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"THE LEAN MANUFACTURING IN DELONGHI APPLIANCES SRL: THE DELONGHI PRODUCTION SYSTEM"

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"Go see, ask why, show respect"

Fujio Cho

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INTRODUCTION

The work aims to explore and represent the actual situation on the DeLonghi Italian productive site, for what concerns improvement and lean manufacturing. The site is DeLonghi appliances s.r.l., based on Mignagola di Carbonera (TV).

The most important part of the work is the creation of the DeLonghi Production System (or the so-called DLPS), also represented with a graphical form, and the explanation of the different sections and areas. The element orders in the system are based on their importance, and consequentially the amount of invested efforts by the company. The model is the final project of the internship period in the already mentioned site, and free elaboration from the Toyota Production System made by Toyota adapted on the DeLonghi context.

For each element of the model, there are also practical examples; the aim is to demonstrate the direction of the company and its progress toward the improvement philosophy. The used cases are mainly related to the internship period activities, and, for this reason, some of them could be still in progress or on their first state of implementation.

The experience in the lean department, of the six months duration, was the occasion to analyse several projects and ideas, that are born and carried forward. Some of those were asked directly from the management; some others were taken by the everyday necessity in the productive site.

The work is divided into three parts. In the first part, the chapter focuses on the literature, in particular with an *excursus* on the Toyota Production System, the TPS, and some other knowledge regarding the lean philosophy, fundamental for reading the DLPS efficiently.

The second chapter, then, is about the history of the DeLonghi company, the business, the markets and the characteristics of both products and plants. Moreover, the managerial direction of the company and the hierarchical organisation are briefly mentioned.

The third chapter is entirely based on the internship experience, in particular, the TPS application on the DeLonghi Italian site.
The lean transformation for DeLonghi appliances started in 2015, with the application of industry 4.0 to the new shorter and more flexible lines, more explained later on the work. The management strongly wanted those technical activities, and the project to convert every traditional line into the new ones is still unfinished.
However, during the internship period, the most critical analysed area is the base, in which there are listed those activities that provide stability to all the other areas of the system. To this area was dedicated more projects and efforts, according to the recognised importance of those activities.
However, this model isn't the final representation of the DLPS but could be taken as a starting point for future implementations and modifications.

CHAPTER ONE

In the following chapter, is explained the lean manufacturing evolution, the basic concepts, the benefits and the Toyota Production System invented by the Toyota company. The aim of the system is the continuous elimination of *Mudas* so that the company could produce more with fewer resources. The *Mudas* elimination is possible with the application of some instruments and methods, but especially with a proper mentality oriented to continuous improvement.

1.1 LEAN PRODUCTION

The first part of the chapter is dedicated to exploring the social and economic condition of Japan. The context is fundamental in order to understand better the *Kaizen* philosophy and the lean production, ideas born as an answer to some necessities, different from the ones of the Western companies.

1.1.1 SOCIAL CONTEXT

The lean production, manufacturing, and philosophy born in Japan on the Toyota plant thanks mainly to the figure of Taiichi Ohno (1912-1990).

The lean production was an alternative to the mass system and had its foundation several years before the Toyota Motor Company creation when the Toyoda family owned a textile company. After the foundation of Toyota Motor, lean manufacturing was developed by Taiichi Ohno during his period as president and perfectionated, then, with the TPS, the Toyota Production System, and spread into the western countries.

The idea of production without wastes born because of the economic condition of Japan: after the second world war the country was left without resources and favorable

conditions for sustaining the usual mass production system used in the United States. The identified reasons for the need of a mass system alternative are mainly five[1]:

1. The modest but vast demand in the Japanese market, composed of luxury cars for government officials, big trucks for delivering materials, small tracks for farmers and small vehicles for town and cities.
2. The Japanese workforce refused to be treated as interchangeable parts, a concept introduced by the American occupation, and seen as a vile practice. Moreover, there weren't permanent foreign people or the so-called 'guest worker' in the country. Those workers in western countries, such as the US, accepted sub-standard working conditions. The power of the native Japanese workforce, indeed, remained untouched and robust.
3. The post-war conditions left Japan in a weak status, especially for the economy. There was no possibility to purchase and convert the actual plant, with the western new technologies.
4. The outside markets were already full of players in the automotive mass-production, that wanted to enter the Japanese market too. This consistent presence was a treat not only for the internal market but also for the external exports.
5. The foreign investments were strictly forbidden.

At that time, Kiichiro Toyoda, had only in mind to fill the gap with the American automotive industries, characterised by high demand and low variety. In order to better understand the techniques used by US companies, especially related to the mass system, the Toyoda family went to America several times, the first time in 1929. The journey, made by Kiichiro on the Ford plant, was the preliminary study for the future Toyota Motor Company, founded in 1937.

The first approach for implementing the lean production system was shifting from a *'one operator, one machines'* system, to '*one operator, many machines in different process'* system (Taiichi Ohno, 1995). The new production didn't bear without problems, but the system evolved with the difficulties, with slow but steady growth. The effort was then noticed, out of Japan, in 1973, due to the oil crisis worldwide, when the country registered zero growth, with the consequent decline of all the companies,

[1] James P. Womack et al., 1991

except for Toyota Motor Company, which survive the crisis with positive numbers[2]. The American companies, then, studied the model, at first with resistance, and then with the genuine willingness to learn how to implement the system also in their companies. Toyota and his production system became famous in the ’80, when the analysis between his machines and the western’s made a clear winner: not only the Japanese cars were more lasting, but also required fewer repairs (Jeffrey Liker, 2003). Then, at the end of ’80, the model was adopted by few American automotive companies, included Ford and General Motors. The idea also reached Europe that with more suspect applied the techniques on the ’90. The diffusion of lean production was also helped by dedicated books, that spread further and faster some concepts such as the TPS, now applied to the most successful companies worldwide.

1.1.2 LEAN AND MASS PRODUCTION

The best way to describe the lean production system is through comparison with the mass system by Ford. Lean manufacturing uses flexible methods in order to provide consumers with what exactly they are asking. This method is particularly similar to craft production that established earlier than Fordism. The hand-made goods are more costly and inaccessible for clients, so to provide to each people the product, the companies switch their way of doing.

The father of mass production is without any doubts, Henry Ford (1863-1947). In 1908 Ford invented the ‘Model T’, a more easily assembly method because the same parts were **interchangeable** and easily attachable with the others; in other words, Ford achieved the **standardisation** of the components. Consequentially, the standard pieces brought to a new level of simplicity in the assembly process. Aside from the parts, also the workers became interchangeable[3]: the first change, indeed, was using less prepared and un-skilled operators. Moreover, new high-skilled figures born, such as designers, contractors and engineers. Part of their job was to handle the un-skilled staff. The operator work, then, was divided into sections, so one operator had to replicate repeatedly the same movement. With mass production, Ford was able to

[2] Taiichi Ohno, 1995,
[3] James P. Womack et al., 1991

decrease the manufacturing cost, thanks to the high volume and low variety. The consequential step was also standardising the instruments and the process.
There were, obviously, collateral disadvantages, including the increasing of space, number of workers, stocks, suppliers and so on, with a reduction for the costumer of variety and personalisation, and for the worker a less exciting and alienating work condition.
The lean production born after the mass system, taking the best of the two previous productions, in particular lowering the cost of the crafting, but avoiding the rigidity of the mass system. Another way to identify the differences between mass and lean is the results that the production systems have: for the mass system, the objective is to reach the 'good enough', that means that for a certain number of defects, the production is acceptable and trying to reach another type of result, both in positive and negative, means raising way too far the cost. Lean manufacturing, instead, has as objective perfection:

- Zero defects.
- Zero (excess) lot size.
- Zero setups.
- Zero breakdowns.
- Zero (excess) handling.
- Zero lead time.
- Zero surging[4].

The effects of lean are also unexpected ones: the people with the lean system will feel more involved in the company life, management and decisions, more committed and feeling to be more accountable, factors that could also be seen as collateral benefits for their productivity.
Lean manufacturing is more similar to a new way of thinking about the company and the value creation instead of a rigid model of rules. The lean is indeed a philosophy and a state of mind, oriented to the ***Muda*** **elimination**, another concept ideated by the Toyota company former director.

[4] J. N. Edwards 1983, Seven Zeros Theory. Si riferisce alla sua teoria ma lho trovata nel compenndio di bruni citato in bibliografia

The Japanese word means ‘waste’ and the concept about eliminates all those activities that producing waste instead of value. Taiichi Ohno identified the three ‘Ms’ and seven types of *Mudas*, during his experience in the company. His idea was that for every company, those *Mudas* could be identified and that the elimination is possible, by only switching the focus from the production and the cost to the value for the client. With the *Mudas* elimination and lean manufacturing, the aim is to reach more successful goals, using fewer resources. The concept is then restudied by James P. Womack and Daniel T. Jones's in their book *‘Lean Thinking: banish waste and create wealth in your corporation’*. With this work, Womack and Jones wanted to summarise the step by step analysis that each company has to follow for sorting the waste from the value-added activities, which are exposed in the next paragraph.

1.1.3 LEAN THINKING

For wastes are indicated every human activity that doesn’t add any value. In every company, there are *Mudas,* and one way to find out where those wastes are is using the lean thinking approach. Lean thinking is based on the lean philosophy to do the same, using fewer resources: less cost, less time, fewer defects, less space, and so on.

There are **five lean principles** explained in ‘Lean Thinking’, by Womack and Jones (2003), related to the *Muda* analysis (Figure 1.1):

- Value
- Value stream
- Flow
- Pull
- Perfection

The first concept to analyse is **value**. The value is only what the client is willing to pay for; in other words, what the final customer sees. The idea then is that also the place where the value is created could be considered as the value itself. The analysis always started to the question: ‘*what does the customer want from this process?*[5]’

[5] Jeffrey Liker (2003)

The next step for the *Muda* analysis is the **value stream.** Once identify what is considered value, then it is fundamental to underline what is value in the specific process. Proceeding in this way also means to find out which part of the process isn't value. This step could be easy or unnecessary, but most of the companies are organised by departments and barely analysed as a whole. With this method, the company is studied as one entity. However, in order to proceed with the analysis, there is a fundamental distinction to underline. From the mapping of the activities could be possible that some actions represent unavoidably *Mudas*. Indeed, there are two types of *Muda*: first type *Mudas* are the ones that include necessary activities, that don't add any value to the good, one typical example is transportation; type two *Mudas*, instead, could be eliminated. One big challenge for companies is represented by the conversion of type one *Mudas* in type two *Mudas* and then remove them.

After the identification of value and the separation between value-adding activities, the third step is the **flow** creation. Creating a flow means to eliminate the batches and so, all the barriers or boundaries in the value process, making it continuous. The challenge, for Toyota, was working with small quantities, low demand, and high variability. In other words, in America with Ford, it was more use the ***Kaikaku*** concept[6] in contrast with ***Kaizen***[7] *,* ideated by Toyota.

In order to make a flow analysis, there are several steps to follow:

1. Identify which is the subject of observation, and keep focusing on it through the process
2. Ignoring the traditional boundaries dictated by the roles, jobs, departments, batches, and so on.
3. Reconsidering the specific work content, including the instruments used, the practices, the design, shape, and order of production.

The idea, in order words, is to start again with a white sheet and eliminate all the physical and mental boundaries.

The next step is the **pull**, meaning that the production is subordinated to an order or a request by the market. The traditional idea for companies, based on **push** logic, expects that the production predicted the demand and so the final product is made in

[6] From the Japanese 'radical improvement'.
[7] The concept means 'continuous incremental improvement'.

advance and push on the market. This way to operate brings to increase the number of pieces both in final product supermarket, both for the raw material supermarket. Another side effect is obsolescence. Indeed, more time passes through the stocking of the final product to the delivery, the higher will be the risk of obsolescence. With the pull method, the time required between the creation of the concept, to the delivery for the client, drops dramatically, compared to the push logic timing.

Perfection is the last step to sustain a *Muda* analysis. Applying all the previous actions mean that the company is entered in a virtuous circle, dedicated to the value creation. One of the best qualities of implementing those five concepts is the so-called open-book management, which means that the production became transparent. The transparency also means accessible, so everyone, whatever their competence level it is, could easily read the process and provides feedback. Perfection represents an ideal objective: once reached a nearly-perfection level, the company could work more to reach another higher level of perfection. In other words, the *Kaizen* philosophy sustains continuous improvement because there always be occasions to getting close to perfection.

Figure1.1 *- The Five Lean Principles.*

Source: project-management.com

1.1.4 MUDA, MURI, MURA

On the lean philosophy, there are three types of errors, that have to be eliminated; each one has a different impact on the production and different meaning:

- ***Muda***: is the avoidable waste, the non-value-added activities. The client doesn't perceive those as value and so is not willing to pay for it. Those *Mudas* includes seven types of waste mentioned below.
- ***Muri***: overburdening of people and equipment, means that the resources are pushed over their limits. For people, this causes different *Mudas*, included the creation of defects and safety problems, and for the machines means the possibility to induce breakdowns and defects.
- ***Mura***: (unevenness) is the natural conclusion of the two previous Ms, due to irregular production. With *Mudas*, indeed, the production isn't at its best potential and with the muri, the production is over-saturated.

Regarding the first M, *Mudas*, Taiichi Ohno detected seven different types, but with the addition to an eight based on the TPS philosophy[8]:

1. **Overproduction**: regards the production of items to which there aren't any orders by the market. Consequentially, this *Muda* generates another one, including the transportation *Muda* and the excess inventory.
2. **Waiting:** workers are not operative because they are waiting for materials, or there are tools delays, missing products, idle machines, bottlenecks, stockouts, and so on.
3. **Transportation**: for transportation is included the moving of materials, finished goods, work in process (WIP) for long-distance, stocking materials.
4. **Overprocessing**: the overprocessing, also due to incorrect practices, it means wasting time, cost and producing defects.
5. **Excess inventory**: the condition in which there are excess raw materials, WIP (work in progress), or finished goods stocked in the inventory, causing the consequential cost of holding, transportation, obsolescence, delays.

[8] Jeffrey Liker, 2003. In the book 'Lean Thinking', Liker adds the eighth *Muda* to the original seven invented by Taiichi Ohno, in the '*Toyota Production System: Beyond Large-scale Production',* 1995.

6. **Unnecessary movement**: related to the overprocessing, but also wasted time for searching tools, walking for picking materials, or any other waste generated by the worker during his/her work.
7. **Defects**: defects are considered whatever products that are far from the optimal condition. A defect means to waste resources, such as effort, energies, working hours for fixing the defected product.
8. **Unused employee creativity**: the loss of commitment and creativity for the operators that may be generated by inadequate resources management.

1.1.5 EFFICIENCY ANALYSIS

Another moment of analysis for the company, besides the *Muda* evaluation, is represented by the **efficiency** study (Taiichi Ohno, 1995); the main points for performing this analysis are two:

- The efficiency could be pursued through the reduction of human resources and only producing what asked, leaving the same cost.
- The efficiency has to be studied for each position on the line, for the entire line, and for all the lines that compose the company. The efficiency analysis, indeed, is not only about the job content of one operator but as the whole production plant.

Those principles born when the Toyota company started to face some production issues related to the efficiency and the workforce. The struggle was to increase the production of the company without consequentially increasing the number of operators too; in other words, the aim was to increase efficiency. The analysis started with the study of missing and wasted time from the operators. It was a common situation seen a lot of them waiting for the product and made unnecessary movements. The basic idea was that the plant, at that moment, already had more capacity and this is limited only due to the waste. The situation could be summarized with the following formula:

$$\text{Present capacity} = \text{work} + \text{waste}$$

Eliminating all these wastes mean to increase the present capacity and so, the efficiency; looking at the formula, it is assumed that the efficiency could be increased whatever reaching:

- higher production; or
- elimination of the exceeding workforce.

When asked, most high managers preferred to increase production because reorganising the employees, it's more complicated. However, increasing the production without the consequently growing of the market demand generates overproduction, which represents another waste. On the other hand, it is possible, in order to meet the asked production, reducing the human resources that exceed the needed quantity.

Of course, the condition of releasing some people from the production was seen with suspicious eyes, but Toyota saw this situation not as a problem, but more like an opportunity. Taiichi Ohno then introduced another principle: **respect for humans** (Nigel Slack et al., 2014). With this principle, Ohno meant that whenever excess workforce was identified in the Toyota Company, then the employees had to be reinserted in an efficiency context, in which their work was useful, and their creativity wasn't wasted.

To identify *Mudas*, excess workforces and also for conducting the efficiency analysis, people have to walk by the plant; this was a solid point even for Taiichi Ohno's career, that called the walkthrough '*Gemba* walk'[9].

1.2 TOYOTA PRODUCTION SYSTEM

For describing the system, the Toyota company used a univocal graphical representation of a house. The structure was chosen because it is also a symbol for representing a system: the house, such as the Toyota Production System (TPS), is stable only with at least those three elements: base, pillars and roof. The house is later used and adapted by other companies, but the original concept studied by the former president of the Toyota motor company Fujio Cho included:

[9] *Gemba* is a Japanese word for 'place in which there is work', meaning that in that specific place the workforce operates and the issues come out.

- TOP: the objectives with the lean manufacturing the company is willing to achieve.
- TWO PILLARS: one about the JIT (just in time), one about the *jidoka* (automatisation).
- BASE: elements such as *heijunka* and the lean philosophy that provided stability.

Then, at the centre of the system, there are the people and the methods that create and identify the value (Figure 1.2).
The most important thing for the system is that those elements reinforce and sustain each other.

Figure 1.2 *- the Toyota Production System.*

Source: Liker, 2004.

1.2.1 TOP

Since the diffusion of the mass system, the top management aimed to lower the cost, in order to whether being able to win the market through low price, or for increasing the profits. For reaching those results, at first, Henry Ford took some countermeasures, for example, he hired unskilled workforce and postponed the exchange of die only after large batch quantities. Recently, the manufacturing companies use the relocation of assembly, logistic, and design, where the workforce cost less (Masaaki Imai, 2016). However, cost-saving and competitive advantage in the market couldn't be sustained with only those actions. The Toyota Production System suggests making everyday improvements in the *Gemba*, and so straighten the company position in the market by reaching three objectives, accurately positioned on the top of TPS: Quality, cost and delivery time, or the so-called QCD objectives.

1.2.1.1 QUALITY

For quality, it isn't considered only the product creation of the products and services but also every process and operation that anticipated and generated that moment, for instance, the assembly, production, maintenance of tools and machines and so on. In other words, the quality improvements move from only considering the *Gemba*, to also include other collateral areas. From this, the need to distinguish between:

- Product quality.
- Process quality.

Moreover, in order to provide an appropriate level of quality, there is the fundamental participation of higher management: it has to invest in the overall quality operations and decide which quality standards the companies have to reach at every level. The process quality standards have mainly three essential benefits:

1 Increasing the product quality: the process quality helps to reduce the probability of defects on the *Gemba*.
2 Lowering the cost and the efforts for the post-sales assistance: fewer defects mean fewer after-sale complaints from the clients.

3 More focus on the client's needs: using less effort on chasing the defects, means focus on new quality improvements, starting from a more concentrated analysis on the market requests.

The quality objective could be summarised with the constant effort, at first from the high management, but then extended also to any corporate level, for increasing the quality level of the whole process. This commitment will create a cascade effect on product quality and, consequentially, for the clients. The aim, indeed, is avoiding any arrival of defects to the client and, bringing the concept to the extreme, on the *Gemba*. The first step for understanding if the actual level of quality could be acceptable is conducting an analysis of the entire process, based on the standard check, 5S implementation and Value Stream Map for the *Mudas* elimination. The next step is implementing some actions for strengthening the process. Here some suggestions for starting the improvement:

- Applying the 5S rules in order to make the defects easily spottable.
- Conducting defect-recognition training for the workforce so that the defect could be immediately dumped.
- Promoting problem-solving group works.
- Collect data for understanding the root causes of the problems in order to resolve them with adequate solutions.
- Building instruments and tools that help to avoid mistakes.

