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Optimization of a surgical process through Lean Thinking

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Forward

"Non c'è niente di più difficile da condurre né più dannoso da gestire dell'iniziare un nuovo ordine delle cose." *(Niccolò Machiavelli)*

Change is an ever-present feature of organizational life, especially given the nowadays relentless innovation characterized by increasing rates of development, forcing companies to sustain the pace. To be effective, changes must affect both the operational and strategic level, therefore it is essential the organization's ability to identify where to position itself in the future and how to manage changes which are required to reach that goal (Burnes, 2017).

Yet, what results from literature is the persistence of an innate, pervasive and dysfunctional resistance to change, coming either from employees or top management, which prevents a smooth transition of companies towards innovation. The core argument is that humans are naturally programmed to resist change and defend the status quo. At the same time, behaviour of individuals derives from the totality of coexisting forces present in their organization (Burnes, 2017). Therefore the nature of the company could influence the resistance to change of its members. Factors like a supported strategic plan, environment of trust, training programmes and rewarding systems are responsible for the readiness to change and need to be assessed at the macro and micro levels (Burnes, 2017).

Literature about how to prevent resistance to change is plentiful and clear, however there exist companies who still fail when approaching organizational or strategic changes. This is due to the belief that resistance to change will be managed by the consultant instead of being a concern of the internal top management, therefore missing the core concept of the influence that the company environment can play on resistance behaviours. Especially when it comes to an IT change, companies address a new supplier certain that the implementation of a new system will solve all current inefficiencies. What happens in the majority of the cases is that operators still work on printed papers and use a small percentage of the functionalities released by the new software, not willing to learn new and easiest ways of accomplishing tasks. The problem here is that IT changes profoundly alter the way of working of operators, at the same time the scope of the supplier company is analysis processes in order to configure

the new IT system, completing their job once the software has been installed. The human dimension is not a big concern for IT companies, but this leads to a wasteful use of the new application, generating dissatisfaction among operators and the company itself that doesn't achieve the expected results.

Being an IT company, Afea s.r.l. pays close attention to the aspect of change management, since it shapes the totality of its clients' projects. Substituting the information system means changing procedures and routines of operators, adopting a new terminology together with a new interface of the program. This generates reluctancy and discouragement among employees who face the new HIS implementation with little interest in the first place. In favor of a better approach to change, Afea has reinvented its way of delivering the software, going beyond the merely informatics aspects and focusing the attention over all factors enabling change: people, processes and technology. From the bonding of these three aspects, has been developed the idea of *3d Project*, which represents the structure of Afea delivery projects and the philosophy of Afea consultants when approaching a new client (Fig. 1).

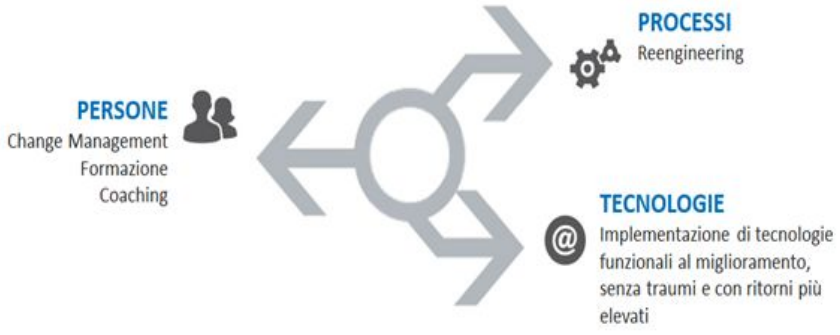


Figure 1: *3d Project* structure of Afea delivery system (afeasanita.it)

Processes

Digitizing processes that are not efficient will only generate greater inefficiencies; from this statement Afea affirms the necessity of redesigning processes before digitizing them. Indeed H2O implementation projects all start with an analysis of the client organization and its operative flows. The goal is to eliminate wastes embedded in the current system and redesign processes, with the support of employees and management of the customer company, in order to get leaner and higher quality work.

People

Employees are the critical factor to change management. To achieve a successful project, people must be the central focus: it's fundamental to involve them, to understand their current criticalities and their suggestions, at the same time, empower them and cooperate with them to reach common goals. Once people are active participants to the project and are informed about the mission, their resistance to change will be wiped out. In Afea's project, preceding the implementation phase, there is an education phase in which employees are taught how to work with the new HIS in order to use it in the most efficient way. The worst waste is the waste of resources; Afea considers this dimension and seeks to reduce it by enhancing employees capabilities.

Technology

Finally, technological support is fundamental to reach operational excellence, because it enables fast and accurate solutions that otherwise will be lengthy and inefficient. Afea concern is to offer a solution that adapts to clients requirements and permits the implementation of best practices.In the current context, marked out by dynamic evolution, the use of information and communication technology (ICT) together with a continuous adaptation to changing environments represent the drivers of a company competitiveness.

The *3d Project* approach differs substantially from the classical IT project approach because the central focus is value to be created for customers rather than the product to be implemented. Through this model, the impact to change results less severe and the final outcome is a company characterized by leaner processes and optimized operations. The purpose is to diffuse a lean culture in healthcare, spreading the concept that technology alone is not sufficient to bring efficiency and effectiveness to the company businesses; it is instead necessary to sustain a radical change starting from the organization's environment, achieving collaboration and better utilization of spaces together with a redesigning of processes aiming at a zero-waste solution. The concept was already sustained by Taiichi Ohno, inventor of the Toyota Production System (TPS), who said "technology is fundamental, but on its own is not sufficient; in order for it to function at the highest levels, it must be integrated with people so that the support of the latter complements the functionalities of the machines. Only by

combining these two aspects and driving them towards the same goals, the company will achieve greater efficiency and reduction of wastes". Indeed, the idea of *3d Project* came from the cohesion of Afea's values with the philosophy of lean thinking, and its structure recalls the 3P model developed in lean management. The 3P model as been developed by J.P.Womack (2006), who recommended attention over three business issues when embarking a lean transformation (www.lean.org). According to them, first it is important to understand the *purpose* of your business, reflecting what needs to be done to better satisfy customers and what is necessary to survive and prosper as a business. Usually the two aspects are aligned but both of them need to be taken into consideration when defining the purpose of the business. Secondly, attention has to be posed over *process*, which defines how the company achieves the purpose intended. Since all value created for customer is the end result of a process, this must be designed thinking of the final outcome it has to produce. Instead of focusing on the single activities, a complete vision of the entire process permits to understand if value generated flows smoothly from one step to the next. Finally, engagement of *people* is fundamental to the correct functioning of processes. People are responsible to evaluate the process congruence with the business purpose and continually improving it in this direction. Given that people are the ones operating within the processes, they are the key factors to the successful implementation of the project and the attainment of the expected results. To conclude, lean principles are applicable when people operate according to improvement objectives and problem solving purposes, originated by a process view of the company operations (Bracci, 2014).

Introduction

The unstable economic context, together with the turbulence characterizing markets and the pressure of competitiveness, is requiring a wide set of companies, included healthcare facilities, to redesign their organizational setting and profoundly renovate their strategies and business models. Healthcare providers are currently facing a situation of crisis: budget cutting, institutional uncertainty, lack of employees motivation and a decreasing reliability and reputation from the patient's side. The challenge is how to assure high quality services despite the decreasing availability of resources. To this aim, it becomes fundamental to adopt innovative interventions which permit waste reduction and quality enhancement, transforming the crisis into an opportunity of organizational refurbishment. Lean thinking is the answer to this challenge. As a matter of fact, in the recent years lean applications obtained successful results in contexts not related to manufacturing, such as healthcare, public administration, banking sector. In healthcare, thanks also to the institution of a Lean Healthcare and Life Science Award, lean thinking has gained attention, together with important results, reaching a wide number of applications in this sector. Today, the increasing involvement over lean practices has risen consciousness over the required factors enabling a successful implementation, factors that numerous times prevent facilities from obtaining the expected results. Businesses in all industries and services, including healthcare and governments, are using lean principles as the way they think and do. The expression lean transformation is often used to characterize a company moving from an old way of thinking to lean thinking. It requires a complete transformation on how a company conducts business. This takes a long-term perspective and perseverance.

