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Defects Digital Management for Industry 4.0

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1 - Lean manufacturing

In recent decades, the world of industry has seen a development that has shifted the focus of production from cost to quality and time, to understand that all three aspects must be considered together and traced back to a single point of reference: “the value as perceived by the customer”.
Lean production is the maximum expression of this concept and is the result of a historical evolution divided into several stages.

Principles of Lean Thinking

The principles on which Lean Thinking is based are simple: the starting point is to identify “waste” in order to eliminate it and produce more with less resource consumption. Lean waste can come in the form of time, material, and labor.

1. Identify the **value**: The starting point for the hunt for waste is to identify what is valuable. Consumption of resources is justified only if it produces value, otherwise it is waste (MUDA). We need to try to accurately define value in terms of specific products with specific characteristics, offered at specific prices, through dialogue with specific customers. In other words, value is defined by the customer and only acquires meaning when it is expressed in terms of a product/service that can satisfy his needs at a certain price and at a certain time.

2. Identify the **value stream**: The value stream for a particular product consists of the totality of activities required to transform raw materials into finished products. Analysis of the value stream always reveals large amounts of waste by dividing the activities into two categories: Value-creating activities are all those whose costs can be transferred to the customer, and non-value-creating activities, for the latter they distinguish between necessary and unnecessary. Necessary activities cannot be eliminated with the current systems for product development, order management and production, so we can only reduce waste, while unnecessary activities can be eliminated immediately suppressing waste.

3. **Flow** of value: Invest value assets without interruption. Identify the value flow for a particular product or product family and reconstruct it by eliminating redundant activities through flow mapping. The remaining value-adding activities must form a flow that must flow continuously, with a relative reduction in the lead time of the material. Make sure that the flow is **pulled**: make the flow according to the customer's requests. Satisfying the customer means producing only what he wants, only when he wants it and only as much as he wants. The production is thus "pulled" by the customer, rather than "pushed" by the producer.

4. Aiming for **perfection**: take perfection as a reference for continuous improvement programs. This last principle may seem presumptuous and must therefore be interpreted in terms of continuous improvement (**KAIZEN**).

When the first four principles have been applied correctly, unimaginable synergies are indeed created, setting in motion a continuous process of time, space and cost reduction.

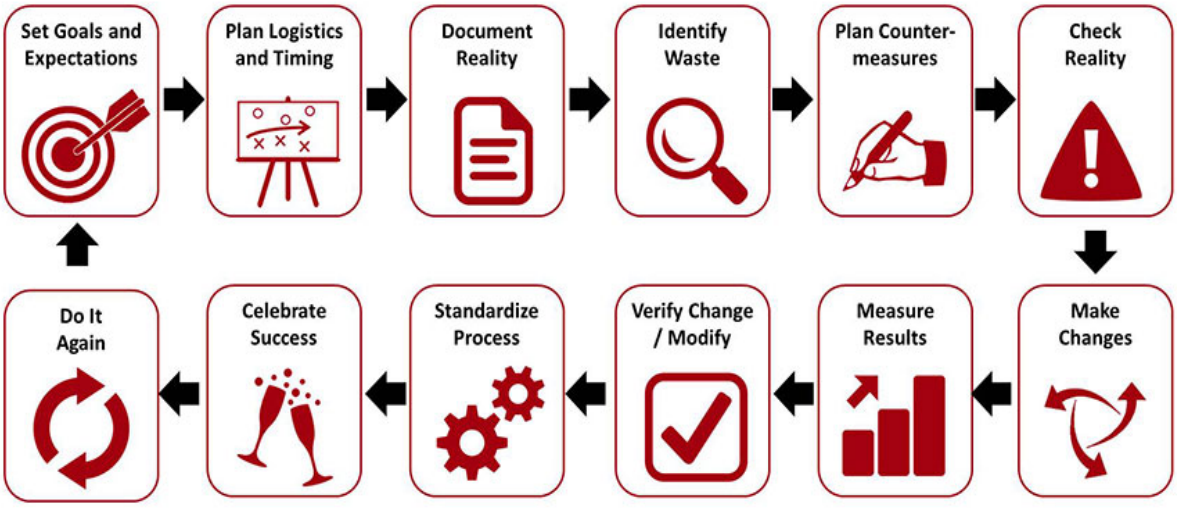

Figure 1 - Lean Production Principles

Lean production is a set of principles, methods and techniques for managing operational processes that aim to increase the value perceived by the end customer and systematically reduce waste.

This is only possible if people are committed and motivated for continuous improvement. The goal of lean production is to "do more and more with less":

- less time
- less space
- less effort
- less materials

An important step is to evaluate which activities add value and the ones which do not or decrease the value. The goal is to classify all the activities and group them into two main categories in order to apply the right action aimed to improve the former and eliminate the latter.

Two kind of waste are identified: "what needs to be done but does not add value" and pure waste.

Clearly identifying "non-value-added work" as opposed to waste or labour is difficult to identify the existing premises that need to be addressed and challenged in the future.

An obvious waste in Lean Manufacturing is **defects**. Defects include parts, assemblies or products that do not meet specifications and therefore are unusable or that require rework. Defects are often one of the most costly forms of waste because they can snowball into other forms of waste such as additional transportation, overproduction or over-processing.

So new waste management procedures need to be put in place to try and recover some of the value of the product that is at 100% risk of being discarded, for example applying a standard repair cycle to manage the most common defects; standard repair cycle means a validated procedure to correct certain defects in certain areas of the workpiece.

Anything that consumes resources, in terms of cost and time, is wasteful, without however creating value for the customer. The three negative elements that lean fights in processes are called “**MU**”:

- **Muda**: waste, loss (eg: excessive stock of raw materials). One of the key steps in Lean Manufacturing is identifying which activities add value and which do not. The classification of all the activities of the process in these two categories then makes it possible to start the actions to improve the first and eliminate the second.

Figure 2

- **Muri**: is a Japanese term used to indicate overload, unreasonableness or absurdity. Overloading for people can lead, in the long term, to the possibility of occupational injuries or illnesses, due to the overexertion to which workers are subjected. In the short term, on the other hand, the consequences of overload can appear as muscle tears, bruises or the like. The effect is the absence from work for shorter or longer periods by the workers and general dissatisfaction of the staff. Similarly, the excessive exploitation of machinery can lead, in the long

term, to accelerated wear, to breakages with consequent production stops for maintenance and repairs, or even the need to change machinery may arise.

- **Mura**: indicates fluctuations, variations, irregularities in the workload (of demand). These fluctuations lead to phases in which there is an overload of work and to other phases in which the workforce and machinery are oversized; the production flow is disturbed. The cause of these fluctuations is the non-standardization of demand through the use of methods used to flatten the peaks and valleys. Mura is the mother of other waste and that is why lean thinking is based on the stability of the system which is obtained by eliminating the causes of fluctuations and standardizing activities, a stable system does not stress people, it does not solicit resources and promotes continuous flow.

Fundamental elements of Lean Manufacturing

The fundamental elements of lean manufacturing can be represented in the so-called "**House of Lean**"

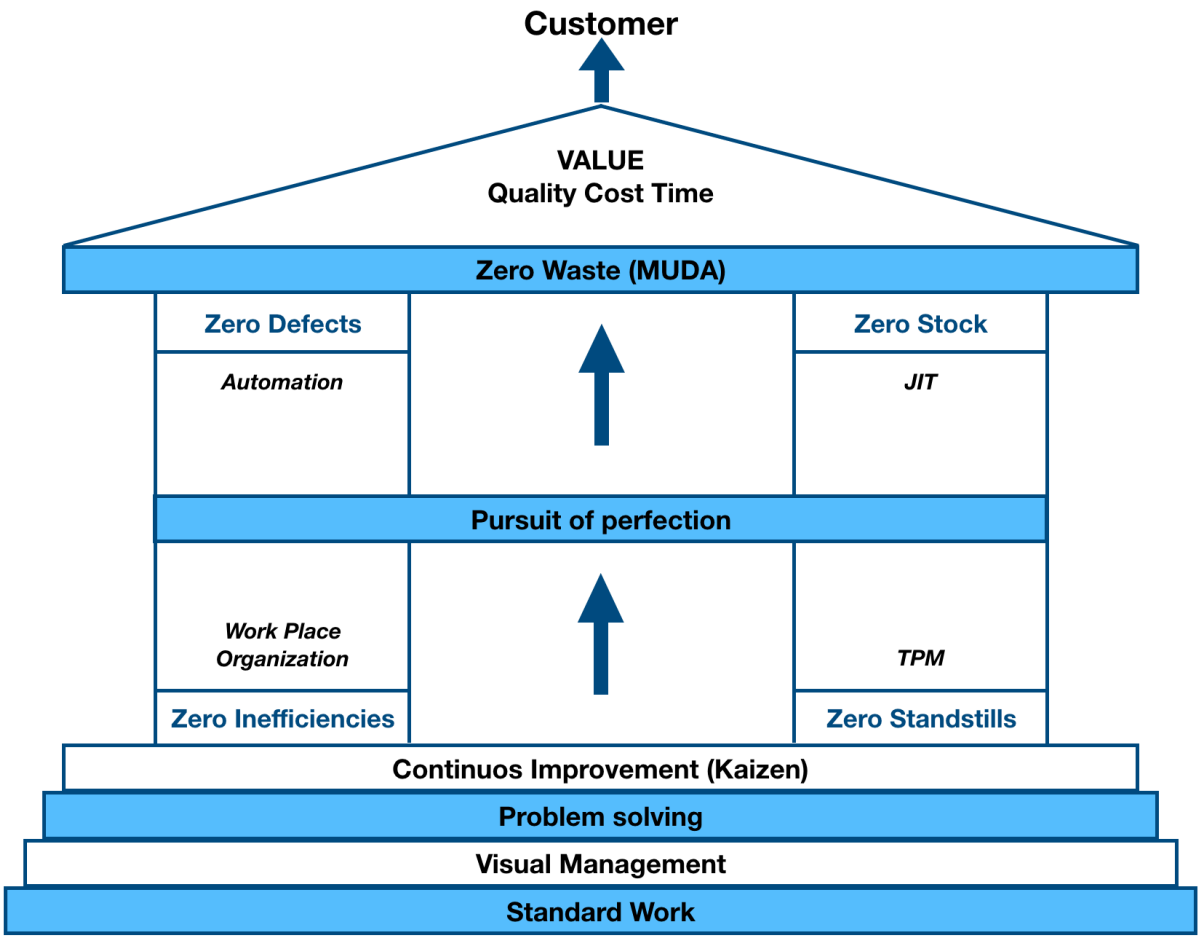

Figure 3 - House of Lean

At the base of Lean Production there are two fundamental concepts:

