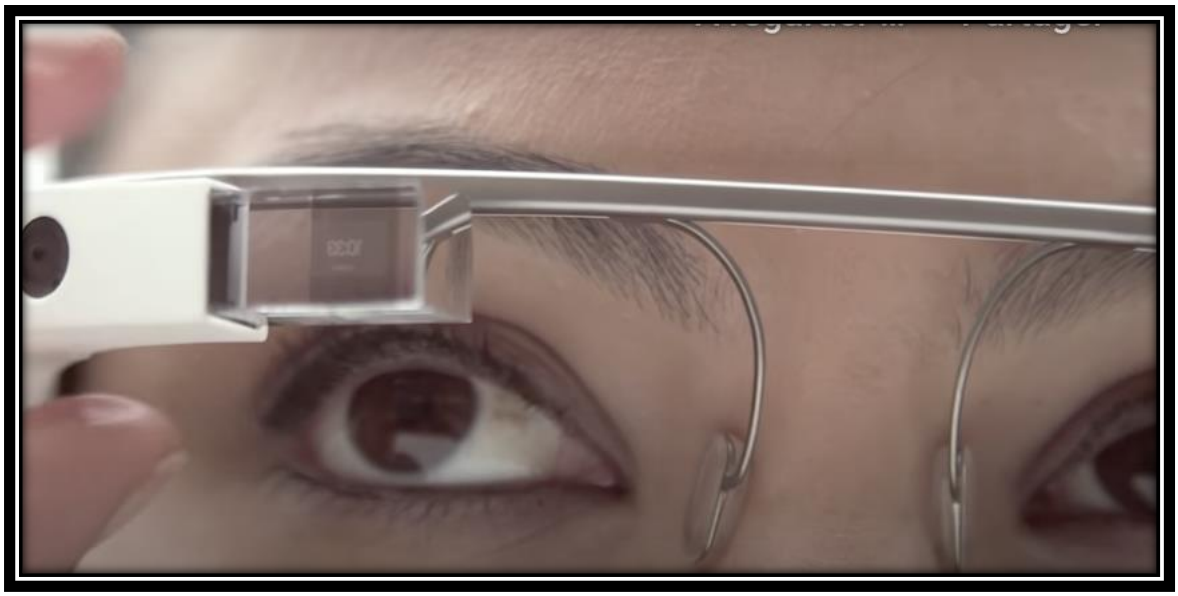
*"Backpack connected to a screen" (Artefacto)*

# 2010's

The developments in the history of augmented reality were mainly in the service of particular industries such as transportation, military security and manufacturing during the subsequent decades. While launched in the 2000s on some smartphones, augmented reality really took its place in ads in the 2010s. In order to establish wide-scale business activities, large corporations such as Disney, Coca Cola or Pepsi have captured AR, especially thanks to screens installed in bus shelters.

- **Google Glass**

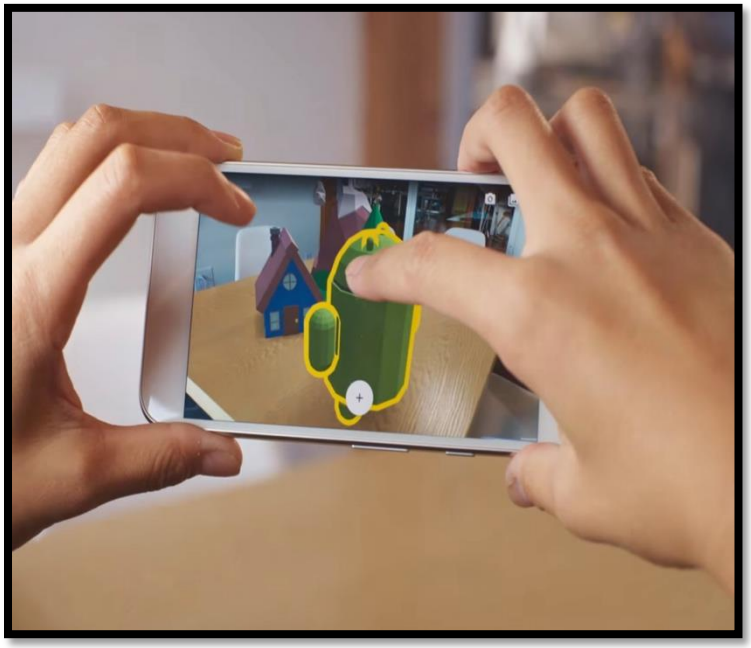
In 2012, in the test process, Google released Google Glass, the first large-scale commercialized AR device, rendering the technology available to anyone. This product, however, did not please its audience and is one of the biggest flops in the history of augmented reality. In early 2015, Google swiftly ended the development of these glasses. The web giant opted to relaunch the development of its glasses in 2019, a new episode in the Google Glass adventure, except this time exclusively for professionals.



*"Google Glass" (Google)*

- **The ARkit/ARcore Revolution**

This technical advancement is the result of two American giants, Apple and Google, who have created modern technologies of augmented reality specifically integrated in mobile and tablet operating systems. These systems, called ARkit for Apple and ARcore for Google respectively, detect space, user location and ambient light.
This enables the 3D part to be viewed on the scanned surfaces and fixed. It is now possible to simulate a full virtual room with location capture and to walk around within it using your smartphone or tablet.



*"ARcore" (Google)*

- **The Snapchat Turn**


In the social networking page, AR for all apps has been democratized by the Snapchat program, even without really understanding it. In 2014, the program first implemented "geofilters," filters that have changed according to where you are. In reality, to let subscribers know where you were, they were more like 'frames' or artifacts that you might put on your computer.

*"Pepsi/Snapchat" (Snapchat)*

Filters emerged on a social network in 2015. This function analyzes the front camera of the user's face and incorporates different graphic features, which can then be shared in pictures and videos. The usage of social networks has been revolutionized by this option, and the phenomenon has rapidly taken control of Instagram, Messenger and WhatsApp to keep in the fight for the number of users. This new possibility often attracted brands in making their Snapchat filter and thus gaining exposure, which saw it as a privileged means of marketing a commodity, an idea or simply working on their image.

More recently, Gucci has collaborated with Snapchat to allow users to digitally try on their range of shoes or watches.

- **The example of Pokemon GO**

*"Pokemon Go" (Pokemon)*

Published in 2016, the smartphone game put augmented reality at the center of its application. Indeed, it is for the player to switch with his phone in his actual world, in order to grab Pokémon or face other actors during fights. Who has never crossed a horde of Pokémon fans moving, attention riveted on their phones to grab Pokémon? While in 2020, the game is no longer at the peak of downloads, it remains quite successful and manages to carry a lot of revenue to Niantic, the company that created the game. It also accomplished its most financially successful year in 2019, with a turnover of $900 million. A success attributable to the prominence of the series but also to the AR's incorporation, which has revolutionized the smartphone game. Subsequently, several other games have been created based on AR.

# 3. Fields of Application in Society

## ■ Medical

- **Augmented reality, on the verge of revolutionizing surgical practice**

Augmented reality tends to be one of the most exciting developments in the healthcare industry, opening up spectacular opportunities for advancement for both doctors and patients.
Unlike virtual reality, which consists of constructing a 3D world fully disconnected from the user's reality, augmented reality allows the integration of virtual digital elements into the experience of the real environment. While the idea is not new, recent developments in cameras, sensors and software have made augmented reality fully applicable in fields as diverse as video games, marketing, fashion and tourism. But it is definitely today in **the health sector where its implementation is the most impressive** and indicates major developments for both practitioners and patients.

*"Augmented reality" (Medicitynews)*

- **AR on the increase in the health sector**

So-called "immersive" devices are still in their infancy in the field of healthcare. According to a recent study published by Market Research Future, their adoption could increase by more than 30 percent per year by 2023, with greater growth in augmented reality than virtual reality.
From diagnosing diseases to educating new doctors, surgical visualization and treatment simulation, the applications of AR and VR in the medical sector are numerous. Not surprisingly, experts believe that this form of technology has a promising future ahead of it.
Among the factors driving the growth of AR in healthcare, MRF cites the need to minimize healthcare costs, the growing introduction of IoT in the medical field, and above all the increasingly demonstrated benefits of its use in a variety of medical disciplines.
In particular, teaching is one of the areas of application of AR that has already been widely proven in the medical sector and elsewhere. As they learn about anatomy and biological and physiological processes, aspiring healthcare professionals find in AR the ability not only to imagine the human body in 3D, but also, and more importantly, to communicate with these virtual representations. This is a significant advantage in the process of learning and bringing knowledge into practice.
However, the use of augmented reality is now moving beyond the walls of medical classrooms to increasingly invest the reality of care rooms and operating theaters.

- **What AR will change in surgical practice**

One of the most spectacular uses of AR is undoubtedly in the field of surgery. Some surgeons today use AR to visualize in 3D an area they have to operate on.
The start-up Accuvein, for example, has developed an AR application to map the patient's body and show the exact location of veins so that medical staff can take a blood sample or place an intravenous line more accurately and quickly. Another application allows the reconstruction of a tumor in 3D that can be observed under X-rays in real time, without exposure to radiation. Finally, the 3D representation of organs from different angles also allows to gain precision in the placement of stitches.
Whether for benign or more invasive procedures, the applications of AR in the healthcare world, and more specifically in surgery, undoubtedly improve the efficiency of interventions and the way patients are managed.

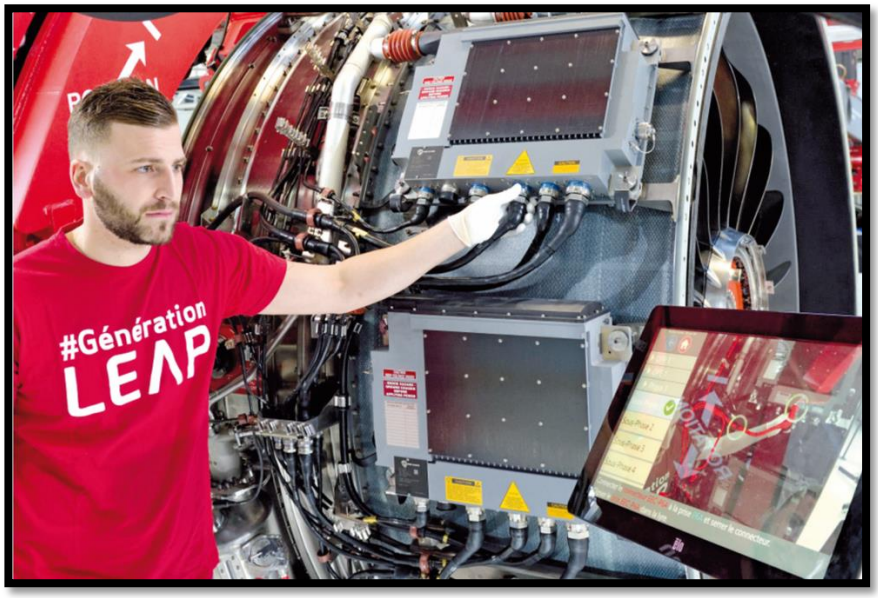
Current and future advances in PLAR, medical imaging and artificial intelligence, combined with the growing appetite of healthcare professionals, could revolutionize the world of healthcare in a much shorter time frame than previously thought.

*"MARTA" (Researchgate)*

## ■ Industry

### - When the factory switches to augmented reality

In 2017, manufacturers have multiplied proofs of concept, pilots and commissioning of solutions focused on this technology. Safran also introduced a collaboration with start-up Diota to minimize defects in the construction of electrical harnesses on board aircraft. Naval Group tested augmented reality for the construction of piping in its submarines. Renault Trucks is using it for the quality management of its engines in its Lyon factory. Behind all all-round applications, there is a luminous principle: to get the best knowledge in real time, in real-life circumstances. This is what augmented reality ensures, by superimposing visual sensory knowledge on the screen of a tablet, a smartphone or glasses, or even directly on the item involved with a video projector. Created during the past ten years and tested in a manufacturing setting over the last four to five years, augmented reality is now being implemented due to advancements in technologies and related hardware.