The thesis has the aim of proving the incidence that lean projects obtain when applied in healthcare. Aim of the pilot project is to determine the consistency of a lean application and the alignment with Afea’s core business in order to introduce this approach to the company offering. The bounding of Lean Thinking with the software house delivery project will determine a diversification of Afea’s business respect to competitors. Indeed, facilities asking for a new HIS are driven by the desire of getting returns out of the new implementation. An integrated HIS definitely generates returns in terms of operational improvement, but as Bill

Gates said “The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency.”, therefore for pursuing operational excellence it is determinant to operate on processes first. The lean project has been an idea developed during the six-month internship experienced at Afea s.r.l., software house specialized in the healthcare sector. After participating to educational courses organized by the company and lead by an external lean consultant, there was the ambition to embrace lean values and transmit them to the client companies. The goal is that of enforcing Afea’s delivery system with a deeper analysis conducted in a lean direction. Nevertheless, given the necessity of implementing a pilot project first, it was decided to start with a client company already using Afea’s software, also to understand which was the impact generated by a lean transformation alone. Therefore the pilot project has been applied to a current client, Casa di Cura Villa Donatello, in order to test capabilities of the methodology and assess potential results.

In the first chapter lean thinking will be presented in its core values, principles and objectives. It will be evident how lean thinking modifies previous ways of thinking since the focus of management changes from optimizing separate assets, activities and vertical departments to optimizing the flow of products and services through the entire values stream, flowing horizontally across departments. Then, tools will be explained in order to understand how to apply the philosophy and the possible results to be expected from the adoption of each tool in the different contexts. In the second chapter the focus will be over the sector of appliance. Healthcare differs from other business models for a series of peculiarities that will be explained, together with their impact on the system nowadays. Surely healthcare is facing a period of shortage while request for healthcare services is in growth. This guarantees a perfect ground for lean applications that have gained considerable significance in this sector; few examples will be mentioned so to understand the powerful impact of this new strategy.

In the third chapter will be presented the pilot project, core argument of the thesis, which has been implemented in the private care facility Villa Donatello. The project refers to the optimization of a surgical process through the application of lean thinking. Finally the fourth chapter will discuss about the results of the analysis. The solution proposed will be explained and inserted in the future state map that will be presented to Villa Donatello staff in order for them to accept the proposed countermeasures.

1st Chapter: Lean Management

The term Lean management refers to an efficient and waste-free business strategy that aims at increasing value created for the customer by reducing the wasteful activities and enhancing employees capabilities. Value refers to whatever contributes to the creation of customer satisfaction, while waste concerns every activity that does not generate an incremental value. Lean management has obtained relevance since it has been applied in many industries with the purpose of redesigning management methods in order to produce more by having less (less resources, less costs, less time), which has become the challenge of today's companies.

The origin of this method comes from a Japanese innovation, that has been applied since 1950s in Toyota, known as Toyota Production System (TPS). This system has been the most important source of Toyota's competitive advantage, as a consequence other firms started to adopt it from the late 1970s. TPS has been associated to the term Lean manufacturing given its principle of "obtaining more by having less", meaning more quality by eliminating wastes and reducing human resources, inventories, time and space. The concept of Lean manufacturing, while spreading worldwide, has been adapted to a wider range of industries, assuming slightly different meanings, but remaining anchored to the core principles. The term Lean Thinking has been firstly introduced by Womack and Jones (1997) in the book "Lean thinking: banish waste and create wealth in your corporation".

From 2000 on, concepts like Lean logistics, Lean healthcare, Lean supply chain and so on have been used in order to describe Lean principles applied to different contests. The difficulty lying behind the adoption of Lean management is the strong reliance on the implementation of a cultural change before being able to apply tools and practices regarding the method. After numerous senseless implementations, has been clear that a Lean transformation requires a prepared top management able to involve personnel and a dedicated team constantly stressing the attention over Lean principles. Numerous programs of Lean Management based on TPS have been launched by consulting companies in order to successfully apply Lean thinking principles.

1.1 Lean origins: Toyota Production System

Toyota Production System is an organizational strategy created for the purpose of obtaining efficiency and resource optimization in the production process. This system has been developed since 1940 in Toyota, one of the main car producers in the global market (Nicosia, 2017). The inventors are Taiichi Ohno[1], and Kiichiro Toyoda[2], but some of the approaches have been introduced earlier in Toyota by Sakichi Toyoda[3], while other modifications have been launched by Eiji Toyoda [4]some years later.

The foundation over which TPS has been developed is the consciousness that resources within a company are scarce and expensive. Consequently, to reach efficiency is it required to constantly improve the productivity of each single resource (Nicosia, 2017). The context in which TPS has grown is significative of the core values characterizing the strategy. In the years after World War II, military destructions affected the Japanese industry with a dramatic scarcity of resources of every kind. Having obsolete technologies, limited disposable capitals and shortage of resources, the key to success has been for Toyota the enhancement of people, their skills and their responsibilities. In this direction, empowerment of people has been a distinctive feature of the TPS reflecting one of the intrinsic beliefs of the Japanese culture (Nicosia, 2017). Even though Toyota has been extraordinarily open about its strategy and methodologies, few companies have managed to implement the Toyota Production System successfully. This is due to the wrong belief that TPS is just a set of tools and routines to be

[1] Taiichi Ohno was a Japanese industrial engineer and businessman, considered the creator of the Toyota Production System and father of the Kanban System. He joined the Toyoda Automatic Loom Works, then renamed Toyota Motor Company, where he has been Chief Engineer for many years.

[2] Kiichiro Toyoda turned Toyoda's focus from automatic loom manufacture into automobile manufacturing creating what would become Toyota Motor Company (1938). He headed the automobile manufacturing operation between 1936 and 1950.

[3] Sakichi Toyoda, father of Kiichiro Toyoda, was a Japanese inventor and industrialist who founded the Toyoda Group in 1902.

[4] Eiji Toyoda was a Japanese industrialist. He has been largely responsible for bringing Toyota Motor Corporation to profitability and worldwide prominence during his tenure as president and later, as chairman.

introduced; it requires, instead, a pervasive cultural transformation at all levels of the organization. The peculiarity and strength of TPS relies in its intrinsic nature, that builds its roots on the Japanese culture (Spear, Bowen, 1999). Toyota has been able to realize this system and make it effective because the strategy was not introduced by the head of the company, instead it grew naturally from a continuous improvement of behaviours over decades. As a result, it has not been articulated on paper, but has always been very well defined in employees' minds (Spear, Bowen, 1999).

All we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes.

Taiichi Ohno, 1988

1.1.1 From craft production to lean production

In the pre-industrialized world, manufacturing was for the most part performed manually by individuals. Craft production refers to this way of processing products without the aid of automation, a production method that shaped the industry until the beginning of the 20th century.

The term is associated with the work of skilled artisans that follow the product from the design phase, to manufacturing until testing, supported by the use of simple tools and generic machinery. Craft production generates a one-by-one production of unique customized items, perfectly adhering to customer requests; one of the advantages of this manufacturing process is the close relation between producer and customer and the strict attention to the needs of the latter. At the same time, craft production held many disadvantages that made an evolution necessary, especially in the car manufacturing industry.