- **Standard work**, which makes extensive use of visual management with the aim of highlighting waste, so as to prevent it from occurring in the future, make operational standards known to all employees and improve the efficiency of the work area being reorganized. Standardization consists of the definition,

maintenance and improvement of standards or precise working procedures that guide each operator in a work process. The standard corresponds to the safest, simplest and most efficient way of doing a particular task to date. It forms the basis for continuous improvement.

- **Continuous Improvement** (**Kaizen**), which leverages on specific problem solving techniques. Continuous improvement (Japanese term *Kaizen* composed of the words *kai* (change) and *zen* (good)), literally means “change towards the better” and indicates the process of continuous evolution that aims to create more and more value. The fundamental lever for this to happen is the involvement of everyone in the constant elimination of all waste in order to use resources more effectively, this is possible through the elimination of non-value activities. The kaizen is a form of improvement that is strongly distinguished from the radical and sudden "leap" of innovation, as it consists of a cumulative succession of continuous progress and therefore proceeds "in small steps”. **Tools** to identify waste and determine where and what improvement interventions are to be done are the Mapping of the value flow and Problem Solving techniques.

The **four pillars** of Lean Manufacturing are:

- Just-in-Time (**JIT**) → Zero Inventory
- Automation (**Jidoka**) → Zero Defects
- Total Productive Maintenance (**TPM**) → Zero Downtime
- Workplace Organization (**WO**) → Zero Inefficiencies

To achieve the goal of **zero inventory**, the mapping of the value flow is essential. It consists of the graphical representation of all the steps in the flow of materials and information that take a given product from order to delivery.
With this tool, waste and thus opportunities for improvement are immediately and visually identified
Production in "continuous flow" involves the gradual reduction of batches and ideally tends to produce and move one piece at a time (one-piece flow). In this way, production flows continuously, without interruptions, waiting times and warehouses for half-finished products.

Automation is a preventive method of quality management in which operators and machines activate themselves to detect process anomalies, understand their causes and eliminate them promptly. The effectiveness of autonomy systems from the ability to detect errors before they become defects in the product, to stop the process if necessary, and to make the causes of problems visible as soon as they occur, thus facilitating their elimination.

The most important tool of autonomy is *poka-yoke* ("foolproof"). This is a behavioral constraint or method of avoiding mistakes by placing limits on the execution of an operation to enforce its successful completion. The concept of this word is, in fact, "to avoid (*yokeru*) the errors of distraction (*poka*)". Without knowing it, our daily lives are littered with poka-yoke.

Total Productive Maintenance (**TPM**) is a continuous improvement program that addresses the effective and efficient use of machinery and equipment.
With this new approach, responsibility for plant maintenance is extended to several levels and thus lies not only with the maintenance technicians, but also and above all with the direct operators. They are involved in maintenance, improvement projects and simple repairs, all of which become part of their routine.

Avio Aero Lean Manufacturing

As stated by Larry Culp, *“Lean is not about manufacturing. It is about everything we do at GE and using the tools in that way giving us the opportunity to observe real change and real improvement that serves everybody”*

In Avio Aero, eight forms of waste are defined:

1. **Defects**, efforts caused by rework, scrap and incorrect information
2. **Over Production**, production that is more than needed or before it’s needed
3. **Waiting**, wasted time waiting for the next step in a process
4. **Non-Utilized Talent**, underutilizing people’s talents, skills and knowledge
5. **Transportation**, unnecessary movement of products and materials
6. **Inventory**, excess products and materials being processed
7. **Motion**, unnecessary movement by people
8. **Extra processing**, more work or higher quality than is required by the customer

Every forms of waste must be managed with a different approach, for example “**Defects**” and “**Extra Processing**” could be worked out thanks to the use of digital tool, from which to analyze the data for future improvements, standardization of nomenclature and creation of digital database, as will be deepen in the next chapters.

The work place organization is one of the fundamental tools for improving the **efficiency**, quality and safety of processes. It allows to facilitate the flow of work and to eliminate waste related above all to occupied space, search time, movements and displacement and rework and checks.

As in the automotive industry, also in the aeronautical field having a gears continuous material flow becomes more and more important and this is where the "**Waiting**", "**Transportation**" and "**Motion**" are attacked.

First of all, manufacturing material flow is defined as the movement of components, raw materials, and other inventory through the processing cycle to create a finished product and deliver it to the consumer.

Material flow is arguably the most important function in a manufacturing company because it addresses the process of creating products from materials, and those products and their sale are necessary for the financial viability of the company. Efficiency in material flow results in increased profits. By having a lean manufacturing consulting company conduct a material flow analysis in manufacturing, a company can save on capital investments and significantly reduce costs for storing, transporting and handling. In addition, energy usage and waste is reduced and required floor space is minimized, decreasing overall production time and allowing more efficient allocation of resources and work hours.

The most important step to improve an existing process is defined its Value Stream Map, from which it is possible to highlight the weaknesses of the current process so as to implement actions to eliminate the Roadblocks.

Considering a general Part Number stream map, four bursts are identified: two services, intermediate testing and final testing.

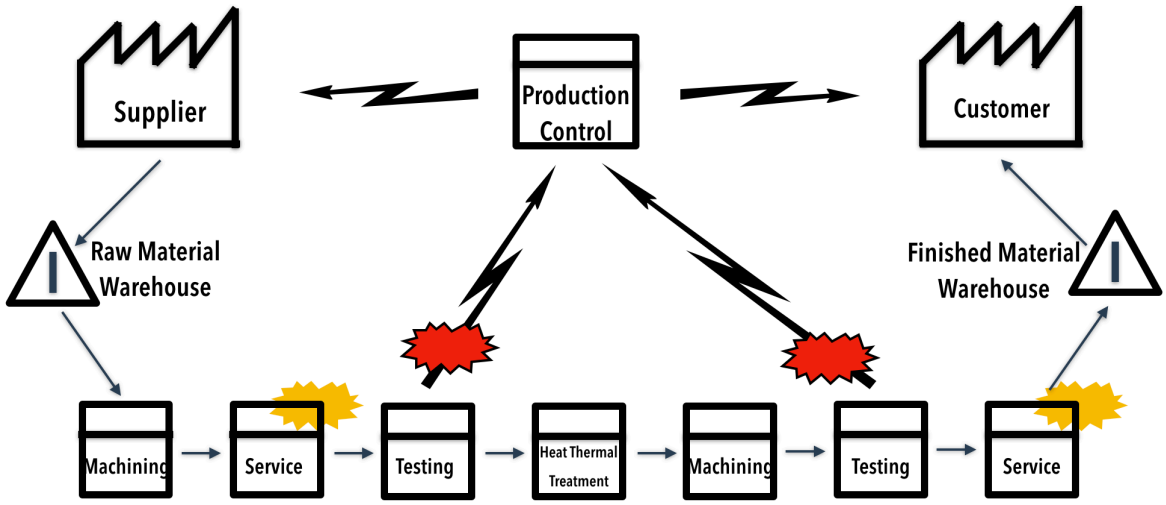

Figure 4 - General PN Stream Map

The **service** is seen as a weakness for the flow because of it is based on manual operation that interrupts and slows down the flow, furthermore a manual operation is subjected to human error with the following generation of anomalies. For example in manual deburring operations the operator risks scratching the gear teeth causing waste or the need for a repair cycle, with the following loss of time and money. In this case one solution could be the implementation of machines capable of performing these operations automatically.

Testing is a set of activities conducted to discovery and evaluate the properties of one or more items under test. Each individual test, known as a test case, exercises

a set of predefined test activities, developed to drive the execution of the test item to meet test objectives; including correct implementation, error identification, quality verification and other valued detail. The test environment is usually designed to be identical, or as close as possible, to the anticipated production environment.

In Avio testing is based on a visual test, a dimensional test and an hardness control, once the anomalies have been identified, some of these can be repaired through standard rework cycles based on the type of component, defect and zone.
While dimensional and hardness test are made by machine, the visual one and the consequence rework cycle are made manually and this is why the testing phase looks like a roadblock of the flow, as the lot is destined to remain stationary for hours or even days in this area without being able to go on with the subsequent operations.