With these actions, the quality improvement responsibility isn't given to some highly technological machines but, instead, to the workforce and helped by the cleaning of the work spot. Once again, the long-term improvements are not provided by the *Kaikaku* concept, but by the slow and steady growth of the *Kaizen* philosophy.

1.2.1.2 COST

Included in the objectives on the top of TPS, there is the cost. Into the cost objective is not incorporated those activities that are belonging to the cost management, made ordinarily by the companies and aimed to monitor and save the cost. Instead, are part of them only the ones related to the *Mudas* elimination. However, it is also true that both of them influenced each other. For instance, in the cost management made by

the higher levels, are included the investment planning activities and the cost planning decisions. The former activities could influence in positive and negative the possible *Kaizen* initiatives; the latter ones, that deal with the margin between cost and income could affect, for instance, the workforce number and so the quality of the system. The activities made for the elimination of *Mudas*, instead, have as the final aim, the general reduction of excess resources, producing the same with less, without decreasing the quality. In details, the activities included in this category are:

1 Increase the quality: with the reduction of defects, there is the consequential decrease in terms of cost, related to the overtime spends for fixing the damages, the waste elimination cost, the stops on the line and so on.
2 Increase productivity: the productivity increases whether the same output is generated with less input or the same input creates more output. The inputs, in this case, could be identified as the resources: using fewer resources means decreasing the cost of acquiring them.
3 Reducing the stock: that means reducing the obsolescent cost, the lead time[10], the transportation cost and inventory.
4 Reducing the production line dimension: longer lines mean more workers, longer lead time, and work-in-process. Moreover, a large number of workers could be translated into less quality.
5 Reducing the machine idle time and breakdowns: micro-stops and stops mean a delay in the production, stock of work-in-process waiting to be transformed, and increasing in terms of lead time. Moreover, if the problem is in the informatic system, there is also the possible loss of traceability.
6 Reducing the space: putting closer the different production areas and reducing the line dimension, the results will be the elimination of some *Mudas*, including the transportation, the stock, the waiting for materials and the motion.
7 Reducing the lead-time: the less the lead time, the faster the circulation of resources.

Those actions are easier and more efficient to implement if the *Gemba* is already capable of facing part of the lean production challenges, such as the frequent and

[10] The time between the order, or raw material acquisition, and the delivery to the client.

quick exchange of die, the production mix, and has the total production maintenance. The improvements in the cost reduction have to reflect the development of the *Gemba*.

1.2.1.3 DELIVERY TIME

With the delivery time is indicated the punctual and rapid delivery of products or services to guaranteeing the satisfaction of the client's needs. Working for reducing the delivery time means working on the JIT implementation (see paragraph 1.2.2.1 below). Using the Just in Time, the manufacturing produces what is required by the client, at the moment that is asked and provides to the company the advantage of flexibility, reducing the cost and eliminating *Mudas*. The delivery time is compatible with the other objectives: the quality alone doesn't answer correctly to the client's needs if it is delivered three months later the necessity. At the same time, a low-cost product, immediately available, but with zero quantity, doesn't fix the client needs ideally. The role of the management is finding a balance between the TPS objectives.

1.2.2 PILLARS

The two pillars of TPS are Just in Time (JIT) and Automatization (*Jidoka*). For automatisation, Sakiichi Toyoda means the machines characteristic to recognise and stop itself whenever any defect could be generated. The idea was inspired by the looms of his textile company, before the creation of Toyota Motor. The JIT concept, instead, born after the deep studying about the mass system at the Ford plant, made by Kiichiro Toyoda, when there was the desire to convert the textile company into an automotive company. After the foundation, in 1936, he defined the Toyotism, a completely new system compared to the Fordism.

1.2.2.1 FIRST PILLAR: JIT

The lean manufacturing base itself on the Just in Time principle, the technique to synchronise the market demand with the company's internal production time. In other words, the production started from the market, and so for the production are brought and used only the necessary resourced.

The JIT is supported mainly by three elements:

- Pull system.
- One-piece-flow.
- *Tack* time.

The **pull system** is defined as the capacity of the market demand to pull and lunch the company production. The mass production uses a push system indeed, so there is the production regardless of the request. However, this way of doing helps and generates *Mudas*, included the overproduction one.

One-piece-flow is an organisational way of production that focuses on the elimination of any buffer or waiting time in a continuous flow. The idea of one-piece-flow, born as a substitute for the mass system. Indeed, in the Ford plant, the raw materials went through the conveyor belt, and there were transformed into finish goods. The system, at the time, worked thanks to the significant batch quantity and rare die exchanges, because the process may be too costly, both in terms of money, both in terms of time. However, as already mentioned, in Japan, there wasn't the possibility to replicate the US batch quantities, for the limited and various market demand. The batches were small and frequently changed in order to adapt to the market flexibility.

The perfect flow is the one without any pauses and stocks, but a preliminary step could be reducing the batch quantities, move nearer the assembly departments and made fast and frequent set-up changes. The one-piece flow has multiple benefits, the first is without doubts the eliminations of some *Mudas*, for instance, the waiting and the overproduction. Other benefits are:

- Increasing in quality: with the one-piece flow, each operator become responsible for quality inspection, and spotting the defects is immediately diagnosed and corrected.
- Creation of flexibility: working with a short lead time means to respond quickly to some changes in customer demand.
- Creation of productivity: the one-piece flow makes immediately recognisable the value-added activities and so the *Mudas* could be spotted and eliminated.
- More space creation: with the cell instead of departments or working areas, there is a lot of space-saving.

- Improving safety: a lean cell also means the elimination of some materials that could generate accidents.
- Improving job satisfaction: working on just value-adding activities helps the workers to feel better about their contribution to the company.
- Reducing inventory cost: due to the implementation of one-piece flow the stock is reducing drastically, along with the obsolescence

The one-piece flow and the pull logic, however, work with a common element in order to be implemented and perform properly: the beat of the market demand, or in other words, the *tack* time.

The ***takt* time**[11] is the rhythm in which the system has to coordinate each department. The *takt* time is referred to the market demand, so if the market asks a piece every 30 seconds, the aim for the company is to produce precisely one piece every 30 seconds: using more time for the production means that some part of the demand isn't answered, spending less time means instead that the company is overproducing.

One aim of the JIT is the elimination of every kind of buffer, warehouses or stocks for materials. The ideal flow is continuous and starts with the suppliers that bring the content for the line, with one piece at a time, according to the *tack* time and following the pull logic. The instrument for making the pull logic works is the so-called *Kanban* that in Japanese, means sign or signboard. An empty bin with the *Kanban* provides three types of information:

- Pickup information
- Transfer information
- Production information

In other words, when the bid is sent back empty, the information is the need to be refilled, and there is also additional information about the required material and who is the supplier. The *Kanban* represented an easy way to manage the inventory, a simple system that uses visual characteristics to communicate. This information was used for both internal and external process, for the Toyota company and its collaborators.

[11] *takt* in German means meter or rhythm.

1.2.2.2 SMED

SMED is an acronym for single minute exchange of die and is about bringing to a single-digit the time for changing the die. Indeed, one point of differences between mass production and lean production was the time used for exchanging the die. For the western companies, that used the mass system, such as the Henry Ford's company, the change represented an action especially hard, that could take a whole day (James P. Womack et al., 1991). The adopted solutions, in that case, were mainly two:

1. Larger batch quantities, in order to change the die sporadically; or
2. Dedicated multiple machines for the production, that stamped pieces continuously for the whole year, without changing the die.

Both solutions, for Taiichi Ohno, represented the opposite direction in which operate in order to own a lean industry. With the large batches, is guaranteed the creation of *Mudas*, both over-processing and for the excessive incoming and outcoming storage. Observing the changing process of the western companies, and noticing the improvement opportunities, Ohno decided to use his operators for performing the exchange. The observed mistakes in the Ford company were the idle moments that were generated by the change of the die. The operators just waited that the machines were ready again and the situation, not only represented a *Muda* but also it was disrespectful for the operators, according to Taiichi Ohno. Instead, if the operators had to change the die, on the one hand, Ohno eliminated *Mudas* and generate commitment in the workforce, and on the other hand, there wasn't the need to hiring high-skilled professional experts as Ford did.

Taking this risk and working for reducing the exchange die time, Taiichi lowered it from about a working day to only three minutes: a single digit. In this way, he could make a smaller batch of products and faster and frequent exchanges. One prioritised work was mapping the activities and separate them into what could be done when the machines were working from the ones to perform when the machines weren't running. The next step was the change of the flow activities, in order to convert the second type activities into the first type. The result was that the majority of them could be anticipated and, consequentially, the time in which the machine stopped was reduced to the minimum.

In his analysis, reducing the batch quantity was more convenient than big batches, for mainly two reasons:

1. Less holding cost.
2. Faster spotting of mistakes, with a consequent increase in quality.

He was able to use the workforce for the exchange, because of their willingness, commitment and fidelity to the company. The Toyota Motor Company, indeed, offered them lifetime employment and wage bonus based on seniority. In return, the company asked unconditional commitment and lifetime loyalty to the company, making them promise to work for the Toyota family for all their life. Taiichi Ohno once said: *"if we are going to take you on for life, you have to do your part by doing the jobs that need doing". (*James P. Womack et al., 1991, Page 54)
By job, Taiichi included multiple duties, including the cleaning of work spot, repairments, quality inspections and so on.

1.2.2.3 SECOND PILLAR: JIDOKA

With the Japanese term *Jidoka*, that could be translated with the concept 'automatisation with a human touch' is expressed one of the first concept introduced by Sakiichi Toyoda when the Toyoda family didn't own the automotive company yet. Their business was the textile industry and the idea of *Jidoka*, or automatisation, came, indeed, from a loom: when a loom detected some risk of producing defect parts, a device automatically stopped the loom, in order to contain the threat. This approach not only helped the elimination of *Mudas* but also increased the quality of the production. For this reason, *Jidoka* was a fundamental part of TPS, giving to the second pillar its name, even in a new and more technological company. The concept remains the same: when the quality is no longer guaranteed, then the process stops. On the Toyota company, the production was also guided by *Poka-Yoke*[12] systems and by *Andon*. *Andon* is another Japanese name that indicates 'signal' and 'alarm'. This instrument, part of visible control system, sends a signal when there are some issues

[12] In Japanese means fool-proof. "the poka-yoke device is (…) a method of detecting defects or mistakes (…). Shingo S., 1989, Page 22

on the line. The light colour could be yellow or red, according to the situation seriousness. (Monden Y., 1998)

Once an error occurred, Taiichi Ohno used to approach the problem with scientific methods. The instrument also presents in the TPS and mainly use even in modern companies, is the **5whys technique** (see paragraph 3.2.5.4). The idea of Taiichi was to study the problem with a root-causes analysis, so the resolution fixed precisely the real causes. With this approach, Ohno guaranteed that the problem was definitely resolved and didn't occur again. Indeed, the method is about asking five times the causes of the problem, so the analysis reveals the sunken risk and purposes, and the proper solution could be found. Without this scientific and rational approach, the resolved issue could be the superficial one, and so the error could show up again. The method used by Taiichi Ohno, then, included also the block of the entire production. When the *Jidoka* system alarmed the employees, everyone started to analyse and work on the problem. The intersection of the line, installed to the operators a strong sense of urgency and commitment, because was everyone responsibility to fix it and restart the production.

1.2.3 BASE

On the base, there are those activities and concept that sustain the system and, as the foundation of the house, have to be implemented first. In the following paragraphs are explained those elements:

- Total Productive Maintenance
- Heijunka
- 5s
- Value Stream Map
- Total Quality Management.

The majority of efforts has to be made on the *Gemba,* in order to prepare the system to the other activities contained in the pillars. Indeed, it could be challenging to implement, for instance, the Just-in-Time without firstly guaranteed trough the Total Productive Maintenance the correct functioning of the machines.

1.2.3.1 TOTAL PRODUCTIVE MAINTENANCE

The TPS works with the exact quantity of products, and with a *Kanban* system, when those are finished or almost finished, new materials arrived. With the mass system instead, the material is always available. With these conditions, lean production may appear riskier than mass production; for this reason, one key element is prevention. One example of prevention is the Total Productive Maintenance (or TPM). For what concern the repairments, Ohno thought that an error wasn't to consider as a random event, such as the mass production taught, but a unique event to analyse with a scientific approach. When a problem occurred in the Toyota plant, the first step was to stop the line. The basic concept is that if the line was blocked, then is a problem of everyone resolve it. The defect was then analysed with the 5whys approach, with the aim to discover the most rooted causes for a problem.

In order to avoid those wastes, the company has to anticipate every possible activity, such as performing periodic preventive maintenance or important quality management. The core idea is to make small but constant improvements, that could guarantee the *Muda*-hunt and the pursuing of only what is considered value-adding.

The modern companies adapt the TPM with the new necessities and with the higher level of technology reached. Nowadays, the maintenance is about the informatic system, data, software and know-how.

1.2.3.2 HEIJUNKA

Highly related to the one-piece flow and the quick changes of dies, the Toyota company introduced the concept of levelling the production, the so-called *heijunka*. The levelling is about the demand for the period and organised the production mix and the volumes in small and mixed batches. *Heijunka* has several advantages compared to the batch production:

- Flexibility: the customers don't follow a predictable path for the acquisition and so the company, through the *heijunka*, reflects this chaotic behaviour, unlike the batch production. The rapid and frequent change of model guaranteed the reduction of the inventory plant and provided exactly what the customers need and research.

- Reduction of unsold goods risk: if the company works for orders, all that is produced is also sold.
- The use of workforce and machines are balanced: the production and so the effort is balanced among products.
- Smoothed demand on upstream process and suppliers: the levelling on the production brings benefits to the suppliers and upstream process with a cascade effect.

1.2.3.3 5S

One of the most crucial principles presents on the base is 5s. The 5s are programmed activities that help to identify and avoiding mistakes. This powerful method bases itself on a precise sequence (Figure 1.3):

1. *Seiri*
2. *Seiton*
3. *Seiso*
4. *Seiketsu*
5. *Shitsuke*

Seiri means to sort, and is the sorting of useless items from the useless ones.
Seiton means to keep in order (or straighten). The basic concept is that there is a place for everything and everything in its place.
Seiso, or shine, indicates the cleaning process.
Seiketsu or standardisation referred to the creation of new rule and procedures in order to keep the first three S under control.
The last, ***shitsuke***, could be translated as sustaining of the process: the process has to be kept stable and monitored, aiming to reach a continuous improvement. If the 5s are used and applied in a plant, the visual control will be quicker and easier.
The 5s alone, however, doesn't guarantee the lean manufacturing benefits, but represent an instrument to sustain the change and implementing the *Kaizen* philosophy.

Figure 1.3 *- The 5S.*

Source: www.atpgroup.it

1.2.3.4 VALUE STREAM MAP

The value stream map (or VSM) is an instrument that graphically maps a particular process and separates the activities that are considered valuable from the non-valued added. The VSM could be made for family, product category or sub-activities, considering partially the process, or including all the supply chain, starting from the suppliers and ending with the clients. The aim of the process is finding the elements inserted in the whole process and implementing new improvements to increase the value of it. It's essential, moreover, drawing the **current** stream map and the **future** stream map, which represented the starting point and the desired outcome. The analysis then must proceed with a list of activities for the *Mudas* elimination. The critical point of the analysis is making the VSM universally understandable, so everyone could add his/her ideas. Another fundamental aspect of the VSM creation is

to get and continuously see the *Gemba*, where the value is created in order to observe and study better or new ways for improvement creation.

1.2.3.5 TOTAL QUALITY MANAGEMENT

TQM (Total Quality Management), includes all the activities that guaranteed the quality of the process, the absence of defects, and the establishing of good practices. The quality became more and more appreciated by the market. In the book 'The Toyota way' written by Jeffrey K. Linker, the author compared the mass system with lean production. The aim was studying which companies between Ford and Toyota manufactured the best product. The analysis demonstrated that the Toyota cars last longer than Ford's. Moreover, the Japanese vehicle needed less maintenance, and the fixes were more accessible and less expensive. The results confirmed the investments and the efforts made by the Toyota motor company.

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CHAPTER TWO

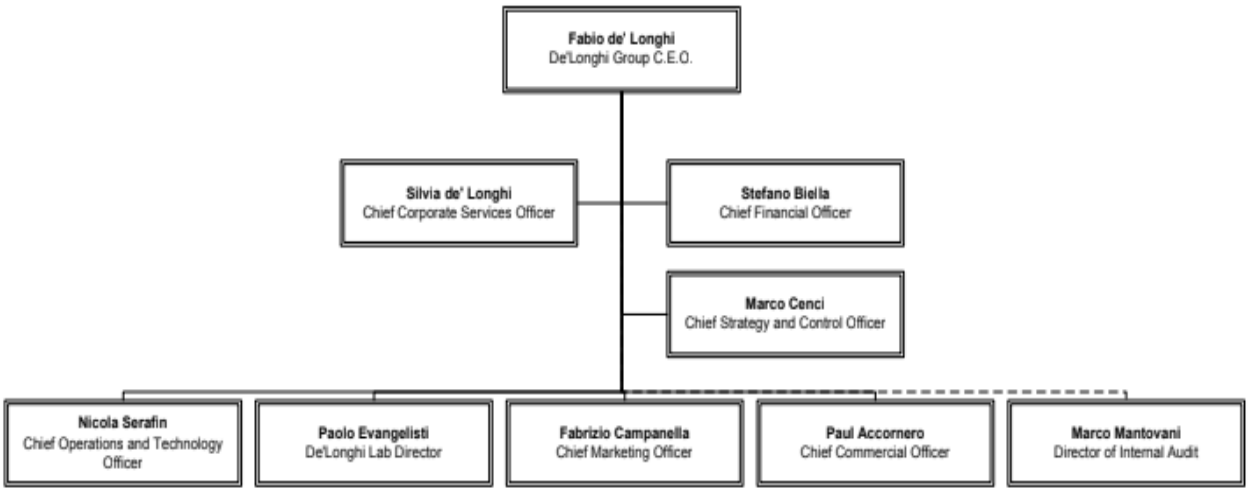
The second chapter will be focused on the company introduction, history and the organisation of the group and the Italian site. The aim is to give a context and understand better some investment decisions. The chapter is going to present the company, through its history and brand identity, a brief explanation of its business, market and products, with the focus on the production sites, especially the Italian one.

2.1 COMPANY PRESENTATION

DeLonghi S.p.A is an Italian small appliance company based in Treviso, Italy, listed on the Milan stock exchange on 2001. The company owns four brands: DeLonghi, Kenwood, Braun and Ariete.

The actual president and also founder of the DeLonghi company is Giuseppe DeLonghi, and the Chief Executive Officer is his son, Fabio DeLonghi, from 2005. The organisational chart of the group could be seen in the following picture (figure 2.1):

Figure 2.1 *- Organizational Chart of the DeLonghi Group.*



Source: www.delonghigroup.com

2.1.1 HISTORY

The DeLonghi family founded the company in 1902. The business was, at first, a small component manufacturer for other companies, until in 1950 the company switched to produce portable heaters and air conditioners. The next phase of the business was to expand in other small domestic appliance areas, for, i.e. the ironing machines and the food preparation, and change the model idea. The company, which was on the B2B market, switched the business model, becoming a B2C company. From this choice new products were born, for instance, the crown's jewellery '*Pinguino*', part of the portable air conditioner production, the gelato maker and the espresso machines.

For the following years, the lead aimed to focus on specific areas and proceed with the grown; for this purpose, the company started to acquire and dismiss companies or just part of them. An example was the acquisition of *Climaveneta S.p.A*, which allowed DeLonghi to enter the market of the heating ventilation air conditioning and refrigeration market, in 2000.

The following years are known for the multiple acquisitions that were made. The company finally became international: in 2001 the group acquired Kenwood, which is a UK company with a plant in China. The acquisition was fundamental in this sense

because this opens a whole new world of possibilities for DeLonghi. The new idea was to manufacture where the cost is lower but preserve the European soul, keeping the designing and R&D in the original countries of each brand.

On 2013 there is, then, the acquisition of the German company Braun, for what concern home care products. With this acquisition, the majority of product in homecare, especially the kitchen appliances, was owned by DeLonghi company.