By the end of the 19th century, there were few small car producers and a scarce demand for this good, because of the high price and the long time required to have a car manufactured. Indeed, craft production applied in a car manufacturing process generated very high costs of production, given the consistent number of small components that were processed one-by-one. Consequently, only rich people could afford to buy a car. Also, because of small

volumes, the technology was not very reliable, requiring long testing time before having a car safely usable. Not enough, there was another big problem jeopardizing craft production systems, being the lack of development of new technologies in order to get a more reliable and standardized product. At the time artisans were very efficient in designing and manufacturing, but they weren't researchers, so they didn't have the resources required to develop an evolutionary innovation in the car manufacturing world. The current industry was reaching maturity, becoming a fertile ground for new ideas to come (Womack et al. 1990).

At the beginning of the 20th century, was Henry Ford, founder of the Ford Motor Company, to benefit of the situation. The car industry was being prevailed by a new manufacturing system known as Fordism by the name of Henry Ford, the first one to apply it. Fordism refers to a model of economic expansion based on mass production, aimed at producing high volumes of standard products. With the use of assembly lines, the production process has been cut down in small and simple tasks performed by unskilled labour with the use of special purpose machinery. High specialization of jobs was attained by the continuous repetition of the same task, a routine aimed at reducing variations. As opposing to craft production approach, standardization of outcomes was a peculiar element of this production system, leaving apart the close attention to customer's needs. The famous quote of Henry Ford "any colour so long as it is black" referred to the Model T car that, for a period of time, was produced only in black because it was the colour that dried quickest. Model T, in one colour and nine variations built on the same loom, has been a great success in the American industry, increasing domestic automobile production from 50,000 to two million units per year (Fujimoto, 2012).

Fordism brought a new paradigm shift in car manufacturing, where most of the interventions introduced are opposing to the old craft production system. The major goals achieved by mass production are high reduction in costs and substantial increase in productivity. The former thanks to the low salary of unskilled employees, the reduction of components and the limited variety of outcomes. The latter given by the simplification and reduction of tasks, given a cycle time (time to perform all the activities assigned before repeating the sequence) shrieked from 514 to 1.9 minutes and given the shortening of setup times of dedicated machines. However, the crucial aspects introduced by mass production have been the interchangeability of components, those being accurately processed in order to have them fit perfectly with each

other, and the facility of assembly that has been articulated in many easy tasks to be performed without requiring particular skills.

Thanks to these achievements, Ford attracted many competitor firms interested in applying the same production system; being willing to share his knowledge and his methodologies, Henry Ford has encouraged the spread of mass production worldwide. Indeed, it has been the driving force of automobile industry for more than 50 years, adopted in all industry sectors from USA to Europe (Womack et al., 1990). As the high margins of improvements started to saturate, limits of mass production became more evident. Firstly, the lack of flexibility; it required huge costs and time to modify a processing method or a component because of the high specialization of machinery. Secondly, the accumulation of spare parts and work in progress components generated high costs of storage making vain the earnings of filling machine productivity. Thirdly, and most importantly, the repetition of a single task if, in one side, increased the productivity of employees, in the other side, provoked alienation and lack of motivation, therefore increasing turnover. To defend labour rights, at the end of the 1930s, syndicates started to emerge, with the Job Control Unionism that regulated labour introducing rights for seniority. At this point, Toyota could not anymore fire employees only because of their reduce productivity, as a consequence productivity index started to decrease.

Although the presence of limitations, mass production hegemony continued until 1980s, when a Japanese firm entered the international scene with a new way of thinking (Fig.1.1).

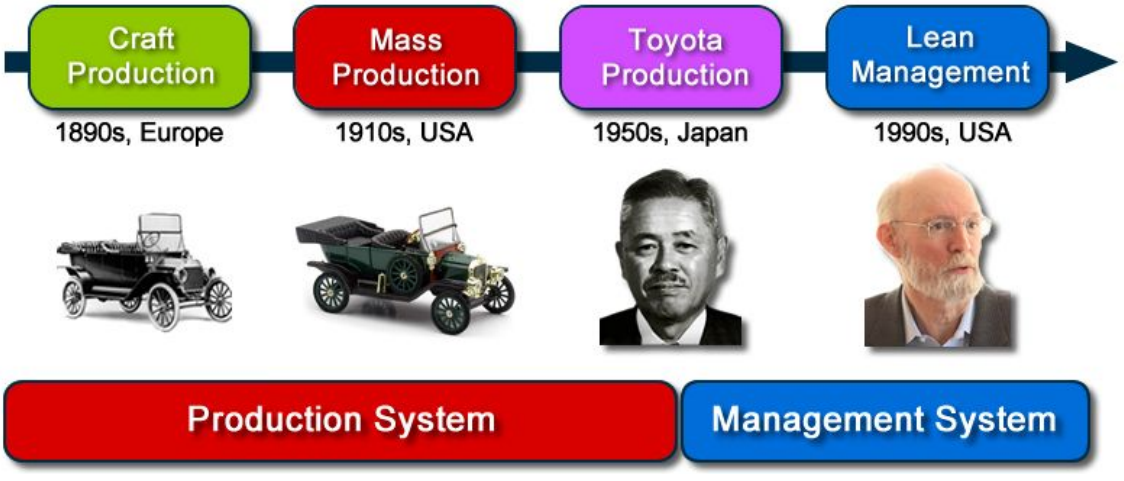


Fig 1.1: From craft production to lean management

As the fierce competition of big players existing in the car manufacturing industry was spreading worldwide, local companies were suffering the mass production system, because installing a system like Ford's one required conspicuous investment. Particularly, the Japanese industry, in the post-war years, was affected by considerable scarcity of resources and production was still relying on craft made products. The shortage of capitals hindered investments in the modern technologies used in occidental countries. Internal demand for automobiles was limited and diversified: there was necessity of luxury cars for government officials, small lorries for agriculture, trucks for transportation of goods and compact cars for citizens having to deal with traffic (Ohno,1988). In addition, with the introduction of syndicates, low-cost labour was not permitted anymore and rights for better working conditions increased the bargaining power of workers. At the beginning of the 1950s, the Japanese government established regulations to protect local car manufacturing industry by abrogating the possibility for foreign companies to invest in local firms and by introducing taxes over the purchase of import goods. Actions that encouraged local companies to enter the market of car manufacturing. Although these regulations enhanced the local industry development, they weren't enough to guarantee an entrance in the international market.

In this critical environment, few were the companies that stepped in the challenge, among them, Toyota and Nissan. In Toyota the chief of production systems, Taiichi Ohno, together with the CEO of the company, Eiji Toyoda, spent several years in the Ford factory of River Rouge, studying how to introduce mass production methodologies in their company. However, they knew that replication of the same system was not effective for their situation because they did not have enough resources to establish a factory with dedicated machinery. Also, their problem was about providing small amounts and variety in outcomes, something that the occidental world wasn't considering as a necessity. By analysing the current system, Ohno discovered that significant improvements could have been possible. First, he found the way to reduce setup times of machinery, considering the utilization of general-purpose machinery instead of dedicated ones. Activities that in River Rouge required a day-time of skilled employees, were translated in a simple three-minute activity to be performed by any worker. Having these short setup times, the production of small lots and the frequent change of tasks on the same machine resulted convenient compared to the production of large batches

typical of mass production. This, due to the fact that components produced in great amounts needed to be stored, therefore generating costs of storage. Another important advantage is the impact on the detection of defects: by processing small quantities, defects were quickly identified before proceeding with assembly, therefore eliminating costs of final outcome repairs. Ohno identified a core requirement in order to have an effective system working this way: motivation and capability of labour. Employees had to be responsible and proactive in the detection and prevention of defects and provided with the essential skills for generating themselves solutions. This aspect was profoundly lost with the diffusion of mass production (Womack et al., 1990).