Furthermore, if the tester does not detect a defect there will be an escape problem. The defective product will reach the buyer who will ask for a refund, making the company waste time and money.
The aforementioned standard repair cycles will be performed in the second service; it is here that a first attempt to improve the process can be seen. If the same anomaly is recurrent on almost all the details then the standard repair procedure can be implemented in the Part Number processing cycle thus saving precious time.
Therefore it is precisely on these phases that we will act to ensure that the flow is as continuous and rapid as possible.

Toyota Kata

The concept of Lean Manufacturing is nowadays known by most companies, but it hasn't always been this way.

It all started in Japan in the 1950s from the ideas of Sakichi Toyoda, Kiichiro Toyoda, Taiichi Ohno, founders and managers of the renowned 'Toyota'. The automotive market of those years was dominated by the USA which based their work on mass production.

In 1950, Toyota developed a new production system (Toyota Production System) based on a simple but effective idea: to do more with less. Behind this idea was the desire to use the least possible and available resources in the most productive way. This way of working goes back to an analysis of the automobile market in 1900.

In the USA, mass production guaranteed low prices and high quantities, elements that guaranteed high demand in the market. The problem was in the manufacturing process and production: there were many cases of breakdowns and defects. The car companies had high maintenance costs both in the processes and in the finished products. From these analyses, the Toyota system was born: avoid waste, do not make mistakes.

Zero defects means continuous improvement processes, as we can read in "Toyota Kata", a management book by Mike Rother.

Toyota Kata defines management as "the systematic pursuit of desired states through the purposeful application of human skills”.

Rother suggests that the base of the success in terms of advantages is not the solution alone which provide the advantage and long term survival but the way in which the organization is able to create an effective routine capable to give back appropriate solution in unpredictable ways. To do so is necessary to teach the skills behind the solution.

The Improvement Kata pattern is a four-step model for a practical, everyday scientific way of thinking and working. It represents the human creative process, which has probably been around as long as humans have existed. Scientists and entrepreneurs follow this pattern every day. The four steps, divided into planning phase and execution phase, are shown in Figure 5.

The insights and perspectives gained in the first three "**planning**" steps of the improvement kata provide the framework or context for effective iteration and discovery in the "**executing**" phase. There are three steps here:

- Understand the direction or challenge
- Capture the current state.
- Set the next target state

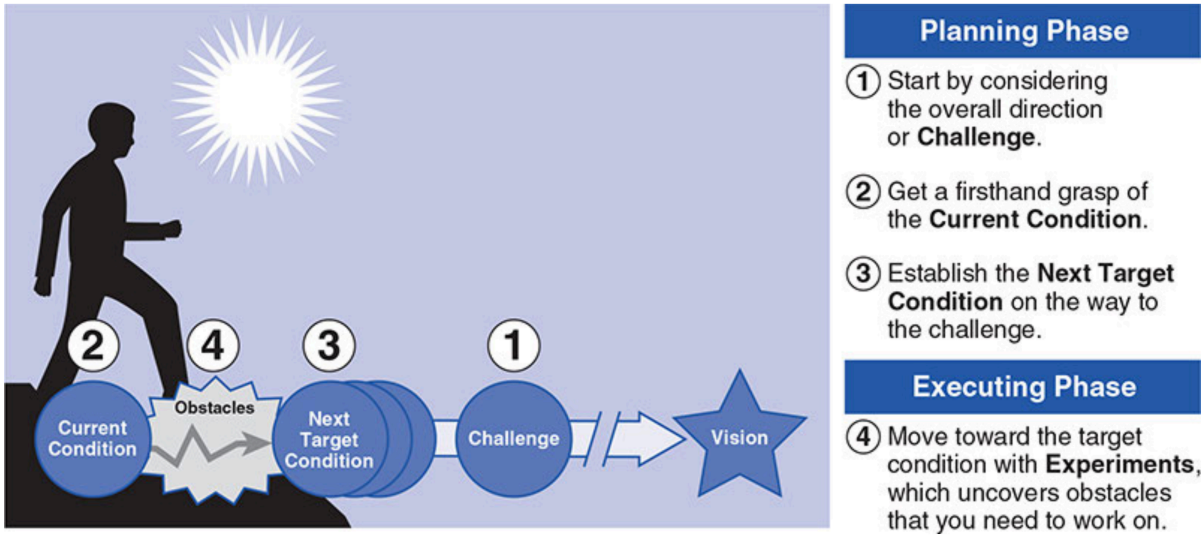

Figure 5 - Kata Four Step Model

First of all, a manager has to understand the direction or challenge defining the purpose of the improvement. This is usually a longer-term goal to differentiate themselves from competitors, usually something customer-centric and strategic that cannot be achieved today.

An overall challenge is usually set at the company or business unit (value stream) level and broken down into smaller challenges.

Once the direction coming from the higher level is understood, the current process and operating patters are studied in measurable detail. The results of this observation and analysis represent the current threshold of knowledge about that process and are an input to define the next target condition for it .

Examining the current state provides the facts and data necessary to set an appropriate, vivid, and measurable next goal state for the process of focusing on

the greater challenge. A target condition is the next target and has a much shorter time frame than the challenge, usually with a reachability date of between one week and three months. It is not known exactly how to achieve this and it may be difficult, but it doesn't seem impossible.

A target condition usually has the following three elements:

1. an attainability date.
2. the desired outcome performance of the process - an outcome metric.
3. a verifiable description of the desired operating model that is believed to provide the desired result. This includes a process metric.

While achieving a long-term challenge may seem overwhelming, with a short-term goal state it is possible to focus on specific obstacles to reaching that closest state. A number of objective conditions are required to achieve the challenge.
However, these target conditions are set one after the other, not all at once. It is not a predetermined list of action points. When a target condition is reached or the date by which it was reached, the focusing process has a new current condition.
It cannot be said in advance exactly what the chain of target conditions will be needed as the threshold of knowledge shifts. An initial plan can be useful but it should be expected to evolve over time.

Once the current state has been understood and a subsequent target state is achieved, there is a gray area or learning zone in between. If the date by which the target condition is met is more than a week or two away, some planning is needed.

However, it is not possible to predict and plan the exact path to a target condition. The obstacles encountered along the way will highlight what needs to be worked on. One must not work on every conceivable obstacle, but only on the obstacles that prevent the focusing process from functioning in a way that is consistent with the next target condition. This has the advantage of not wasting time, skills and resources trying to fix everything.

The path to the goal state will not be a straight line, but a continuous learning and discovery, gradually learning how to reach the goal state. With each experiment new information can be obtained and the next steps adapted accordingly. When the target state has been reached, there is a new current state and the four stages of the improvement kata are now repeated.

2 - Six Sigma methodology

The need of all companies that intend to pursue continuous improvement of their processes is answered in the **Six Sigma methodology**.

Six Sigma is not only a quality program, but it is at the same time one business strategy, robust processes and skills development of people. The advantages introduced in the company by this methodology can be summarized in a wide use of measure and data, a new language with statistical terms, solution-oriented practices and the ability to always take correct and robust decisions over time; that allow the company to obtain clear short and medium term benefits.

The methodology can be summarized with some illuminating statements of the Six Sigma's acknowledged father, Mikel Harry:

- *We cannot act if we do not know*
- *We do not know the processes until we measure them*
- *We have not measured if we do not know how to give a numerical value*
- *If we do not know how to give a value then the processes are out of control*
- *If we can not control them, we are at their mercy*

In other words, the basis of everything is measure. If we are not able to measure every process in its decisive features, we are at the mercy of events and our future is determined by chance.

Six Sigma brings a new practice to the organization: **the culture of data**.

The methodology states that problems are not worth considering until we can represent them in numerical form. If we do not have data, we will have the impression that we do not have problems.

First of all, the phenomena are studied in order to make decisions after a statistical analysis of the data, taking into account the risks associated with the different solutions.

Six Sigma emphasizes the use of a new tool: **statistics**.

The reality of business processes is becoming increasingly complex and we are often in possession of an enormous amount of data and information.

To know these processes, to know how to regulate and control them, we also need to know how to navigate the very large amount of data that we have to read and interpret to make sense of them; statistics is the tool to analyze data and find solutions.

In order to improve the performance, the customer covers a fundamental role on the Six Sigma methodology. With the word “customer” is not intended only the final recipient of the product or something external to the company, but in this category are included also all those, internal or external, which takes advantages of the results of the object process of the improvement.

Six Sigma's main focus is therefore on improving performance of all business processes, focusing attention on the expectations of the customer. The involvement of suppliers upstream of the process is also of great importance, sometimes indispensable to achieve results of excellence.

The customer's indications must be the constant reference for highlight those characteristics that, in his opinion, are critical to quality (**CTQ - Critical To Quality**) so that they constitute the goal towards which to direct actions for improving the performance of our processes.

At the basis of the Six Sigma methodology lies the concept that the CTQ characteristic of each product or service provided to the customer is “measurable” and that therefore it is also possible to measure the final result of the improvement actions. Only through measurements can we have reliable data. Only based on reliable data can we intervene, analyzing the causes of non-compliance and promoting improvement actions to pursue customer expectations.

A certain process, for example production, is said to be at the level of “Six Sigma”, when the value of the standard deviation, which represents an index of the variability of the process, is contained six times in half the specification range; this (assuming a shift between the distribution average and the 1.5s target) corresponds to 3.4 defects per million opportunities.

Therefore, operating according to the Six Sigma methodology means reducing, for the most critical activities, the defects with the ultimate goal of bringing it basically up to this value. However, remember that it is the customer who determines what our true sigma target is.