On 2019, the group is reaching the presence of 33 countries worldwide for the subsidiaries and the DeLonghi itself four production sites.

The main milestones in the DeLonghi growth worldwide are connected to those acquisitions. For instance, the group registered an increase in the revenues with the purchase of Kenwood in the first place, started in 2001. The second big shock in profits was then in 2007, with the first model of *'Lattissima'* born with the Nespresso partnership.

Later, in 2011 the group became a pure player in the small domestic appliances, with the spin-off of the air conditioner *Climaveneta* and reached *a* boost in sales acquiring Braun in 2012 (Figure 2.2).

Figure 2.2 *- Brands own by the DeLonghi Group.*

Source: www.delonghigroup.com

2.1.2 GROUP IDENTITY

Each of the brand owned by DeLonghi has its unique identity.
The distinctive trait for DeLonghi itself is the reliable Italian quality and the unique design; meanwhile, for Kenwood, the main characteristics are the duration and the simple design. In their segments, the single brands could rely on a strong recognition, due to their leadership status: DeLonghi is the leader in the espresso coffee makers, Kenwood is seen as the first brand for kitchen machines in Europe and Braun has the primacy as the hand blender brand. Ariete, of course, isn't as big as the other brands, in term of awareness and market share, but is active in Italy because of the fun and young design.
However, the group decided to provide a unique group identity for all the brands all over the world. In 2016 the company renewed the mission, vision and values (Figure 2.3).

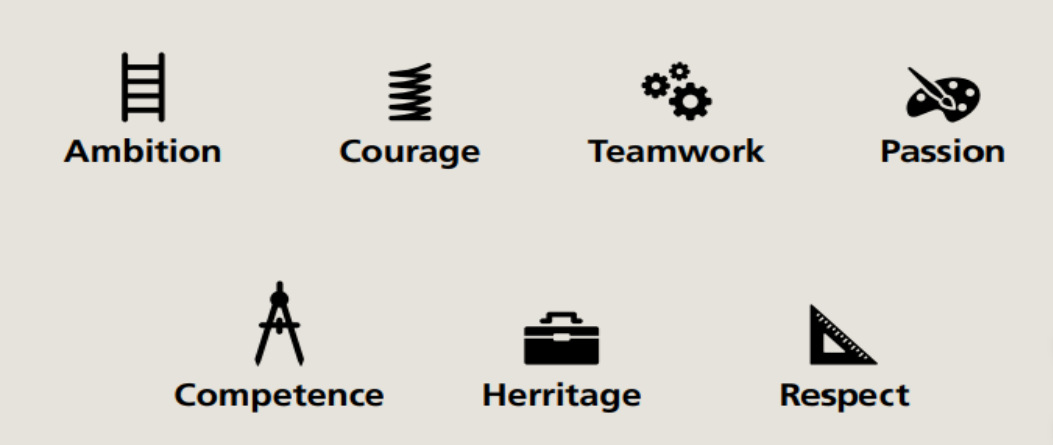
The vision
Our vision
Worldwide, Every day,
By your side
A desirable object,
An emotion,
An authentic experience,
To be lived,
To be shared
Our values - Everyday Makers
We build things that make life better
And we got really good at it
We believe in shaping the world with our hands
We are makers
"Making" to us isn't just about producing and selling products
It's about the endless dedication and drive to create
It's about people working together to make the difference
We're part of a global community that shares the same passion

We improve every day to offer unique experiences,
brick by brick, stitch by stitch, code by code
We are quality craftsmen and innovators
Feeding our knowledge with

Ambition Courage TeamWork Passion Competence Heritage Respect

We are Everyday Makers
We are the ones that make it happen

Figure 2.3 *- DeLonghi seven values.*



Source: www.delonghigroup.com

Our mission

To be a global leader in the industry of Small Domestic Appliances by developing categories, segments and geographies through a clear competitive edge generated by:
Listening to consumer diversities, a source of inspiration for superior solutions that can anticipate and influence new market trends
Building up our brands' value potential, with a

clear strategy to support all markets
Accelerating the offer of distinctive products with a strong focus on design, innovation and technology, that enables us to win the trust of today's and tomorrow's consumers
Strong growth in markets with the greatest potential, to balance our presence globally
Strong commitment to draw on the diversity and talents of our people to accomplish challenging goals through determination and passion of each and every one
Moreover
To explore expansion opportunities in related categories, with the ambition
to be a leader, leveraging the De'Longhi Group's strengths.

Our vision is to turn people's everyday into something special.
Our aim is to make each person's life a little simpler by providing innovative solutions to their domestic needs for a happier and more fulfilled life[13].

2.2 BUSINESS

The following paragraphs will be dedicated to the analysis of the group and of the single DeLonghi brand, with a focus on the geographical market and the product family. In particular, more space is dedicated to the coffee market analysis, source of the main profit for the group. Moreover, they have then listed the production plants and the principal good manufactured in each site.

[13] From: Group profile - De'Longhi Group. https://www.delonghigroup.com/en/group-profile

2.2.1 MARKETS

The revenues for the group, according to the financial statement of 2018 for the DeLonghi group, indicates that there are three principal areas for the sales: Europe, APA (Asia, Pacific, America) and MEIA (the Middle East/India/Africa). Europe has the best revenues, about 66%, with a distinction between South-West Europe and North-East Europe[14].

For the South-West market, the most crucial target countries are Germany and Italy, with some other smaller markets in the Mediterranean areas. This area doesn't have a homogeneous trend: indeed, while Germany is increasing and leading the growth, the other regions showed some slowdowns.

North-West Europe, instead, shows a growth, especially in Poland, Russia and Benelux area, composed by Belgium, Nederland and Luxemburg, which increased their acquisitions, especially for coffee machines. The UK represents the only exception to the growth.

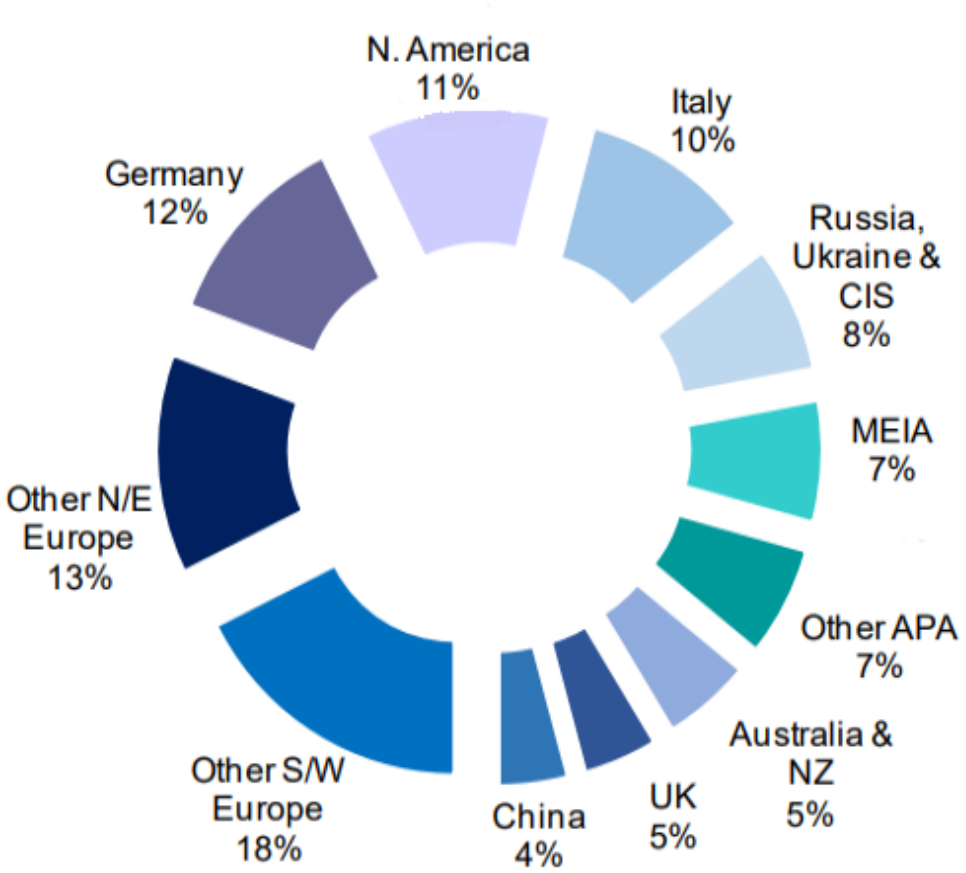
The APA market represents a fundamental growing reality for the group, with the most meaningful participation of the US, that became the second most profitable geographic area officially, after Germany, followed by the Chinese market, that increases its importance.

For what concern the MEIA area, the growth is equally spread in the countries, with a positive trend.

The Figure 2.4 represents the percentual revenues per country.

[14] Source: the sustainability report of DeLonghi group, 2018.

Figure 2.4 *- Revenues breakdown per countries, 2018.*



Source: www.delonghigroup.com

The coffee segment still guides the growth of each country. Indeed, for the group, the sales in coffee machines represent the most important business:

- Coffee makers: around 47%.
- Cooking and food preparation: 31%.
- Comfort and home care: 23%.[15]

[15] From: www.delonghigroup.com, 2018

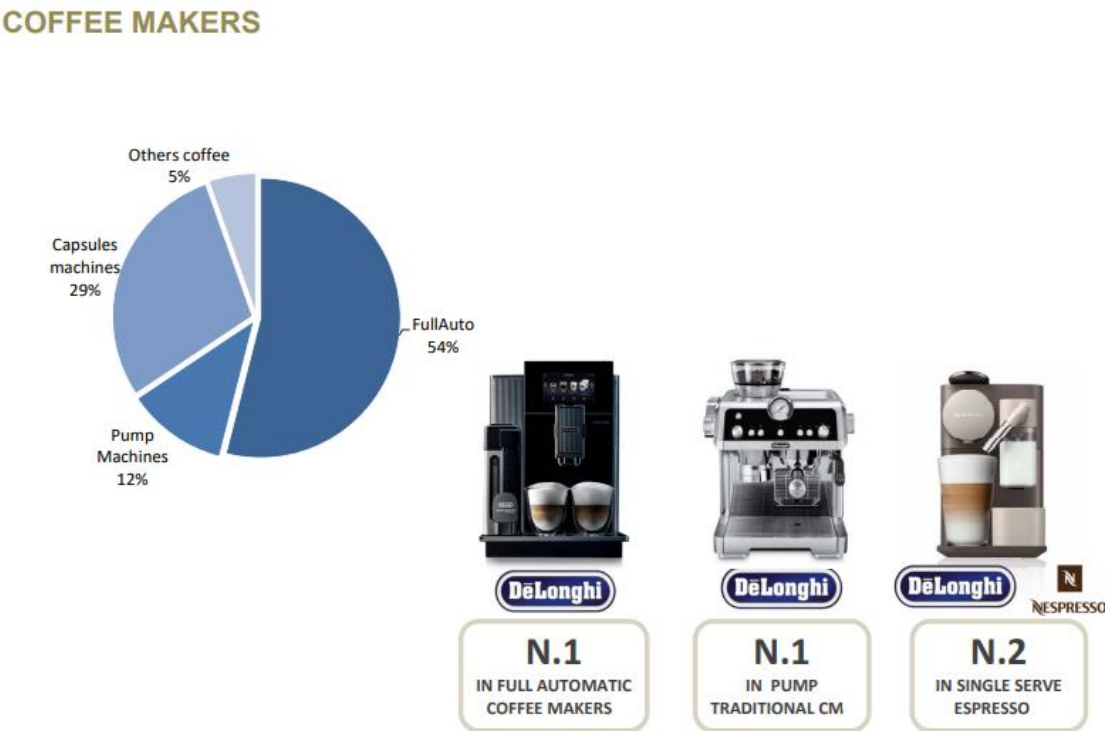
2.2.2 COFFE MACHINES

As already mentioned, the coffee machines are the most profitable field for the group. The revenues segmentations are divided, as shown in Figure 2.5, in:

- Fully automatic for 54%.
- Pump machines for 12%.
- Capsule machines for 29%.
- Others type of coffee machines for the least 5%.

For each of those categories is forecasted an increase in growth, both supported by profitable geographical areas, both because of the penetration in some unexplored markets, such as the Chinese one.

Figure 2.5 *- Revenues segmentation for product, 2017.*



Source: www.delonghigroup.com

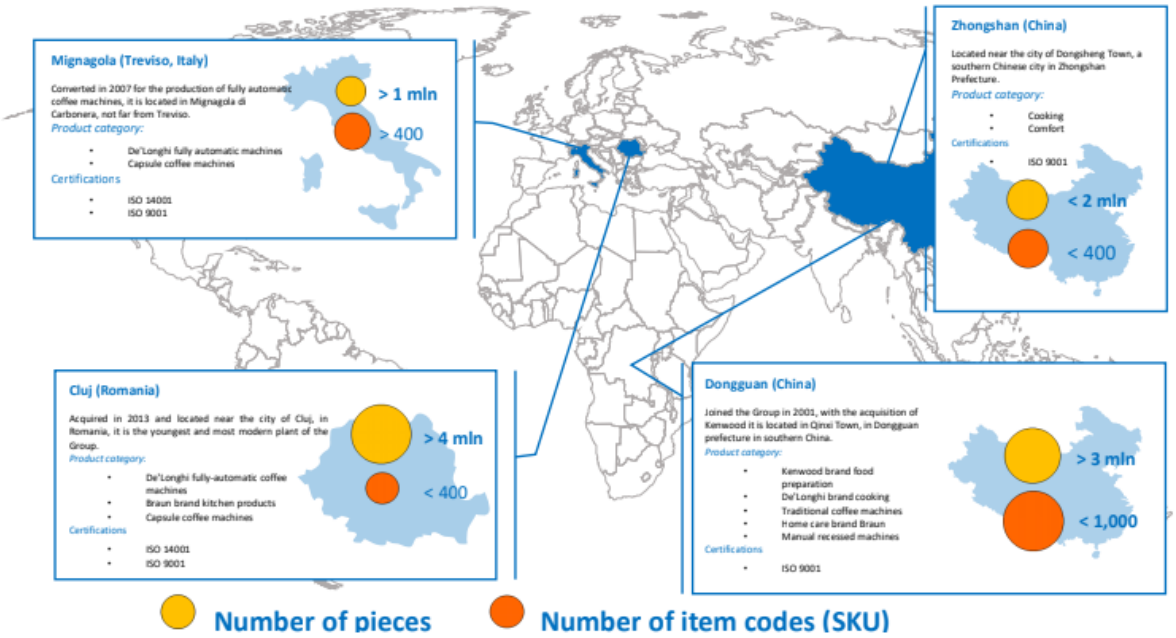
For what concern the group, the coffee machines are made almost exclusively by the DeLonghi brand. As already mentioned, there are mainly three types of devices:

- Fully automatic machines
- Capsules machines
- Pump machines

The machines reach all the different client targets, dividing the market into low, medium, high and luxury ranges.
The products are divided into the four production plants, according to the quantity requests by the market, and the capacity of the plant (Figure 2.6):

- Mignagola (Treviso, Italy).
- Cluj (Romania).
- Dongguan (China).
- Zhongshan (China).

Figure 2.6 *- the four DeLonghi production plants.*



Source: www.delonghigroup.com

The Chinese Plants, as shown in the picture, host the low and medium ranges of coffee makers, entirely the production of pump products and the capsules low range makers. In other words, the plant is characterised by a wide variety and quantity closer to mass production.
The medium and high ranges of fully automatic coffee makers are then produced by the Romanian plant, with also some high range of capsule machines. The production quantity is high, but the variety for the items is low.
For Italy, the production is almost entirely composed by fully automatic makers, from high and luxury ranges, and high fields of capsule machines. The volume is less than the other plants but has and high variability of products. The explanation for this organisational division could be the introduction of industry 4.0 in the Mignagola site.

2.3 THE ITALIAN SITE

Italy was the first site for the DeLonghi company. The first plant, burn after a massive fire in 2007, was the crib to both production and innovation in the small domestic commodities.
The first steps into the coffee preparation started in 1993 with the first Espresso coffee maker, called ‘Bar5’. In 2001 was born the first simple electric coffee maker, the Alicia model. The next step was to implement a fully automatic coffee maker. In 2004 was born the *’Magnifica’* fully automatic machine. After that DeLonghi launched the first cappuccino machine born from a partnership with Nespresso, it was 2007. From the moment until now, DeLonghi launched new devices with plenty of different functions, including the tea, hot chocolate and milk beverages. The actual site based close to Treviso, on Mignagola di Carbonera, host about 800 operators, divided into ten lines, the moulding department and other supportive departments, which could be seen in the layout of the plant (Figure 2.7).

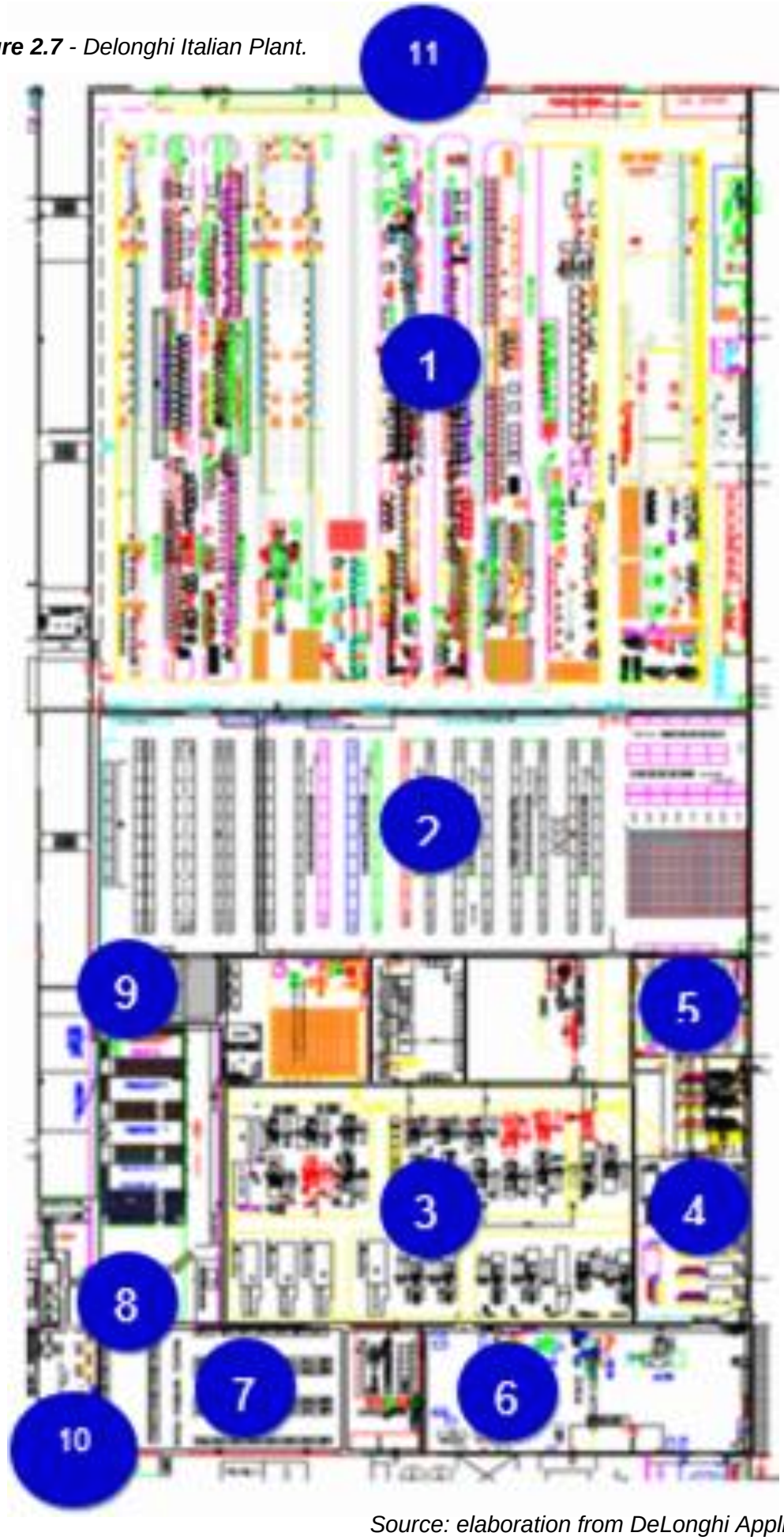
1. **Assembly department**: composed of ten lines, is the place where the value is created: the *Gemba*. The lines have their heads that face the raw material supermarket, and the tails, that are directed on the final product supermarket. On the area, there are multiple offices, such as the OEE, quality, hr and assembly area management departments.