Ohno, by combining the advantages brought by mass production in terms of lower costs of production together with the flexibility that was determinant of the craft production system, created a new production concept, called Toyota Production System.

1.1.2 TPS key to success

In 1973, with the first oil crisis, Toyota was the only company in the automobile sector registering positive income, attracting the attention of numerous Japanese companies. Later, in the 1980s, Toyota caught the world's attention when it became clear that efficiency and quality of Japanese car were overtaking the rest of the competition. Faster time to design cars, with more reliability, yet at a competitive cost and worker that were well-paid and motivated (Liker,2004).

Improvements that seem quite impossible to achieve simultaneously, Ohno was able to reach them by healing the current system, which was already performing but with a lot of wastes. Among the changes introduced by Toyota to improve mass production according to its needs, there was, as mentioned before, the increased reliability on workers' skills. Ohno discovered, indeed, that workers on the line cultivated better knowledge about the process functioning rather than engineers. Therefore, the mass production practice of separating the two functions of planning performed by technics and manufacturing performed by workers seemed unproductive to Ohno's eyes. On the contrary, he gave continuity to the two activities, with workers that had to be part of the planning process in order to highlight problems and suggest solutions. Also, to enhance employees' motivation, portions of the process were divided

among teams of workers with the requirement that people within the team had to be collaborative, so each member had to perform more than one task. With syndicates regulation, Toyota had to provide job for the lifetime of its workers, making the latter a fixed cost for the company that so decided to invest in them by stimulating capability improvement and asking them the effort to go beyond the merely task processing. Employees had the job of constantly improving the system by identifying inefficiencies and implementing corrective actions (Liker, 2004).

With TPS, what matters most in people capabilities is versatility rather than specialization, another aspect that disrupts from previous beliefs and that derives from the approach based on flow rather than single functions (Womack & Jones, 1997). Flow is the heart of the TPS philosophy, and it emphasizes a change in perspective when looking at the production line. The process, divided in a sequence of tasks, is no more subjected to the efficiency maximization of each task, but it's to be considered in its entirety. It means that, in order to improve the functioning of the line, it is of fundamental importance to focus on the totality of the process, because it shows how the product flows along the line and if the consecutive activities are performed smoothly or not. In mass production processes, the focus on single tasks made each activity perfectly standardized in order to achieve the maximum productivity out of each step, thus transition processes were generating wastes or redundancies. With flow, attention to the single step was performed after having coordinated the whole process and balanced the tasks. *Heijunka* is the Japanese word referring to the levelling of the workload in each workstation, and it is an essential practice in order to have activities flowing one after the other without interruptions. The aim of applying flow perspective is the shortening of elapsed time from raw materials to finished goods or services by eliminating wastes; this ultimately leads to lowest cost and shortest delivery time (Liker,2004).

The strength of TPS relies considerably on its attention over *muda*, Japanese word for waste. Ohno's goal was to eliminate every kind of waste arisen in the current production system. For this purpose, he identified seven categories of wastes to be pinpointed and corrected, if possible, eliminated. These 7 categories are the following (Ohno, 1988):

- *Overproduction*. Producing more than what it is required by demand, generates wastes as overstaffing or excess inventory, meaning increased costs of storage and transportation;

- *Waiting*. Every Time workers remain unproductive because they don't have the required resources to start processing the tasks. For example, it could originate from processing delays, from lack of materials, tools, supply required for the next processing step, from capacity bottlenecks or equipment downtime;
- *Unnecessary transport*. Transferring of material, parts or finished goods into or out of storage or between processes creating inefficient transportations;
- *Over processing or incorrect processing*. Adding unneeded steps to the process or having inefficient routines with duplication of activities. Usually due to poor design of the processing steps;
- *Excess inventory*. Having more materials, components or finished product than required means increasing costs and transportation, risking damage of goods or obsolescence, causing longer lead times;
- *Unnecessary movement*. The motion of employees is another source of waste because time spent walking is time lost for production;
- *Defects*. Production of defectives parts thus requiring corrective actions to be performed. Repair or rework, replacement production and inspection are all sources of wasteful handling of both time and effort.

People are trained to see wastes and are given the rules and tools to resolve them. Problems must be solved by conducting a 5 whys analysis, with the aim of understanding the root causes. Also, the resolution development must be performed, according to the principle of *genchi genbutsu*, at the actual place where the problem occurred, in order to see what is really going on (Liker, 2004). The hyper attention over *muda* has distinguished TPS because it brought the company to a single target: perfection. The pursuit of perfection is in clear contrast to the target chased by mass production that was yearning for a sufficient level of quality in order to sell high volumes, permitting wastes under a certain threshold (Womack et al.,1990).

Toyota's perfection is an ambitious and never ending goal that requires perseverance, precision and motivation. De facto, people in Toyota have a common understanding of how the ideal production system would be, and this mission motivates them to improve beyond what would be necessary to meet current needs of customers (Spear, Bowen, 1999). What

Toyota's employees are pursuing is called *Kaizen*, standing for continuous improvement and achievable by applying the Deming cycle PDCA: Plan, Do, Check, Act (Chiarini & Associati). *Kaizen* was supported by a defined plan: daily, workers had to keep neat their stationing and check the quality of the parts processed; periodically, employees participated to collective meetings with the aim of generating solutions directed over improvement. Whenever a defect was detected during production, the line would be stopped in order to fix the defect immediately (*muda*); this routine did generated a lot of stops in the first years of implementation of TPS, but by instantly correcting the error and understanding its cause, soon the stops were reduced almost to zero (Womack et al.,1990). *Muda* elimination and *Kaizen* have been possible also thanks to the aspect of standardization. Differently from mass production, where tasks were reduced to childproof operations to be performed by unskilled workers, in Toyota, standardization was a powerful method to detect problems. Standardizing activities consists of three elements to be defined: takt time, sequence and stock. Takt time refers the time required to complete one task at the pace of customer demand; sequence is the ordering of activities and the definition of how to perform each task; stock is the amount of inventory each individual worker needs in order to accomplish the job (Liker,2004). According to TPS view, standardization is about finding one best way of performing a task and freezing it so that each employee works the same way. Whenever a defect is detected, it is possible to determine if the problem occurred because of a variation in accomplishing the task, or because the standard has to be modified. Since all workers have been trained to work the same way, whenever a standard is modified, everyone performing the same task will be asked to adopt the modification and everyone will be able to understand it. As a consequence, standardization fosters improvement.

It is clear now that the success of TPS relies on a network of practices and beliefs nested to each other in a way that excluding one, the rest will be ineffective. In this sense, it is significative the representation that Fujio Cho [5], disciple of Taiichi Ohno, has developed to describe the essence of the Toyota Production System (Fig.1.2).

[5] Fujio Cho has been serving as Chairman of the Board and Representative Director of Toyota Motor Corporation from June 2006 to June 2013.