Each problem is addressed starting from the identification of the CTQ of the customer and can be divided into two possible paths:

- The **DMAIC** path is used for incremental process performance improvement, when faced with processes that have the potential to perform excellently but are out of control and their instability makes it difficult to repeat / maintain their performance over time.

- The **DMADV** path, on the other hand, is used to design new processes or to redesign processes whose maximum performance is still far from the target and therefore an incremental improvement could be insufficient and sometimes useless.

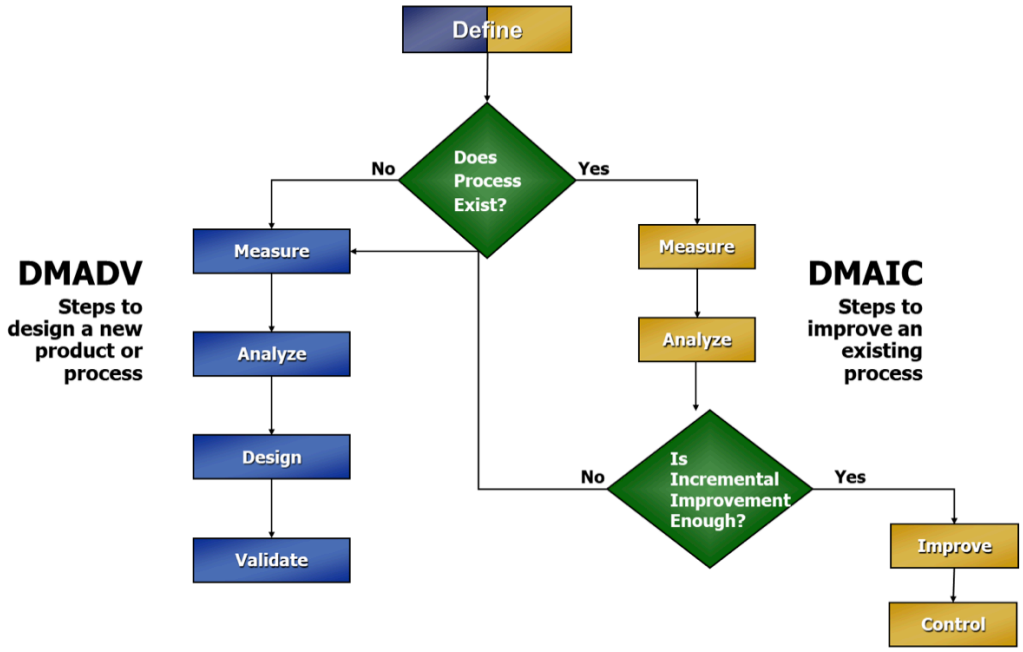

Figure 6 - DMAIC vs DMADV

- There is also a third path called **DFSS** (Design for Six Sigma) which concerns the Product Development methodology in a Six Sigma perspective. In short, it is a question of designing a product so that its performance immediately satisfies customer CTQs with Six Sigma reliability.

DMAIC

The DMAIC is a powerful data-driven quality strategy able to improve the processes through 5 main phases. The acronym represent the phases of the process which are define, measure, analyze, improve and control. It is directly connected with the Six Sigma initiative being an integral part of it, but generally is implemented as a standalone quality improvement procedure.
Can be performed also as part of other process improvement initiatives such as lean.

The first phase is obviously that of defining the problem: this allows to have a clear vision of the improvements to be made and the objectives to be achieved.
In the **Define phase**, the "reference scenario" of a project will be defined in which it will be appropriate to specify:

- the problem to be analyzed;
- the potential recipients of the process and their needs;
- process indicators to be measured (CTQ - Critical To Quality);
- the objectives to be pursued with the project;
- the necessary resources and time to finish.

Always in the Define phase, the customer's requests (Voice Of Customer - VOC) will be listened to, fundamental for the DMAIC process: it will be necessary to identify the real needs of the customers and evaluate how they perceive the goods/services offered (also in comparison with those offered by competitors). Business processes are central to a DMAIC project: they must be modeled to meet the customer's needs, so they need to be analyzed in detail.

In the **Measure Phase** the performance of the As-Is process will be analyzed, ie the characteristics of the existing process are measured and the “critical” areas to which improvements will be made are monitored. The activities carried out are typically the following:

- Planning of data collection, necessary for understanding the problem
- Validation of the measurement system
- Analysis of yields and process capacity

In this phase, a structured data collection plan will be created to:

- understanding the problem
- confirm or disprove ideas, preconceptions and theories
- establish a basic level of performance
- identify and understand relationships that could help explain the variability

The objective of the **Measure Phase** is to better understand the problem, to better concentrate the interventions. The Measure Phase is necessary to allow the

subsequent Analyze Phase to function correctly, because it provides the real data that will then be analyzed. One of the fundamental tools in this phase is the "**Pareto diagram**", a graph that represents the importance of the differences caused by a certain phenomenon and useful for visualizing the relevant elements of a system.
The Pareto Diagram, consisting of a series of bars whose height contains the frequency or the impact of the problems where we find the causes on the abscissa line and their percentage incidence on the ordinate line. The graph is useful for analyzing the dynamics of a type of activity and for grouping them according to the observed effects;

In the **Analyze phase**, the few significant causes that lead to the generation of defects or non-conformities are identified. This analysis will be carried out using management and statistical tools.
The objective of the Analyze Phase is to identify the root causes of the problem and quantify their influence on the critical values for quality (CTQ Critical To Quality: the key elements on which to work to improve the quality of a service / product).

In the **Improve Phase**, corrective solutions are selected and implemented to ensure the reduction of defects, strategic effectiveness and management efficiency.
At this point it is necessary to generate opportunities for improvement, develop and implement corrective solutions and plan a "pilot test", or a prototype to monitor the effectiveness of the solutions in the short to medium term.

The objective of the **Control phase** is to verify the efficiency of the implemented solutions, analyze the performance of the improved processes and ensure the achievement of the project objectives.

In this phase, the processes will also be standardized, i.e. the working method will be defined and finalized on paper. All variables, specifications and actions will be documented and shared, to make the processes more effective and to simplify the work of the staff, who in this way will become more productive.

Poka-Yoke is often used in order to consolidate new processes and prevent errors in the Control phase of the DMAIC process.

As already mentioned, Poka-Yoke literally means "to reduce the involuntary error".

It is a Lean Production methodology, which allows to reach the "zero defects" production status.

The starting point of this methodology is the awareness that no person, no matter how hard he tries, is able to completely avoid involuntary mistakes. For this reason, the Poka-Yoke methodology acts by applying various measures to prevent these errors, in order to support the staff in their daily work avoiding errors.

The Six Sigma methodology consists of a simple but rigorous process. It is essentially based on the correct analysis of the process or of the service, identification of defects, substantial intervention on causes of the same to remove or reduce them.

The operational phases are clearly defined, as are the statistical tools identified that must be adequate to provide, through the data, the identification of the problem

and then promote corrective actions for improvement and to check that these are maintained over time.
Precisely for this purpose, appropriate measurement indicators and control charts must be prepared that allow the periodic monitoring of the results by the Owner.

Any company, even those of medium or small size, can certainly adopt the Six Sigma methodology, as a working philosophy and methodology, obtaining significant advantages. Outlining company strategies clearly, accurately assessing their performance by comparing them with customer requests, planning opportunities for improvement, impacting the way each operator works with an appropriate training action, will ensure that each company is able to face with ever greater force the competitive challenge that the global market imposes today.

To conclude, with the Six Sigma methodology, it is possible to gain a competitive advantage over "competitors", achieving excellent quality standards that will certainly be detected by the customer with a consequent consolidation of the company on the market.

3 - Visual Defect Management

As mentioned earlier, testing and service are the two main gates that hinder the continuous flow of gears. One of the main problems identified is the lack of digitization within these areas.

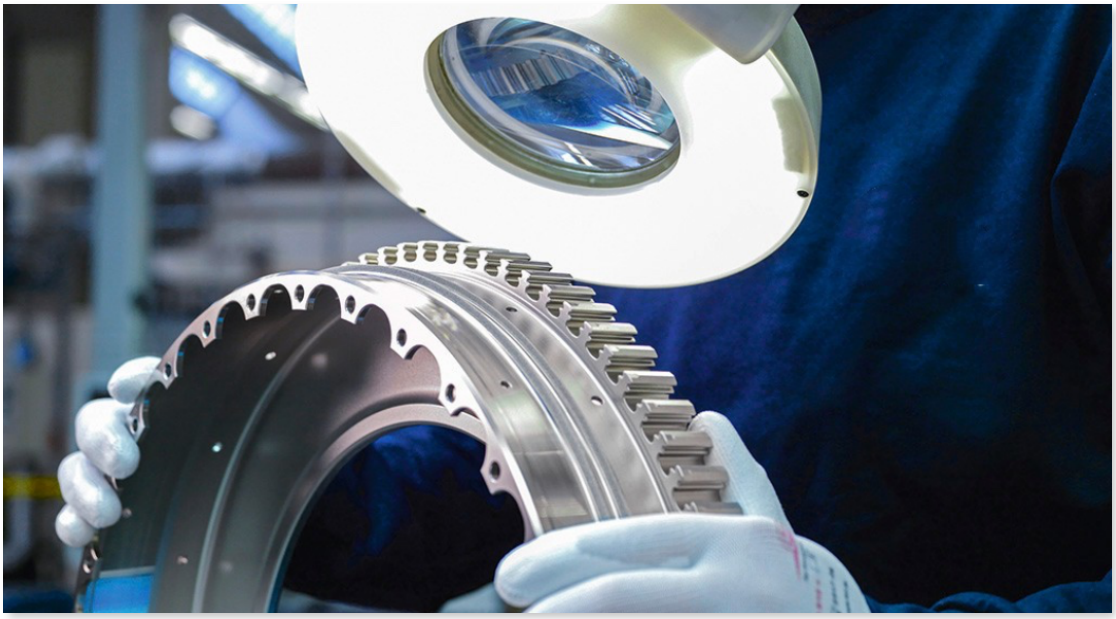

Figure 7 - Example of visual inspection

This entails the lack of a database from which to extrapolate the data for possible future improvements, both from the point of view of the industrial process and management.