The lines are mostly for fully automatic, two reserved for the Nespresso capsule machines and one for the built-in devices, made and designed for particular kitchen assets.

2. **Raw material supermarket**: this area is organized following the same sequence of the lines. There are different levels for the material on the shelves; the lower are for the material immediately useful for the lines. Once those are loaded on the train, the shelve is filled again with the material of the upper shelve, and so on, until the higher level. At this point, new material arrived from the temporary stock, directly from the suppliers. The supermarket is organized in order to follow the FIFO for the components.
3. **Moulding department**: in this area are installed thirty-three hydraulic moulding machines, that cover the need both for Mignagola, both for the Cluj plant. In this area, the materials are located in a temporary stock and bring to the raw material supermarket for filling the empty shelves. In order to support the activities of the area, there are some permanent quality operators and technicians.
4. **Turnery**: the turnery area hosts a small number of operators and technicians. The area aims to work the materials in order to compose the grinder. The grinder is a fundamental part of the coffee machine, because the coffee beans have to be smashed by it, and Mignagola is the only plant that produces it.
5. **Serigraph department**: in this area, it is possible to personalise the machine displays, aesthetical component and composed the logos on coffee makers.
6. **Tool department**: the moulding machines shape the hot plastic granule with a system of complex moulds. In this department, there is the creation of new moulds, the modification of them, the assistance and the maintenance and the problems studying, even for foreign companies.
7. **Granule stock**: in this location are stored the plastic granule pallets. There is also a complex system that brings to the moulds the materials.
8. **Receiving material office**: this office has the responsibility to accept the material from the suppliers and located it in temporary stocks, according to the material's characteristics and the heaviness of them. A critical job for the operators is to discharge the trucks and manage the materials as soon as possible, avoiding the creation of a queue.

9. **CQ department**: the incoming controlling quality department stops some materials located on the temporary stock and analyses the content. The aim is to guarantee through a sample inspection, the quality of supplier materials for the lines.
10. **Maintenance office:** in this office, the maintenance men work in order to fix and prevent problems in all the plant areas.
11. **Finished product stock:** the finished product exiting the line, goes into this logistical area, that for its complexity and dimension is independently managed from the other stock areas.

Figure 2.7 *- Delonghi Italian Plant.*



Source: elaboration from DeLonghi Appliances s.r.l

CHAPTER THREE

3.1 DELONGHI PRODUCTION SYSTEM

This chapter is going to explore the DLPS model, with all its sections and categories. The elements that compose the model are four: the Base, two pillars and the Top.
The analysis starts from the **base**, in which all the main areas bring stability to each project, sustaining the system and the lean transformation activities. At first, DeLonghi started with implementing those activities, also with external consultants help, following a long-term improvement project. These activities aim to spread the necessary knowledge not only to the operators but also to all members of the organisational pyramid, including the managers. The principles at first taught and then implemented had the aim to commit the operators with the continuous improvement values and with the lean philosophy, knowledges that are fundamental for sustaining the system. The activities on the base are:

- 5S.
- Standards.
- Total Quality Management (TQM).
- Total Productive Maintenance (TPM).
- Methodology.

After the base, the next steps are to explore the pillars. Indeed, the second part of this chapter is dedicated to the **first pillar** and the third to the **second pillar**. Into the pillars are included all the activities or methods that are the natural consequence of the base element implementation. The idea, here, was to consider the base elements like input and the pillar as the sum of methods and instruments able to transform and elaborate them, in order to reach the objectives present on the top, or in other words, turning them into output.
The first pillar is about traditional lean techniques and related activities, implemented on Mignagola plant.

For the methods, the explored areas are:

- The Excellent Centres model.
- Single Minute Exchange of Die (SMED).
- Just in Time (JIT).
- *Heijunka* and balancing.
- *Jidoka.*

As explained earlier, this pillar is taken very seriously by the management, that works for transforming the old and traditional lines, into new e flexible ones, closer to the Japanese philosophy and standardised to each other. The actions for changing the lines into 4.0 industry lines were started earlier than 5S. The actual situation in the DeLonghi site is almost a total conversion of every line, except for the last line that will be converted in 2020. The section dedicated to this pillar will be general and shorter. Indeed, the period spent in Mignagola plant was more focused on making progress for the evolution of the second pillar.

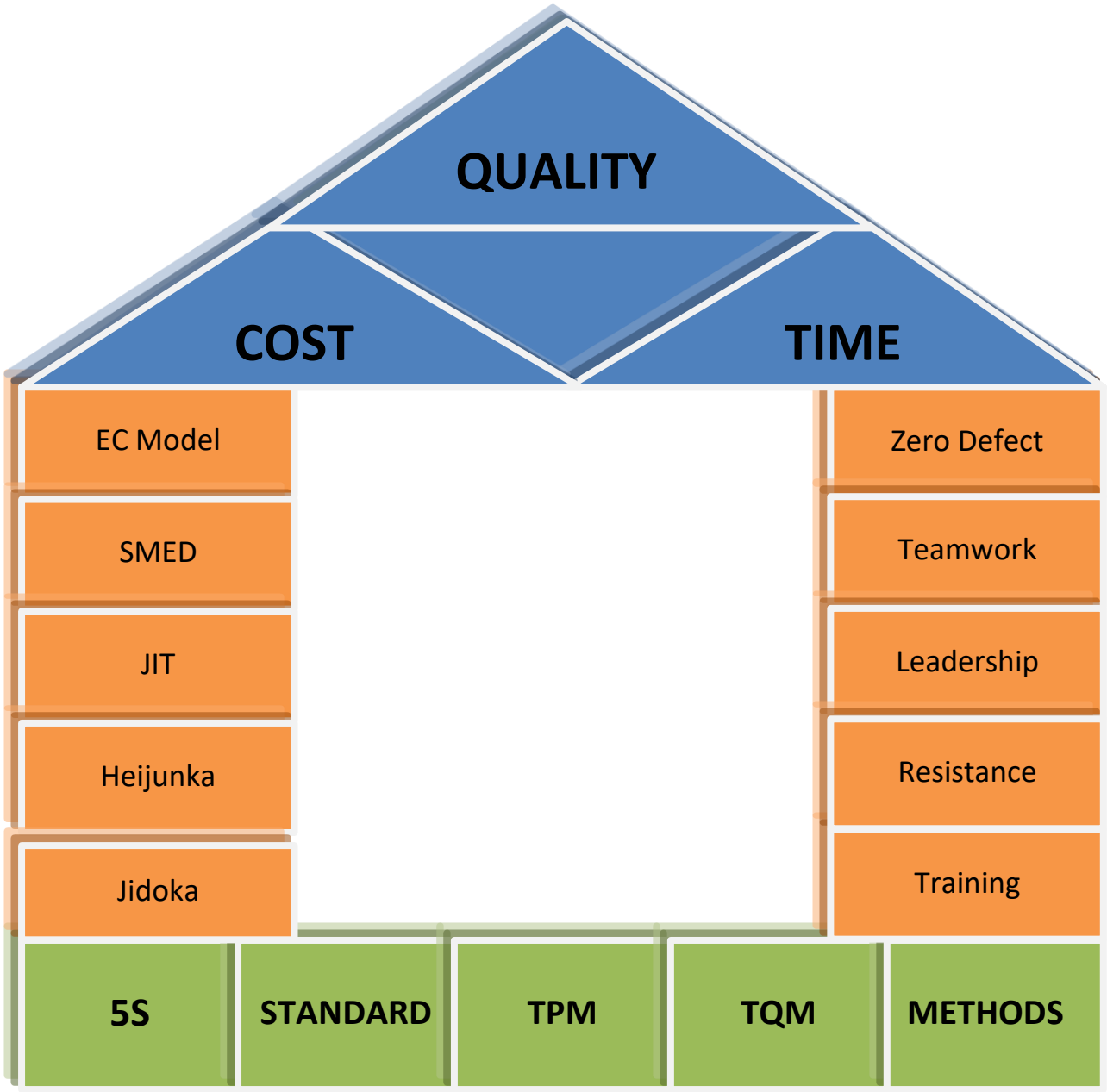
For this pillar, there are, in general, associated more difficulties due to the high number of projects that involves the operators. They have to learn a new way of doing their job, and the changing process needs more time for being implemented.

The main points explored for the second pillar are:

- Zero defect.
- Teamwork.
- Leadership.
- Resistance.
- Training.

For the pyramid **top**, there are the typical three overall objectives: quality, cost and delivery time (QCT). Those are vital outputs and the particularity is that are measurable, so evident. However, it’s not an immediate and easy calculation. The fourth section of the chapter will disclose these elements briefly with an indication of the expectations and also some data in order to support the conclusion. The DLPS could be seen in the following figure (Figure 3.1).

Figure 3.1 *- The DLPS*



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Source: free elaboration.

3.2 BASE

With this section, the work is going to explore the base elements in detail. In literature, and so in Mignagola plant, the **5s** is maybe the most important value that the management wants to communicate, because of the hygiene strict quality gates that a food-contact machine needs to pass by. Moreover, there is also the need to include another S in the system, **Security.**

The **standards** are fundamental for the system, which complexity constantly demands rules and, consequently, control in order to be sustained correctly. The standards are useful not only for identifying which are the good practices from the dangerous ones but also, in some cases, for guarantee to the people security. The standard is also seen as the method to which an improvement action is fixed and become the future starting point for the improvement.

The **methodology** is the sum of all the instruments and the knowledge that is used each time a project or an improvement action are started. In this category, there are project management tools not patented by the group, but generical ones, such as the PDCA or Gantt analysis. The particularity is that those instruments are used daily, such as a standardised way to face problems. Indeed, as a part of planning, the methodology is a fundamental part of the DeLonghi Production System, also due to the ability to evaluate risks and investments.

The **Total Productive Maintenance** (TPM) is an operation scheduling in order to keep the machines in a state of well-performing and safety performances. In literature, also shared with the DeLonghi Group idea, is to convert the majority of operations from unplanned to planned. The underlying assumptions when a new project starts are that the other involved elements work at least sufficiently. This condition allows the improvements because the starting point is stable enough to sustain the change, without maintenance, the development couldn't be applicable.

The least, **Total Quality Management** (TQM)**,** is essential in a food-contact society such as DeLonghi, for the strict hygienic rules to which it must submit, and for the quality standard that makes the company the sector leader. The quality management includes multiple controls, both for the finished products, both for the incoming materials. Sustain the quality process is one of the most severe management objectives.

3.2.1 5S IN DELONGHI

The 5s is both an instrument and a methodology. The common aim is the implementation of cleaning and order on the Mignagola production site. First of all, DeLonghi asked for the intervention of expert consultancy society '*Kaizen Institute'* for what concern the lines and other critical areas. The productive lines interested in the process were EC01, A133, EC04, EC05, A132, EC09[16]. Each of the different centres generally had various necessities. Taking the assembly area elements, for instance, the ECs needed mostly a total reorganisation of space. Those are modern product lines, the heredity of the industry 4.0. The necessity of space organisation is due to the flexibility that characterised the daily multi-production. For the A133, one of the survival most extended lines, and for A132, one of Nespresso dedicated line, the primary necessity was the cleaning and the order. For the latest, the secondary aim was also to compare the 5S progressions concerning the complementary twin line, in order to understand how the implementation and the investment activities were processing.

3.2.1.1 KAIZEN INSTITUTE WORKSHOP

The lines were involved in 4 workshop days, at the end of June, and then, for the other areas where the 5S were implemented, the training was comprehensive of one day. The interested sectors were the supermarket and the moulding area. Here the significant necessities were the cleaning and the order, besides providing to the operators a powerful instrument to express their thoughts.

For the first day, the team lean with the management and *Kaizen institute* decided to block all the lines and held a workshop, or the so-called '*cantiere*'. For this event, the operators joined the consultants and the lean office in a dedicated section of the plant. The aim of the days was, generally, mainly the transmission of the Kaizen philosophy to both the operators and the team leaders, and also the implementation of cleaning and order principles on the workplace. The objective, indeed, was not having the line sorted for just a few days, but the input was to standardise the methodology and the order each day, every day. The idea, also nowadays, is that mentality and knowledge could sustain better the improvement, instead of mere rules and standards. Besides

[16] EC stands for excellent centre, and is the way in which the new lines are named.

the first training part, more theoretical, the workshop represents a practical and authentical application moment about the 5S philosophy: sort, straighten and shine (Figure 3.2).

The first S, **Sorting,** was about dividing the used materials from the useless ones. The line was utterly undressed of unnecessary elements, and those were later taken away from the work spots.

The second S, **Strengthen**, means to reorganise the spot, according to the necessity and the physical constraints. The instruments and materials were arranged in importance and frequency of usage, but also according to how the operator needs to hold in hands the elements, with which hand, and the facility of movements.

With the third S, **Shine**, the operators are expected to clean the area. Everyone was engaged in the wiping of their spot with degreasers and rags.

Figure 3.2 - The 5S workshop on the line.

Source: DeLonghi appliances s.r.l

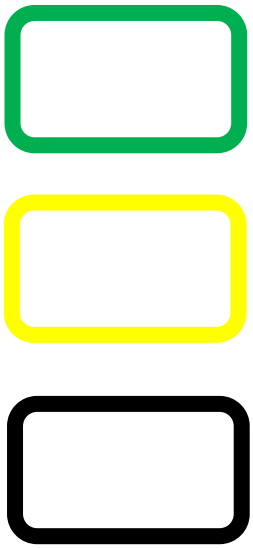
The next step was the **standardisation** of the positions. The fourth S was applied and has been decided for each material a specific place, even for the physical structures. In order to delimitate the areas, adhesive tape in different colours and plastic boxes was used (Table 3.1):

- Green carpet (or tape): incoming materials.
- Yellow carpet (or tape): structures and supportive materials
- Blue carpet (or tape): outcoming finished goods.
- Red carpet (or tape): wastes and defects.

Table 3.1 *- Standard colours.*

STANDARD IDENTIFICAZIONE AREE PER FLUSSO MATERIALE O STRUTTURE

SCHEMA AREA	DESCRIZIONE AREA	NOTE
	**TAPPETO** GRIGIO BORDO VERDE: MATERIALE SU PALLET IN INGRESSO	DOVE SI USANO PALLET
	**TAPPETO** GRIGIO BORDO GIALLO: PALLET VUOTI E CARTONI IMBALLO	DOVE SI USANO PALLET
	**TAPPETO** GRIGIO BORDO BLU: MATERIALE IN USCITA (PRODOTTO FINITO O STG FINITO)	DOVE SI USANO PALLET
	**TAPPETO** GRIGIO BORDO ROSSO: MATERIALE SCARTO	DOVE SI USANO PALLET

	**NASTRO** VERDE: MATERIALE IN INGRESSO **NASTRO** GIALLO: MATERIALE LAVORAZIONE O STRUTTURE/ATTREZZATURE **NASTRO** NERO: AREA RIFIUTI, BIDONI RIFIUTI, ECC.	

Source: DeLonghi Appliances s.r.l

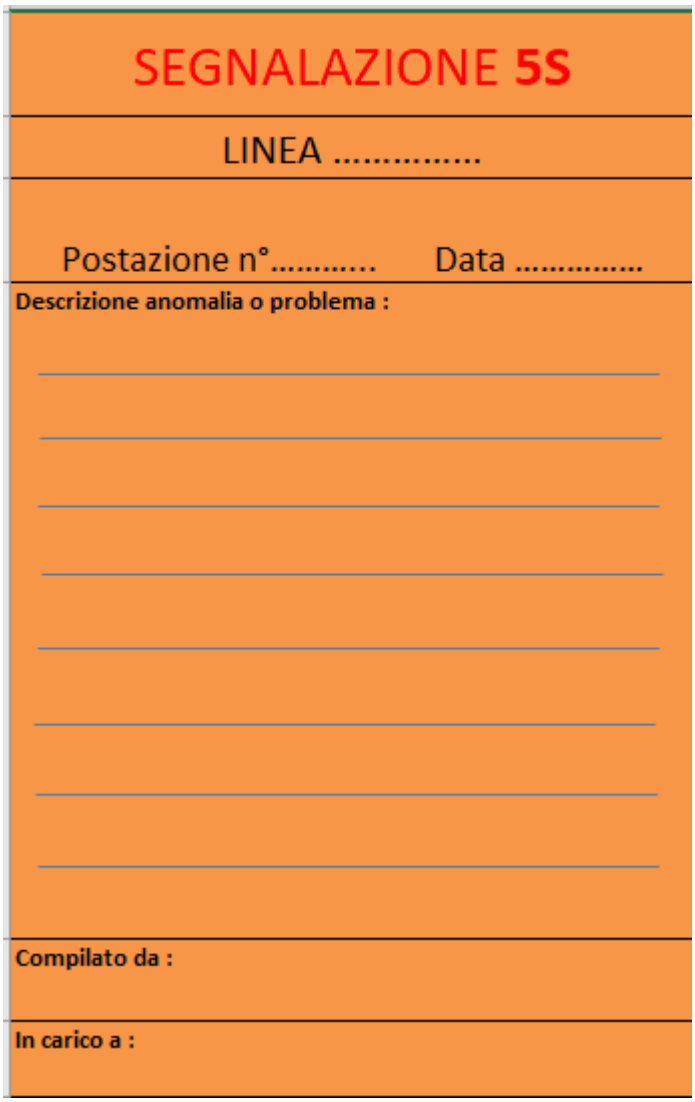
3.2.1.2 SUSTAIN THE 5S: ESCALATION MEETING

Then for the last S, **sustain**, was implemented a system of problem signalisation. If the operators are facing a problem could use the 5S ticket (Figure 3.3) in order to let every interested person know about it. Then, once a week, a team of stakeholder reads the signalisation and tries to provide solutions in a meeting called **Escalation**. The meeting is held once per week and lasts about 15 minutes. The stakeholders are from different departments and with different responsibilities and knowhow. The 'essential' team includes fixed actors and people on-call that are convocated right away only if there are some problems related to their fields. Mainly the fixed participants are from the supermarket department, the team leaders, the quality, maintenance, lean team and PPE (production process engineering). The signalisations are mostly related to order and cleaning, the methodology, small and vital maintenance, and sometimes about security on work, standard requirements or ergonomic needs. The request is read in front of everyone at the meeting, and, at that moment, the responsibility is passed to the person most capable of taking care of the solution. For some requests, mainly about the cleaning, order, and small maintenance, the management dispones of a well-trained operator who could help in this sense, the so-called '*Officina Kaizen'* operator. For what concerns other problems, to which sometimes there is not an easy solution, the team lean could proceed to an analysis

of the actual situation and open a dedicated project in order to resolve the request. Sometimes, the most crucial action is pulling the problem through the stakeholders, transforming the request into one of the actor's major priority and connecting people into each other, fighting back the communication problem (more about it on the Resistance paragraph).

The tickets are put in front of each line, on the board, in particular pockets. From the very first moment is asked to the operators to use the instrument as a method to express their voice. The pockets are defined by a title and a dedicated instruction paper.