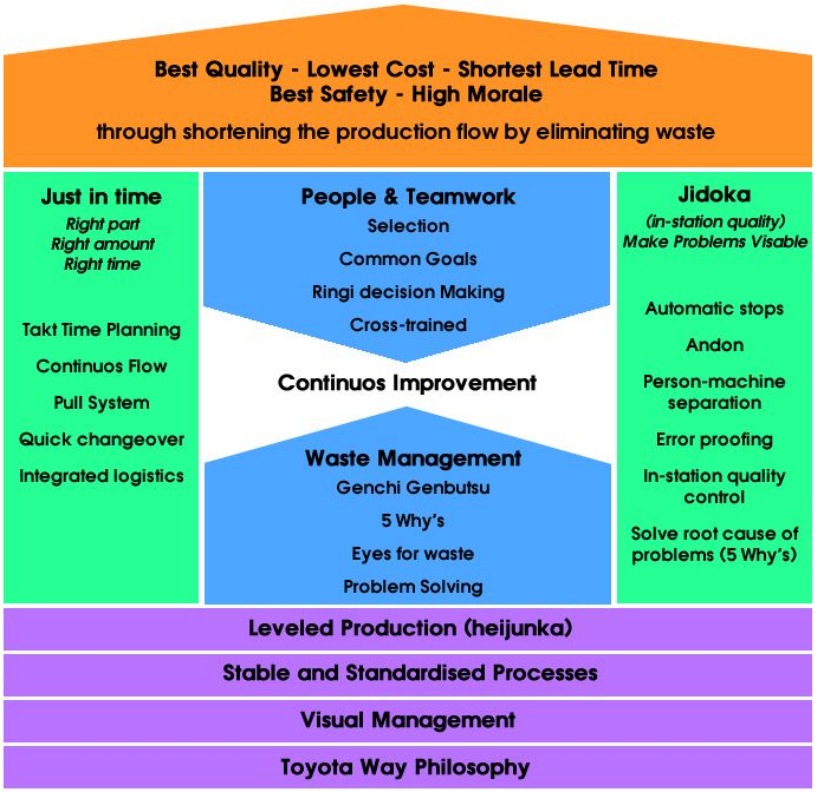


Figure 1.2: Toyota Production System House (Fujio Cho).

The TPS house diagram has become one of the most recognizable symbols in modern manufacturing. The choice of the house is meaningful, because the house represents a structural system where each element by itself is critical, but more important is the way elements reinforce each other. On the roof are placed the goals of best quality, lowest costs, shortest time to market and empowered employees, emphasising also the attention over safety and morale. There are then two pillars sustaining the structure: *Just-In-Time* and *Jidoka*.

Just-In-Time means removing, as much as possible, inventory used to buffer operations against problems that may arise during production (Liker, 2004). A JIT system is characterized by processes supplied with the required items, in the required amount, at the required time; it does not allow early delivery because it generates accumulation of products or delayed delivery because it creates waiting. Working in pace means that every component is delivered right at the time when it is required by the next activity to be performed and guarantees interoperability of different functions working for the same final product. Synchronization of tasks allows the products to be ready in a minor timeframe, enabling a

faster response to the demand of the market (Nicosia, 2017). JIT is feasible only if production is based on a Pull system, which means that production starts only when a customer request occurs. Together with Pull, that will be discussed deeper in the following paragraph, JIT relies also on quick changeover because general purpose machinery is efficient when setup times, moving from a processing to another, are minimized.

Jidoka refers to the practice of never letting a defect pass into the next station. Is a method of built-in-quality, meaning that whenever a defect occurs, the production is stopped in order for the employee to fix the problem, avoiding the proceeding of the defect downstream. Jidoka is fundamental in a system like TPS because of the low inventory levels; in case of a quality problem, there is no buffer to rely on. Detection of abnormalities, in some cases, is committed to devices placed inside the machineries that stop automatically, otherwise is assigned to employees that, through buttons or *andon cords*, signal a need for help to solve a quality problem. Correction of defects is a standardized activity that must be performed according to the *5 whys* assuring that the root causes are analysed and understood and that the problem will not happen again. In the centre of the system are people, skilled, empowered and motivated. People have decision power based on a bottom-up and informal approach (*ringi system)* in order to solve problems and are being trained to identify waste. The combination of skilled people and defined waste detection procedures enables the continuous improvement (Liker, 2004). Finally there are various foundational elements, like levelled production and standardized processes supported by a visual management system that clarifies and spreads knowledge about the actual performance of the entire plant.

These individual routines, combined into a coordinative system, sustain the organizational capability in manufacturing. In Toyota, at least three layers of organizational capabilities are identifiable: routinized static capability, routinized dynamic capability and non-routinized dynamic capability (Fujimoto, 2012). The first one is the manufacturing capability that controls the efficient flow of value to customers. The second is the improvement capability, in order to increase manufacturing performance through numerous kaizen proposals. The third one is the evolutionary capability, which is the ability to maintain such manufacturing and improvement capabilities over time; it is related to an organizational preparedness over learning, whether intended or not. The major source of competitive advantage of the Japanese auto industry has been this aggregation of routines that simultaneously achieve high

productivity and quality while making constant improvements, called total capability approach (Fujimoto, 2012). In the book "The Machine That Changed the World", Womack and Jones define this set of mutually consistent routines under the name of Lean Production System.

When Japanese domestic automobile production grew from 50,000 to two million units between 1950s and 1960s, it was the cumulative effect of differentiated small-volume models, as opposed to the single Model T pioneer of Ford's success. The strength of Toyota relies in the capability of being flexible and efficient at the same time, two fundamental requirements to compete in the local market (Fujimoto, 2012). An aspect that influenced Toyota to succeed has been its continuous attention over customers and the fulfilment of their needs. (Spear, Bowen, 1999)

1.2 Lean Principles

The successful example of Toyota has risen attention over the principles that characterize TPS, which became the new manufacturing paradigm in the post-Fordism age. The Japanese approach to manufacturing has been the major precursor of what later has been known as Lean Management. Originated in the manufacturing environment, lean approach has later been applied in different businesses, getting managerial relevance in a wider scope. Lean has been shaped in many ways according to the contexts in which it was transposed: Lean management, Lean manufacturing, Lean logistics, Lean healthcare, are just few of the terms used nowadays. Although its adaptability, when talking about lean, no matter what the applied context is, we refer to a new way of thinking. Indeed, the term Lean Thinking has been used to refer to the core of the philosophy (Lean Enterprise Institute).

As already said, the concept of Lean thinking has been for the first time introduced by J.P. Womack and D.T. Jones in the book "Lean Thinking: banish waste and create health in your corporation" (1997). According to them, Lean thinking builds its roots over 5 principles (Fig.1.3):

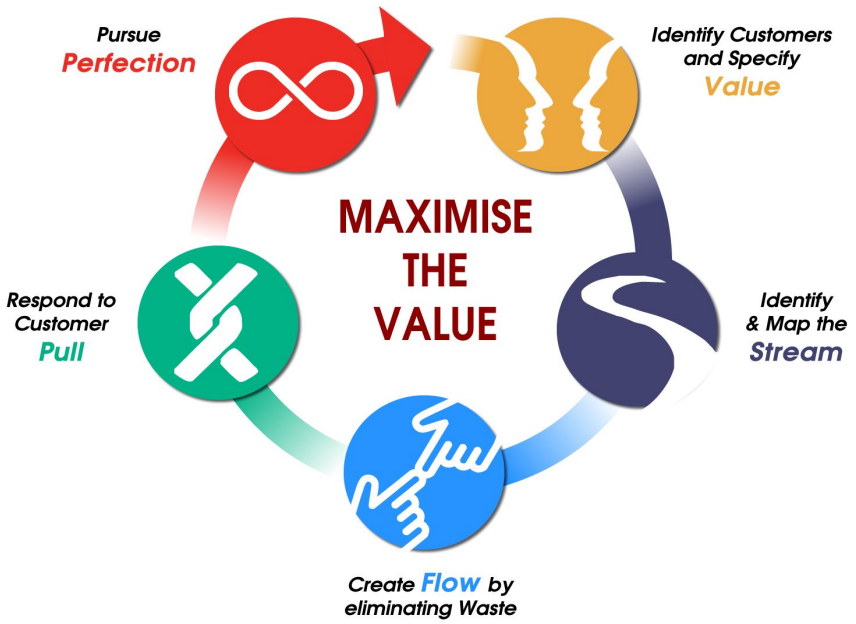


Fig.1.3: Lean Principles (Womack & Jones, 1997)

1.2.1. Value

Value refers to whatever the customer is willing to pay for. Value can only be defined by the end user/customer and must be expressed in terms of finite product or service which meets customer's needs at a specific price and at a specific time. It is identifiable as a value creation step each activity that holds a modification of the product, compliant to the customer requirements. To separate value-added steps from non-value-added ones, it is fundamental to observe the process through the customer's eyes (Liker, 2004).