*"Safran has invested in augmented reality tools to speed up production of its Leap engines" (Safran)*

- **Multiple applications**

Augmented reality offers easy, on-site access to details, including the background and documentation of industrial machinery. The most mature applications in the automotive sector are preparation, repair and quality management. But it would be a shame to confine this invention to these uses alone. Since it may also help the operator benefit in productivity, for example, during complicated assembly, as at Safran and Naval Party. It was the numerous electrical harnesses, measuring up to 80 meters in an airplane for the former, and the hundreds of thousands of kilometers of pipes that crisscross a warship for the latter, that compelled these manufacturers to look for support in the virtual world. "For assembly, augmented reality responds to the flexibility trends of factories, such as on multi-model lines," says Nicolas Chantrenne, Director of Technology at Segula Technologies. It also decreases the amount of errors, since the augmented reality support tracks all the operations carried out. This knowledge may be combined with the details recorded by the instrument used, such as the wrench used to tighten the screws. It may also serve to make the work more appealing. Another benefit is that industrialists have the possibility to increasingly expand the uses of augmented reality. Siemens started, with the start-up Daqri, by using it to train its technicians to build the burner of a gas turbine: the novices trained in this way managed to install their first burner in less than an hour, compared to a day before! Buoyed by this performance, the Company now aims to investigate the contribution of augmented reality for turbine maintenance.

- **A jury of vendors**

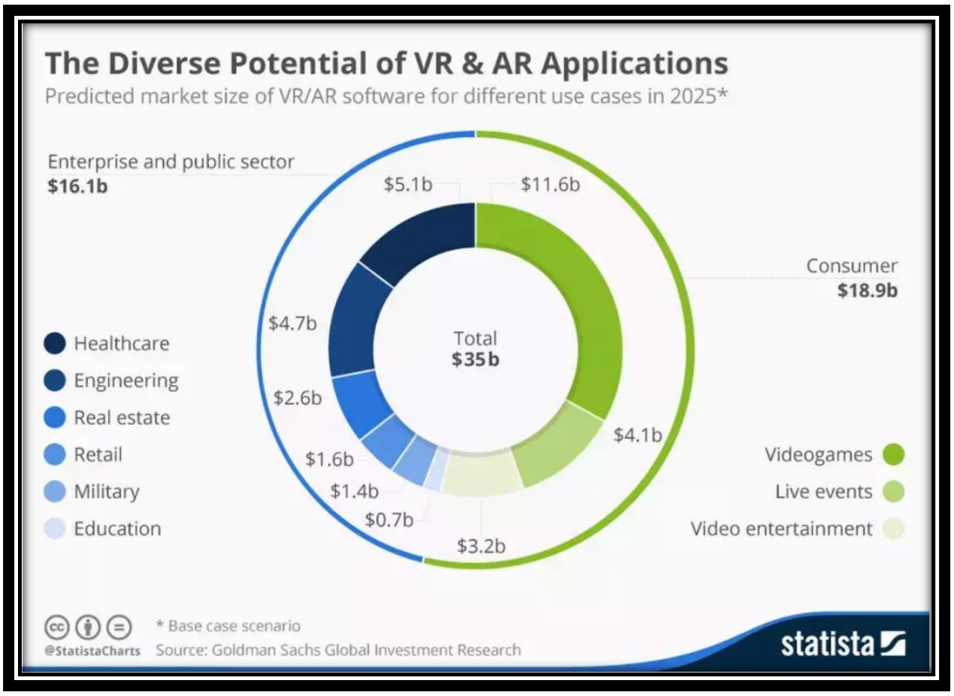
There are several augmented reality solutions sold by French firms and also many manufacturers specializing in the field. Several are start-ups: Diota, from the CEA, Robocortex, from Inria, Allucyne... Others are divisions of groups specialized in applications, such as Diginext, a subsidiary of 3D documentation specialist CS Contact & Systèmes, or SMEs such as Theoris, of which must be attached engineering companies such as Schneider Electric and Actemium. Their understanding of the market and company is clearly a significant criteria for selecting among all these solutions. In specific to include custom use situations, such as chaining activities together to construct maintenance or learning processes. Diota is also cited for the good success of its technologies. But if this start-up has multinational aspirations today, that is because it has been able to establish a relationship with Segula Technology to create content tailored to industrial needs.

- **A number of supports**

To the software dimension, we must introduce the option of hardware support. Next to the hardened phones, several forms of which are perfectly suited to augmented reality solutions, we see of necessity the augmented reality helmets and goggles. This devices have the enormous benefit of releasing the operator's hands. Even while some experts agree that they are not yet entirely equipped for all commercial applications, more and more businesses are taking the leap as this equipment has advanced too far. Renault Vehicles, Naval Community and Ford (for the design) also opted for Microsoft's HoloLens goggles; Siemens for Daqri's helmets (designed with Intel) (designed with Intel). Here again, it is possible to update the media, including Safran, which started by checking Diota's solution on shelves before going on to HoloLens. Not ignoring that the classic video projector often enables hands-free activity. In any scenario, it is important to verify if the chosen method has the requisite energy autonomy and computational capacity. Much as it is necessary to ensure that augmented reality can be utilized in the desired location: inadequate illumination, an excessively flat world in which shapes are not readily distinguishable, or insufficient accessibility can be a significant downside.

## ■ Annotation, visualisation and narration

*Weforum*




*"How VR and AR will be used in 2025" Statista*

One thing is certain: AR is no longer all about technology; it's about deciding how we want to function in the actual world with this modern technology and how we can design meaningful interactions capable of enriching humanity.

- **Visualization**

AR is a versatile visualization method. It helps one to put an idea or principle into a world that is either imagined, inaccessible or challenging to comprehend, and may also help render the unseen noticeable.

There was an AR experiment making us see tiny particles of pollutants wreaking havoc on human wellbeing. Via the application, you will see a contrast between the world's most toxic environment and the air in your area. This eye-opening experience takes place right where you are and shows mild to high emission levels from the San Francisco Bay Area to New Delhi. All of the evidence provided in this experiment followed COVID-19, however AR may be included in a potential project to visualize the major effect of national containments on air quality and the atmosphere.

*"Partnership between Brainlab and Magic Leap" Magic Leap*

- **Annotation**

Annotation with AR helps you to direct you through a mission, navigate in a new setting or even include real-time explanations of what's happening around you.

*"Intelligent subtitling glasses used during a performance at the National Theatre, London" National Theatre*

In another stage, the National Theatre of London utilizes AR to render its shows more available to those who are deaf and hard of hearing. With goggles, users will profit from a translation of the conversation and explanations of the tone of the show they are watching. Cultural outlets around the globe are currently streaming live material amid closures. When organisations reopen their doors and events can once again be viewed "in person" and in public, usability features can begin to be built across AR.

Microsoft's Tokyo Project lets visually disabled people "see" using AR, AI and HoloLens. The system will sense the location of individuals in the user's world and identify faces, then transmit the details to the wearer in audio form. Maybe a potential function could be introduced to promote protection in periods of social distancing, alerting the wearer when individuals are within two meters.

- **Narrative**

AR allows possible new forms of storytelling and artistic communication through encounters that take place both at home and in public spaces. By adding fresh and alternative views, it shifts the way we share.


*"Lessons in the Herstory application" Daughters of the Evolution and Goodby Silverstein & Partners*

Lessons in Herstory utilizes PLAR to help update history books in the classroom and empower tomorrow's leaders by showcasing the experiences of influential people.
You will enjoy the RA software from the comfort of your own house, without a manual, by searching the photos here with your mobile.

## ■ Business

AR plays an especially valuable role in commerce where it helps consumers to evaluate the functionality of goods before purchasing them.
Manufacturers use augmented reality to present their new car models to their customers.
Thanks to AR they will show all the functionality of their cars by breathtaking demos.

*"Augmented Reality" Copper mobile*

The customer becomes an actor of his buying experience. The conversion rate increases considerably because augmented reality reduces the uncertainty when making a purchase.
Indeed, it helps the "customer" to imagine the items in the room in which he wants to see them. He therefore sees the rendering of his buy, long though he has created it.
Thanks to this technology, customers are now rapidly experienced consumer's performers.
But here, we are just talking about facts, without providing with numerical statistics.
You can realize how important augmented reality is in the entire commercial sector. As far as physical trade is concerned, here are a few statistics around AR, which will enlighten you:

- Between 69 percent and 88 percent of customers are more likely to purchase goods from a company that provides an augmented reality interface around the product.
- A Google survey reveals that 61 percent of tablet & mobile consumers claim they choose to shop from shops that sell augmented reality.
- 500 million is the amount of installs of the Pokémon GO app just 2 months after its publication. Any stores were utilizing the Pokémon search to boost their in-store sales.
- Around 2017 and 2022 is the usage of augmented reality that would rise by 159% in commerce and retail.

## ■ Education

Augmented reality and schooling are very similar in terms of their partnership, and it tends to grow and expand. According to the notion, America's existing school structure is going to be fully re-planned in the immediate future. You can realize that this course is not only an essential work, but that it has more strength.

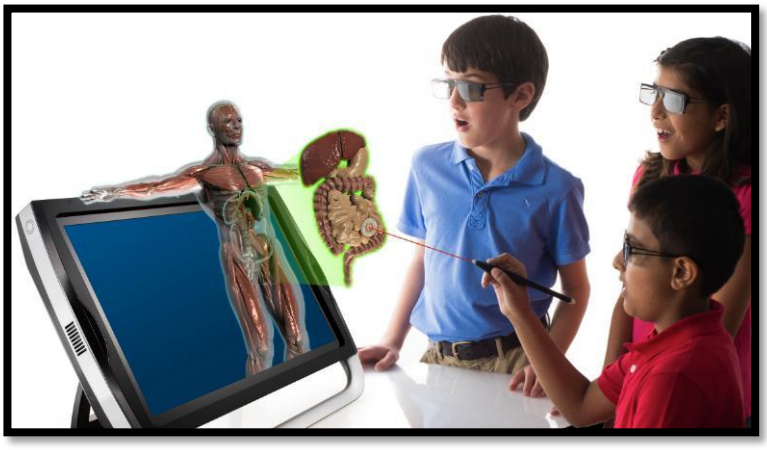
*"Augmented reality in Education" Veative*

One of the conditions for students in order to maintain knowledge in an ideal manner is to be adequately present throughout the teaching process. This is where augmented reality serves a need that is important. Students who are able to utilize digital media will potentially be performers in the process, as is demonstrated by them acting on the virtual stage. The disparity between tea leaves and coffee grounds is not only minor aand it adds up to major knowledge retention.

As the user communicates with the medium, the senses, such as sound, scent, and taste, are more completely engaged. During a typical instruction on a 2D help such as a book or board, the two primary senses of sight and hearing are included. Augmented reality offers the consumer a sense of contact that can be accessed as an optional bonus. As a consequence, the less the cognitive load (how much thought a person has to do) is set to heavy (cognitive effort). Augmented reality is not only one of the many, but an outstanding selling method, further impacting the expansion of the world's schooling.

This technology helps us to see a reflection of knowledge in our natural environment, that is, projected on to a scene, instead of just viewing a flat screen. Rather than being confined to flat 2-dimensional media, augmented reality enables students to see how they will view a live action experience in their own space. The idea that they do not have to make the effort to transpose a 2D theory course into the 3D universe often significantly decreases the cognitive load needed to comprehend the instruction. The details last longer in this kind of memory.

In the future, augmented reality will continue to be a part of our everyday lives. Indeed, since it is completely software-based, we do not have any difficulties in designing personalized tests, reproducing the most delicate and precise application instances.