First of all it is necessary to differentiate the defects from the anomalies, defect is a problem that cannot be managed by the factory and that must be studied by engineering, while the anomaly can be managed through standard repair procedures that allow to restore conformity to the piece.

In the first case, the operators are required to upload the defects to the system, creating the digital data. The anomalies, on the other hand, remain only on a sheet of paper that will be attached to the documentation of the lot, not bringing any benefit from the point of view of digitization, thus making it difficult to start improvement activities.

Precisely for this reason it was decided to digitize the anomaly sheet so as to have a daily history of all the visual anomalies detected on the pieces to be analyzed.

Non-conformities management in the production process

As mentioned above, during the production process the batches pass from the inspection where the conformity of the particulars is assessed; any value or process outside the tolerance limits defined in the applicable specifications, in drawings or purchase orders is defined as **Non-conformity (NC).**

The **Operator/Tester** detecting potential non-conformity (suspect/abnormal material or process) shall describe and document evidence of potential NC using the **Anomaly Sheet** (**FA** - from the Italian “Foglio Anomalia”) by filling in the form in each of its fields, according to competence, separate the abnormal parts from the remaining pending disposition and inform the Area Supervisor or the PR delegate of the cell of the anomalies.

The **Delegate to the Preliminary Review (PR)** is the person delegated by the cell to carry out the evaluation of the Anomaly/Non-conformity. Only qualified personnel may be delegated. In the event that the anomaly concerns the execution of Special

Processes or in general processes that alter the surface characteristics of the material, the competent process specialist or his delegate, even if not PR Delegate, shall always be consulted for the anomaly assessment. The delegate to the PR must define the typology of the NC by making an initial assessment of the possible causes, fill in the FA in the sections of its competence by defining one of the following decisions:

- **Rework:** Procedure applied to a non-conformity in order to eliminate it completely with the result of reporting the characteristic conforming to the design requirements. This procedure involves only operations already planned in the processing cycle. Where operations other than those required by the original work cycle are envisaged, the definition of "**repair**" is applied. In the event that the anomaly is removed with the execution of the subsequent operations planned to cycle, the definition of **Continue to process** is applied, allowing the advancement of the material to the next operation.

- **Re-check:** If there are uncertainties about the measurement carried out, the PR delegate may submit the part for testing indicating which characteristics must be re-checked and the test method necessary to re-check them. The tester reverts the anomalous detail, always reporting on the FA the result of the rechecking. In the event that the rechecking attests that the characteristic value is in conformity, the material may be accepted. If, on the other hand, the re-verification confirms the Non-conformity, the Delegated PR proceeds to a new analysis.

- **Unconfirmed anomaly:** If the Delegated PR verifies that the characteristic marked as anomaly is instead compliant with the requirements specified in the contract, drawing or applicable specifications, it inserts the provision "Unconfirmed anomaly", indicating the reason.

- **Discard:** This provision applies when it is evident that the detail cannot be recovered: this category of discard is always to be included in the "manufacturing losses". Delegated PR arranges the material as waste and sends the material to the waste area. The waste area must be a dedicated and closed area.

- **Submit to MRB:** If you do not fall into any of the previous cases, the Delegated PR must submit the Non-conformity to the Material Review Board (MRB), composed of qualified personnel of Product Quality and Engineering (of the organization responsible for the project) to assess and decide the status of non-compliant materials. The MRB may rely on the advice of additional members with specific knowledge.

In both the last two cases it is necessary to open a **Quality Notification (QN)**, the IT document in order to record the Non-conformity and the subsequent actions taken for its resolution.

You can easily guess that of the whole process the only digital trace is that of the QN, going to lose all the information related to the anomalies that have been repaired. And it is here that we wanted to intervene, managing to digitize the Sheet anomaly, no longer using the sheet of paper but a digital tool that allows you to have a PDF completely similar to the paper form, but in the same provides a continuously updated database that will be the starting point to carry out improvement actions within the process.

Importance of Digitalization

Digitizing the production line provides the plant owners with the solutions to capture important metrics, analyze them and gain useful insight from the analyzed data. Digitizing technologies are hardware and software solutions that work hand in hand to capture production line processes.

Benchmark data is another important KPI that can be used to guide lean manufacturing strategies. Using benchmark data begins with data acquisition and analysis with digitization technologies. Benchmark data can be an OEE (Overall Equipment Effectiveness - a “best practices” metric that identifies the percentage of planned production time that is truly productive) ratio or even performance, and defines a piece of equipment or a process that works at its optimum capacity. Other OEE reports and operational data from different production runs can then be compared against reference data to determine why an asset is underutilized.

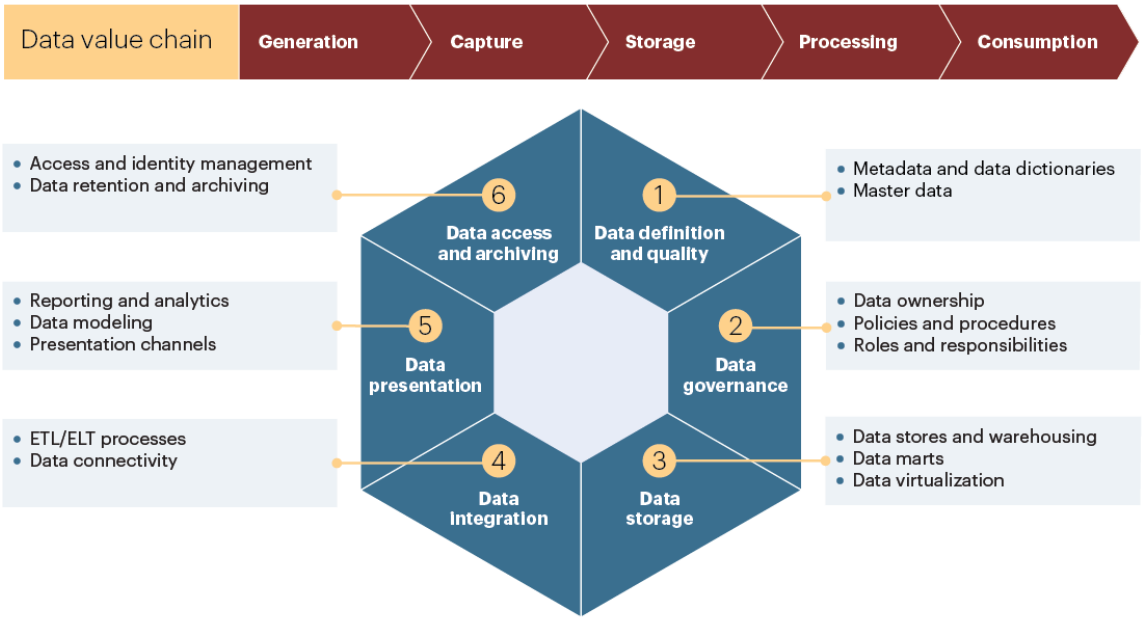

Figure 8 - Data Value Chain

Automating production line processes, such as material handling, production inspection and sorting, should eliminate repetitive tasks and allow operators to focus on more important tasks. The digitization of the plant through the integration of edge-computing, AI and machine learning resources makes it possible to acquire data from interconnected systems. The captured data can then be analyzed and transferred to a certain automated process to allow action without human interference.

Leveraging data from an interconnected system to improve plant processes provides support for the application of different concepts of Industry 4.0 and lean production. For example, the development of plant performance optimization strategies in which planning resulting from data analysis directs the production

cycle. Captured historical data or the digitization of historical data serve as the basis for developing accurate predictive models to reduce unplanned downtime, thereby improving lean production initiatives.

Complete digitalization ensures that every aspect of the production cycle can be measured and analyzed to gain the understanding needed to improve operations on the production line. The implementation of lean production supported by the digitalization of the production line ensures that every decision is supported by objective data. This fact allows the development of high-performance structures that optimize the resources available to provide quality products.

The most important factor that factory digitization brings with it is the ability to accurately capture data. The captured data can then be recorded and used to achieve various objectives, such as the implementation of lean production strategies. A successful application of the digitization can improve revenue growth by 25% for manufacturers in the industrial sector and add $ 13 trillion to the global economy by 2030.

Digital Data

Thanks to digitalization, the data represents an added value inside of a company.
Avio's digitization kicked off in 2017 with the creation of the **Data Lake**. It is a type of data repository capable of storing raw data sets of large and varied sizes in their native format.