Important, according to the Japanese philosophy, is also determining where value is created. Value is strictly related to the place where the product is realized, so it changes according to local needs instead of being a generalized statement. Through a Customer Value Proposition, it is possible to identify which are the variables that hold value for the customer thus focusing on maximizing them. Kano model can be used to classify attributes according on how they participate in the value creation process.

The concept of value is crucial to the definition of *muda*, which in Japanese means waste. Muda refers to every activity that does not generate value, therefore representing a cost for the company. It has to be distinguished in two types: *muda* to be reduced and *muda* to be

eliminated. The former are activities that are necessary because they support the execution of value creation activities, the latter are activities that can be removed without impacting the value creation process.

1.2.2 Value stream

Value stream is the definition of the path through which the company generates value. Defining the value stream means drawing the path along which value is created in order to have a clear idea of how it is articulated. In this sense, visual representation is an aspect of particular importance, recalled in numerous applications of Lean thinking. Value stream involves all the activities from raw materials to a finished product, therefore combining multiple functions or departments acting directly on the value creation process. The perspective is cross so to have a full picture of the process, representing also transitions and waiting. Since nowadays companies are more and more outsourcing, drawing the value stream could imply going beyond the firm boundaries, combining pieces of processes performed by different companies. Although the focus on the big picture, it is also possible to narrow the scope to a single process within a firm. By applying the value stream approach to process improvement, most of the efficiency comes from the large number of non-value-added activities that are squeezed out. Without value stream perspective, it is difficult to see the huge opportunities for reducing waste by shrinking those non-value-added steps.

Value Stream Mapping is the tool used by Lean companies to draw value creation processes. Through value stream mapping it is possible to perform a detailed analysis of the information and materials flowing in and out each process' step. Inserting all required data in a single map, encourages the evaluation of different kinds of wastes and permits the understanding of the impact that each modification could imply in the whole process.

1.2.3 Flow

Once value has been specified, value stream has been mapped and wasteful steps have been eliminated, lean thinking philosophy includes another activity: make the remaining value-creating steps flow. A value stream without interruption is referred to as a flow. Having

value creation activities flowing smoothly one after the other means reducing the total processing time of the product, also named Lead Time. Indeed, one of the cornerstones of lean thinking is maximizing customer satisfaction; one way of doing so is producing value for the customer in the minor time possible. Making the process flow requires a complete rearrangement of the activities with possible consistent modifications involved. One could be the creation of cellular working, which is the aggregation of a sequence of consecutive operations in the same physical space. Core to the definition of flow is the attention over the entire production process rather than focalizing on specific activities along the path. The traditional approach to process improvement focuses on identifying local efficiencies, while flow concentrates of the efficiency maximization of the whole process. The introduction of flow is actually to be appointed to Henry Ford with mass production, that introduced flow in the assembly line of his car manufacturing plant. Though, the innovation brought by lean thinking refers to the continuous flow of small volume production, having the same machine processing activities of different kinds. In this scenario, the goal is right-sizing machines and quickly change over tools in order to perform diverse tasks one immediately adjacent to the other, with the object undergoing manufacture being kept in continuous flow.

The concept of flow is supported by two other practices of lean thinking which are Just-In-Time and One-Piece-Flow. The first, already mentioned, guarantees that the output of each step is delivered as soon as the next step requires it, meaning that activities along the process are being performed at the same pace. The second is a strategy that guarantees the minimization of Lead Time, focusing on the production of one piece at the time. Thus, the aim is reducing work in progress (WIP) components, by focusing on a fast and smooth completion of products. This perspective is disruptive respect to the philosophy of batches, widely used in manufacturing, where components are processed in large quantities in order to saturate machinery, at the same time generating high inventory and WIP.

1.2.4 Pull

In antithesis to the concept of Push system, which is the production based on a provisional demand, in a Pull system is the request from the customer that triggers the production process. Starting from the customer's order, the information about the request of production flows backwards along the production process until reaching the first activity in the line. In this

way, every activity in the production process is activated only once it receives a commission from the subsequent activity, in turn generating an order for the previous activity in the process. A pull system is flexible because the pool of products available can be produced in any combination, thus accommodating shifting demands. The shorter lead time not only satisfies customer better, but also makes the demand much more stable given that periodic price discounting campaigns are avoided when adopting a pull system. This forth principle of lean thinking is another piece of the puzzle that dovetails perfectly with the others in the fulfilment of the same purpose. Sure enough, by setting a pull production system, inventory levels are shrunk because no product will be processed until an order requires it. According to Just-In-Time philosophy, customers will have what they want, when they want, in the amount they require. In the ideal state, the purest form of pull system is One-Piece-Flow, where the production follows only one product at the time.

The more inventory a company has, the less likely they will have what they need.

Taiichi Ohno

1.2.5 Perfection

The fifth and last principle of Lean thinking lies its attention over the continuous renovation of processes in order to improve them in terms of efficiency and effectiveness. Perfection, in an ideal state, means decreasing costs, utilization of resources, spaces and time while reaching zero defects, zero inventory and greater variety of products.

A production process free of wastes and flowing without interruptions is more sensitive to imperfections because every delay in production reflects automatically on the ability to satisfy customer's request in time. Therefore, the detection of mistakes results easier, thus allowing a rapid implementation of improvement processes in order to fix the problem arisen. According to these principles, stimuli to improve the processes are no more imposed from the top management, but are visible and necessary to each employee at every level of the value stream process. Transparency is a core feature when chasing perfection, because it shows evidence of any problem arising in the system. Besides, workers are given the power of introducing improvements themselves, by following the systematic approach to problem solving Plan-Do-Check-Act, known as Deming Cycle. Rewarding for improvements

generates highly positive feedbacks and it is a powerful spur to continuing efforts directed over improvement.

Lean thinking distinguishes two kinds of improvements: *Kaizen* and *Kaikaku*. The already explained *Kaizen* is the process of making incremental enhancements, even of small impact, oriented to the goal of waste elimination. *Kaikaku* refers to a breakthrough innovation, a major change that requires a great amount both in time and effort to be realized and aims at introducing a shift in technology or in the business strategy. Since *Kaizen* drives toward small impact changes, they are achievable in a short time frame, so results are soon visible and beneficial. Both are useful tactics striving to seek perfection, but the support of kaizen is central, because a constant realization of small changes is much easier to achieve, at the same time it generates powerful and fast results.

Being a lean manufacturer means focusing on how to make the product flow though value-adding processes without any interruption, according to a pull system that cascades back from customer demand, replenishing only what the next operation takes and building a culture where everyone is continuously striving to improve (Liker, 2004).

1.3 Tools and methodologies of Lean Management

Lean management identifies a set of tools and practices that combined serve as a support for the implementation of the principles held by lean philosophy. Each of the principles explained in the previous paragraph is translated into daily routines that, if correctly performed, satisfy the requirements of Lean Thinking. The use of tools themselves does not guarantee a lean company, since a correct utilization of tools requires a strong motivation and understanding of the culture in the first place.

The success of lean management is not merely the creation and use of tools, instead it resides in making all these tools a series of nested routines, where the contribution of each one is determinant in the achievement of a unique goal. Tools and methodologies are crucial to the definition of the organizational capability, which is a system of distinctive organizational routines and translates in the firm' ability to sustain a competitive advantage (Fujimoto, 1999).