*"Augmented reality in education" Indiatoday*

# **CHAPTER 2:** AUGMENTED REALITY SERVING INDUSTRY 4.0

## 1. Introduction of Diota


*"Logo Diota" Diota*

**Diota is a startup selling 4.0 solutions for the industry** by exploiting cutting-edge technologies of augmented reality, 3D Interactive and Vision. Dassault Aviation, Air France, Airbus, Safran, Volkswagen, Renault, Bouygues, SNCF, Thales Alenia Space trust Diota.
Diota aims at materializing digital evidence, which washes off from industrial knowledge structures, in the operations sector (a much ubiquitous place for making decisions than the industrial complex). This vision, which consists of **(r)establishing a connection between engineering entities (Design Offices, methods) and human operational space (Production and Maintenance Centers)**, is fully in line with the stated desire of major actors in the industry to differentiate themselves, not just through the excellence of their products, but also through the optimization of their processes over the life cycles of these products.

*In 2020 I did a 4-month end-to-studies internship at Diota as a business engineer. During my first week I provided a market analysis and a competitive analysis based on Diota's marketing references: I'll share them with you and halfway through we'll also look into use cases.*

# 2. Aeronautics Market Analysis in Europe

**Aeronautics is the sector that invests the most in augmented reality.** It is therefore important to get to know the main countries and actors in the field, as well as their challenges, before tackling their respective use cases. At the current time, the commercial airline industry is maintained by the exploitation of competition. With the introduction of automation technology, businesses go through a research and development phase to increase their competitiveness and refine their operating processes. Regarding an aircraft's structure, it is essential that it is made up of several complicated manufacturing processes that are very high-precision and advanced. An error here would likely cost the business a lot of money. In addition, ground handling really is not very common for the airlines, it leads to considerable losses if it's not dealt with swiftly. So, one of the potential ways to increase efficiency and reduce damages in the aviation field is to make a major update and introduce cutting-edge technology, namely, AR smart glasses.

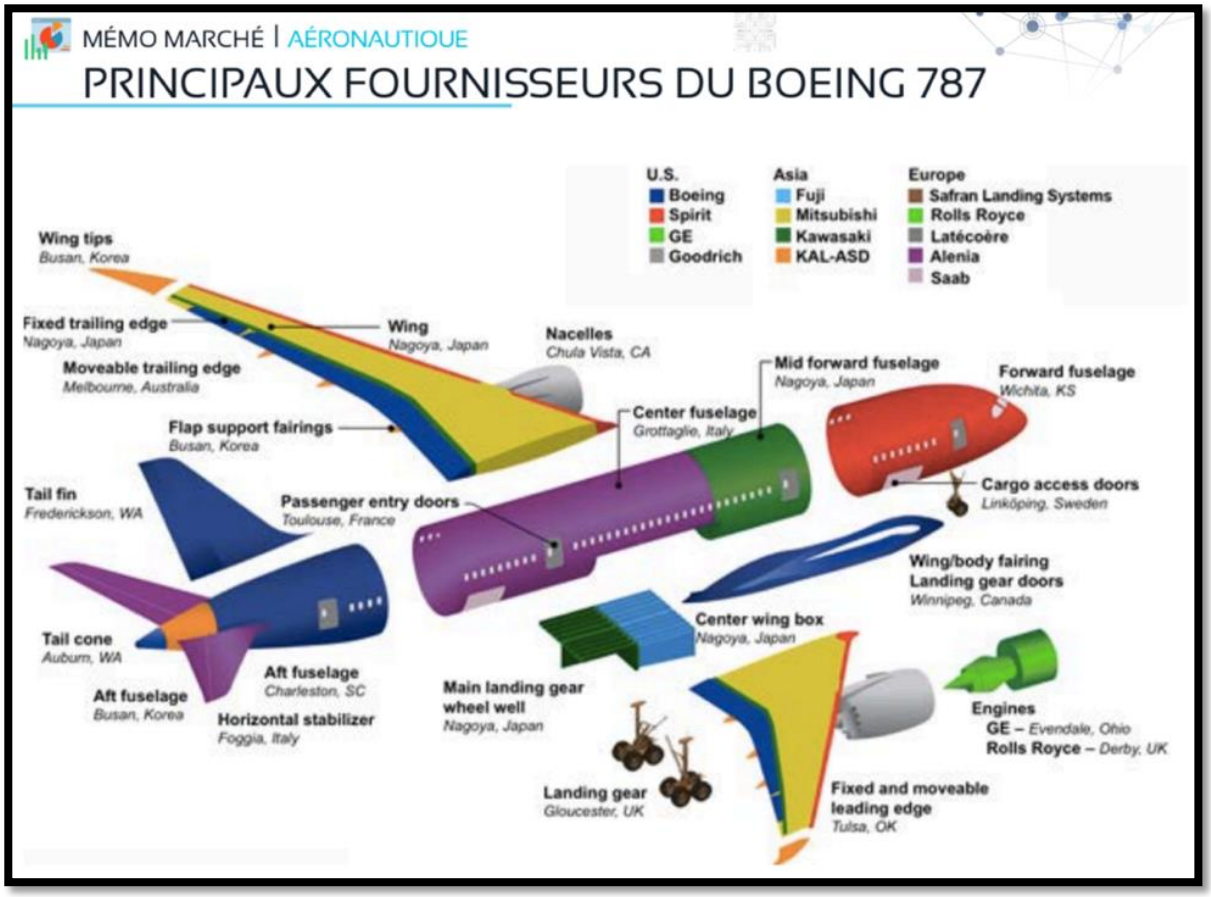
- **France**

**Aeronautics is Diota's preferred sector**, mainly because companies like Air France operate with Catia. Another reason is their need for assistance with assembly and control, because they are uncompromising about the quality of their production and because most of the operations are complex (workshop-type production) in a small series industry.

Indeed, in the $838 billion in sales generated in the aeronautics industry in 2017, MRO alone generates 27% of economic activity. In addition, the division of labor spread over several subsidiaries multiplies the demand for solutions, which is an advantage for the supplier Diota. France alone generates 8% of total sales, making it the second most concentrated country in the aerospace market after the United States (49%) and ahead of China (6%). It accounts for 37% of EU exports. Yet in the industry of tomorrow, France ranks 14th among the countries most favorable to investment in aeronautics production, while Canada ranks second. Indeed, between 2011 and 2016, revenues from the aeronautics industry increased by 20%.

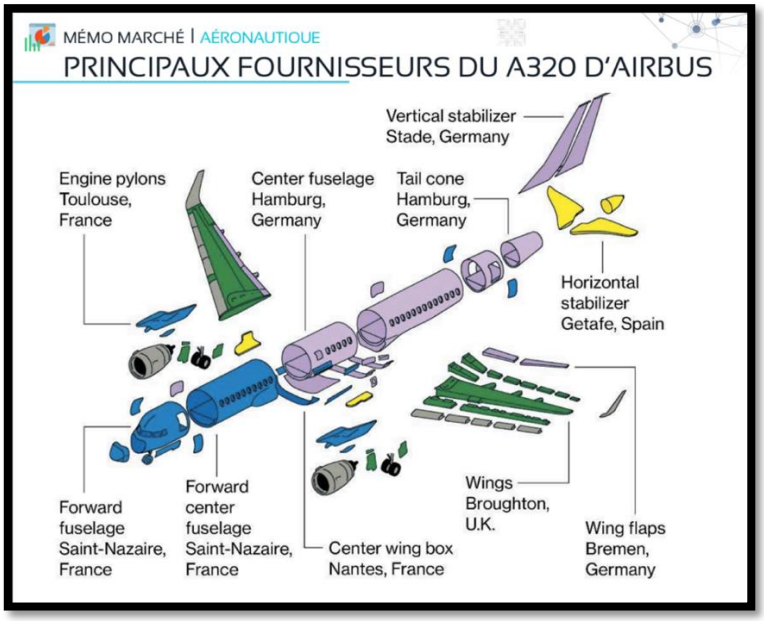
We can use the Boeing 787 as a reference to identify the main suppliers to the aviation industry in France: **Goodrich** and **Latécoère** handle the nacelles and passenger doors, **General Electric** and **Rolls Royce** the aircraft engine, and **Safra**n the landing field.

Finally **Collins Aerospace** is partly responsible for the communications system.




*"Main Boeing 787 suppliers" Diota*

For Airbus A320, France produces the entire nose section of the aircraft up to the wings, with 3 other European countries - Germany, the United Kingdom and Spain - producing the wings.




*"Main A320 Airbus suppliers" Diota*

**France is the leading host country for foreign industrial projects** in Europe according to Business France. Île-de-France accounts for 28% of the workforce, the Midi-Pyrénées 28% and Aquitaine 10%. France has 400 UAV manufacturers with 6,500 jobs.

| Entreprises | Localisation | Effectifs |
|---|---|---|
| Airbus operations | Toulouse | 14 900 |
| Airbus Helicopters | Marignane | 9 000 |
| Safran Aircraft Engines | Villaroche | 5 000 |
| Safran Aircraft Engines | Essonne | 3 400 |
| Airbus Defense and Space | Toulouse | 2 800 |
| Safran Aircraft Engines | Bordes | 2 600 |
| Airbus Operations | Bouguenais | 2 600 |
| Safran Nacelles | Seine Martitime | 1 600 |
| Safran Aircraft Engines | Colombes | 1600 |
| Safran Aircraft Engines | Tarnos | 1 500 |
| Stelia | Meaulte | 1 500 |
| Liebherr Aerospace | Toulouse | 1 00 |
| Dassault aviation | Anglet | 949 |
| Safran Landing Systems | Bidos | 900 |
| Safran Landing Systems | Molsheim | 900 |
| Lacotère | Toulouse | 800 |
| Stelia | Rochefort | 800 |
| Stelia | St Nazaire | 800 |
| Safran Aircraft Engines | Chatellerault | 700 |
| Safran Aircraft Engines | Yvelines | 600 |
| Ariane group | St Medrad | 600 |
| Dassault Falcon | Bonneuil | 600 |
| Safran Aerosystems | Caudebec | 549 |
| Dassault aviation | Argonay | 449 |
| Dassault aviation | Martignas | 449 |
| Airbus Defense and Space | Elancourt | 400 |
| Goodrich aerospace | Colomiers | 400 |
| Safran Aerosystems | Cognac | 349 |

*"Main actors (top aerostructures plants in France)" Diota*

- **Great Britain**

Is Brexit a real danger for the aviation industry in the UK?

*"Airbus is sounding the alarm":* delivery delays and rising costs (to be confirmed)
*"Rolls-Royce is getting ready":* jobs in Germany are on the move
*"Bae Systems: Not A Big Deal For Us":* Few sales in Europe anyway
*"Safran, in the dark":* repatriation of operations with little investment

VSEs and SMEs account for 55% of civil aerospace sales. 75% of activities are dedicated to civil and 25% to defense.

Competitive advantages:

3 Design and production of wings for large aircraft.

4 Production of engines

5 The world's leading fleet of commercial helicopters (potential opportunities: 40,000 units per year, worth $165bn).

6 Assembly of landing gear

7 Creation of advanced systems

| Type | Entreprises | NB employés | Sites |
|---|---|---|---|
| Intégrateurs/ Maitres d'oeuvres | Boeing | 2 000 | 1 |
| | Airbus | 14 000 | 5 dont 2 usines |
| | GE aviation | 4 000 | 3 |
| | Agusta Westland (Leonardo) | 7 000 | 5 |
| | BAE System | 35 000 | 1 |
| | Hybrid Air Vehicles | N/C | N/C |
| Motoristes | Rolls Royce | 22 500 | 6 |
| Fournisseurs TIER-1 | GNK (Melrose) | 3 800 | 6 |
| | Bombardier | 4 000 | 1 |
| | Meggitt | 2 700 | 4 |
| | Marshall | 1 800 | 2 |
| | Chemring | 2 600 | N/C |
| | Collins Aerospace | N/C | 3 |
| | Lockheed Martin | 2 000 | 3 |
| | General Dynamics | 1 450 | 4 |
| | Northrop Grumman | N/C | N/C |
| | Raytheon | 1 700 | N/C |
| | Cobham | 2 300 | 3 |
| | QinetiQ | 6 000 | 3 |
| | Thales | 6 500 | 7 |
| | Safran | 4 200 | 5 |
| MRO | BBA Aviation | N/C | N/C |
| Aerospatial | Thales Alenia Space UK | 5 500 | N/C |
| | Airbus Defence and Space | N/C | N/C |

*"Main actors (top aerostructures plants in Great Britain)" Diota*

- **Germany**

Germany is the leading supplier to a large number of European countries. Airbus is a major customer in Germany. It has 400 companies. France is by far Germany's most important aerospace partner. 66.7% of the turnover is generated by the civil sector, 24.9% by the military and 8.4% by the space sector.

