1. Entity posing the challenge:

- **AZPIARAN, EKIDE, FLANKER, FLEXIX, GARITA & METAL GROUP**

2. Challenge statement

Optimisation of Quality Control processes by applying digital technologies to product design and manufacturing

3. Context

The automotive industry is made up of complex supply chains, which over time have evolved into a global production network. Although only a limited number of countries and companies lead automotive production, the industry's value chain spans the globe and a large number of companies are involved in the design, development, manufacturing, marketing, sales, repair and maintenance of cars and automotive components. On average, each vehicle contains more than 20,000 parts, which original equipment manufacturers (OEMs) source from thousands of different suppliers. The value chain has increased in recent years, integrating new agents from different fields of knowledge and expertise.

The automotive industry has demonstrated remarkable resilience over the years. It has successfully recovered from the last global financial and economic crisis and continues to make a significant contribution to GDP, world trade, and employment.

Right now, the automotive industry is at a turning point: it faces the digital revolution, environmental challenges, climate goals, societal changes, and increasing globalisation. The main trends driving this transition are the development of new technologies in areas such as automated driving, further digitalisation of manufacturing, reducing the impact of vehicle pollution on the environment and health (a crucial competitive issue which is expected to bring about an increase in global demand for electric vehicles), and societal challenges (such as changes in consumer preferences and an ageing population).

The industry is generally assessing and redefining its position in the value chain, as well as increasing its capacity to add more value in its product portfolio and production processes.

Within this context, the Basque automotive components sector is positioned as one of the most competitive and innovative in the world, characterised by its advanced level of management, high degree of effectiveness, and efficiency. The Basque sector also stands out its ability to integrate, as it brings together the entire value chain within a very small area. It integrates steelmakers, capital goods manufacturers, machine-tool producers, tooling and die makers and machinists, as well as universities, research centres, consultancies, and engineering firms.

At the local level, which is completely interrelated to the international context, SMEs in the sector face different challenges that condition their production activities and business operations. Some of the most significant conditioning factors are the following:

- the **high quality specifications** demanded by the main brands in the sector as well as OEMs;
- the increasingly **demanding functional requirements**, which increase the complexity of the manufacturing processes;
- **product designs which are predetermined by customers** leave little room for manoeuvre for the manufacturing companies;
- the demand for **high cost efficiency** which is closely linked to the improvement of productivity ratios, and is also conditioned by the product designs.
- the importance that SMEs must give to revaluing and optimising their production processes in order to provide value when they **lack their own products**.

In this context, some SMEs of the ACICAE cluster have visualised certain common areas of work in order to improve their competitive position in the market, and this is where the following challenge arises:

The Challenge

1. Description of the challenge:

Ensuring the quality of the final product is a fundamental aspect for any company, but it becomes particularly critical when high value products are being manufactured, as in the case of the automotive industry. Quality is a matter of survival for companies that supply components to OEMs and those that manufacture the equipment to produce such components, as well as being a basic requirement for working with the top brands.

The very high levels of requirements defined in the specifications for the different phases of the entire production process make quality one of the priority aspects of differentiation between suppliers. Quality is an essential evaluation criterion in purchasing processes and when investing in new technologies.

Numerous companies in the automotive sector are currently implementing digital technologies for quality control. However, there are still many cases in which these processes are carried out manually and visually by operators using specific tools. This is often because certain problems limit the application of digital technologies. In simplified terms, the problem can be reduced to the fact that component manufacturing companies produce a wide variety of products (as well as different product references) with different geometries and materials, making it difficult to apply a standardised, automated and flexible solution; this is combined with the lack of a technological solution that allows 100% of the parts to be inspected for 100%

of the parameters (size, volume, irregularities, mixture consistency, internal defects, etc.). Until now, this has meant that SMEs in the sector have had to apply different “unitary” solutions to the quality inspection problem. The cost-effectiveness of such solutions and subsequent return on investment is usually not justified.

In this sense, and in response to customers’ quality specifications, two groups of different technologies are envisaged to optimise these processes. The first group relates to technologies applied in the production phase (classic quality control), i.e. those applied at the end of the production process. The second group relates to technologies applied in the pre-production phase, which are focused on limiting product errors when the manufacturing process is designed.

A) **Technologies applied during production.**

The aim is to equip production machinery with a system that has the capacity to see and interpret whether or not a product complies with certain predefined conditions by using different devices (mainly image capturing devices). Technologies such as sensors or cameras should be applied and used to obtain: precise readings of size, inconsistencies in colour, shape defects, missing parts, mixture consistency, or internal and surface defects. With these technologies, tasks should be able to be carried out uninterruptedly and be adaptable to the different cycle times of each production process.