1.3.1 Kanban

Kanban is the Japanese word for card, ticket or sign. In a lean perspective, a *kanban* is a signalling device that gives authorization for the production or withdrawal of items and it is the tool for managing the just-in-time supply system. The theory behind *kanban* is that only what has been used is replenished, in line with the pull strategy. The request of materials, products or semi-finished products follows the logic bottom-up, meaning that is the subsequent activity in the process that tells the previous one when is it necessary to produce more. Through *kanban*, a request for material moves in a regressive way, starting from the end of the production line and reaching the top of it where a production of a new item starts.

Kanban has a double function: a production request or a movement of products. Production *kanban* is used when the downstream process tells the upstream phase the type and quantity of products to be produced. Withdrawal *kanban* is used to authorize the conveyance of parts to a downstream process; withdrawal *kanban* can be distinguished between internal *kanban*, when used among internal processes, and supplier *kanban*, when withdrawal comes from an external supplier. In order to have a pull system, production *kanban* and withdrawal *kanban* must be used jointly. The number of *kanban* is fixed according to the demand analysis, thus limiting production and, at the same time, holding stocks to a minimum level. Each *kanban* card corresponds to one container of parts. In the downstream process, the operator removes a withdrawal *kanban* when using the first item in the container and places it in a collection box. The material handler picks the *kanban* in the collection box and reaches the upstream process, where the withdrawal *kanban* is placed on a new container full of parts to be delivered to the downstream process. As this full container is taken, the production *kanban* on the container is removed and placed on another collection box signalling the need to produce one additional container of parts (Lean Enterprise Institute).

For a *kanban* system to be effective, there are six rules to be satisfied:

1. Customer processes order goods in the precise amounts specified on the *kanban*;
2. Supplier processes produce goods in the precise amounts specified by the *kanban*;
3. No items are made or moved without a *kanban*;

4. All parts and materials always have a *kanban* attached;
5. Defective parts are never sent to the next process;
6. The number of *kanban* is reduced carefully to lower inventories.

The *kanban* system is a widely spread tool used in many occasions, not only in production environments; it is also used to manage the progress of activities performed in a service company, through *kanban* boards. *Kanban* strength relies in its remarkability, simplicity, effectiveness and highly visual impact (Lean Enterprise Institute).

1.3.2 Mapping techniques

The most important operation to carry out, in order to apply lean thinking, is the identification of *muda*. This is achievable by visualizing processes in their whole structure and analysing them carefully step by step. Visual representation is extremely important in a Lean company because it permits a complete sight and understanding of processes, with a clear highlighting of wastes and value-adding activities, and it supports the generation of an action plan according to priorities. Visual representation is obtained using multiple tools, referred to as Mapping tools. In this paragraph, three of the mapping tools will be introduced.

- Value Stream Mapping (VSM)

  The VSM tool is used to graphically display all the activities that participate in the creation of the final product, starting from suppliers, through all the manufacturing process until delivery of the finite good. The goal of VSM is not that of improving a single activity or a function within the process; on the contrary, the goal is the enhancement of the entire process in a global perspective. It means that, what must be ameliorated is the flow of value from upstream processes to the downstream phases.

  Value stream mapping, to be compliant with its goals, must be clear and understandable by employees participating in the mapping activity, must highlight problems, wastes and inefficiencies, must show the whole process and draw attention to the value-adding activities. Beneficial to a complete depiction of the process, is the

integration, within the same map, of the information flows and materials flows concerning the activities included in the map.

As most of the practices characterizing lean thinking, VSM has a standardized representation scheme, with symbols to be respected so that the representation results understandable and recognizable. In the following picture there are common symbols used in a value stream mapping activity (Fig.1.4).

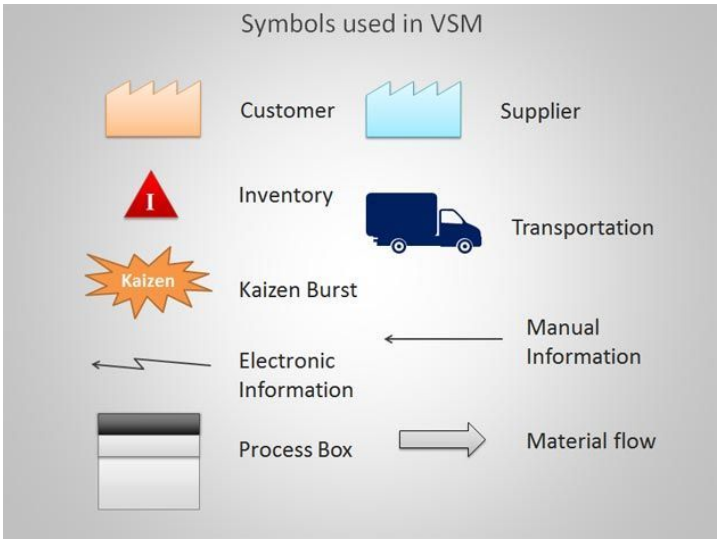


Fig.1.4: Symbols used in VSM

VMS is composed of two steps: Current State Mapping, showing the actual situation of the process, and Future State Mapping, demonstrating how the process will result once wastes will be removed. In order to designate an appropriate future state map, key performance indicators must be selected, reflecting the parameters to be improved. These KPI must be measurable and determinant of the current performance of the process, therefore their improvement will generate significant efficiencies in the future state process.

- Makigami

Similarly, Makigami is a mapping tool used to represent processes and sub-processes. It is more suitable for services and administrative processes rather than manufacturing processes, and it stresses the attention over the cycle time. Interface problems, between individual departments or with customers or suppliers, are difficult to be

recognized at first glance; Makigami achieves the necessary transparency. Hence, in a makigami map, all actors performing in the process are listed and activities are connected to the person fulfilling it. The process appears as a flowchart and interfaces are easily recognizable. Also, process steps are defined in detail and few symbolism is used (Fig.1.5).