Hamburg ranks third in the world in civil aeronautics after Seattle and Toulouse, and first in German aeronautics research.

| Type | Entreprises | NB employés | Sites |
|---|---|---|---|
| Intégrateurs/ Maitres d'oeuvres | Airbus/Eurocopter | N/C | 29 |
| | Eurofigther | N/C | N/C |
| | Bombardier | N/C | 2 |
| | MBDA | 1 300 | 3 |
| | Boeing | 600 | N/C |
| Motoristes | MTU Aero Engines | 10 000* | 4* |
| | Rolls-Royce | 10 000 | 11 |
| Fournisseurs TIER-I | Liebherr Aerospace | 33 698** | N/C |
| | Dielh aviation | 5 480* | 12 |
| | Becher avionics | 200 | N/C |
| | Collins Aerospace | 70 000* | 300* |
| | General Electric Aviation Systems | 10 000 | 50 |
| | Lockheed Martin | 25 000* | N/C |
| | Leonardo | N/C | 2 |
| | Premium AEROTEC | 10 000 | 6 |
| | Zodiac Aerospace | 2 007 | N/C |
| | OHB Systems | 650 | 2 |
| | PFW Aerospace | 2 000** | 1 |
| | CAE Electronique | 6 000 | N/C |
| MRO | Lufthansa Tecniks | 26 000* | 7 |
| | Ruag Aerospace Services | 9 127* | 8 |
| | Honeywell Aerospace | 40 000* | N/C |
| Aerospatial | OHB Sytem | 1 900 | 2 |
| | Astrium | 4 590 | 2 |
| | Ariane | 9 000** | 4 |

*"Main actors (top aerostructures plants in Germany)" Diota*

In Germany, Safran has 14 sites (12 production, 2 R&D), 2,500 employees, six businesses (Aerial Work Platforms, Engineering Services, Helicopter Engines, Aerosystem, Cabin, Electronic and Defense) and four joint ventures (Europrop, MTR, AES Aerospace Embedded Solutions, Ariane). Safran Nacelles is well equipped in Hamburg: 20k sq. m. of land, 8k sq. m. of building, €10 million investment, 4 lines of 4 engine casing assembly stations, 33 nacelles delivered per month in 2020.

- **Italy**

While growth was expected to slow down in 2019 following the March 2018 legislative elections that affected business confidence, the coronavirus is making things worse in Italy. Germany (16.61% imports) and France (8.61%) are the main suppliers to Italy. Italy has companies heavily involved in Boeing and Airbus production programs, but they are mostly SMEs subject to the activities of the Leonardo group (61.7%).

Italian industry is characterized by a strong competence in traditional trades (precision mechanics, plastics, composite materials, etc.) particularly complementary to the highly innovative French industry. 75% of the companies in the sector have less than 100 employees.

| Type | Entreprises | NB employés | CA en million en 2017 EUR |
|---|---|---|---|
| Intégrateurs/ Maitres d'oeuvres | **ATR** (Leonardo/Airbus) | 1 300 | 1 620 |
| | **Piaggio Aerospace** (Mubadala) | 600 | N/C |
| | **Airbus Defence & Space** | N/C | |
| | **Leonardo** | 47 156 et 48 sites industriels | 1290 |
| | **Agusta Westland** | 12 500 | 3 480 (en 2013) |
| | **SuperJet International** (Leonardo Sukhoi) | N/C | |
| | **Eurofither** (Leonardo, BAE Systems, EADS DE, EADS CASA) | N/C | |
| Motoristes | **Piaggio Aerospace** | 600 | N/C |
| | **GE Avio Aero** | 800 | 344 |
| Fournisseurs TIER-1 | **Lacobucci** | 125 | 25 |
| | **Tecnam** | 250 | N/C |
| MRO | **Atitech** | 734 | 148 |
| | **Goriziane** (JV avec BAE Systems) | 25 | 125 |
| Aerospatial | **Telespazio** (Leonardo & Thales) | 2 500 | 632 |
| | **Thales Alenia Space** (Thales/ Leonardo) | 2 300 | N/C |
| | **Avio** (Leonardo & Space2) | 800 | 340 |

*"Main actors (top aerostructures plants in Italy)" Diota*

- **Spain**

Spain has been rebuilding its identity since the 2008 crisis. It has a privileged relationship with Germany, which is its 1st supplier with more than 12.54% of imports.

France is second with 11%. It is equipped with all the technologies necessary to carry out the entire process of design, development, manufacture and flight of an aircraft, but stands out above all in terms of:

- ⇨ Manufacture of aerostructures in composite materials (carbon fibers).
- ⇨ Small and medium-sized military transport aircraft (implementation in Seville of the final assembly line for the A400M and CN-235, C-295).
- ⇨ Low-pressure turbines (ITP, world-renowned group)
- ⇨ Air traffic management systems)

| Type | Entreprises | NB employés | NB sites | CA 2016 (en million d'euro) |
|---|---|---|---|---|
| Intégrateurs/Maitres d'oeuvres | **Airbus Defense & Space** | 12 700 | 10 approx | 1 560 |
| Motoristes | **ITP (Rolls Royce)** | 3800 | 5 | 594 |
| Fournisseurs TIER-1 | **Aciturri** | 1440 | 9 | 243 |
| | **AERnnova** | 4300 | 5 | 424 |
| | **CESA (Héroux-Devtek)** | N/C | 3 | 93 |
| | **Alestis (Aciturri)** | 1400 | 5 | 286 |
| Fournisseurs TIER-2 | **Alter technology** | N/C | | > 2,5 |
| | **Arquimea** | | | > 2,5 |
| | **Crisa (Airbus)** | | | N/C |
| | **HV Sistemas** | | | > 2,5 |
| | **Cadamadrid** | | | |
| MRO | **Iberia mantenimiento** | 4000 | 1 | N/C |
| | **ITP** | 3800 | 1 | 594 |
| Aerospatial | **DAS Photonics** | 60 | N/C | 6 |
| | **IberEspacio (Safran)** | 97 | | 10 |
| | **Sener** | 6 000 | | 1 305 |

*"Main actors (top aerostructures plants in Spain)" Diota*

## ■ Poland

Politics in Poland is not very conducive to relations with the EU. Poland has a privileged relationship with Germany, which is Poland's first supplier with more than 26% of imports. However, France is only 6th with less than 5% of imports.

Recently, President Trump announced the military build-up in Poland, hence the close relationship with the US.

The Polish aeronautics market is largely made up of SMEs: only 24 companies in the sector have more than 49 employees.

Polish aeronautics production is mainly concentrated around:

- ⇨ Aircraft
- ⇨ Helicopters
- ⇨ Sub-assemblies (aluminum, composites)
- ⇨ Of components

| Company | City | Employment |
|---|---|---|
| Pratt & Wittney Rzeszów | Rzeszów | 4050 |
| WSK „PZL - Świdnik" / Augusta Westland | Świdnik | 2900 |
| GE EDC Poland | Warsaw | 1800 |
| PZL Mielec, Sikorsky a Lockheed Martin Company | Mielec | 1700 |
| Thoni Alutec | Stalowa Wola | 1500 |
| Pratt & Whitney Kalisz | Kalisz | 1400 |
| HS Wrocław | Wrocław | 900 |
| PZL „Warszawa Okęcie", Airbus Defence and Space Company | Warsaw | 850 |
| HS Wrocław | Wrocław | 500 |
| Safran Transmission Systems Poland | Sędziszów Małopolski | 700 |
| MTU Aero Engines Polska | Rzeszów | 700 |
| PZL „Warszawa Okęcie", Airbus Defence and Space Company | Warsaw | 680 |
| WSK PZL Kalisz | Kalisz | 600 |
| Avio Aero | Bielsko-Biała | 400 |
| UTC Areospace Systems (Goodrich) | Krosno | 400 |
| MB Aerospace | Rzeszów | 300 |
| Hamilton Sundstrand Polan | Rzeszów | 250 |
| Gardner Aerospace | Mielec | 200 |
| Paradigm Precision | Wrocław | 200 |

*"Main actors (top aerostructures plants in Poland)" Diota*

- **Czech Republic**

The Czech Republic has a privileged relationship with Germany with more than 26% of imports. France is only 8th with less than 5% import share.

Aeronautics represents only 3% of the industry with 10k employees and 130 companies for a market size of 700-800M€.

The Czech market is mainly export-oriented. It participates in supply chains by being a subcontractor of major global producers such as Airbus, Boeing and Bombardier.

The main Czech expertise in the sector:

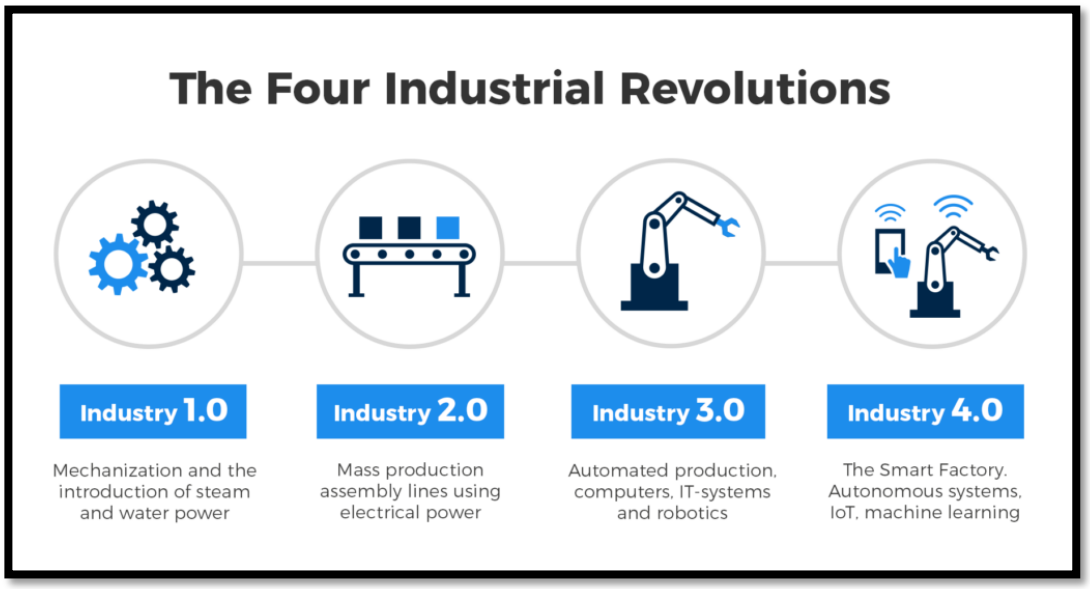
- ⇨ Production of ultralight aircraft: the Czech Republic is among the world's leading manufacturers, ¼. 90% of ultralight products are sold abroad. 25 local companies in this segment.
- ⇨ The production of components: for civil and military aircraft and helicopters.

Also, some Czech actors in the production of jet engines and jet engines, as well as in the subcontracting of structures for assemblies and sub-assemblies.
Having recently sought to bolster its air defense fleet, the Czech Republic is set to boost its imports from the United States and Germany in 2018. A new offer has been launched for the purchase of helicopters for a €553M contract with Bell Helicopter or Lockheed Martin's.