Data lakes provide unprocessed data visualization, offering an increasingly widespread data management strategy to companies that want to adopt a repository of their large, global data. "Raw data" means data that has not yet been processed for a specific purpose. A data in a Data Lake is not defined until it is queried. Data scientists can access raw data while using advanced analytics or predictive modeling tools.
With data lakes, no data is removed or filtered before storage. Unlike when data is processed according to its specific purpose, in the case of data lakes there are no time constraints or restrictions for data analysis, which can be used multiple times.
The data flow comes from multiple sources and flows into the lake, then it is stored in its original format.

Data inside a data lake is processed only when it is necessary to analyze it and, subsequently, a scheme is applied to proceed with the analysis. This schema is called "schema on read", because the data is processed only when they are ready to be used.

Data lakes allow users to access and analyze data where and how it is, without having to move it to another system. The information and reporting obtained from data lakes is processed as appropriate and not regularly extracted from another platform or another type of data repository. However, users can apply a schema and automation procedure to be able to duplicate a report if necessary.

The data is a value because it can predict what will happen in the future. This allows the company to make preventive decisions, avoiding problems instead of correcting them. An attitude of this type is called **data-driven approach**.

Figure 9 - Data Driven Approach

In a data-driven approach, decisions are made based on data instead of intuition. Following a data-driven approach offers measurable advantages. That's because a data-driven strategy uses facts and hard information rather than gut instinct. Using

a data-driven approach makes it easier to be objective about decisions. The results of your data analysis can tell you whether it would be wise to follow a particular course of action.

Starting the digitization three problems are created, as it happens also in Avio:

Figure 10 - Digitization problems

1. **Data Quality**: Having clean data is crucial. The problem in the vast majority of cases is not having a database, but having reliable data. For this reason many companies are introducing a new figure within the organization chart, the **Chief Data Officer** (CDO). The chief data officer is the senior person, with a business focus, who understands the strategy and direction of the business, but their focus is on how to underpin that with data. Typically the process starts from a raw data; the first step, especially if the data is manual input, is to be able to obtain a refined data by reworking it preferably with automatic algorithms with which certain outliers are removed. At the same

time, the data given must be refined to the source, improving the processes, so that the data entry can not be wrong by creating a foolproof system (Poka-yoke), a system that can not go wrong by its very nature.

2. **Lack of Data Culture**: It is very important to explain to the corporate population how much a clean data has value: for example in the data entry on SAP that little more time lost to load a complete data generates a lot of value, obtaining a more complete overview of what really happened. Another problem is that those who create a data typically is not the user, it is rare that who collects the data is the one who benefits from the good quality of the data. The one who imputes it therefore does not understand its value and thus the process is incomplete.

3. **Architecture Problems**: All business data/applications should be seen as a single macro architecture, a mechanism where each element communicates with others. If you introduce an element out of structure you generate non synergies. the goal is therefore to have few applications that dialogue with each other, in the case of Avio converging in SAP.

In addition, it is necessary to distinguish whether the data is to be seen by a machine or by a person. In the first case we talk about Machine Learning and more data is better. Different is the situation if the database must be studied by an employee, as he would be very difficult to have so many different data under control and therefore you prefer to analyze the main ones; if a certain geometric

parameter is being controlled in the factory, it is useless to consider all the dimensions, but only those necessary to study the process, for example, one diameter is measured that is representative of how that process is working.

EyeScream

Eye Scream is a digital tool developed on Visual Basic and integrated in MS Excel program to facilitate the use by operators with a user-friendly interface, which allows you to record visual anomalies identified on components and provides the delegate to the Preliminary Review a preliminary indication on the arrangement of the same, for his assessment.

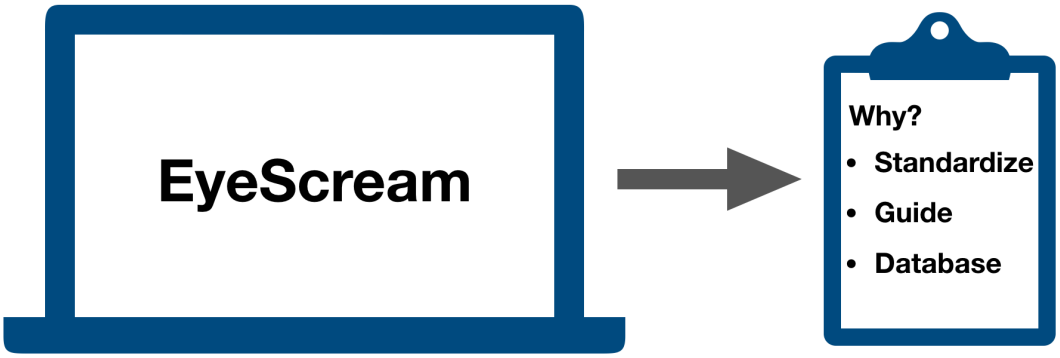

Figure 11 - EyeScream Goals

The Eye Scream tool has been developed for the purposes of:

- **Standardize** the description of visual anomalies detected during testing according to the applicable visual testing specifications;

- **Guide** the delegate to the PR in the choice of the arrangement of anomalies and in the identification of the standard Repair Cycle applicable to the piece.
- Creation of **Anomalies Database** for data analysis and consequent process optimization in Rivalta plant.

The operation of the tool is divided into two phases:

1. **Insertion and description of the anomaly**: The tester who, during the bench/visual testing of an OL (from the Italian “Ordine di Lavoro”), identifies an anomaly with respect to the standard of acceptability of the applicable visual inspection, guided by a series of successive masks, enters the data relating to OL, S/N and the type of anomaly, position and extent. The data required by the tool meets the requirements of the standard for the description of the anomaly. At the end of the insertion, the tester saves the data entered and the tool creates an Anomaly Sheet, identified by a progressive number in the current year.

2. **Preliminary Anomaly Review**: The cell delegate to the PR accesses the tool and selects the FA number to be placed. In the case of an FA comprising several serial numbers, a default line is created for each of them, which requires specific provision by the delegated PR. In relation to the data entered in the tool, which refer to the official standard repair procedures for the Gears product family, the tool suggests an arrangement of the anomaly, which may include the application of a standard repair cycle or the opening

of a QN. The delegated PR evaluates every single defect line and defines its decision, in accordance with the rules, which can confirm or not the result suggested by the tool. Once the disposition of all the lines of the FA is completed, the data is saved and the Anomaly Sheet is printed, ready to be signed by the Delegate PR.

Debug and Optimisation

Once the tool has been created, a debug and optimization phases take place in order to be able to validate the instrument from the Quality System.

It is necessary to know the behaviour of the tool firstly of the creation, in order to be able to catch also the smallest variation with respect to the standard operating behaviour.

Sometimes, the software developer code do not match with the expectation and when this happen is necessary to investigate the problem through the debugger.

The debugger is not able to find all of the problems in the code in a single run, it needs an iterative process in order to find the exact line where the problem is present. Performing the code line by line with a program, such as Visual Studio, it is possible to find the error and to adopt a solution in order to solve temporarily the bug and complete the run of the code. After the code has been run and all the problems in the line are collected, it is possible to apply the optimal code rearrangement.

This kind of rearrangement can have multiple reasons, from an error in the code script to normative error, and each of this problems needs to be solved by proper operator which are responsible of the error.

Alongside the debug activity was necessary to create an AI based on the company's normative, which was introduced in EyeScream in order to create this kind of database of anomalies and zones. This instrument is then used by the operator which, selecting the defect and the zone where the defect is present, evaluate the possible action to take in order to satisfy the defects limits or tolerances. The operator is informed by the program of what kind of standard repair operations cycle needs to be performed.
The build of this AI is made thanks to matrices which takes into account the norms related to the admissible rework with the purpose of combine each possible PN, interested zone, defects and extension of it, giving the best advice to remove the non conformity.

Validation and Adoption

The tool was validated by the quality system which verifies that the norms was correctly considered and the nomenclature was consistent with the former.
Furthermore also the FA format was controlled to be sure that was equal to the physical one.

The biggest problem of this kind of digitalization was to keep trace of the tool utilization. Firstly each operator was obliged to put the personal stamp on the paper to keep track of who effectively was involved in the test and preliminary review. Now the solution was founded using the access through SSO from the company PC.

The tester that detects the anomaly accesses the PC of the test area with its own SSO and Password; when the tool is opened, through a desktop connection, the SSO of the user logged in is recorded: this uniquely identifies the person who enters the data. When the FA is saved in digital format, the SSO is saved and this data is no longer editable.

The stamp of the tester shall be affixed to the ODL at the time of the test operation, on which the reference to the FA shall also be indicated. The PR delegate accesses the PC with his SSO and PSW and opens the tool in the PR section. Only qualified personnel can carry out the preliminary review of anomalies. Such personnel must sign or stamp the printed FA at the end of the analysis carried out, in the space affixed.

After the tool had been completed, probably the hardest part of this project started, the teaching of the operators. That was hard because change the workflow of the operator can be easy for someone and impossible for others. The teach was made through a refresher course with the goal of explain the tool in all of its aspects, but also to receive the feedback from the operators in order to find possibile problem from the users point of view.

This subsequent optimization, assisted by getting used to a new system, has made possible the achievement, in three months, of a 100% adopt over the entire Bevel Gears area, with an exponential increase in the size of the database.