Figure 3.3 *- 5S Ticket.*



Source: DeLonghi Appliances s.r.l

The operators, or the person who wants to open a point, pick an empty signalisation, in the pocket **EMPTY**, and write down the date, the place, his/her name and the problem, then put the paper in the **NEW** pocket. When the Escalation meeting arrives, the team leader picks the new signalisation, read it, and once it is defined the responsible and wrote down in the paper, the signalisation is moved again in the next pocket. At this point, if the team leader could take action, the pocket is called **TEAM LEADER ESCALATION,** and if the work is taken by someone else, the pocket is called **ON ESCALATION**, that means that someone, external to the line, is taking care of the request. On the next meeting, the open points are read again, and then the different progress made are explained. Sometimes the action requires a week; sometimes, it takes more because the problem involves multiple departments or externals. The paper is reread each week until it is not closed or decided that it is impossible to solve, and then moved into the last pocket, **CLOSED**. Instead, if the problem is not a priority and something else occurs, it is moved back to NEW and opened again when possible. The cancelled points are however explained to the operators that write it down in order to provide an answer in any case. The importance of 5S in Mignagola site could be explained by the guarantee that characterised its production. Indeed, DeLonghi is the leader in the coffee makers market. The aims of the company are provided guaranteed quality to the clients and consequentially, to be a synonym of excellence. In order to keep the asked quality by the market, and so the market supremacy, the cleaning and order are well encouraged by the leadership: a clean work spot reduces mistakes and saves times.

Moreover, in this way, it’s easier to detect missing components from the BOM (bill of materials). Sometimes, indeed, those elements, could be forgotten and not installed, but most importantly, some of those human mistakes aren’t always detected by the quality gates. These are, for instance, accessories, instruction books and not tracked components.

Furthermore, the machines are food-contact. Food-contact means that on the line, there are multiple spots in which the operators work with high hygiene components, the one that allows the final user to drink the coffee. Those include parts that are directly in contact with water, hydraulic and milk system, coffee circuit and coffee beans.

For these elements, the rules are stringent. With the 5S, it's possible to see immediately find out if the standards and regulations are respected by only walking through the line.

3.2.2 STANDARDS

The standard represents a correct model on which basing the actions. In a company, standards are rules and codes made with the intent to bring mostly safety and control. The aim is ensuring guarantee for both the operators and final clients.
The standard in a multinational company as DeLonghi is fundamental. With these, it is possible to immediately find out if the people are doing a correct job. There are three principle concepts when it comes to standard:

1. Standard
2. Standardisation
3. Standard work

3.2.2.1 STANDARD CHARACTERISTICS

A good standard has to include some characteristics. The standards have to be:

- **Specific:** not based on opinions.
- **Respected:** because if no one follows them means that are not right.
- **Known:** so documented and shared so people could follow them.[17]

All those three characteristics have to be present in a standard creation. In order to understand if the standard is specific, respected and known, a short analysis could be made, by only asking four questions about the standard usage.

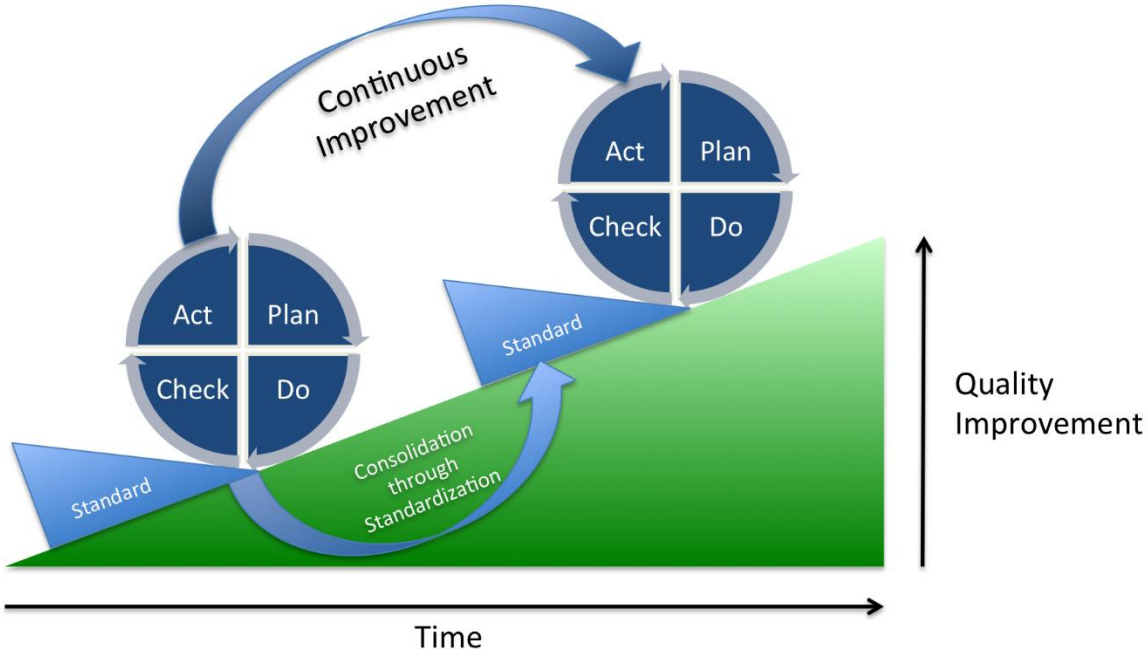
1. Is there any standard? Yes/No
2. Is the standard recent? Yes/No
3. Is the standard known? Yes/No

[17] Matteo Bianchi and Fabrizio Bianchi, 2012.

4. Is the standard respected? Yes/No

Only in case of all four affirmative answers, then the standard could be considered valid, otherwise, through the negative responses, either the standards or the operator approaches have to be changed.
The standard is necessary because it ‘blocks’ the improvement progress through the time (Figure 3.4).

Figure 3.4 *- The standard as a 'block' for the improvement.*



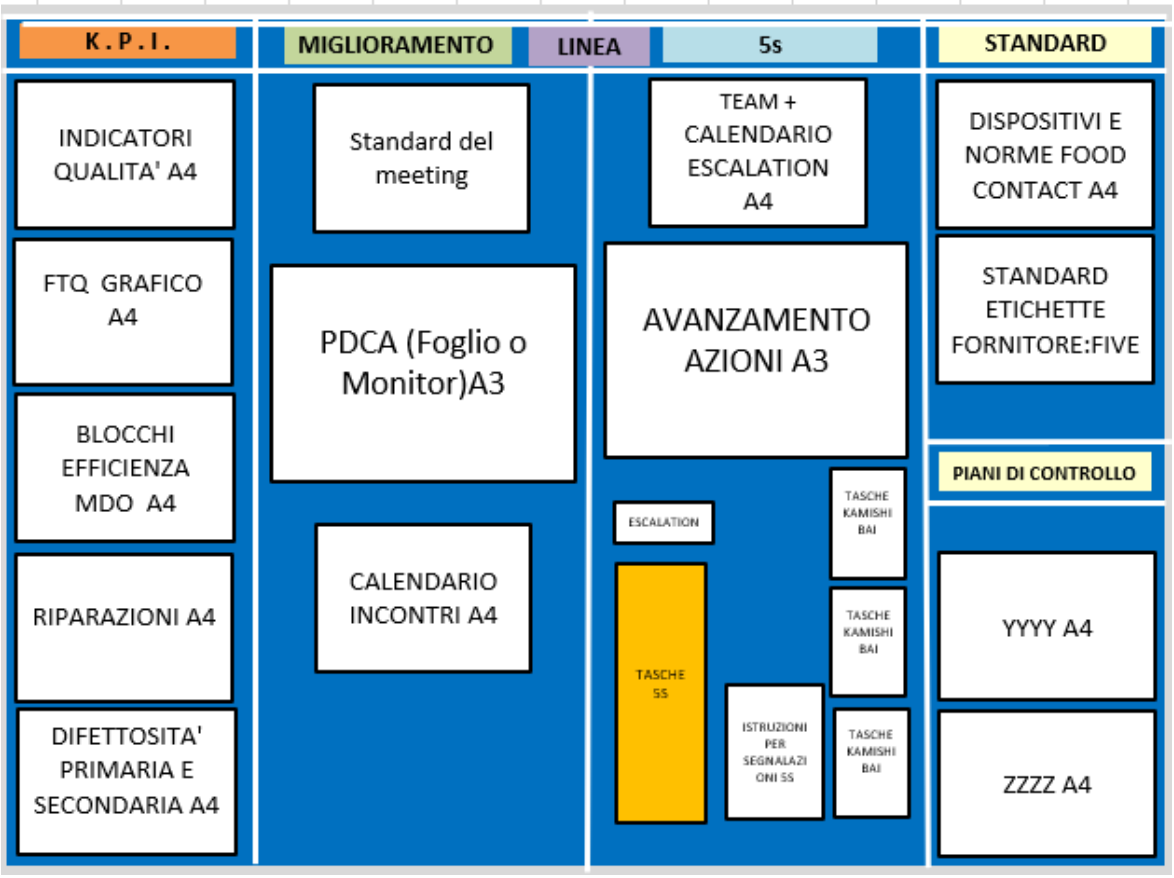
Source: Wikipedia

3.2.2.1.1 THE STANDARD BOARD

In DeLonghi, the standard is a fundamental instrument. There are, indeed, multiple examples of the standards. One of them is the board, as shown in the following figure (Figure 3.5).
The board is fundamental for the 5S activities. It represents the physical space in which the new, in escalation and the closed ones, are located. On the board, there is also other vital information about the specific line.

The board is divided into four sections. Each of them is labelled with a title, and the elements are sorted by topic.

Figure 3.5 *- The DeLonghi board.*



Source: DeLonghi Appliances s.r.l

The first column is about the KPI. The Key Performance Indicators are performance target set mainly by the quality department. One of the main documents attached to the board is the KPI identification for each macro machine families. The KPIs are about FTQ (first-time quality), primary defects and secondary defects, imputable or not imputable. The FTQ rate is the percentual value of how many machines come out from the line without reparation or fixing labour hours added. The rate has to be high, generally about 98% or 99%.

The defects are then divided into first and secondary defects. For the first type, means that the mistake is grave, and the machine doesn't even turn on. For instance, in some

case is a missing component, in other examples could be a defection, such as some problems with the circuit board and electrical connections.

A secondary, instead, is an aesthetic defect or a less important one. For instance, could be a scratch in the machine or boxes. A missing accessory is a secondary, but a lost instruction book is a primary error because the user, theoretically, can't even turn the machine on without it. Each of these defect categories is split into imputable or not imputable. Imputable stands for 'due to the line', so the defect responsibility is on the line. Not imputable is instead due to other factors, such as the supplier, the transportation or moulding disservice.

With the paper with all this indication, are also attached to the actual FTQ of the line per days, weeks, months and year.

The second column is about improvement. In this area, the meeting schedule and attendance name are attached. Then there is the PDCA[18] (Figure 3.6). The PDCA, or also noted as Deming cycle, is a method used for taking tracks not only of the progress of a solution but also such as historical memory of a problem. For instance, if a problem occurred every time a particular model is built, with the PDCA, this connection is easier to detect, and, of course, decide which solution to adopt is faster.

Figure 3.6 - *PDCA.*

DeLonghi

PIANO DI MIGLIORAMENTO

Rev. Doc. : 01

02/08/2019

Piano delle azioni per la risoluzione dei problemi ed il miglioramento continuo.

REPARTO STAMPAGGIO **MESE** **AGOSTO 2019**

Compilazione a cura di: Animatore del team
Quando : al fast
Da compilare sempre per l'efficacia delle attività!
Causale : indicazione sintetica dell'origine dei problemi
(L=Linea/STG=sottogruppi interni/I=causa interna per es. stampaggio/E=causa esterna)

Data in cui si decide | Data in cui si fa | Data in cui lo STD creato è fissato | Data in cui si verifica l'azione

PLAN DO CHECK ACT

NUM	ANOMALIA	CAUSALE	CAUSA IPOTIZZATA	AZIONE CORRETTIVA	CHI	FINE PREV	P	D	C	A
1	Area sosta centraline in disordine e senza chiara identificazione delle centraline in manutenzione e manutentate.	I	Area non organizzata.	Sistemare e organizzare l'area.Rendere visual le centraline manutentate e da manutentare.	I.Piovesan/A.Quarato	wk 32	24-lug			
2	Luogo di ritrovo del fast su passaggio carrelli elevatori	I	Area di ritrovo piccola.	Rivedere la posizione del tabellone e posizionare transenna per dividere l area dal passaggio dei carrelli.	I.Piovesan/A.Quarato	wk 32	24-lug			
3	Processo di stampaggio innesto en 650 non costante	I	Centralina compressore bauer da controllare	Mandare in manutenzione la centralina durante un fermo produttivo di 2 settimane.	S.Veneruzzo/F.Poggiolini/ L.Bergamin	wk 35	24-lug			
4	Su P 87/4 e P 85/2 ci sono sempre tubazioni dell aria compressa posizionati alla rinfusa.	I	Mancano tubazioni fisse aria compressa su P 87/4 e P 85/2	Tubazioni da implementare.	F.Poggiolini	wk 32	24-lug			
5	Sbiancatura su caraffa ecam (impronta C2)	I	Accumulo di gas in fase di stampaggio su zona superiore	Si richiede sistemazione dello stampo(RSS)	Vanio Fasan	wk 32	01-ago			
6	Pannello fondo en560 con bava su impronta C2 e perdite d'acqua continue	I	Fori inserimento canne dell'acqua da allargare e pulizia generale dello stampo	Si richiede sistemazione dello stampo per pulizie varie (RSS)	Vanio Fasan	wk 32	01-ago			
7	Rientri utenza per sbiancatura su rottura materozza del telaio sinistro ECAM su zona anteriore inserimento vaschetta	I	Punto iniezione da spostare piu avanti	Rivisto modello dello stampo e modifica del punto di iniezione piu internamente	Vanio Fasan	wk 34	01-ago			

Source: DeLonghi Appliances s.r.l

[18] PDCA is a acronym that stands for Plan, Do, Check and Act. The cyrcle represents a scientific approach to the problem, studied by W. Edwards Deming.

The problems tracked by the instrument are mainly the ones related to the quality. The paper is composed of multiple sections. The first one is for the anomaly description, so the problem without any assumption, then there is the space for the problem responsible, that could be internal or external of the line. The next section is dedicated to the hypothetical fault, and in this sense, the assumption is required. The final section is for the action to implement in order to resolve the situation. Could be a simple action, such as talking with the supplier, or more prolonged work. The PDCA then is characterised by the timing of the resolution.

The first P, **plan,** is about taking care of the problem, understanding and studying it; the development happens, instead, in the second phase, **do,** in which some solutions are adopted.

Successively, with the **check**, there is the analysis of the applied actions and the last step, the **act**, finally means that the problem is resolved, through the punctual application of the former activities.

In the paper, the dates are written for each PDCA section, in order to keep track of the solution.

The third section on the board is the 5S; the column includes the pockets (already explained in section 3.2.1.2), the meeting attendance names and the schedule.

The fourth section is about the standards and control plans. In this column, there are some standards, including the elements disposal on the standard board, and the control plans for the audits. In this way, the board is used with the right purpose, without any extra unauthorised adding.

The boards are also standardised for shape, dimension and colour. Each section has a precise wideness, title and font, so they are identified univocally such as the meeting point and the information point of each line.

The communication of this standard was made in 5S days, and all the primary users are informed about how to use the different sections.

Other examples of a standard in the plant are the pallet measure, that has to fit precisely the spot in the supermarket, the train’s wagons, the trash bins and so on.

3.2.2.2 STANDARDISATION

With the term standardisation, it is included each action, adaptation, monitoring and improvements made on the actual standard. Standardisation is also the fourth S and has the aim to establish what is created with the first third S: sort, straighten and shine works. The standardisation is essential because it could also be measured the improvement in an objectively way.

A critical characteristic of standards is their need for modification and renew. A standard might have to be replaced with a new, most complete one. The standardisation, consequentially, is a fundamental process of modifying the old standard with the most recent version.

An example of the changing standard is the train's wagons. In order to take a managerial decision, there was an in-depth analysis of the dimension of a specific train' wagon, the last one of the passengers. The wagons were two per line, for ten lines of production, and the analysis showed that all twenty wagons were different between each other for every dimension. The idea then was to standardise not only the last wagons, but also all the trains, and to prevent people from adding or removing something aside from the standardised cart. The modifications are asked then through the signalisation 5S, and the new standard has to be adapted for all the wagons. The most important aspect of this example is how the consent, habit, and arrangements can't be allowed anymore in a significant company as DeLonghi; on the contrary, a new standard has to be shared, agreed with the most important stakeholders and modify only with an improvement purpose.

3.2.2.3 STANDARD WORK

The standard work is the sum of all the work procedures, the methods and the process for the best job approach. It comes from a scientific analysis of the work content and could be modified if there is a better standard. In this way, each person could work safely and avoid a lot of mistakes. For instance, on the lines, there are the so-called '*Dime di Lavoro'*, that works such as a template. The material that is moved through the line goes in one of these templates in which is well kept, and the operator works consciously about the piece position. By using standard work tools, it is also possible to add to the line new operators because the template has the same function as a *Poka-Yoke*. Consequentially, there is only a way to hold or assemble the piece

correctly, and the work could be more accessible because it is learned easier and quicker. The immediate benefits are the quality improvement, because of the errors reducing, and the flexibility, which is a fundamental characteristic for the short ECs line of production. However, the sharing part is necessary also for the new operators. DeLonghi uses multiple techniques in order to share information, explained in more details on the training section.

The sum of all three standard methods makes it possible to reach the objective of the DLPS, that are: more quality, less cost and minimum time used for delivery. The respect for all procedures has reliable diagnostical power. If an instrument is out of the designed spot, it is immediately evident to anyone. In this sense, the signalisation 5S and the PDCA are fundamental instruments for keeping tidy the work spot. The signalisation could also be used for changing a standard. The operators are the first value resource, and they know best which kind of modifications could be made in their position, both in the instrumentations, then in the process.

3.2.3 QUALITY IN DELONGHI

Quality performance for DeLonghi is the most crucial aim. For this purpose, there are different operative practices that the company strictly follows. The paragraphs explain the overall quality flow, starting with the raw material analysis, made by the quality control department, proceeding on the assembly line with multiple actors and ending with the after-sales controls.

3.2.3.1 QUALITY CONTROL

The Quality Control (CQ) department represents the first quality gate in DeLonghi. This department has as objective the incoming control of the materials from external suppliers. From a material delivering, the QC stops a sample of incoming raw material, generally one pallet per delivering. They proceed to run some tests about the components, both functional and aesthetical, and once the test provides positive results, they unlock the components, and those could be stored and then used. If the tests indicated some problems, the entire party is blocked, and the suppliers are immediately contacted.

At the same time, the moulding department stamps pieces and materials. Also, in that case, the quality is present in order to assist the production. The right functioning and stamps of the materials for this department are hard to control, even using the sample tests, due to the massive quantity of elements produced. Indeed, the control is mostly done by the operators, to which the training for the identification of defects is fundamental. In this area, it's planned in the immediate future to build a specific area for the aesthetical comparison, in order to understand faster and more efficiently if there are some problems with dies or the moulding machines.

Sometimes could happen that defect materials arrived on the lines, and only in the assembly moment, the operators recognise the defection. In that case, the elements are isolated, and more analysis are conducted in order to understand the right procedure, based on the number of defective products and which is the supplier of the critical party. For what concern the external suppliers, the defection is accepted with a certain percentage, the is around 3-4% of the total pieces in the batch.

When a problem occurs, and the issue is discovered after a while, the entire batch of raw materials is quarantined for future tests, and in some specific critical cases, the drastic solution is also applied on the batch of finite products, because the defects could be already installed on some machines.

3.2.3.2 QUALITY ON THE ASSEMBLY LINE

On the line, rules the *Muda* elimination principles. In this case, for the operators, is forbidden to make sorting on the line, so if there are some defected products, the interventions have to be in a different moment.

However, the deficiencies couldn't always be attributed on the defection of raw materials but also for the installation of a component in the right machines, especially for those elements that not only have the same function, but that are similar to each other.

3.2.3.2.1 TRACEABILITY

For how the lines are built, it's a daily situation to change the model of finite products, even multiple times per day. The switching batch could regard completely different family models or the same product but directed to a different country. The human error is still possible nowadays, even with *Poka-Yoke* systems and sample quality controls, and the operators are well trained to stay focused on the batch changing. Regarding this problem, the **traceability** is the most effective damages control for the production. With traceability, there are two essential pieces of information:

- Which kind of product it is.
- From which supplier comes the products.