*"Main foreign investors in Czech Republic" Diota*

# 3. Introduction of Industry 4.0

As for the word "Industry 4.0", it refers to the fourth industrial revolution, marked by the latest technological innovations. A significant change in our technological capabilities and the analog age has occurred in the period of digital revolution, which means the integration of emerging technologies into industrial structures would be essential. We're about here an integrated warehouse, where people, machinery, materials, and goods are all in relationship, meaning a continuous work process.




*"Evolution of Industry" SpectralEngines*

In the future, businesses can operate in line with current patterns of production. Technological systems are everywhere with newer generations taking the place of those who preceded them and removing the strategies that people have already been using for transformation, and therefore tools that are comprehensible to those generations is essential for succeeding generations. Technology strives to aid the working life of workers while still helping their growth. Augmented reality is based around the concept of immersion or the whole or total engagement in a simulated environment.

These result in a higher level of focus and understanding for participants, offering more full or limited freedom from reality.

**By 2021, the majority of augmented reality investment will be on industrial maintenance.**

As we have shown, plant construction, manufacturing, schooling, cooperation, and quality assurance both rely heavily on augmented reality, research, in simulation, and digital prototyping are common too.

Both aspects of the consumer use should be well-documented: the more important one is another. Essential ones are likely to include augmenting and immersing as well. in addition, manufacturers need to be aware of the manufacturing technologies for this boosts the overall technical position of the commodity as well as well as the product's value the fact that vehicles which can help vehicles more accurately know where they are, steer their wheels, allows more detailed diagnostic software, which has the potential to help in improving cars (and certainly luxury car manufacturers.
In the correct equipment and using the proper approach, the facilities and staff will conduct their duties more effectively! These operators are more free-to-use their two primary working muscles because they have all they need right in front of their eyes: the left muscle is their brain relaxed, while the right muscle is given an opportunity to relax.

In Factory 4.0, apart from augmented reality, by digitalization we also talk about Pick To Light, 3D Printing, IoT, automation, cobotics / robotics, sensors.
Outside factory, we evoke augmented reality and for maintenance: sensors, robot, Big Data (prediction) and optical computer monitoring system (3D printing control).

Many are skeptical of the promise of augmented reality, but one cannot ignore the fact that it has the ability to change the industry in a good way. In an interconnected organization, details and knowledge are shared between departments in real time to maximize various departments' productivity and function.
Thus, it is important to be prepared to react to the next step in this ongoing evolutionary process of innovation which results in increasingly applicable techniques. Thus, the industry of the future would profit from this technology to boost efficiency, tailor goods to suit consumer needs, and help meet their needs, making customization of products feasible.

# 4. Diota: The Pioneer of Digital Solutions For Industry 4.0

Essentially, Diota's presentation should be divided into two main parts: DAO and DBR.

## ■ DAO: Digital Assisted Operations

### - Linking Digital to Field Operations to Optimize the Process

Specially designed for industry, Diota's DAO solution creates an unprecedented interactive link between industrial digital intelligence and operational know-how. Exploiting a high-performance augmented reality technology, it allows:

- The optimization of operations through the assistance of complex gestures
- The optimization of processes by capturing the reality on the ground
- Optimization of skills development.

Connected to industrial information systems and compatible with various materials, DAO adapts to multiple uses in order to improve productivity, quality and traceability from design to after-sales.

### - Reduce cycle times, errors and costs and improve efficiency

DAO enables operators to benefit from an organizational terrain enhanced by emerging technologies by bringing immersive content from the digital model into the workplace (3D templates, work orders, contextual details, etc.). They imagine the right details, at the right time and in the right place, using the most appropriate equipment, in order to properly understand and carry out their assignments.

- **Digital Data**

1- The DAO binds directly to information systems through the DiotaConnect plugin (PLM MES, CRM...). It extracts geometric and procedural data, which is transformed and made available in the field automatically.

2- Via DiotaPlayer, a generic software platform, data exported from information systems can be manipulated without specific expertise to support field operations.

3- Digital data is visualized in real time on objects by operators from both trades using a variety of hardware peripherals (tablets, projective devices, glasses, etc.).

*BENEFITS:*

Productivity and quality of operations are greatly improved.

- Complexity related to paper manuals eliminated
- Gestures without added value minimized
- Tasks completed faster with low errors.

- **Improve the operations tracability and optimize industrial processes.**

DAO allows operators to capture the reality on the ground during operation. Back office engineering therefore benefits from the observation and experience of the field through data of various types (comments, photos, digital twins, inspection results, etc.), synthesized in automatically generated task reports.

- **Field data**

1- Via DiotaPlayer, operators note comments, take photos, perform compliance checks... during operation.

2- Via DiotaPlayer, the field information collected (differential analysis, task reports, controls results...) is automatically included in a reporting document, ready to be transmitted.

3- Via DiotaConnect, reports and other field data can be directly uploaded into information systems (PLM MES...) by synchronous or asynchronous queries.

*BENEFITS:*

Traceability of operations is improved, and process optimization is promoted.

- Loss of information is avoided
- Processing times are reduced
- Information systems are enriched by field data.

- **Suite Products**


Generic and plug-and-play, DAO solution integrates pre-existing software environments. It allows you to exploit digital data with flexibility.

It guarantees a high level of profitability

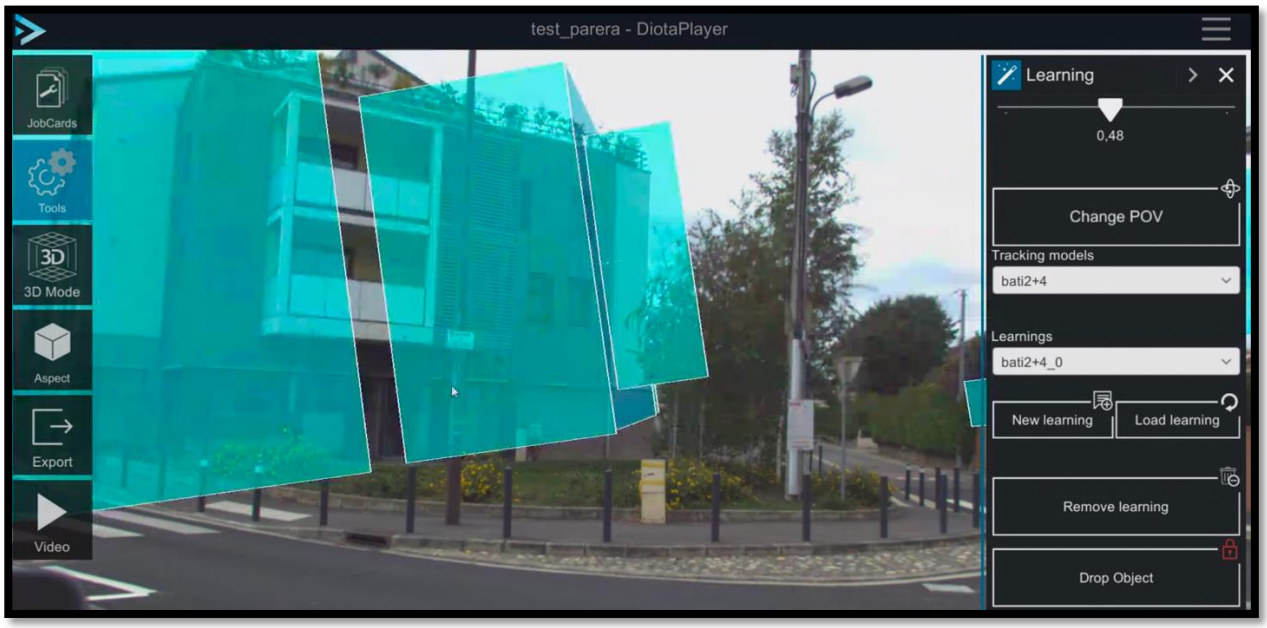
- **DiotaPlayer**

A high-level application environment allowing to restitute digital data in the operational space and to collect data in the field.

*Functionalities:*

1- Exploitation of AR data in direct connection with info.
2- Adaptation to use cases.
3- Customization through generic or custom modules.
4- Capture of Field reality.

*During my internship I was given the opportunity to use the DiotaPlayer so that I could better understand the use cases. It is an innovative and user-friendly solution that accompanies operators from A to Z during their activities in many sectors. I didn't use the DiotaPlayer in the middle of a mission, but I watched my co-workers do it and it was still understandable.*




*"DiotaPlayer tracking" Diota*

⇨ The first task is almost always to **fix the tracking of the part** using the camera of the DiotaPlayer then save it in *Learnings*.


*"DiotaPlayer 3D" Diota*

⇨ **Control classes** are first realized in PLM via the DiotaConnect module and are then associated to the digital model of the object (usually "the 3D") given by the customer.


*"DiotaPlayer Jobcards" Diota*

⇨ **Jobcards** are also device elements realized in PLM to be integrated in the reality: here is augmented reality for you.


*"DiotaPlayer Comparative Reality/Virtual" Diota*

⇨ The **superimposition of the virtual on the real** is what the operators like best from what I have seen in the field. You can slide from right to left for a better visualization by using the DiotaAugment module. We'll see an example later in a use case.

- **DiotaConnect**

An agnostic plugin allowing direct and bilateral data transfer between information systems (PLM, MES, CRM...) and DiotaPlayer.

*Functionalities:*

1- Import/Export of data via generic and proprietary standard formats.
2- Composition of procedural contents.
3- Automatic data processing for vision adjustment and restitution.
4- Integration in standard and specific information systems.

- **Equipment**

A number of material goods have been tailored to the constraints in the market, providing standardized solutions that enable for the introduction of consistent uses.

⇨ **TABLET**

Particularly adapted to operations requiring numerous interactions with information systems or high-quality graphic rendering.

⇨ **HOLOLENS GOGGLES**

Particularly suitable for operations requiring hands-free operation and high-quality graphic rendering.

⇨ **PROJECTIVE SYSTEM ISAR**

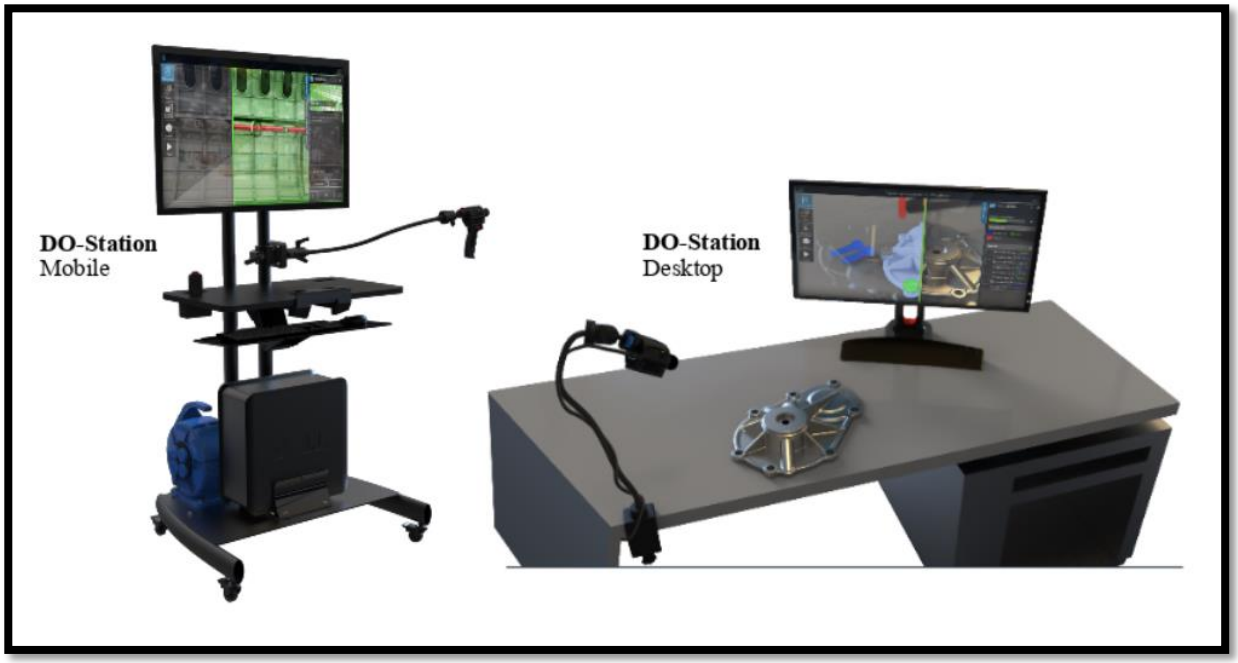
Recommended for processes where complex and exhaustive information must be consulted on objects, especially on large surfaces.