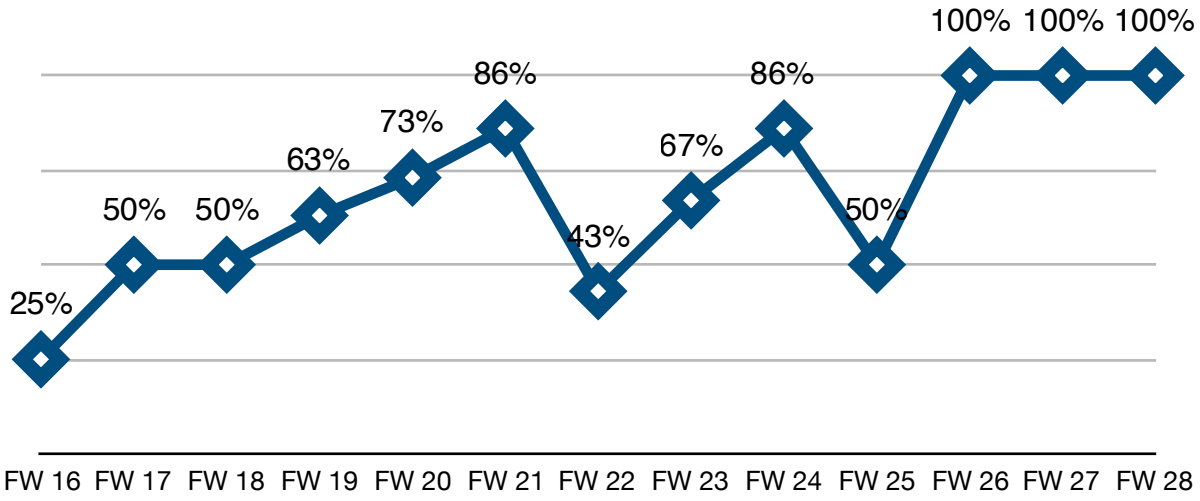

Figure 12 - Tool Adoption by Fiscal Week

At this point it was possible to start the data analysis phase, thus being able to evaluate the most impacting anomalies for the details and thus be able to start improvement actions with the application of Six Sigma analysis.

4 - 6S application

Visual Anomalies

After a series of data was collected, the data analysis was possible through DMAIC approach. First of all the visual anomalies Top Offender are defined, like is possible to notice from the graph below where the percentages of Defects Per Unit and impact are shown.

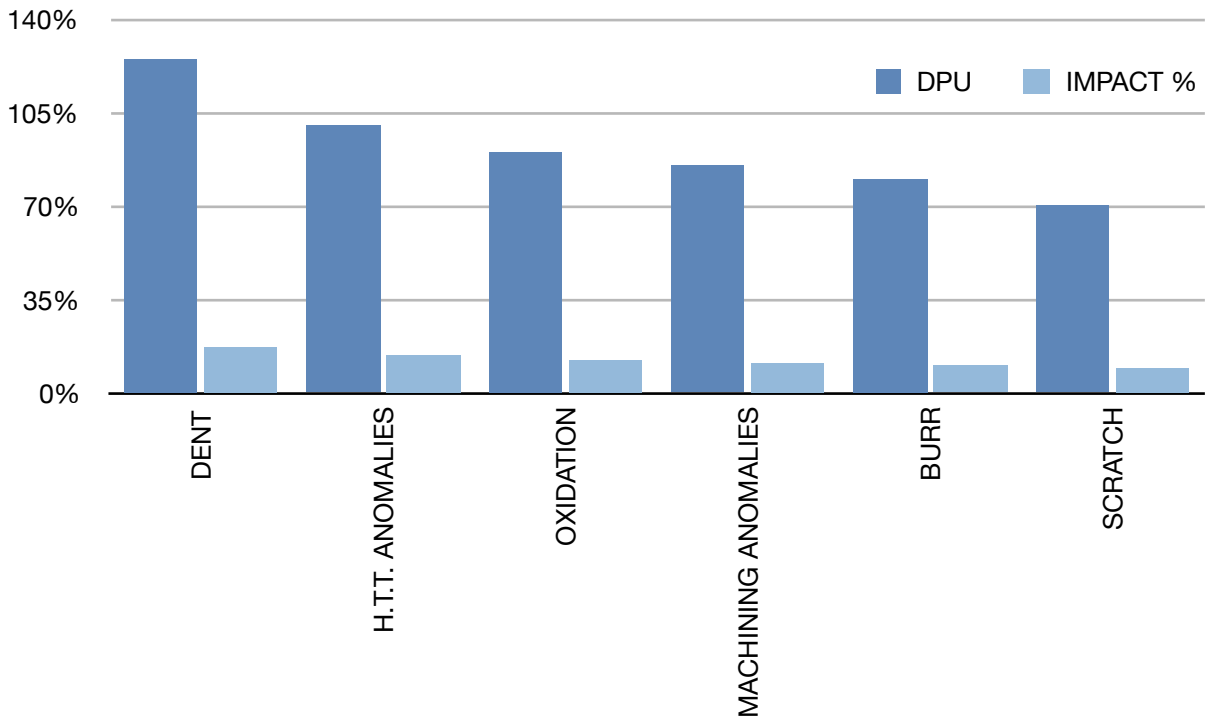

Figure 13 - Top Offender's Pareto

The Top Offender represents the 80% of the all the possibile visual anomalies.

In this set of anomalies are present also defects that have already a corrective action taken into account, like Heat Thermal Treatments anomalies and burr. The other have not already defined any kind of operation, but some possible operating solution are proposed below, except for machining anomalies for which there are not enough data to perform the correct analysis.

Analyzing in detail the **dent** is possible to see that the problem is related to external surfaces of the pieces. Some actions was already taken into account, for example using designed trolley, without particular advantages. For this reason is necessary to apply a different kind of action teaching the operators in order to teach them how to move the pieces inside the factory in the proper way, avoiding shock between pieces.

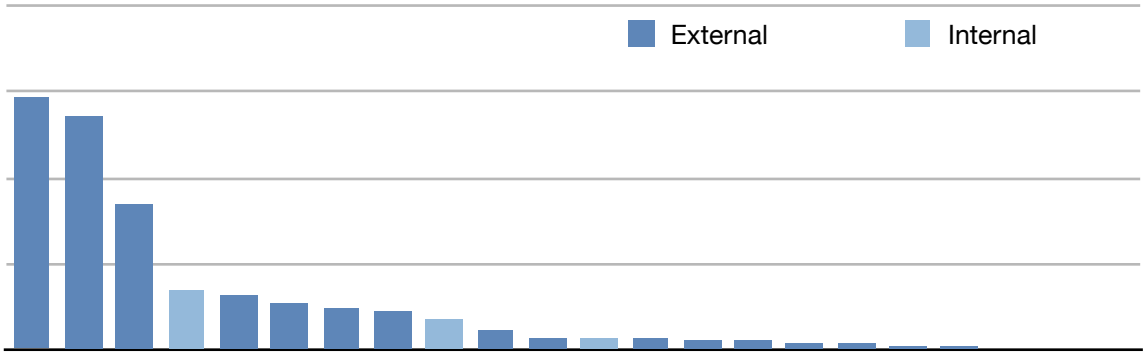

Figure 14 - Dent Column Chart

For what concern the **scratch** anomalies, a distinction between external and internal surfaces has been made. The external anomalies are already been solved by the use of 5-axis machine for deburring. The machine was necessary to solve this kind of problem because that was linked to the manual deburring of the pieces,

so even if a particular training was possible to be made the risk of human error was too high and the machine was preferred.

Also the internal one are related to cultural problem, but in this case is not possible to use a machine to solve the problem because the machine is not capable to remove the chip inside the piece, so the operator needs to manually remove this product waste each time the machine automatically stops.

The cultural problem consist in malpractice of the operators which tends to ignore the stop of the machine thinking is not important to do this task.

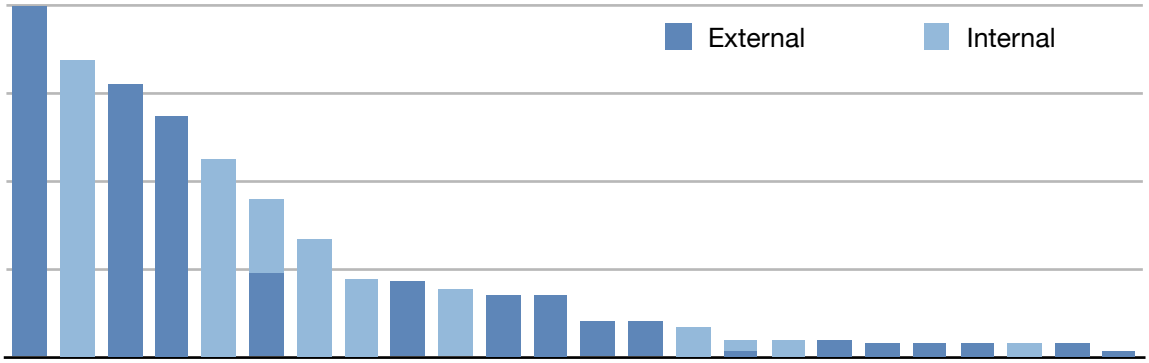

Figure 15 - Scratch Column Chart

Regarding **oxidation** the problems are mostly related to the wrong lubrication after the machining operation. That is because from an operation to another, if the resident time is too long the pieces could be subjected to oxidation process, if not properly lubricated.

In conclusion has been noticed that the most of the problem are related to the **culture**, so an operator refresh is necessary periodically and a constant control is highly recommended in order to check if refresh is giving the desired results.

5 - Culture Problem

Importance of communication

The success of any project depends essentially on the ability of a Project Manager to have a systematic and methodical approach. An approach that must be in tune not only with the objectives, but also with the characteristics of the team.