For keeping the products tracked, DeLonghi uses **univocal codes** for both the identification of suppliers, both for the products. The operators have, at this point, few possibilities of taking from the wrong boxes the component. For some pieces, there is also digital traceability, that uses a QR-Code that block the line in cases of the wrong element. However, there are still daily problems due to the failed traceability.
For instance, the international card is very different compared to the Chinese one, not only in physical characteristics but also for the voltage required and other technicalities. The cards, however, are very easy to confuse. Moreover, the boxes are recycled and could happen that for a box, there are multiple codes on it because the old one isn't removed correctly. Another possible situation is that a component is removed from its box and bring on the line without codes.
One example of loss in traceability, for instance, was the case of plugs. The plugs were delivered to the company in heavy boxes, that weight a lot more over the permitted standard, for security and ergonomically reasons. Here there was a trade-off choice: brings the boxes on the line, with security risks, or lost the traceability and brought only the needed plug without the boxes. For a while, the chosen solution was to keep the traceability, using more attention during transportation from the supermarket to the line, but at the same time, the suppliers were contacted and a reduction of box dimension, and so pugs number, was asked.

3.2.3.2.2 QUALITY TESTS

Another quality institution is the process quality. This position is about the standard analysis and the identification of improvement, and also the best practice application. There are then some quality gates. On the new lines, the first quality gate is the electrical test, in which the machines are tested in all the electrical connection and water circuit. In particular, the examined elements are:

- The right hydraulic connection.
- The right electrical connections on the main card.
- The correct installation of each subgroup components.
- The O-ring tightness with elevated pressures.

The second test, equally important, is the aesthetical one. Here the expert operators observe the machines and research small external imperfections.

At the same time, in a position external to the lines, there is another quality check. With the term EOL, the acronym of ‘End of Line’ is indicated a quality operator that took from the line a machine as a sample, with a frequency of about 1,2% (Figure 3.7). The operator proceeds with more detailed tests, using coffee and milk, and using all the machines preparations.

Figure 3.7 *- A quality operator performing the End Of Line analysis.*

Source: DeLonghi Appliances s.r.l

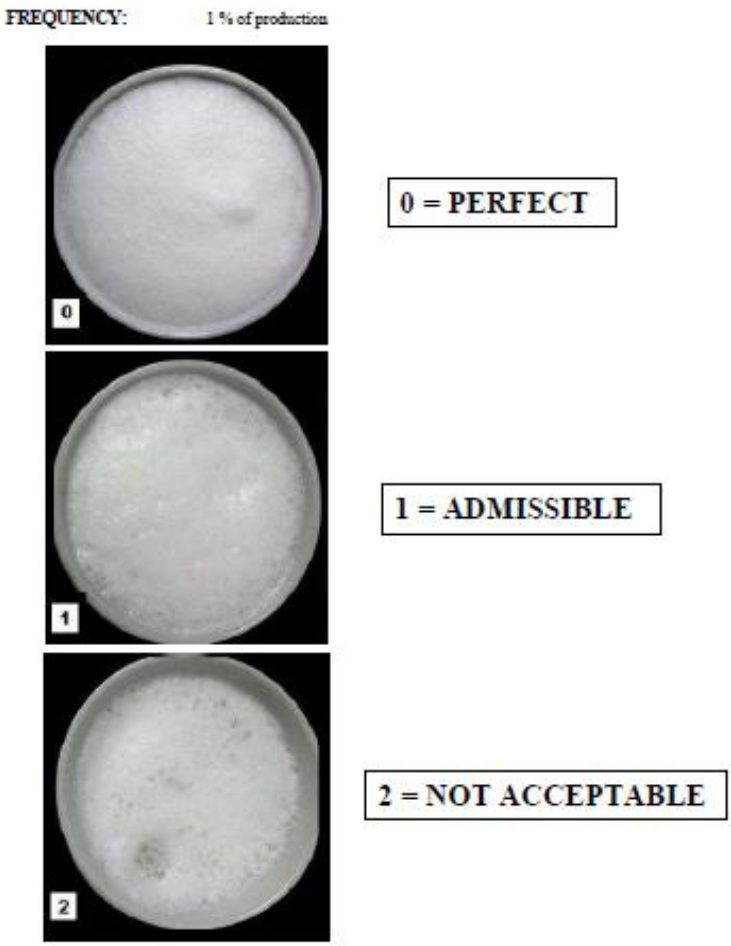
While they run the test, aesthetical controls are made, then with the coffee, they took temperatures, timing, quantity and other indicators asked on a checklist. External entities run those tests independently, in order to define the best machine on the market. DeLonghi always keeps tracks about those requests, that each year grow in importance and have to be added on the checklist and quality parameters.

One of these new requests is the same amount of coffee made in the dual-mode, in which the coffee machine prepares two coffee at the same time. Another critical parameter is **FTL**[19]. This indicator is the jewellery of DeLonghi's quality because it represents the quality to which the company is famous all around the world. The test could be made with only milk, or with milk and coffee, for creating the famous DeLonghi Cappuccino, with the three sections. The quality operator runs the

[19] FTL stands for flow liquid rate.

'cappuccino' function, then is waited one minute in order to let milk and coffee combined at the right temperature. Then the mix is analysed. To the quality operators is asked to identify the perfect quality of the mix and blocks the unacceptable ones. For conducting this analysis, they dispose of a guide (Figure 3.8), but also have plenty of willingness to decide the positive or negative result. The non-acceptable machines are considered as defects; the problem, indeed, is highly related to a plastic component that blocks the airflow and doesn't allow the correct absorption of air and, consequentially, doesn't create the accepted FTL quality.

Figure 3.8 *- Guidelines for the FTL test*



Source: DeLonghi Appliances s.r.l

3.2.3.4 POST-SALE QUALITY

For what concern the post-sales, there is also analysis from client feedback, that regularly update the quality checklist on the line. Another quality gate after the product is the kitchen test. The kitchen blocks some machines and runs the test in order to understand the coffee machine's life duration. If they found out some problems, or some shorter life circle, more in-depth analysis is running from the quality department.

3.2.3.5 CERTIFICATIONS

The quality could also be communicated with certifications. DeLonghi achieved plenty of certifications, such as EN ISO9001 and ISO14001.

The ISO9000 and ISO9001 are international certifications both for self-guaranteeing the company, both to guarantee a certain quality level for the clients. If a company owns the certification, that means that internally there is a structured system for controlling the quality, implementing a series of actions in order to meet the client request of excellence quality. For instance, there are controls over particular areas: the procedures and the required standards.

Moreover, owning the certification sends a second signal for the clients, not only the observation of some hygienic and quality standards but also the willingness of the company to be continuously monitored in order to keep the certifications.

3.2.4 TOTAL PRODUCTIVE MAINTENANCE IN DELONGHI

The Total Productive Maintenance (TPM from now on), is the maintenance of the overall production plant. The TPM aim is to keep the maximum efficiency over time. There are several types of dedicated actions, also in DeLonghi appliances, for each department, characterised by different needs. Maintenance is divided into two big families, based on the ability to anticipate the problems**: planned** and **unplanned**.

For the planned activities there are:

- Preventive activities
- Corrective activities

Instead, for the unplanned maintenance, there is:

- Emergency activities

Of course, working on regular maintenance means to avoid machine inefficiencies. Consequently, the long-term objective is to convert every emergency intervention into scheduled activities over the years.

3.2.4.1 GENERAL MAINTENANCE ORGANIZATION

Regarding the planned maintenance, the major of activities in Mignagola plant are scheduled. The dates are saved and then processed by SAP application, that, with an alert system, reminds and scheduled the events to the maintainers. The appointments are dictated by the regulations, certifications, insurers and clients.

The activities are mainly related to the electrical circuit, air circulation, water depuration and sprinkler system.

The scheduling could be yearly, monthly or weekly, according to the necessities. The maintenance could be both internal and external, so managed and executed by suppliers. There are other areas concerned by the maintenance interventions, the most important ones for work content are the moulding department, the assembly area and supermarket.

The moulding department has thirty-three moulding machines dedicated to the production of small and medium plastic components for the assembly area. The maintenance here includes the moulding machines, the dies, structures and installations. For each of these components is recommended planned maintenance, for the fundamental role of the department and the massive cost in case of stopping, both related to the production and in economic terms.

The machines are complex and delicate instruments, to which is needed both interannual and yearly interventions. For the easier operations, the scheduled maintenance works well, because of the possibility to operates even with the working mould. For the invasive interventions, the ones that need the engine shut down, the scheduling is still not working correctly, and the maintenance is still in a state of emergency. The indications about the maintenance are provided in most cases by the instruction book, in which there is a section of the needed interventions: the so-called ‘interventions plan’.

The other improvement area is dice maintenance. Here the planned maintenance is working for most of the moulds because the scheduling could be more organised due to the rotation of moulds and through the re-organization of the production planning. For both the structures and the rest of the maintenance, the work is planned and effective. The primary activities are the maintenance of instruments and tools, the cleaning of the food-contact spots, and the regulation of the light system and air circulation.

Another area of operations is the supermarket. Also, here there are different actions regarding the maintenance. For instance, is planned the trucks revision, twice per year, or the dock checks, but isn't scheduled the control of train wagons and wheels, that are only fixed once broken.

Moreover, for the assembly area, the activities are both planned and unplanned. The robot, instruments and tools, have scheduled control, but for the structures and the functional tests stations, the interventions aren't always planned. In view of the facts, DeLonghi appliances set a sort of priority system, to which the activities for the critical components, the ones closest to the creation of value, are scheduled, and for the other areas, the interventions could be generated from an emergency. Probably, the actual organisation of maintenance comes from two different constraints: the few numbers of maintainers compared to the number of activities, and the negative cost-benefit analysis. The general aim for every company regarding the TPM should be to convert each unplanned action into a planned one. Emergency interventions represent, indeed, a considerable cost for the company. The basic idea is to prevent the problems and consequentially to avoiding the expense of working hours for the interventions, the cost related to the lost productions and the loss related to the waste. The transformation from unplanned to planned involve general studies and cost-benefit analysis; only when the feasibility and the economic analysis are both positive, then there is the scheduling part for a specific activity.

3.2.4.2 A PRACTICAL CASE: THE TEST STATIONS

During the six months internship in DeLonghi, there were several projects in which convert unplanned activities into planned such as, for instance, the maintenance to the moulding machines, but in this particular case, the analysis requires a lot of time

and involve professional abilities. On the other hand, there were projects to which a minor effort provides a lot of benefits, such as the test station case.

The need to convert the emergency interventions into preventive ones is coming from a 5s signalisation, in which the test stations, so-called ‘system’ or more simply ‘bay’, of one particular production line was losing water during the test execution. From that moment, the problem became an opportunity: was funded the teamwork for this project, that included lean team, maintainers, quality and one production representative. The first action was to started multiple analysis in order to understand the situation better. The approach was, in this case, to apply the same planned activities that characterise PDCA. The first action was to ‘**PLAN’**. After an analysis that clarified the causes, a maintainer proceeded to extend the analysis not only on that bay but also the other systems, even from the other lines. Each bay was on average in the same condition and needed the same treatment. After this datum, were listed all the bays that needed a maintenance action, and with which actions most of them could be repaired. For instance, a common problem was the need for new pipes and cleaning of the water circulation system. The next step was **‘DO’**. Maintainers started with a pilot bay, the one mentioned in the signalisation. For this system, they changed pipes and clean all the internal parts of the bay, then proceeded with other small maintenance actions. The pilot aimed to take note of every work on the bay with a referring time and number of operators. In this way, the activities could generate an official document to which based the planned maintenance. The maintenance man helped with the prevision about the maintenance frequency, and a draft was completed. (Table 3.2)

Table 3.2 *- Example of maintenance actions on the systems.*

Descrizione Operazione	Frequenza	Tempo necessario	Incaricato	Modalità	Strumenti necessari
Decalcifica attu atori collaudo (caraffe)	1 volta al mese	minuti linea	Manutenzione	Flussaggio con decalcificante con pompa locata in manutenzione	Decalcificante (**ENTALKER**) pompa locata in manutenzione
Sostituzione tubi sporchi circuito acqua	Annuale	30 minuti baia	Manutenzione	Sostituzione con TUBO DI UGUALE MISURA e controllare calcare nel raccordo	Sostituzione tubi
Apertura e pulizia valvole circuito collaudo acqua	Annuale	30 minuti linea	Manutenzione	Chiudere acqua, aprire copri valvola e controllare che l'otturazione sia libera	Chiavi meccaniche
Pulizia vasche bilancia	1 volta la settimana	15 minuti linea	Produzione	Sgrassaggio vasca	Sgrassatore (**OPTIMAX EXTRA**), spugna e pennello
Controllo fissaggio pompa su vasca rilancio	Trimestrale	45 minuti linea	Manutenzione	Manutenzione ispettiva per controllo funzionamento	
Pulizia supporti serbatoi in acciaio	1 volta la settimana	1 ora linea	Produzione	Spruzzare sgrassatore, pulizia con spugna abrasiva e pennello su angoli, lasciare	Sgrassatore (**3MSSC**), spugna abrasiva leggera,

Sources: DeLonghi Appliances s.r.l

With the **'CHECK'**, all the actions were also tested in the other bays of the same production line, so with the same problem of the first pilot bay, and then extended also to other lines to understand if the maintenance list was applicable even for other bays. At first, another line test was negative, and some actions were added to the list. For other activities, specific to a particular bay and not applicable to all of them, another file was created. In this way, the test was extremely positive. For the last step, the list was shared, and the approvals were needed. The planned maintenance required the quality and the management approvals and needed to be shared with operators and

to the rest of maintainers. The list includes also cleaning activities, that in this case was a fundamental part of the maintenance itself, and who is responsible for each activity.
Once all the approvals were collected, the documents shared, the bays returned in an operative state, the team of this project decided a date to which get started with the planned maintenance: January 1, 2020.

3.2.5 METHODOLOGY

The methodology is fundamental in the DLPS. In this category, there are the instrument and tools that are helpful for every activity and project. The methodology is the approach that is used by the company, such as a scientific and standard way to plan and execute in DeLonghi appliances. The sum of all the instrument takes place on the base of the DLPS temple because every other part of the company is based and referred to those activities.
During the internship period, were born several projects, both with a low, medium and high impact, some of those with limited influence, other with a huge one. The effectiveness of those instruments is that are applicable to each of those projects.

3.2.5.1 CHARTER

For starting, every project needs some boundaries, because could happens that after an idea, there is a positive cascade effect in which for instance, each part of the process, each flow, each resolution or problem will trigger and open new discussions, new projects and unique solutions. It’s essential to focus on the objective, without getting lost, and if it’s needed, explore in a new project, all the collateral ideas. The boundaries to apply are:

- General Introduction.
- Goals.
- Objectives.
- Activities.
- Tools.

- Perimeter.
- Teamwork.
- Scheduling and Timing.
- Budget and Expense Evaluation.

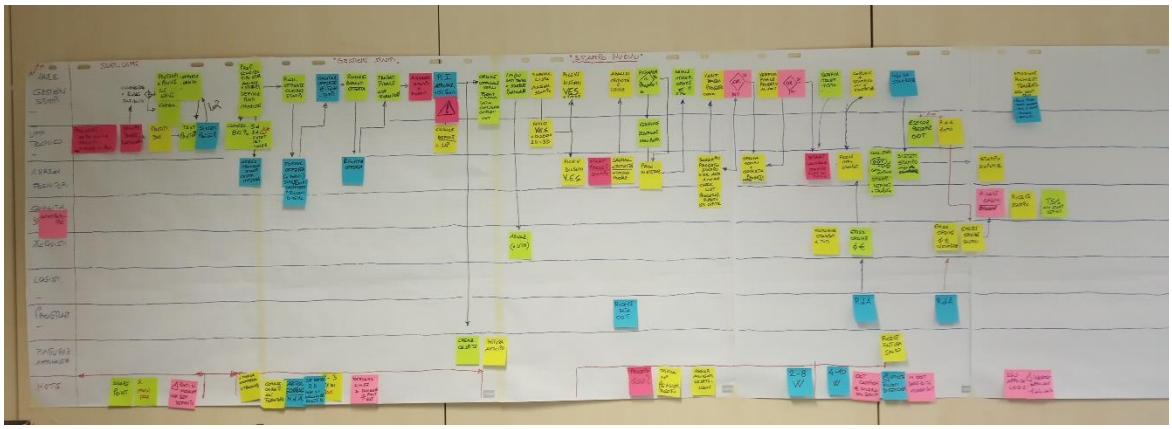
This information is written down into a document called project **charter**.
A **general introduction** is asked and recommended because other people could also read the document, generally because at first, not every teamwork person is informed until the official presentation of the project, the so-called kick-off meeting. In the introduction, there is the need on which the activity is based.
The **goals** are the explanation of necessity and the expected consequences of the activities.
For the **objective** section, the request is to write down the measurable results, expressed in output, key performance indicators, or data. For this section, it is better to reveal the objectives schematically.
In the **activities**, are shown the steps to take in order to start the project; also, this part has to be schematic and with measurable activities. Generic activities such as 'the next action is to improve the flow' couldn't be accepted, instead 'execute the Value Stream Map and then divided the value-adding activities from the *Mudas*' represented a concrete action.
The **tools** are all the instrument useful for the specific project; most of the instruments are explained in this section.
The **perimeter** is the area to which the project referred to, and the **teamwork** is about the team members involved in the project. Some members are permanent, some other on-call or just passive actors.
Scheduling and **timing** are essential conditions in order to plan the project effectively.
The least, **budget,** represent the available investment for the project.
In most cases, the budget is considered as infinite, because in the first part of creative thinking, every proposal is accepted and encouraged. Besides, if the project regards a changing stream process, another document is attached: the **WBS** (work breakdown structure). On this document is represented the breakdown structure of a project, with a focus on each detailed step.

Those documents are shown and explained in the kick-off meeting, that represents the first official step with the complete teamwork. Another step is to define the project leader, the one that will push the project and the referent.
The second meeting is generally dedicated to creative thinking, usually, in this phase are used classic instruments such as **brainstorming** and the **white sheet** approach. With these methods, people are encouraged to think outside the box and without constraint provided by the actual situation.

3.2.5.2 MAKIGAMI

Another instrument is the Swim Lane or the so-called *Makigami* from the Japanese word. With this tool, the project teamwork could 'photograph' the actual situation (AS-IS) and understand in details the flow in every part, with the fundamental indication of which actor or department is accountable for a specific segment or action in one particular stream.
The departments or single actors are located on the left of the chart, and each of them has their line. The flow, then, is analysed in chronological order, following every little activity and associating the operation to a specific actor. The studying also took note of the possible opportunity improvements, accurately written in the last row. (Figure 3.9)
The graphical situation helps to underline the problems and which are the bottlenecks of the process, and so became the starting point to define a new ideal flow (TO BE). The tools are used more for lean office projects because of the multiple participants in a flow.

Figure 3.9 *- An example of Makigami for a lean office project.*



Source: DeLonghi Appliances.