⇨ **DIOTAWAND**

An ergonomic handle that integrates an industrial camera and allows flexible data capture, especially in hard-to-reach places.

⇨ **DIOTAHOLDER**

An ergonomic support facilitating the handling and handling of the shelves and integrating an industrial camera.




*"DO-Station Movile and DO-Station Destkop" Diota*

- **Customer references**


*"Diota customers" Diota*

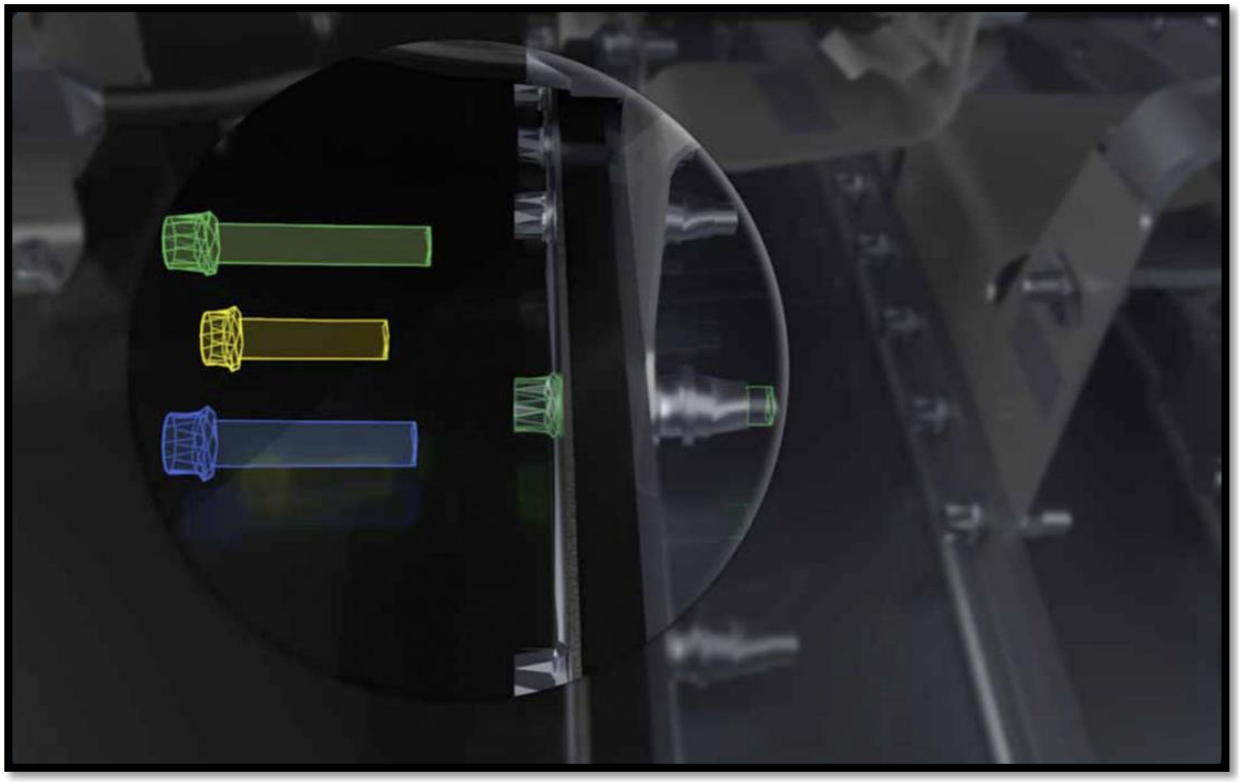
Sectors of activity concerned by the solution

Aerospace, Automotive, Naval, Railways, Energy/Petrochemicals

## ■ DBR: Digital-based Robotics

DBR can be adapted with no specific envolvement to variant effectors (2D, 3D, multi-spectral, etc.) and variant robots and cobots. It automatically detects defects from various methods.

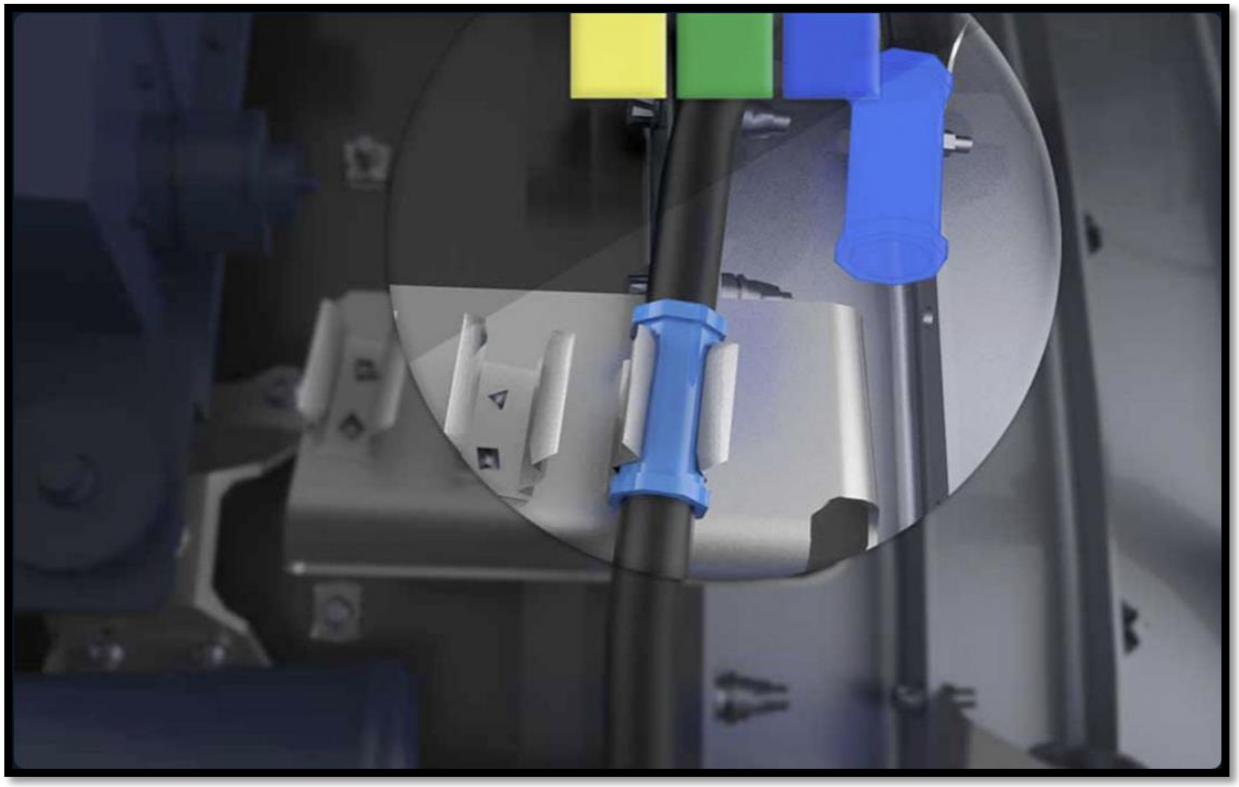
- ⇨ **Geometrical controls**
- Screw length
- Presence/absence of supports
- Positioning of supports
- Interference
- Inversions



*"Geometrical controls" Diota*

⇨ **Colorimetric controls**

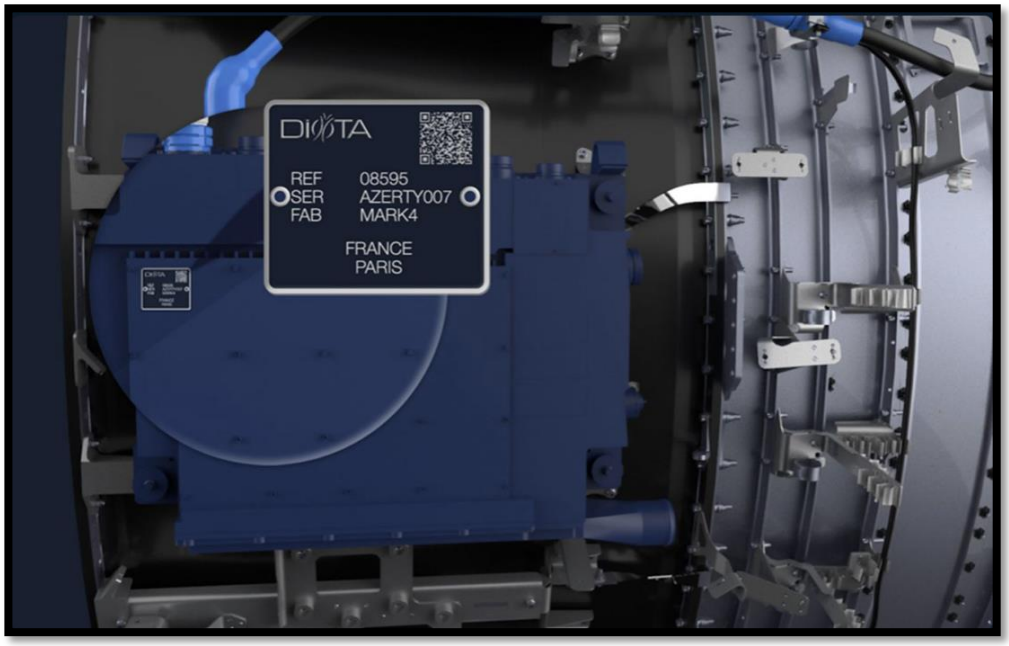
- Detection (flame)
- Presence/absence of objects (plugs for example)
- Painting areas
- Markings
- Reserves



*"Colorimetric controls" Diota*

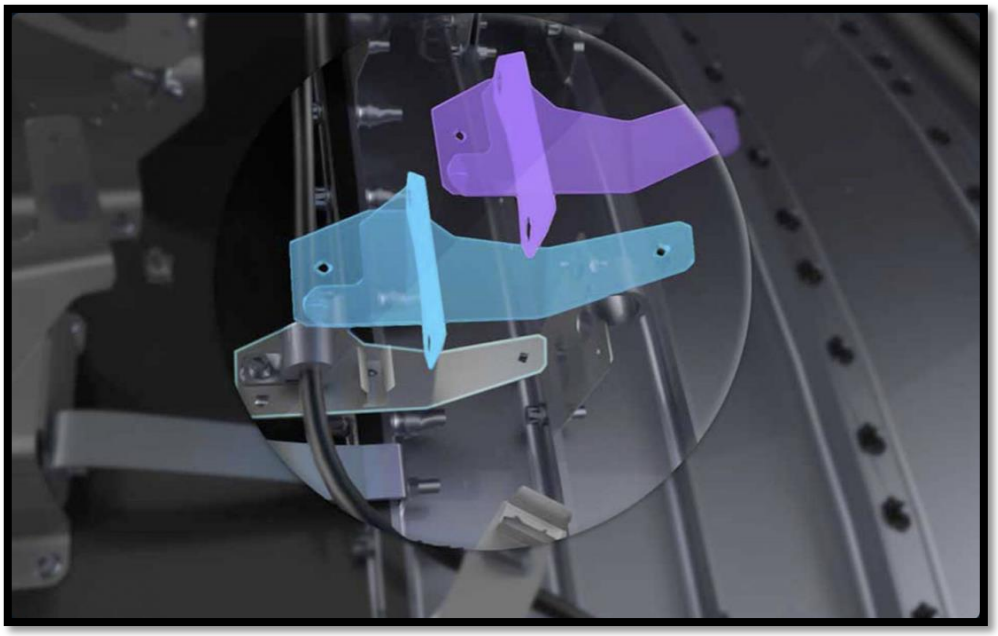
⇨ **Recognition/Reading**

- Texts (OCR)
- Serial numbers
- Nameplates
- Datamatrix
- Barcode
- Symbols
- Markings




*"Recognition" Diota*

- **Comparative analysis**
- Comparison by image recognition
- Learning on reference database
- Machine learning
- Deep learning
- Image Correlation



*"Comparative analysis" Diota*

- **Missions**

- **TIME**

  The time it takes to prepare, maintain, and evolve the ranges has been reduced to a bare minimum.