For a Project Manager it is essential to devote special attention and concentration to time management, planning and maintaining the organization of activities in the planned track, with an overview of the progress of the work and acting where necessary with any adjustment measures.

Figure 16 - How Communication Plan Contributes to the PM Process

Project communication thus becomes a fundamental topic. Often, however, project managers have a tendency to invest time and resources on technical activities, more closely related to the stage of execution of the work, underestimating the weight and impact that communication has on the project. A very controversial aspect, also because in general a successful Project Manager uses up to 90% of the time dedicated to the project to communicate.

It is important to establish the frequency and the communication system to be used, discussing and defining communication expectations immediately, so as to reduce the uncertainty linked to the frequency and arrival of information. Regular communication facilitates and helps in case of misunderstandings or even unclear needs.

In other words, clear and frequent communication positively influences the way team members see their Project Manager as a leader, helps control product quality and project life, and promotes risk management.

The involvement of all is always necessary to feel always aligned within a project, whatever your role. In fact, in the absence of a structured communication the project can easily lose interest, support and credibility, it lacks the knowledge on the state of work shared by all, the team struggles to understand how it should operate and has no visibility on the decisions affecting it.

The role of communication in projects is essentially to enable everyone to understand the content and importance of the information exchanged, to have complete information for the performance of the assigned activities, have enough time to think about it, in this way being able to give answers or propose solutions.

In project management problems such as understanding and a fair definition of the client's expectations, as well as clear requirements and objectives, overlapping responsibilities, frequent changes in the project scope, constraints, interface management, decision making,... This is why good communication is essential. A significant number of problems are actually caused by poor communication, which is more likely to affect the quality, effectiveness, satisfaction and productivity of a project team.

The best way to identify all communication requirements is to have a comprehensive and complete overview of both the organization and the project, focusing on elements such as organization chart and organizational structure, project organization and responsibility, internal/external communication needs, so as to meet the simple 5W rule that determines with whom (Who) it is necessary to communicate, what , when, where, why and how.

The main obstacles to be overcome in order to ensure effective project communication are essentially political, cultural and linguistic issues.

Different organizations are distinguished by different organizational cultures and values. Therefore, when communication takes place between two different entities, it is not said that everything always runs smoothly and without problems.
In this case the project manager, together with his team, must be aware of the differences and take them into account during the development of the communication management plan.
In the communication, in addition to the linguistic differences that could give rise to misunderstandings and misunderstandings, there are also differences due to the use of terminologies, often understood only by specialists and experts.

Having adequate knowledge and preparation, you will probably have no difficulty in following any kind of discussion but, if not, this could also create some problem of misunderstanding. It is important, in every field, to always speak the same language, being understood by all, without generating uncertainties. This is also part of the task of a good Project Manager, standardizing and tending to a common project jargon: often it is useful, in such cases, the use of a glossary, within the documentation available and used.

Projects often have a profound impact on the organization and, of course, on the people within it, especially those who work there directly.
Projects transform all or part of an organization and by their very nature create changes in the organization in general and/or in individual departments.

Like already said the main role of the project manager is to interact with the people and in order to do so, he must be able to interact with various sub-cultural elements.

Communication problems can be the base of possible misunderstanding which leads to errors during the work time. This means that the project manager needs to makes an effort to speak, listen and understand “different languages” and needs to be able to create a peaceful working environment to improve the productivity.

Projects are more likely to succeed when:

- They begin with the premise that organizations are living social systems.
- They evaluate, identify, work and align with the basic culture of the organization.
- They are directly related to the organization’s strategy.
- They are aligned with culture and leadership initiatives.

For this reason, culture plays the most important role in the determination of the success of the organization exculpating the project managers if the projects are not correctly completed

All this can be seen in the creation and optimization of **EyeScream**.

At first its development had not seen the involvement of those who actually use it, creating a stalemate in the project. Instead, once supervisors and testers were involved, various improvement activities could be carried out, making this tool really useful for the company.

Thanks to the support of the testing, in fact, it has been possible to make the tool's input interface more efficient, with new functions that make inserting the anomaly lines faster, and to have a functional output for those with the anomaly sheet must carry out the repair activities of the piece.
In addition, it was possible to find an alignment in the nomenclature used going to update from time to time the database that is the basis of the operation of the tool.

Quality culture

Building an internal culture of quality in an organization is part of the development of a **quality system**. One might think that "quality culture" means "doing something well for the first time", because working well right from the start when you face a task saves time and money to the organization.

Doing something right the first time establishes the expectation that a worker will meet the requirements of the norm, those of the customer and those of the company the first time he performs a task and can then do it every time he faces it. In this case, if the basic thinking is this, we will have an organization that measures the result, that is, the number of mistakes made, instead of the successes, that is, the number of votes in which that task was done well.
The culture of quality, however, should be to prevent problems at all stages of the work and not to count errors and try to solve them afterwards. It might seem like a subtle difference, but an organization with a culture of quality should define quality

as something that helps workers prevent mistakes and do the right thing whenever a problem is found.

This way of thinking puts all the people who work in a company in the conditions of having to make a reasoning together with the top and to develop a mentality that makes them feel involved together with the management and managers in this project. We need to understand that to really build a culture of quality we need to plant the seed of "doing the right thing" at every stage of every process and activity that is carried out within the organization because this is the only way to prevent problems.

People need to be trained, **training** is a useful investment that pays, but you have to be aware that, sometimes, it can be ineffective because sometimes, after just one month, we tend to forget up to 90% of the information we have learned. Given the cost of external training, this statistic is an important cause for concern. Often this is due to the mentality of those who are trained who do not understand how this personal training can serve the company and effectively add value. In addition, training is often required under regulatory requirements but should be understood as an opportunity for people to grow professionally and develop new skills that can be used to improve products and processes.

Investing in a quality management system that can rest on the solid foundations of a quality culture often produces a solid return on investment. Preventing problems as much as possible does not mean that people, processes and machines will

never make mistakes. The goal must become to change the process of thinking that must move from the mere measurement of errors to prevention and knowledge "to do the right thing when a mistake happens”.

The term "**quality culture**" refers, therefore, to the objective of an organization and its members to guarantee quality permanently and to develop it in a sustainable way. We will truly have a culture of quality where members of an organization will genuinely care about the quality of their work and make decisions based on achieving that level of quality. In concrete terms, it means creating a culture based on trust, participation and clear communication, in which quality objectives are supported by the participation of all employees.

6 - Conclusions and EyeScream Future Improvements

From the point of view of industry 4.0 and lean manufacturing, the world of industry has no longer only considered the aspect of **cost**, but also that of **time** and **quality**, with a single goal: “the value as perceived by the customer".

The principles on which Lean Thinking is based are simple: the starting point is to identify identify and remove “**waste**”, in order to produce more with less consumption of resources. Lean waste can come in the form of time, material and work.

An obvious waste in lean manufacturing is **defects**. Defects include products that do not meet specifications and therefore are inoperable or require rework. Defects are often one of the most expensive forms of waste since they can turn into other forms of waste such as **additional transportation**, **overproduction**, or **extra processing**.

The most important step to improve an existing process is defined as its Value Stream Map, aimed at highlighting the weaknesses of the current process; in Avio there are two troublesome areas due to the lack of digitalization: **Testing** and **Service**.

This entails the lack of a database useful for data extrapolation and consequent improvement, both from the point of view of the industrial process and management.

To solve this EyeScream has been developed, a digital tool developed on Visual Basic and integrated in MS Excel program to **standardize** the description of visual anomalies detected during testing according to the applicable visual testing specifications, **guide** the operator in the identification of the standard Repair Cycle applicable to the defective part thanks to AI based on the company's normative and create the **Anomalies Database** for data analysis and consequent process optimization in Avio Rivalta plant.

With a great work of optimization and debugging, also thanks to the involvement the operators, a great result was achieved: in three months the tool **adoption** reached 100% over the entire Bevel Gears area, with an exponential increase in size of the database.

At this point it was possible to start the data analysis phase, thus being able to evaluate the most impacting anomalies for the details and to start improvement actions with the application of **Six Sigma analysis**.

In conclusion, has been pointed out that the main issues are linked to the operator quality **culture**, so an operator refresh is necessary, periodically remembering that quality culture means "doing something well for the first time"; also a constant

control is highly recommended in order to check if continuous training is giving the desired results.

It is clear that digital technologies enable workforce productivity and business process optimization. Companies must adopt advanced technologies to become more resilient and agile.

The most effective approach for the future is to leverage integrated and extensible digital platforms, which offer excellent value today and are ready to quickly adapt to the new business requirements of the future. It is crucial for organizations pursuing a holistic business transformation to integrate advanced cloud communication and collaboration solutions with important workflows, to improve key performance metrics in a more tangible way, such as employee productivity, operational efficiencies and customer satisfaction.

The **digital integration** is the real problem of EyeScream, the tool looks like an excellent mock-up working 100% that allows a great customization, in excel adding a field or a feature is easy and almost without additional costs, differently from SAP. The latter is - in fact - cumbersome to update, requiring higher budget and longer editing time.

From the point of view of digital architecture, however, an Excel-based tool is counterproductive, as it creates data that is not integrated with company databases.

In the future, in fact, the process of corporate digitization will need the integration of an external software with the same functionality of EyeSream communicating directly with **SAP** through APIs, so as to have a single database and integrate new functions, such as the ability to open QN directly from the application interface.

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