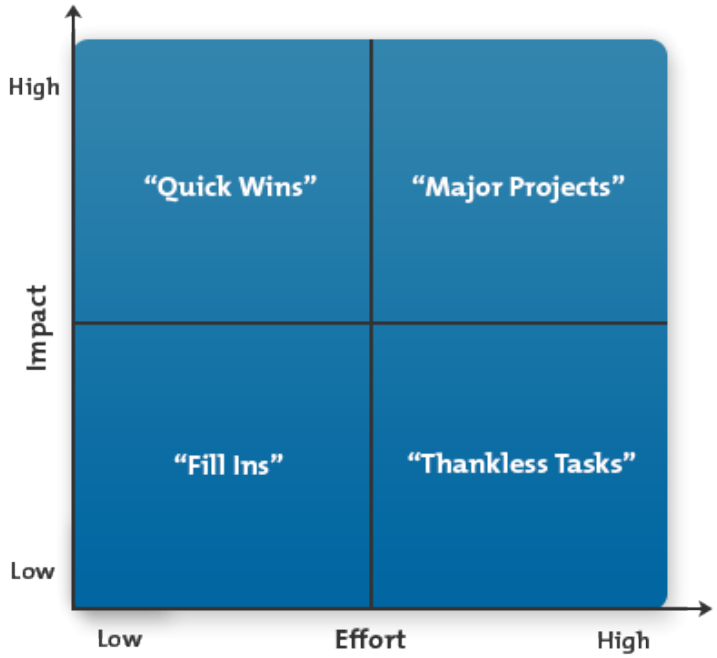
The next step is the identification of the priorities. In order to divide the corrective actions or the most urgent problems, the criticises are positioned on a pay-off matrix. The matrix has two variants: **effort** and **impact**. The effort, in the matrix case, means the level of inputs that are used for accomplishing that task, that could be express in hours, workforce, money, time or the sum of all those elements. For impact, instead, are considered the benefits for the changing situation from the AS-IS to the TO-BE situation. The results will be a separation of the area into four sections: quick wins, major projects, fill-ins and thankless tasks (Figure 3.10).

1. **Quick wins**: (high impact-low effort) this section is about the actions that will be immediately implemented for the project because it is going to bring critical results without the excessive investment of energies.
2. **Fill-ins**: (low impact-low effort) are the second type of action to implement, but delegating to someone else, because the effort is little, but the majority of the project leader attention has to be dedicated to more impactful activities.
3. **Major project**: (high impact-high effort) once the quick wins activities are studied and implemented, those are the next activities to explore and plan. The results will arrive after a longer time than the quick win, but the results will bring extremely positive success.

4. **Thankless tasks**: (low impact-high effort) those activities are almost useless. The improvements will be so little compared to the effort spent.

Once the tasks are inserted on the matrix, the plan will be based on the activities that will ensure more impact.

Figure 3.10 *- Impact-effort matrix.*



Sources: www.mindtools.com

3.2.5.3 GANTT

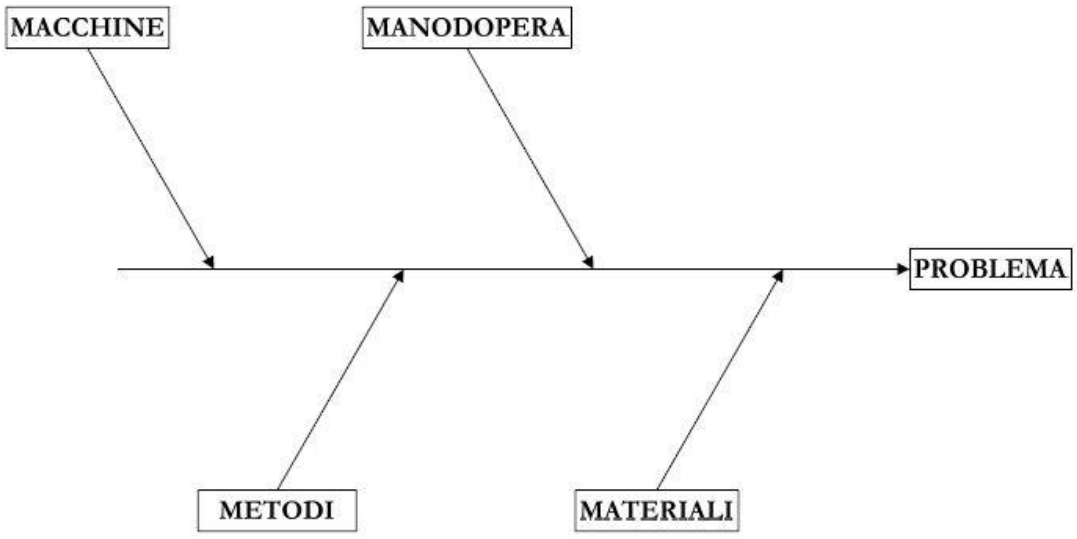
For scheduling the activities, the project manager uses the Gantt chart. With this instrument, the management could plan tasks among weeks, with the reference of when it starts a specific action, and how many weeks will take for finishing the activity. Moreover, there is also the possibility to separate and to manage the sequential operations from the parallel ones. For subsequent activities, the theory means dependent (to each other). For instance, ask for a certification for a new method of transportation, requires first to pass through the transportation test. The parallel

activities, instead, are those tasks that could be made simultaneously. For instance, during the transportation test, a lower cost could be asked by the buyer to the suppliers.

3.2.5.4 5WHYS

Other instruments used especially from Quality Department are the cause-effect charts. The two main tools are the *Ishikawa* diagram and the 5whys technique.
Starting with the *Ishikawa*, most noted as 4M; the diagram represents an instrument for the identification of responsibilities and root-causes. The graphical representation (Figure 3.11) follows the structure of a fish, in which on the head, there is the major problem and, on the ribs, the possible causes: men, methods, machines and materials. Recognised the roots, then the corrective actions could be applied. The analysis proceeds from the problem to the solution, in most cases, is used a brainstorming section.

Figure 3.11 *- Ishikawa diagram.*



Source: Wikipedia.org

Another way to reach the same conclusion is the 5 whys analysis, a method in which from the problem it's possible to find the solution asking for five times the why of the problem. For instance, an example could be:

1. Hydraulic test failed→ why?
2. Components wrongly fixed→ why?
3. O-Ring installed wrong→ why?
4. Lack of lubricant oil→ why?
5. Operators can't find the oil→ why?
6. **Improve the oil supplying on the line**

At this point, opening a PDCA could help the management to resolve for good the situation.

3.3 THE FIRST PILLAR

This chapter aims to explore briefly the content of the first pillar, that includes activities well launched in DeLonghi appliances and that are not included in the internship tasks. This part is, however, fundamental for the work because of the critical importance of lean techniques into the company's production system.
In this section are indeed explained the first steps toward the lean philosophy and the direction that took the company from the moment on, starting with the implementation of the new shorter lines: the Excellence Centres.

3.3.1 THE EXCELLENT CENTRES MODEL

The first step made by DeLonghi for what concern the lean manufacturing, in the Mignagola site, was toward industry 4.0, with the creation of a new line type: the EC, Excellent Centres. With this name are indicated the new lines, in which the EC09 represented the pilot for the line conversion.
The work made on EC09 opened the doors to a new Production System, that was more in line with the lean philosophy. The change wasn't born by a need related to a

required boost in the production; however, the decision was made in a long-term view of future benefits. Indeed, after the conversion, the ECs compared to other traditional lines, reduced the cycle time and the volume of production, compared to the same amount of time. This decision, made in a period in which the sales are increasing, could be seen as the opposite of the DeLonghi needs, but the aim was to reach another type of benefits, mostly related to the cost reduction:

- Reducing the holding cost associated to the input supermarket.
- Reducing the holding cost related to the output supermarket.
- Reaching a new level of flexibility.
- Implementing JIT.
- Increasing the quality on the line.
- Reducing the lead time.

3.3.2 SINGLE MINUTE EXCHANGE OF DIES

In order to reach the objectives of cost and time, the important job to do was working on the batch quantity. For the new line, the keys to success were fast set-up time and flexibility, in order to lower the minimum batch quantity from 200 to 20 pieces.

The analysis was made analysing the efficiency loss of the other traditional lines and the consequent effect generated on the Production Programming. The benefits of starting a SMED revolution were reducing not only the cost of holding for the materials and the set-up time but also the programming frozen period from five weeks to only five days. Regarding the two principal factors, reducing the batch quantity will mean a decreasing of holding cost because the material will be moved faster than usual, and also a decrease of set-up cost, due to the line's time saturation. The set-up cost, indeed, is partially composed by the production loss due to the changing model, that in this case, is reduced by the SMED applications.

The decreasing of holding cost doesn't reduce only both the incoming and outcoming supermarkets but has other interesting benefits.

For starting, there is a reduction of obsolescence, both for raw materials, both for finished products. Other sunk benefits are the opportunity cost for the saving materials, the creation of more space in the supermarkets and the reduction of the need for warehouse workers in peak period.

3.3.3 JUST IN TIME

The long-term strategy in DeLonghi was to switch slowly but steady into an **Assembly to Order production** from a **Make to Stock production**. The final aim is the reaching of one-piece-flow with the pull system, but actually, the company couldn't make it for all the lines, except for only one model: the EPAM. The model is generally defined as the very best, the jewellery of DeLonghi automatic coffee makers, and for its prohibitive cost, received few orders by the market. Fewer orders mean having the possibility to implement the Just In Time (JIT) principles. Indeed, the line is U-shaped, and an operator follows the entire machine-building, from the start to the end. For the other tracks, which volumes are more consistent than EPAM, the keyword is flexibility, as already mentioned in the previous paragraph. The demand seasonality doesn't allow the lines to producing at the same rhythm of the market *tack*-time.

On the first quarter, the production overcomes the demand and a small part of machines are kept in the supermarket.

On the middle quarter, the market demand remains the same as the first one, but the lines started to produce more to be prepared for the last quarter.

In the last period, the demand overcomes the production capacity, and the stock is used and consumed.

In order to manage the increasing demand, flexibility is the best weapon. The line, switching from the traditional one to the EC, could follow the increase in the demand just converting and readapting their scheduling, and adding a second seasonal turn in order to produce the requested quantity. The lines, moreover, will be capable also to managing a negative swing of demand.

The other lines are served with a logic close to the pull one. The replenishment is scheduled, with a particular amount of materials that have to cover the hours between one refilling and another. On the line, there is the space only for several materials equal to one production shift, so when the dock of components is empty, is the signal for the replenishment operators to fill it. Other materials are directly called when finished, and so the empty space once again is the sign for bringing others.

3.3.4 HEIJUNKA AND BALANCING

The *Heijunka* and the balancing were a fundamental part of the conversion of the traditional lines into the Excellent Centres (EC), for what concerned both the flexibility, both the smoothing of the material flow.

For starting, the new lines dislocate some parts of their production in the so-called subgroups, which work with a different schedule and with a separate frozen period, for guaranteeing the highest possible flexibility. The flexibility, indeed, is the most stressed asset of the Excellent Centre lines. Another example of the newly reached level of flexibility, aside from the already mentioned fewer batch quantity, is the operator contributions on the lines: the new lines are, indeed, shorter than the classic ones, about half of them (from 80 metres to about 40). On the line, with the space reduced and increased efficiency, there is space for 14 operators, instead of the 40 operators of the classical lines. Moreover, the operators received a specialised preparation (explained in the training section below) in which they are trained for switching the models very quickly and also adapt completely to every product families, even made by other lines.

Another point of the conversion was the levelling of the work content and the elimination of some *Mudas***,** for instance, rethinking about the disposition of materials and identify and isolate the bottleneck.

One critical change, in this sense, was the dock disposition and dimension: the new dock has the capacity of one shift plus a security stock of about 20%. This change helps the implementation of the pull system on the line, leaving only the essential materials available. In this way, the elements on the dock have to follow the scheduling strictly, and the docks aren't used as an indeterminate storage point, but as the punctual supplier for only what is asked by the line.

The next step was to conduct with the suppliers an analysis in order to reduce the waiting time of their materials. The ideal flow is bringing directly on the line what is supplied, but nowadays it represented still an impossible objective. The response to this situation by DeLonghi is reducing the storage with the implementation of the *milk run* system. With the ‘milk run’, the DeLonghi company brings daily to the lines the required materials for that day, organising a collection door-to-door with the available suppliers. With this system, also the suppliers have to adapt their production with the same flexibility logic used by DeLonghi.

Another fundamental part was the balancing on the line. The approach to the conversion was the elimination of *Muda*, so all the activities that could be moved or eliminated were displaced from the lines: this is the example of the fixer and EOL desks.

The fixer is a figure that isolates the broken machines from the line and repairs them instantly. For the new lines, the desks of those two operators are eliminated from the central body and moved in an external position. The chosen place for those activities is the second part of the line, dedicated mostly to aesthetical composition and checks, and for the packaging. The second part of the line is free of components and materials, with few exceptions, so there is plenty of space for moving them. The choice is not only convenient but also logical. The warning for a broken machine is typically the system that divided the first part of the line to the second one. Indeed, in order to prove that the system works in the best way, the quality checks made by the EOL are made after the system test. The line is so composed by the dock at the head of the line, the first part with all the materials and components from the subgroups, the systems and the second part of the line, with the fixer desk, the EOL spot and the team leader location.

Regarding the system, the number is reduced and readapted to the EC rhythm, leaving only four system bays for the checks. The choice was made because the time to execute the test is superior to the cycle time of the line. The system represents the bottleneck of the line but raising the number of bays allows the EPP engineers to leave the same circle time. The cycle time of the line is now close to 3 minutes, adapting the speed to the unavoidable bottleneck: the packaging position. For this operation, the last position of the second line is supplied by machines and other automatisation in order to reduce the time spent.

3.3.5 JIDOKA

The automatisation on the line is a fundamental thing for DeLonghi because it could help to avoid mistakes and improve quality. For all the projects of this kind, indeed, the aim is to adapt and pass the technology also to the other plants, in order to share the benefits among the group. One introduced element on the new line, for instance, is the display. For each position, on the line, there is a monitor pc that helps the

operators through their work. The first one regard directly the operator job: on the platform, there are instructions, imagines, video and the best practice suggestions. The monitors are used more by new operators compared to the old ones; however, there are regularly available. This necessity born by the management decision to implement and encourage the so-called ‘job rotation’. With the implementation of the new lines, shorter and with fewer operators, the contribution of each one grow in importance, but the line couldn’t stop because of absenteeism. To the operators, is asked to move and change his/her job internally the line and through one line to another. Another benefit of the PC is the traceability of components. In some spots, is asked to the operator to read the material’s code that could be rejected or accepted by the system. There is, indeed, constant communication with the SAP system, and so the Bill of Material, and MES system, that follows the amount of raw material on stock.

Moreover, when the batch is finishing, and the next is incoming, the computer alarm the operator to keep the focus high. With a change, only 30% of materials stays the same; the others switch and renewing the attention is fundamental. Also, the team leader and quality operators have their personal monitor. For the team leaders, the alarm for the change is the same. They have to explain the possible causes of broken machines. For EOL, the system sends a notification instead when it’s time to pick the sample from the line and examine it. There is also the possibility of scroll the checklist of activities and signalise the problems with the machines. The MES system, with SAP, communicate the material information to the procurement office, that works on the MRP, both for the lines, both for the suppliers.

3.4 THE SECOND PILLAR

This section is about human resources and how the management deals with them in the DeLonghi plant. For implementing and sustaining the *Kaizen* improvements and activities, both the administration and the employees are fundamental. As shown in the previous paragraph, the lean techniques applied to the company bring tangible benefits, but not only in an economical way but also for the employees. The lean manufacturing represents indeed a way to increase the respect for people, improving

the standard, raising the commitment and brings benefit in a slow and low-cost way (Masaaki Imai, 1997). The main sections of this paragraph, as already mentioned, are:

- Zero defects
- Teambuilding
- Leadership
- Resistance
- Training

Those elements, like the ones in the first pillar, couldn't be sustained without the first explanation of the *Kaizen* philosophy, because it represents a requisite in order to create a sense of commitment.

3.4.1 ZERO DEFECTS

Zero defect is a philosophy born in Japan, related mostly on Total Quality Management. The aim of Zero Defect is the elimination of mistakes and the decreasing of errors, even with the root-causes analysis. In DeLonghi, Zero Defect has the same function and works like big project-storage related to the elimination of problems. The majority of projects are born by auditor activities, both internal and external, or for the company willingness to access to new international certifications such as ISO22000.
In particular, for the Nespresso's lines to which are dedicated more *audit*, was born a specific Zero-Defect activity. On the *audit*, the external controller found out a mismatch between the codes on the material boxes and the codes on the storage docks. From this signalisation, a team were selected, and another way of categorising the materials was found. The new system consisted of eliminating from the material's tags on the storage dock all the codes and leave only the images and the description of the materials. In this way, there is not the possibility of misplacing the boxes with their right positions and made it easier for the warehousemen to keep and maintain the proper order on the dock. The comparison between the old method (in yellow) and the new one (in white) is proposed in the following figure (Figure 3.12)

Figure 3.12 *- Comparison between the old and new tags.*

Source: DeLonghi Appliances s.r.l

Another ambitious project is the replacement of every element findable on the *Gemba* with their cleaner version, for instance, wood pallet with the plastic ones and plastic boxes instead of the paper ones.

3.4.1.1 A PRACTICAL CASE: THE WOOD PALLETS

For the first project, the multiple requests were born in the first place a security problem. Wood pallets are kept together by screws that could be damaged by rust and misplaced by time and weight, that generate possible incidents and complaints. On the other hand, the second motivation was about the dirt left by the pallets. A clean place is fundamental for implementing ISO22000. The first step in this sense was to analyse for each line the amount of wood pallet and the reason why they arrived on the lines. The response demonstrated that the most important material supplier that delivered directly on the line using wood pallet was the internal one: the moulding department. The next step was to understand the reasons why there was this situation because in DeLonghi the dispositions to avoid wood pallets aren't new. Usually, indeed, the majority of transactions were from the moulding to the lines, and for these operations are used mainly plastic pallet. However, the moulding department has some other clients, external ones, to which delivers with plastic pallet too. Those

clients are at the same time suppliers of the moulding, and they send back the same elaborated materials on wood pallets, after a couple of months. The moulding department, when needs to deliver something to the lines, could be, of course, left without plastic pallets. The solution here was to re-order plastic pallets, in order to provide the right components to the lines, and at the same time, working with the purchasing department. The aim of this collateral operation was avoiding the giving of plastic pallets and having in return the wood ones from the externals. The necessity isn't just monetary, due to the higher cost of plastic pallet, but also for preventing the continuous purchasing of plastic pallet for keeping the internal flow. The solution agreed with all the involved departments was to put into the order documents also the pallet cost in case of failure in the returning, and to dispose of that every material for the selected suppliers coming back on plastic pallets.

For the other supplier of which materials are arriving directly on the line, the procedure is more extended, because most of them are foreign companies that have to face a long way before delivering in Mignagola the materials. In this case, the solution could be raising the cost of the materials and re-adapting the transport conditions.

3.4.2 TEAMWORK

One of the seven values of the DeLonghi Group is teamwork, which is elected, as a matter of fact, for the second year, the most important value of the group for 2020. When the company decides the new mission, vision and values, in 2016, the subsidiaries of the society were present worldwide, with more than 8000 employees. Having those culture differences among the workforce means that for each value, the countries have their personal views of the connotation, but teamwork is the only one with the same universal common meaning.

After a couple of years, the strength of this value loses its communicative power, and so new actions have to be implemented in order to keep high the company's sense of identity. Yearly, the company, launch a survey in which people express their doubts and improvement requests so that the HR department could work in this sense. This survey is called 'Your Voice', and its mostly oriented, indeed, on the community sense and the values. The survey is felt by the employees that each year reach a large number of participants, this year, for instance, over 92% worldwide. After the last edition, new training is available for the entire group, the 'Value Maker'.

‘Value Maker’ started in 2019 and worked for a couple of months, from March to December and includes more than 500 people. The course is a sort of escape room, with 12-15 participants each edition, divided into three groups. The game is all based on collaboration between groups and group work. There are several enigmas, which are resolved only with teamwork and passion, in about two hours of average. At the end of the game, there is a sharing moment, in which people are encouraged to provide some positive feedback to each other. At the centre of the table, there are positioned some tokens with the group values. One person has to give and receive one token. The sharing moment is crucial because of the force of positive reinforcement and feedback. In everyday life, it could indeed happen that people avoid sharing thankfulness among collaborators, and this brings to lose self-esteem and passion toward her/his contribution to the company.

Another example in this sense is the ‘Tugether’ paper, the official DeLonghi semester paper in which are shared the success and the people contribution worldwide to every level in every subsidiary. The articles are written down by employees, and the story is about their progress and shared success. The company in this way keeps close the people among states and also reminds that each person is important and deserves to be known and shared for their effort and passion.