- **RELIABILITY**

  Robust controls, always up-to-date ranges, and prompt identification of anomalies

- **TRACEABILITY**

  Control reports that are automatically created and customizable

- **EFFECTIVENESS**

  Controllers refocused on their skills, allowing for faster analysis and arbitration, as well as greater responsiveness in the event of anomalies.

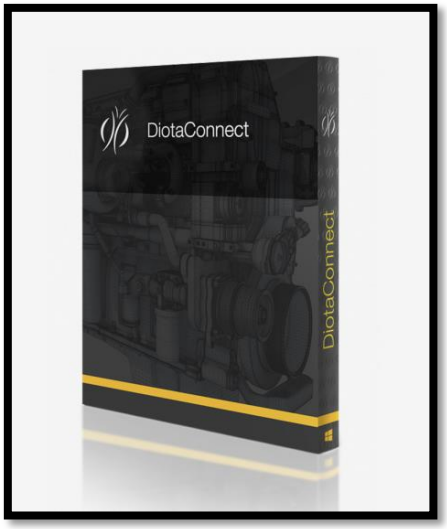
- **COSTS**

  Costs of programming, repair and improvement are reduced.

- **Suite Products**

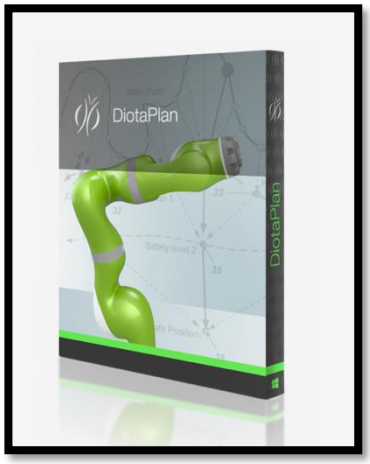
  - **DiotaConnect**

    Generic plugin that integrates industrial information systems and allows for direct data sharing between PLM, CRM, MES, and other applications and DiotaPlayer software with just a few clicks.



- **DiotaPlan**

  Software that optimizes the automated choice of observation points according to the elements to be monitored and the scheduling of collision-free trajectories for robot trajectories during simulation and automatic preparation.




- **DiotaController**

  Software that monitors the progress of the control ranges and automatically pilots the robot, the cell's components, and the capture phases.


- **DiotaInspect**

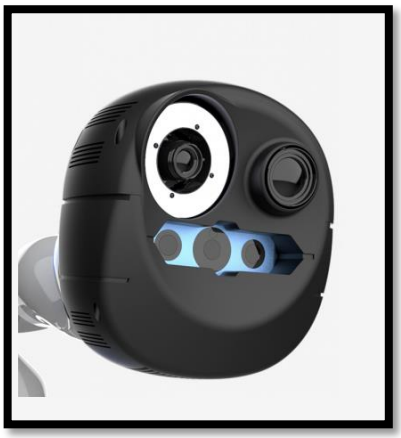
  Several automated control functionalities to track and characterize non-conformities are included in this set of algorithmic operators.

- **DiotaAnalytics**

  Real-time tracking and reporting of the progress and execution of operations using software.


- **DiotaSensor**

  Autonomous control effector with a broad control capability and a high degree of versatility. It allows for a variety of functionalities since it is made up of many fields of vision.




*"DiotaSensor" Myself*

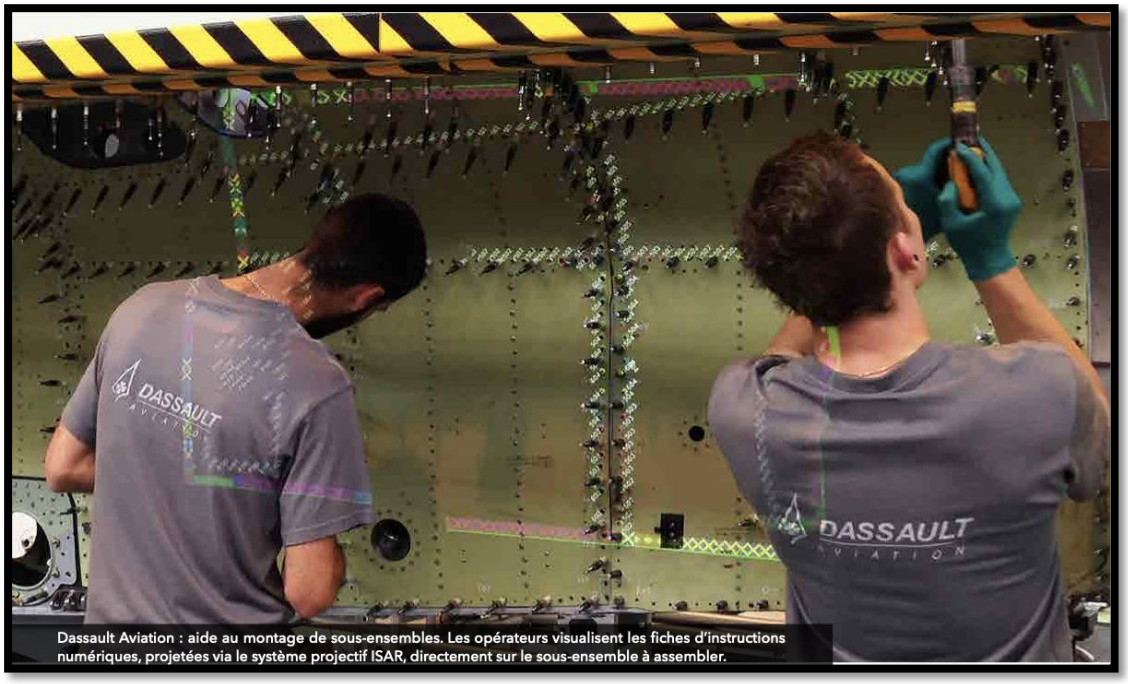
# 5. Diota Use Cases

## ■ DAO use cases

### ⇨ Production use cases

#### ○ Aerostructure assembly assistance

This case represents an aid to the assembly of sub-assemblies. **The operator positions the tools on the locations indicated by the ISAR projective system according to instructions displayed in AR on the part.** The operation can also be drilling, pinning, milling, etc.
The required part color is assigned the color of a disc that is displayed at the corresponding AR position on the part, with a label as a reference.




*"Diota ISAR projective system" Dassault Aviation*

**Mission:** Help operators minimize errors by avoiding complexity. Hands free.

- **Engine module assembly**

Operation assistance to the assembly.

In this case, on a mobile DO-Station, the operator uses the camera of the mobile station to capture the data of the (complex) part in 3D. Then, **he follows the instructions displayed on the touch screen to perform his operation** (screwing for example). He could also superimpose the virtual and real configuration via the DiotaAugment module in the DiotaPlayer to make a comparison on the touch screen.

*"DO-station mobile" Diota*

**Mission:** Help operators minimize errors by avoiding complexity. Hands free. Eliminate the need to use PDF format for consultation.

⇨ **Inspection use cases**

- **High-precision control on table**

On a DO-Station Destktop, with a camera at the end of a flexible hose and equipped with a touch screen, the operator performs a confomity check on the part after the tracking is fixed thanks to a real time tracking with sub-millimeter precision (<0.55 mm), carried out beforehand, with the information displayed in the right place: **eventually the operator places a red marker on the touch screen on the place where the operation is required.**

*"Diota DO-Station Destkop" Diota*

**Mission**: Better precision and improved ergonomics

- **Auto assistance for the detection of non-conformities**

**The operator uses tablet to detect non-conformities to which color statuses will be assigned:** first automatically (green, red, blue) with the Defect Detection Assistance software, then it is the operator's turn to characterize the anomaly with other color attributes.

*"Tablet" Diota*


*"Diota Tablet" Diota*

**Mission:** Increase reactivity

- **NDT of composite nacelle panels inspection**

Safran has inaugurated a new process for non-destructive testing (NDT) of composite panels for aircraft nacelles. The use of infrared thermography technology followed by augmented reality projection is a world first in 2017.

In this case, the NDT process relies on a robotic means, called IRIS (InfraRed Inspection System), which uses infrared thermography to collect data. After processing, they are then analyzed by Diota and, if necessary, **the areas to be checked are projected by augmented reality on the part then the operator does a conformity check**.

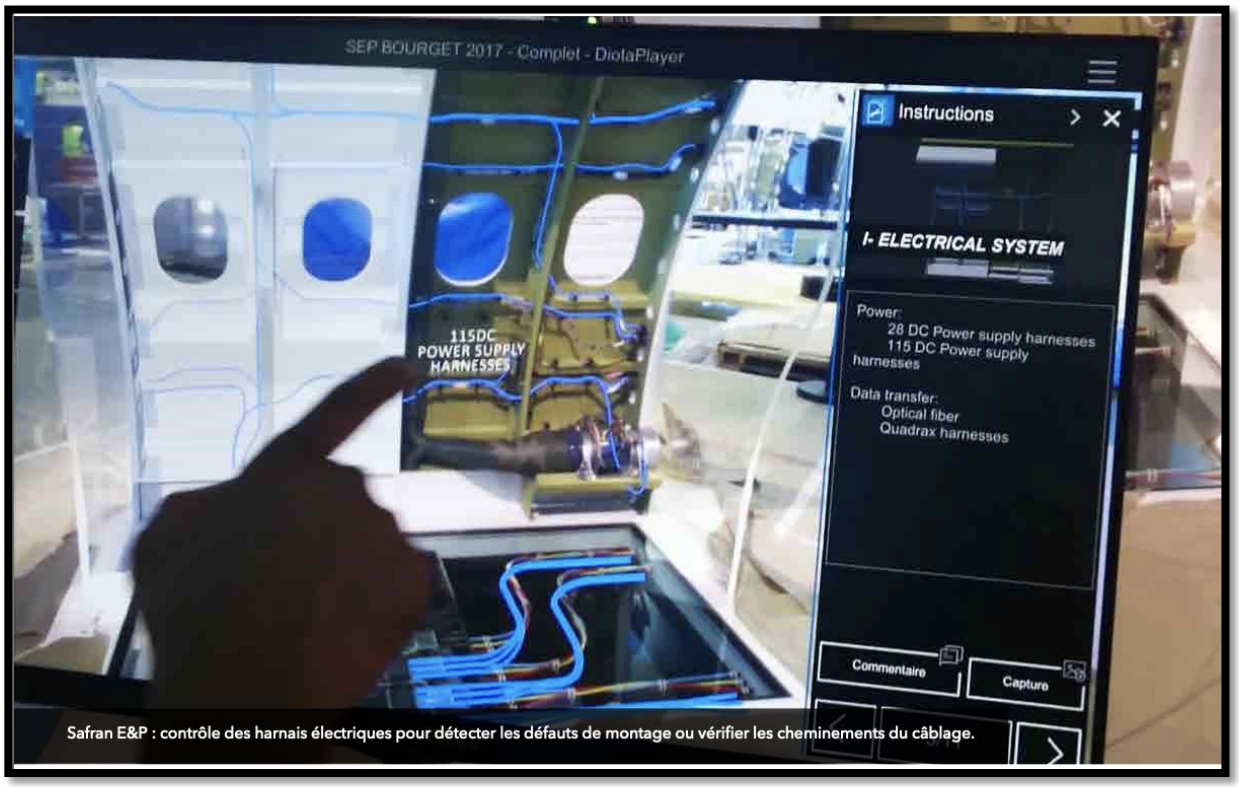
*"Diota DO-Station mobile" Safran*

**Mission:** The operator no longer has to read the contact information by himself.

- **Aerostructure inspection and maintenance**

**The operator visualizes the digital model in superimposition of the real object thanks to the DiotaAugment module.** He quickly detects breakdowns; then guided by digital instruction sheets and with the help of contextual information, he efficiently carries out the appropriate maintenance operations (assembly/disassembly, replacement...).