- **Computer Vision**

As noted, many quality assurance activities are still visual and depend on specialists who sample a certain number of products per batch. This is especially difficult in companies that manufacture multiple references in long runs of thousands or even millions of pieces. Initiatives aimed at making improvements in these processes, which were considered difficult to automate, have become particularly important in recent years. This has been made possible by the speed at which technologies such as computer vision and data analytics have evolved. These technologies are making it possible to maximise the efficiency of inspections, significantly reducing operating costs. However, it is important to mention the **challenges facing the application** of these technologies:

- The need to apply **solutions that adapt to the speed of the production line** (the difficulty lies in applying technology that matches the cycle time).
- The **production process is not a clean process.** In many cases, stamping, machining, and other processes are carried out in “somewhat unclean” environments where materials such as oils and lubricants are used, making it difficult to apply Computer Vision technologies.
- A lot of data needs to be provided (parts - images with defects) for the system to learn, which are not applicable afterwards due to production reasons (e.g. the position in which the part comes out of the machine).

As can be seen, there are certain limitations to **applying CV technology on an individual basis**, given that quality control is influenced by the type of part material, the type of production process, or the way in which the parts are arranged (transported), among other factors.

- **Other quality control enabling technologies**

Beyond computer vision, **the sector is calling for a solution that integrates different technologies** and applies to manufacturers/producers of more than one part, which may also have different physical and chemical qualities. In this sense, **non-invasive and/or destructive technologies (NDT- Non Destructive Testing)** are valued, such as: Metrology, Electromagnetic Waves, Colorimetry, Thermography, Ultrasound, X-rays, "Zero Defect Manufacturing" cells, etc.

B) Technologies applied during design:

When a company designs the products that it will subsequently manufacture itself, the design activity should not only be restricted to the product. It will also involve **designing the manufacturing processes to make the corresponding product**. Producing a high-quality end product from the outset is fundamental in sectors such as the automotive industry. To do so, **advanced design techniques, predictive models of the manufacturing processes** (e.g. stamping, cutting, or punching) and **advanced techniques to characterise the behaviour of certain materials** (e.g. Rubber) must be used. Within this context the aim is to apply technologies such as Machine Learning and Digital Twins.

- **Machine Learning**

Many plants now have at least SPC (Statistical Process Control) or Sequential Control technologies to provide objective criteria for process quality control. However, this also opens up a huge range of opportunities in the production chain, increasing productivity, reducing costs, and gaining efficiency based on analysing the data generated and algorithms that optimise the production chain in real time. In this sense, there is a challenge to enable **machines to learn from real-world incidents** (unexpected stoppages, urgent orders, staff shortages, etc.), and **to identify non-quality patterns to reduce repeat work and increase production agility and speed.** At the same time, the customisation demanded by customers with tailor-made orders, requires automatic learning for machines to reduce operator dependence.

- **Digital Twin**

The market also demands that industrial processes have the autonomy and knowledge to adapt to changes in products, processes and services in real time, with the ability to learn from experience. Herein lies the need to create virtual models of processes, products, or services using the information obtained through sensors and automatisms. In this context, the

opportunity arises to create virtual representations of the physical world and its relationships, creating digital models that can be used as a test bench, which optimise the manufacture of a specific element. In this line, **data modelling will help to predict the possible deformations that a part may suffer.**

2. Main impacts

As far as **technologies for classical quality control** (applied to production) are concerned, their application will first of all lead to these processes being automated. This automation will in turn make it possible to verify a greater number of elements, obtain greater process reliability, reduce human error, and homogenise inspection criteria. It will be possible to establish objective quality criteria, even in coordination with customers, with which the conformity or non-conformity of the product is measured. This would provide evidence of the process and avoid future discrepancies, penalties, or returns. In the near future, it is very likely that the application of these automated and standardised quality control techniques will become a differentiating factor, and even an indispensable requirement, to obtain supply contracts with automotive manufacturers.

In terms of **smart technologies for product manufacturing design**, both Machine Learning and Digital Twins are positioned as a key part of the digital transformation of the automotive sector, as they allow new processes, services, or products to be simulated. This can cover the design and prototyping phase through to the operation and maintenance phase. Until now, once the company had a first design, it subjected it to finite element analysis (FEA) and corrected the deficiencies of this design depending on the results obtained. More and more precise parts are being designed in less and less time with the help of artificial intelligence. If real-world data is also included to build digital twins, a digital model could be built that allows engineers to accurately predict wear, movement, and interactions with other devices. With the help of machine learning processes and algorithms, design engineers will know how changing design specifications will affect the product, production line, supply chain, and maintenance.

As a final point, it must be clarified that many companies have large data sets related to typical manufacturing/production errors, which in many cases are catalogued/typed and would help in the application of the aforementioned technologies.

3. Main questions to be solved

- Would it be possible to apply a technological solution for the quality control of 100% of the parts in a non-destructive way?
- Would it be possible to do this without taking the part off the line and without influencing the production cycle time?

- Would it be possible to carry out "unitary" quality control based on NDT technologies: Metrology, Electromagnetic Waves, Colorimetry, Thermography, Ultrasound, X-rays, etc.?
- Would it be possible to develop intelligence so that the machine can learn through its use in the real world?
- Would it be possible to develop a digital twin of the machine to optimise the production of the "first part"? (Considering that a single machine is capable of developing multiple parts).
- Would it be possible to develop a digital twin that visualises how work flows will change if production parameters are altered?

4. Expected technological solutions

The technological solutions expected to address the above challenges are:

- Computer Vision
- Machine Learning (Deep Learning)
- Digital Twins
- Other quality control technologies.