3.4.3 LEADERSHIP

In this section, the main point of discussion is leadership. In DeLonghi, there is a strong communication about the change in hierarchical organisations, and people always know to whom they need to report. When there is a change, the communication is provided not only to the direct stakeholders but to everyone in the company, with public and clear communication about the changes. The top-management, with the human resources department, decides then to redefine the vision and the mission of the company, as already mentioned in the second chapter, in 2016, because of the need to renewing the identity of the company after the new acquisitions worldwide. After the work made by the CEO and by top-managers, the company had a new direction, new identity and values. The next step was to share them with each subsidiary among States. One of the biggest problems is communication between people and between cultures: in the next paragraph, the issue is discussed further. The shared information arrived obviously also into the Mignagola plant, and the values are shared and then

attached on the lines so that every employee could see them. For the plant, the manager had to communicate also his approach and direction for future work activities. The aim for 2019, and 2020, indeed, is to raise the security level and the 5S importance.

The fifth S of the 5S approach is Sustain. The mentality is the hardest part to change for people and so the leadership, in this sense, plays a fundamental role. Having a reliable and compact direction helps to avoid shortcuts and, thus, skipping the change difficulties. One important thing is the transmission of the daily improvement importance to every management level so this could generate a positive cascade effect on the upper level to the next one. Unfortunately, also the managers have to face the difficulties of changing, indeed sometimes is useful to choose wisely the right people for starting the process.

The most representative example is the *kamishibai*. When a new instrument, a new project or, in general, when there is a commitment of any kind, people start enthusiastically until the energy starts to fade. This phenomenon could be visible also in DeLonghi: when the 5S project started, in June 2019, people seem enthusiastic about the idea of sharing a problem a find together a resolution. However, the activities had necessarily priority, and it took a couple of months for answering all the requests. Meanwhile, the signalisation started to decrease slowly due to the peak of maximum production started in October. To the team leaders, the connecting point between the management and the lines were asked to keep the pretension level high, bringing every week new points and asking for a resolution to the old ones. However, there were lines in which there weren't the same commitment, and so the occasion was taken for a new instrument: the *kamishibai.*

3.4.3.1 KAMISHIBAI

The *kamishibai* is an internal *audit*, mainly regarding the 5S and their application. The auditor could be anyone, and the analysis is based on a question, which answers could be positive or negative. In case of a negative response, a new signalisation is opened, and on the next *kamishibai*, the problem has to be resolved. For *kamishibai* in DeLonghi, the team lean chooses three questions:

1. Is there a place for every object?

2. Is the line clean?
3. Is there the right number of components?

Regarding the first question, the aim is to understand if there is order on the line, both for materials, both for tools and other support components, such as trash bins, printer recharges and so on.

The second question is about cleaning on the line but could also be included the food contact rules and other quality standards.

The third question, instead, is about the pull system and in general, extra materials, that there aren't useful for that specific model build.

The *kamishibai* is made by the high-level managers, at least for starting: the head of the quality department, the head of the operation and the plant manager of the Italian plant. These three managers are also supported by the team lean and by the team leaders of the chosen line. The *kamishibai* consists of walking on the *Gemba*, the place where the value is created, before the escalation meeting, with the last of a quarter or a half of hour. The managers ask the three questions, and the signalisation are opened and then discussed in the meeting, with the assignation of responsibility. The questions work as boundaries and as a guide, but obviously, there aren't standard questions. At the Escalation also participates the managers, and on this occasion, the importance of 5S is remarked and underlined. The chosen frequency is about a couple of weeks, according to the necessity of showing a compact commitment to continuous improvement. Another fundamental aspect of *kamishiba*i is that also the operators are asked about their preferences and problems and the sense of receiving a single direction is provided also to them.

3.4.4 RESISTANCE

The following paragraph is about the problems and the other resistances made by people. As mentioned in the previous section, people have trouble to accept the change, because, for years, they are used to specific approach, rules, ways, and could be a challenge to change the routine. The leadership in this sense, as already mentioned, play a fundamental part.

One most significant problem in a multinational company is communication, not only between different cultures and different languages, values and habits but also between the same company, among people with the same culture and heritage. With

the dimension of a productive plant, it could be challenging to communicate a concept in a short time. Sometimes, indeed, happen that a responsible can't take part in a meeting, or is busy in other prioritised activity. In this case, the actors can't talk to each other. One part of finding a problem resolution is to account the responsibility to someone, that is more likely the person who has more power and knowledge for resolving the problem quickly and effectively. For instance, with the PDCA, the actors meet each other at the dashboard, and the problem is analysed together. The responsible then took care of the problem and implemented a solution that shares in the next meeting. However, the problem might be shared, but the person universally recognises as the closest responsible is missed. Someone at that point had to take care of the problem and bring it to the attention of the competent person. Then, the responsible have to ask the problem again and precious time is missed. The best solution is to avoid missing people at the meeting, but for an organisational purpose, not everyone is invited, and someone could always have another session or another task. A practical solution for this problem is the PDCA sharing.

The concept is the same as the classic PDCA, but digitally implemented. For PDCA sharing, the printed paper is replaced by a touch screen monitor and a keyboard. The PC is positioned on the board with a plate on the improvement section. Close to the board, there is a plug and an ethernet access point, or Wi-Fi. When a problem occurs, the moderator opens a point on the PDCA sharing platform, with indicating the responsible, causes, anomalies and corrective actions.

The system then will send an e-mail automatically to the accountable person and could open the point on his/her PC, on the same platform online. To the problem, the system also adds the possibility to sign a priority and a deadline for the resolution. The system also allows multiple analysis: the statistical activities for each member, the time of resolutions, or the number of tasks associated with a specific department. The communication problem is resolved in this way. The digital instrument replaces only the tool, not the procedure. The correct way of using the PDCA (online and printed) is still represented by coming to the meeting and resolving together the problem, opening and evolving a discussion. This system is not implemented in every lines or department, because of the high implementation cost, but in 2020, the project is to install at least four new monitors. In this way, wherever the problem is born, there is a monitor close enough for allowing the registration.

The communication problem is maybe the most dangerous in a company, but it is not the only one. Besides the *Kamishibai*, there are other ways in order to keep the motivation and the demand high: once a month is showed the success and the improvement of the 5S and PDCA, in all the production plant. The operators have just the vision of what happens around their work spot, for the physical constraints that don't allow them to move through the plant. The report is an easy way to generate a sense of community in them and motivate operators to ask also for themselves improvements.

3.4.5 TRAINING

The training is a crucial moment for people in DeLonghi.

When a new operator comes into the company, has to follow some training hours for security, learning the work content and quality demands. The formation proceeds in what is called 'learning while doing', where the former operator teaches to the new one in order to make him/her able to proceed alone. The passing of know-how is a delicate moment because together are also passed the practices and 'tricks' that could save some time. The aim of DeLonghi is teaching people the right procedures and the importance of following them. The best practices are defined as the best solution and best way to make something internally to the company, both for efficiency (fewer resources used) both for effectiveness (best results). The best practices had to be shared and explained for reducing the variability in every part of the process.

When the training is done, the new operators receive the correct practices instead of the incorrect ones. For this purpose, is born the 'Training on the Job' formation project. In this one-hour meeting, the operators can learn some skills and take a look at the coffee machines functioning. Moreover, it is explained the importance of cleaning and order on the lines to avoid mistakes and defects and also, is an occasion to express their opinion about methodology or improvements.

For reaching this aim is asked to new employees to join the meeting with the quality department, methodologies department and lean office.

The first part of the meeting is about showing the functioning of the coffee machines. The aim of this moment mainly involves the operators in multiple ways. For most of them, the finished products are not even seen once in their careers, unless they cover the positions on the second part of the line, where the machine is almost completed.

This generates not only a sense of belonging to the company but also helps to build a commitment toward their work and the importance of their operations.

The meeting proceeds with the view of some videos regarding some typical machine's malfunctioning due to disorders on the line, mostly related to lack of order and cleaning on the work spot. For instance, one of the videos shows a short circuit, direct consequences of a misplaced electrical termination. The aim isn't to determinate to whom the blame is, instead is the acceptance of the mistakes and the awareness of the consequences. A good operator, indeed, isn't the one that is not making a mistake, but the one that recognises the human error and speaks up in order to resolve the situation and avoid more substantial implications. The second part of the meeting proceeds with the methodology department that teaches other detailed practices. The focus is more related to operations that could reduce the life cycle of the machines. Also, this part is supported by videos and photos, especially the one recorded on the Mignagola plant. A common mistake that happens most of the time is related to the small component. The operator prepares the screwdriver with the screw for the next machines, but the magnetic force doesn't resist, and the pieces fall in the machine. The operator tries to remove the part, but it embeds, so the line proceeds and the machine with it. The excellent operator doesn't lose the temper but asks directly to the team leaders, which are the first responders that could pull out the machine and manage the issues.

One typical example of photos that are shown during the meeting (Figure 3.13) is the mechanical valve. This is a strong example of distraction on the job. The material is composed external to the line and has to pass by different quality gates of functionality. The mechanical valve passed each test and for the system (and the operators) was perfect and could go directly on the line as a piece good to assemble. There is still no test that could identify such a problem, and also, the consequences aren't clear. The machine with this piece may work its entire life without a problem, or the machine couldn't even turn on or, worst scenario, could work for a year, undermine the quality of the disbursed coffee and then broke down. In the latter case, the problem won't be detected from the after-sales analysis and quality department will ever work on the solution or a quality test in order to identify it, and this piece of information will be lost.

Figure 3.13 *- Defect generated by distraction.*

Source: DeLonghi Appliances s.r.l

At this point, explained the importance of awareness, the situation is explored in another point of view: how the mechanical valve arrives on the line? The answer couldn't be the failed test, because, as already explained, there isn't a specific test in order to detect it. The question is then directly asked the operators. The problem is visible and immediate, so only a very unfocused operator couldn't see it, and at this moment there is the final message of this training course: everyone is responsible, everyone is essential, and so everyone has to be aware of the consequences. The operator itself makes the first quality gate. For the last part of the meeting, the operators could provide some advice for their work spot, due to the quantity of time spent on their position working. The 5S instrument is explained then so that the operators could express their suggestion at every moment.

3.5 THE TOP OF DLPS

On top of the DeLonghi Production System, there are the classical objectives which are also represented in the Toyota Production System: **quality, cost** and **delivery time**.

However, those objectives have different importance for the DeLonghi company, which considered the quality objective as the most important to achieve, in order to stay the coffee machine leader in the international market.

However, the cost and time objectives have also their importance, which is summarised in the next paragraph.

3.5.1 COST AND TIME

As already mentioned in the first chapter, for what concerns cost objective are not taken into consideration those action made by DeLonghi Appliances for reducing the cost in general, but those operations that through the application of lean methods eliminated and reduced some cost, such as the *Muda*-hunt. In this sense, the company started to lower the cost with the cutting of line lengths. The aim has multiple benefits, not only related to cost but also time and quality. Is unlikely, indeed, that a project brings benefit only for one of those elements.

For the implementation of Excellent Centre lines, the output of the investment was, without any doubt, the lowering of cost, mostly related to the holding of stocks and the set-up loss. Another cost result is related to the higher quality, fewer defects meant for DeLonghi less repairment cost.

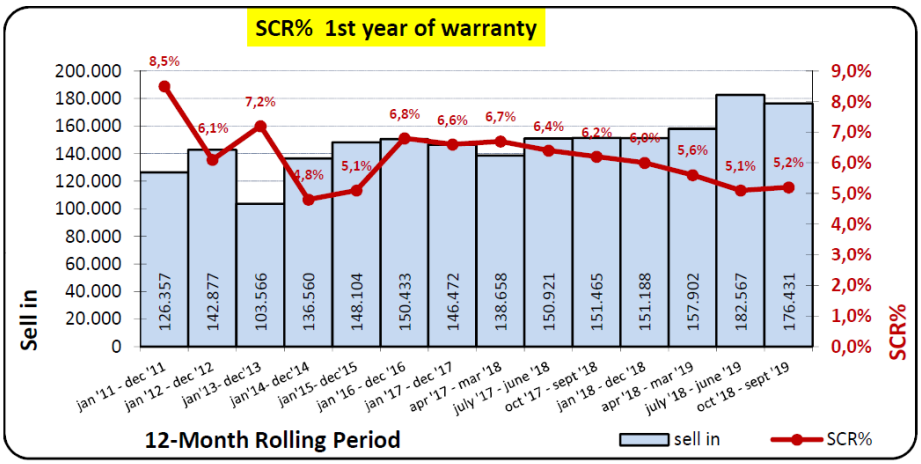
The secondary aim was to reduce the time of delivering and reaction to responses to the market changes and unpredictabilities. Those objective are reached again with the new lines, that increase the flexibility and the mix of batches, and by the reduction of the frozen period for the assembly program, which pass, as already mentioned, from five weeks to only five days, making quicker change the program in case of unpredictable request or issues.

3.5.2 QUALITY

Cutting the length of the line has a collateral effect also for the quality. Fewer operators in the line mean making every operator more responsible for the quality process, an idea also strengthens by the multiple courses, best practices and quality training that the operators have to attend.

Quality is truly fundamental, and it is how DeLonghi is recognised in the market. All the internal quality process and the external certifications are aimed, indeed, to avoid the selling in the market of faulty machines that could bring down the excellent reputation of the DeLonghi quality. Of course, there are a lot of test and checks that the company is running for avoiding that risk, and the Key Performance Indicators (KPI) are continuously monitored and implemented. As already mentioned, there are KPI on the defects imputable on the line and the suppliers, both internal and external, based on their importance and riskiness. Important tests are then conducted for each machine and material, also in the sub-group, and more deep checks are run on a small portion of materials and coffee machines, through a sample and random picking. However, not every defection could be monitored and spotted by the efforts, and even studying the after-sale complaints (Figure 3.14) is impossible to estimate the real defect numbers.

Figure 3.14 *– An example of SCR[20]% within the first year of warranty for a specific model.*



Source: DeLonghi Appliances s.r.l

[20] Social Care Responsability.

However, from the analysis, the company could assume that the overall quality is increasing, due to the lower quantities of warranty requests by the clients, within the first year of acquisition.

CONCLUSIONS

For the last years in the DeLonghi Italian plant, there was a slow but constant transformation from the mass system, characterised by the Ford-Taylorism, to the lean system, symbolised by the so-called Toyotism.

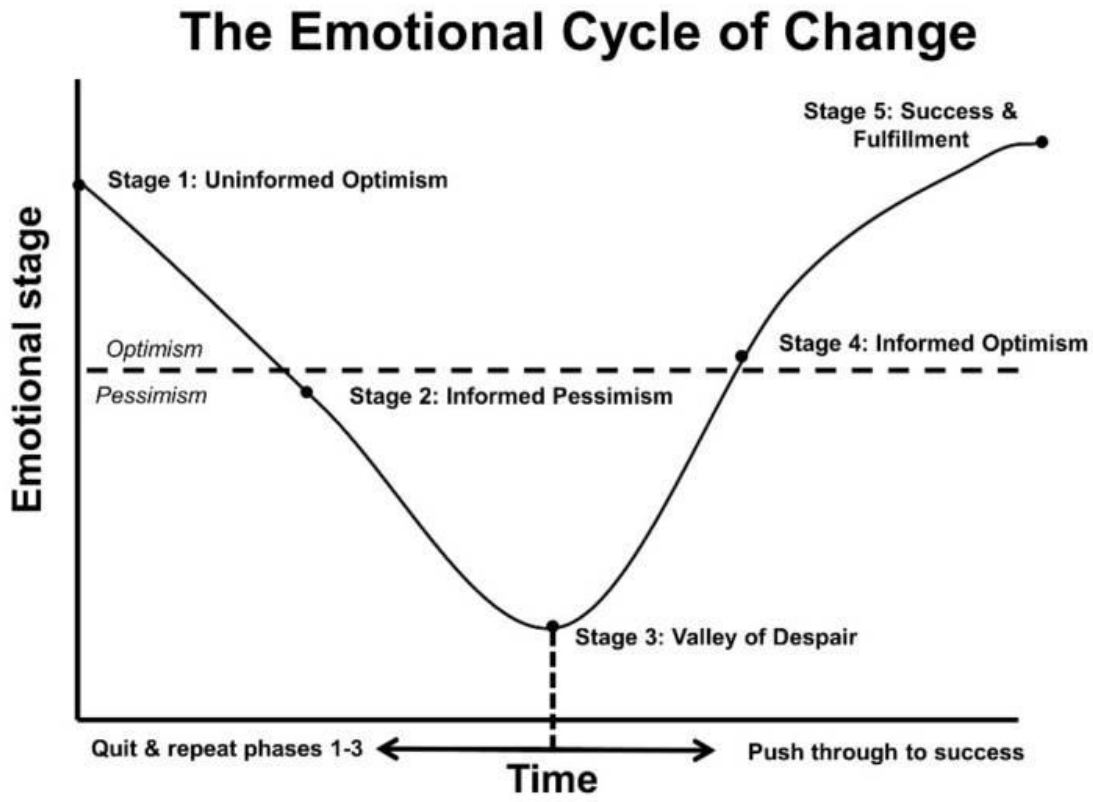
The highest point of the transition is represented by the new lines, shorter and more flexible, and also by the idea of the operator's role. For what concerned the operators, historically, there were different opinions about their responsibility. For the Fordism-Taylorism, for instance, the workforce had to be unskilled, the work was executed without thinking, that makes their job incredibly alienating due to the standardise movements; in other words, the workers were interchangeable. For the Toyotism, and so for the DeLonghi company, the operators have fundamental roles, take important decisions, not only related to their work spot but also regarding the quality of the materials. With this system, the people are the centre of the *Gemba* because they represent an integral component of the value.

Sure is, however, that people are the most challenging element to handle on the TPS, and for this reason, to the human interactions and relationships is dedicated a whole pillar on the DLPS. The explanation is quite simple. The two similar systems of lean management based themselves on a simple concept: *kaizen*. As already mentioned in the work, *kaizen* is composed of two Japanese words: *kai* and *zen*. The meaning for the first word is 'to change' and the definition of the second is 'better/good': change for good.

Changing here is the keyword. Human beings have a sort of resistance to the change in their DNAs. Change means effort, breaking the routine, challenging themselves and losing energies. On the companies, then, change means of questioning the workforce's way of doing, consolidated through years and accepted by the social context, that adapted and created an equilibrium. During the internship period, there is countless time in which someone said: "it had always been done like this", or: "nothing changes". For the management, these judgments are known such as 'killer sentences', because people that pronounce that, already have given up on change. Since the first implementation of 5S, in June, the enthusiasm started slowly to fade.

The cause could be explained with the five emotional phases of change, in the following figure (Figure 4.1), invented by two American researchers in the ’80, Don Kelley e Daryl Conner. At first, there is enthusiasm and people are optimistic, then, with the second and third phases, people start to realise the required effort.

Figure 4.1 *- The emotional cycle of change.*



Sources: Kesterson. 2017.

For passing to the fourth and fifth phases, is required a strong motivation and rational reasons in order to overcome the obstacles. For the company case, the answer is management.

Indeed, for fighting this condition back, the workforce needs a firm and reliable guide from the management. A clear direction, toward an objective, clear communication and scientific methods, are fundamental for making the workers feel comfortable enough for coming out of the comfort zone and at least, trying to change.

The aim for DeLonghi is creating an environment in which the people commit themselves for the continuous improvement logic, with a constant effort. The operators are mainly valorised by taking independent decisions, especially related to quality. The training, in this sense, is a significant ally for their professional growth.

Moreover, the management efforts are also headed to other people in the system: the clients and the suppliers.

The client is guaranteed by the reaching of the DLPS objectives, quality and environmental certifications and a constant study of needs conducted by the after-sale analysis.

The suppliers, instead, are involved with multiple projects of continuous improvement, related mainly to the reduction of waste and lead-time, to which response is hugely positive.

The change, nowadays, is inevitable, and required efforts, energies, willingness and constant involvement of every company levels. In DeLonghi, the direction is simple and well-defined. An example of company direction, are identified in the group President Giuseppe DeLonghi words: “To be winners, we could either buy Ronaldo or each one of us has to improve in a small way every day so that we can take one big step forward all together.”

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