In this case, the operator checks the electrical harnesses to detect assembly faults or check the wiring routing.




*"DiotaPlayer" Safran*

- **Pre-implementation validation of equipment**

The CAD of the equipment is realized in PLM and integrated via the DiotaConnect module in the DiotaPlayer. With the tablet or the Hololens, the operator first checks the compliance of the frame, then **simulates the future by adding the equipment in RA on the real one** for a final overview of the compliance in a global way.

In this case, with Diota, Orano improves the reception of appliances and work sites.

*"Hololens" Orano*

- **Support for product design and configuration**

At the point of sale, **the customer visualizes combinatorics and characteristics directly on the real object.**

In this use case, we are at the DS World showdown and the customer visualizes multiple options directly on the vehicle and easily customizes his vehicle by quickly projecting himself.


*"Tablet" PSA Group*

## ■ DBR use cases

### ⇨ Inspection cases

#### ○ Robot inspection on assembled engine

**Control classes are first realized in PLM via the DiotaConnect module and are then associated to the digital model of the object (usually "the 3D") given by the customer**. Then, all this will be integrated into DiotaPlan which ensures the optimized control range (collision-free trajectory and captures to be made) and the robot/cobot will move accordingly. The DiotaController will play a supervisory role (the path of the robot) while the DiotaInspect automatically and intuitively analyzes the captured data by defining a status for each one.

In this case,using the Siris robot integrated with the DBR for Inspection suite, Safran Aircraft Engines optimizes control of the Leap engine assembly and tests its adherence to its digital model at its Villaroche (France) factory.

*"DiotaSensor" Safran Aircraft Engines*

# 6. Diota Competitive Analysis

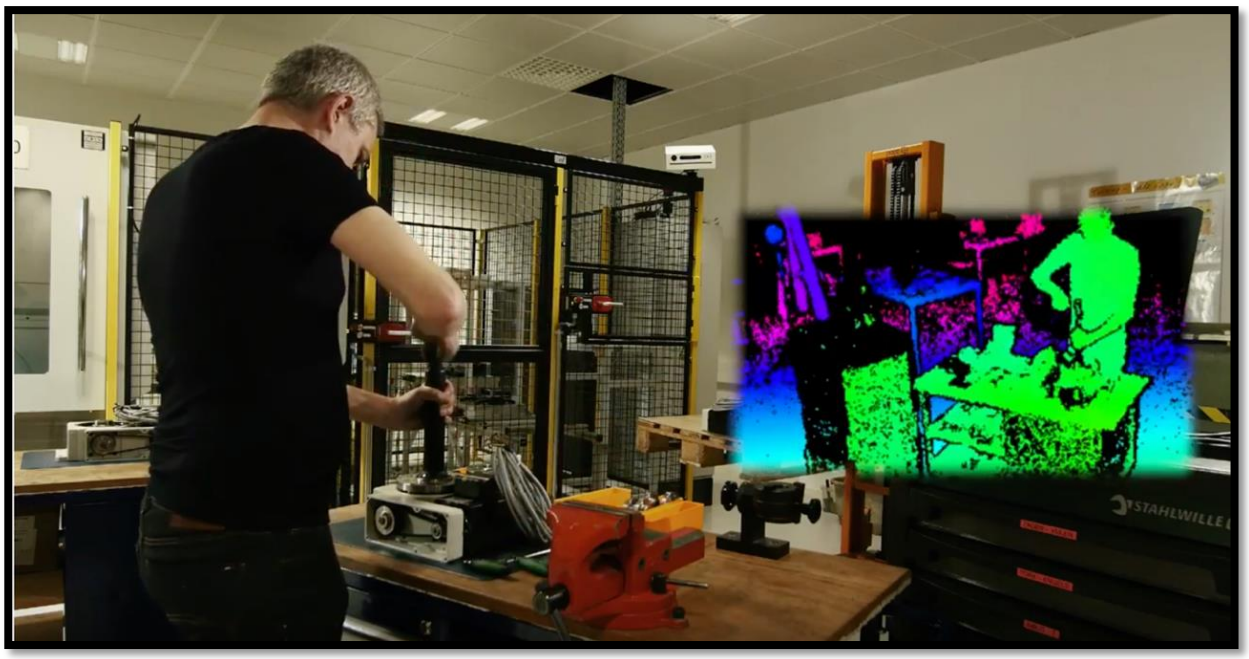
**OBJECTIVE: To produce a large quantity of products with the best possible profitability.**
Objective of any industrial process.
Whatever the sector: automotive, chemical, transport, aeronautics, food processing, energy...
Augmented reality allows the optimization of industrial processes and the democratization of AR helmets is an opportunity to be seized.

Here are some competitors of Diota:

## 6.1 ARKITE

Created in 2015, Belgian, 20 employees.
Proposed solution: **HIM (Human Interface Mate)**

- ⇨ 3D sensor placed in height that inspects the operator assisted during the assembly: it gives him remote instructions on a touch screen and alarms him when mistake.



*"HIM" ARKITE*

**Advantages:**

- Everything is already fixed, therefore automated.
- 3D or 2D not required.

**Weaknesses:**

- One device = one determined workstation.
- Expensive if several workstations, especially in a factory.
- Questionable adaptability: What if operator takes the tool with the wrong hand? If tall?

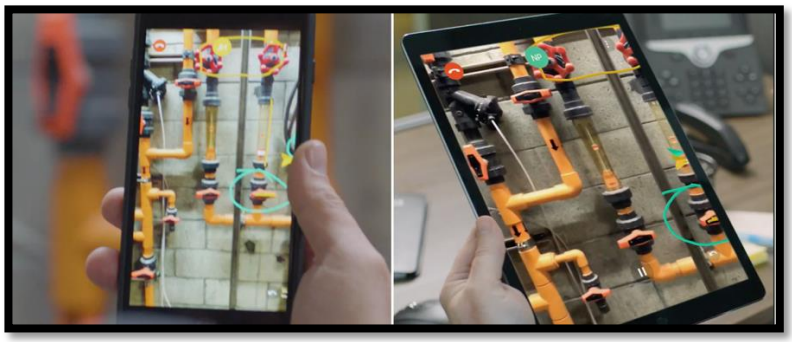
### 6.2 PTC

Created in 1985, American, 6041 employees.

Proposed solution: **Augmented reality**

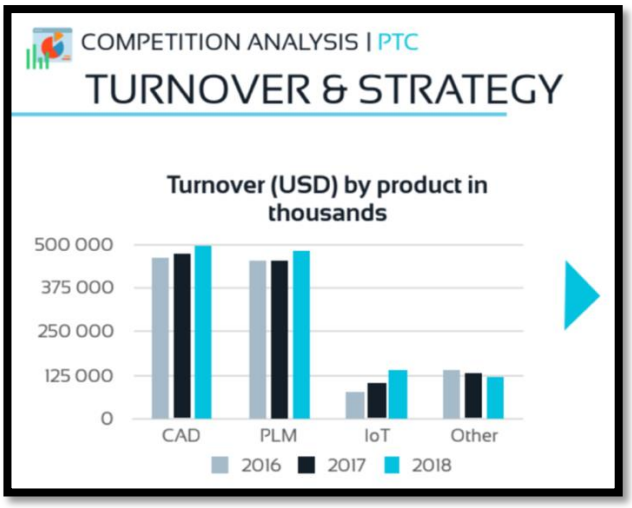
⇨ Vuforia Expert Capture / Vuforia Studio / Vuforia Engine / Vuforia Chalk are Vuforia's IoT products sold by PTC.


*"Vuforia Studio" PTC*



*"Vuforia Chalk" PTC*

According to a market study conducted in 2017, the flagship product was Vuforia Studio, no surprise because it's very sociable principle consists of pure augmented reality, that is to say anatomically visualize the 3D of an object in real life on its touch screen.
Vuforia was acquired by PTC from Qualcomm in 2015 for $64.8M and is today one of the three IoTs used by the giant. Vuforia's turnover/product on the IoT is $125M, but this represents only 10% of the total turnover/product - the best-selling being CAD ($500M, or 40%) - and Vuforia alone covers 20% of this 10%, or $25M of turnover/product.




*"Turnover & Strategy" PTC*

In it, "Augmented reality is $20M" according to the president, a statement that coincides with the calculated $25M in sales/product for Vuforia at PTC. Surely realizing its popularity as well as its effectiveness, Heppelmann expects an 80% growth in AR revenue at PTC. Namely, 6,500 industrial customers use PTC's AR at 800 plants.
Among the collaborations, PTC is partnering with Microsoft, such as Diota, for the HoloLens. But unlike us, PTC sees the HoloLens as fundamental to their plans.
**Vuforia Expert Capture should be the main competing product of Diota.** Created just in May 2019, the software is similar to the DiotaPlayer: assembly assistance & control following real-time instructions provided in augmented reality. Typical industrial customers unlike other products sold. To see CA later... PTC spends approximately 33% of its total revenue, or 1/3, on marketing. PTC insists on the link between IoT (Vuforia) and augmented reality. From this point of view, they are targeting aerospace:
"Working more and faster to meet increasing demand. »

**Advantages:**

- Popularity: PTC has been working on its status as an augmented reality. Leader since April 2017 awarded by ABI Research and was referenced by Harvard BS in the same year in November.
- Multifunction: Vuforia Studio & Vuforia Chalk.
- PLM: Easier entry door thanks to its PLM (Windchill) where you don't have a connection.
- Trial: Selling purely software and not robots, PTC has the advantage of being able to sell a free trial period (Vuforia Studio & Chalk) to allow the industrial customer to estimate his ROI without risk.
- Training: Sells free training courses with AR instructions to learn how to use its software, including Vuforia Studio.
- Humanization: Voice-generation service to keep the eyes on the operation and accelerate the pace of work.
- Application: AR application available to the customer (e.g., Howden) offering a kind of catalog of AR instructions for control/maintenance assistance.
- Drop: AR products have resellers in France and Germany. In France, TechViz, Percall and GFI are mentioned.
- Event: PTC organizes its own event in Boston every year on three days in June between the 10th and 13th with 6500 invitations and 650 speakers. As for the content, 4 keynotes and 28 on-site trainings.

**Weaknesses:**

- Precocity: Still young in augmented reality, technology not yet at the level of Diota.
- Too dependent on its PLM: Windchill is not the reference in France, unlike Catia, more privileged by several giants.

# 7. Conclusion

During my internship, I had the opportunity to attend several important meetings with corporate giants such as Microsft, Safran and Airbus, and the major topics related to future challenges.

**Opportunities arising from the new challenges to be seized for Diota:**

- Increase in air traffic
- Appearance of new aircraft manufacturers on the market

**What augmented reality can bring:**

- Improve operator safety
- Improve operator training
- Improve the accuracy of operations
- Improve the quality of operations

**OBJECTIVE: Synergy between GROUND - DESIGN and CUSTOMERS - SUPPLIERS.**

⇨ Guarantee the security of data exchanges and increase the traceability of critical parts and documents.

Several businesses are now ahead of the market in the use of augmented reality. They can apply this to all of their operations, helping to lower costs and improve overall efficiency, thus minimizing errors. It's becoming clearer by the day that investing in AR has long-term benefits. A targeted integration of AR technology into traditional production processes would be more effective and seamless, instead of trying to make up for the gap left behind by the most advanced and savvy rivals.

# THANK YOU FOR YOUR ATTENTION!

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