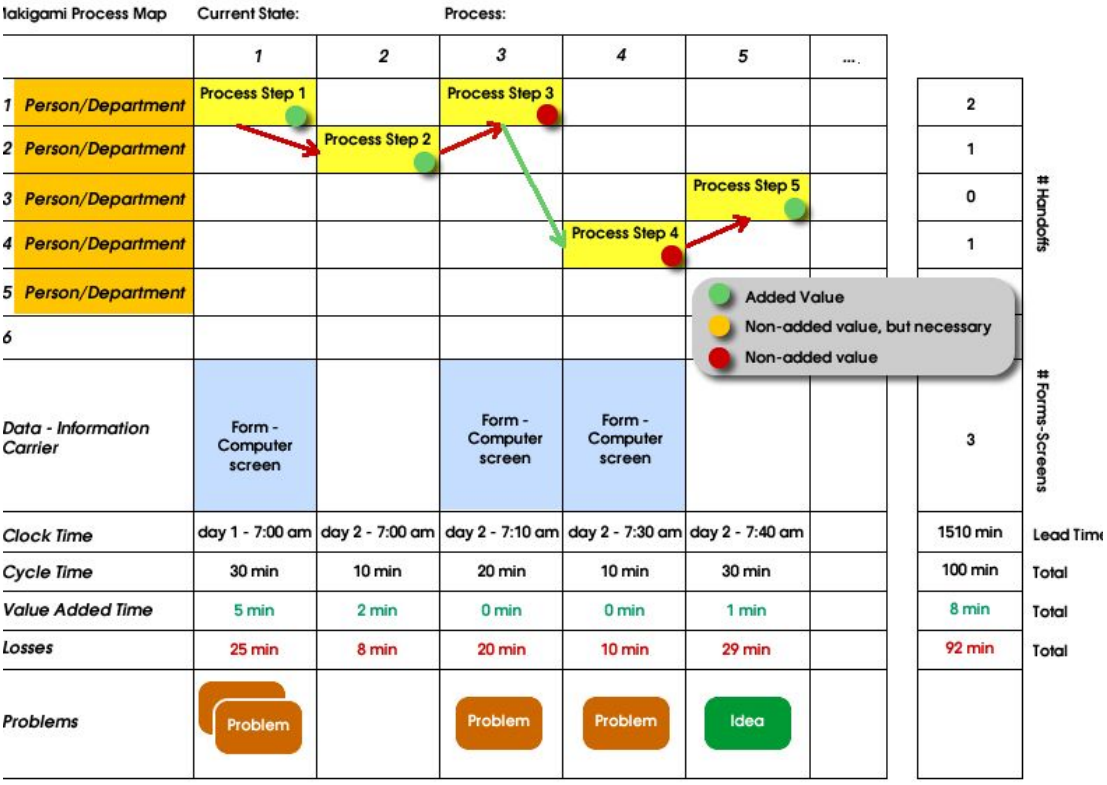


Fig. 1.5: Makigami framework (www.amelior.be).

Mapping starts by dividing the process into sub-processes or activities, bringing those sub-processes into a meaningful chronological order (horizontal), then assigning them to the responsible department or person (vertically) and marking the transitions with arrows. Red arrows indicate interfaces where difficulties often arise. Green arrows represent unproblematic transitions. Finally, times are reported and the identified problems are described in the appropriate line.

- Spaghetti Chart

This tool is useful when describing physical flows of materials or people and can be applied both in manufacturing and service environments. The ultimate goal of a

spaghetti chart is the optimization of the layout, making movements as limited as possible. According to lean principles, transferring of people or material is considered a waste to be eliminated or, at least, reduced. By getting a map of the current layout of the office or factory, the motions of the considered person or material are showed by tracing lines on the map. By analysing the chart, it is possible to determine the amount of motion registered with the current layout and understand which are the most common paths (or most critical in terms of length) that must be considered and minimized when redesigning the layout.

1.3.3 One Piece Flow support tools

The principle of one-piece flow is an ideal state that characterizes lean companies because it guarantees conspicuous gains in productivity and quality, at the same time, consistent reductions in inventory, space and time. It is a very demanding process distinguished for its flexibility that permits a rapid resolution of problems and the ability to adapt to customer demand. Given its complexity, it is supported by numerous practices that, combined, seek to reach this ideal state. Nowadays lean companies are more and more reducing work-in-progress parts and inventories, still, reaching the production of one piece at the time remains a challenge.

- Cellular Manufacturing

  One way to reduce motion and increase productivity is by creating a placement where the operation can carry on multiple activities by remaining fixed in the same position. This layout takes the name of cell stationing and usually it has a U configuration. The product flows within the stationing where activities are performed without interruption. In this way, the operator starts a new product only when the previous one has passed through the set of activities (Fig.1.6).

Fig.1.6: Cellular manufacturing (www.leanmanufacturing.it).

- Takt Time

  To guarantee a continuous flow, not only within a cell but also in the transferring from a cell to the following one, it is necessary to have work stations operating at the same pace. Thus, each working station must be balanced in the amount of workload so that all working stations can be synchronized, and products can flow continuously. Takt time is the rhythm of production and it is calculated by dividing the total productive time available by the demand for that product.

$$Takt\ Time = \frac{Total\ production\ time\ available}{demand}$$

  To calculate Takt time is therefore required to firstly define the horizon over which takt time is referring, define demand for single products of family of products (based on how the cells are configured) and determine the total available time, excluded the programmed time breaks.

- *Heijunka*

  The Japanese term *heijunka* means levelling, indeed this is the practice of levelling the work schedule of each working station, both in terms of volume and production mix. The aim is to spread demand over a fixed period in a uniform way, so that each cell can work according to pace producing a constant amount of goods and avoiding

fluctuations. Heijunka impacts also the supply of materials to the working stations, that are programmed and regular, avoiding accumulation of WIP parts. Smoothing out the volume and mix of items produced assures little variation in production from day to day and minimized inventory.

1.3.4 5S

The 5S tool is aimed at maintaining the working spaces cleaned and well organized. 5S is composed of a sequence of five steps as following:

1. *Seiri* (divide). The first step to the attainment of a cleaned working station is the elimination of all useless items. The correct implementation of this step guarantees an optimal utilization of spaces, a reduction of time required to search for the right material, documentation or tool. Seiri is in line with the JIT concept of supplying only what is required at the right time. Items must be divided in useful ones, useless ones and uncertain ones. The latter will be kept for a period in which their utilization will be controlled; if not used, then they will be eliminated together with useless items, otherwise will be kept with the useful ones.
2. *Seiton* (organize). Useful items must be organized so that their location facilitate search and usage. Meaningfully dispose items in shelves and closets and codify objects through labels. Items must be located also according to the frequency of use, therefore often used items will be positioned in close and easy reachable places within the working station, while rarely used ones will be located in distant storage rooms.
3. *Seiso* (clean). Locations and all working environment must be cleaned together with the machinery and tools. By making employees responsible for their working station, they are instructed on how to keep the designated posts tidy and well structured. Cleaning the working space not only guarantees a better working environment and better health, also it prevents tools from deteriorating and reduces incidence of defects.
4. *Seiketsu* (standardize). Procedures on how to perform these steps are being defined on paper so that everyone within the company knows how to fulfil the task. Also, having a univocal procedure, facilitates the spreading of this culture and its correct accomplishment. Manuals explaining the procedure must be easily understandable and visually comprehensible.

5. *Shitsuke* (sustain). The effects of these four steps is visible only if they are continuously applied. Here comes the importance of the fifth step, because it encourages 5S to become a routine. The company itself must create favourable conditions in order to spread this practice and employees must show effort in applying it. The 5S tool has to be diffused, constantly repeated and improved according to emerging necessities.

1.3.5 SMED and TPM

SMED (Single Minute Exchange of Dies) technology has been developed by Shigeo Shingo[6] to satisfy the necessity of reducing machine setup times. It aims at achieving a quick changeover so to use a single machine for multiple production processes without losing conspicuous time in setting the machine ready. SMED has distinguished setups between internal setup (IED), which are the tasks to be performed during downtimes, and external setup (OED) which can be accomplished when the machine is operating.

SMED is a three-stage process:

1. Separate internal from external setup
2. Convert internal setup to external setup
3. Streamline all aspects of the setup operation

First, it is required to list all the changeover steps and categorize them as internal setup, or external setup. Any unnecessary step must be eliminated while the rest must be simplified and standardized. Second, identify which of the internal operations can be converted into external and list the conditions to implement this modification. The benefit of having, as much as possible, external setup is the possibility of parallelizing activities while the machine is still running, so reducing downtimes and enhancing machine productivity.

At this point, through technologies, automatic adjustments and a huge volume of imaginative approaches, the aim is to shorten the remaining internal setup so to drastically reduce

[6] Shigeo Shingo was a Japanese industrial engineer who was considered as the world's leading expert on manufacturing practices. Shingo contributed to the formalization of some aspects of the management philosophy of the Toyota Production System and, since 1969, got involved for the reduction of set-up time (change of dies) of pressing machines.

changeover time. The application of SMED technology is a key batch destruction technique, reducing WIP and consequently accelerating lead time (LeanManufacturing.it).

TPM (Total Productive Maintenance) is an approach to maintenance whose purpose is to minimize downtimes of machinery and the incidence of other problems that impact on the efficiency and effectiveness of production processes. TPM introduces a standardized methodology of maintenance diffused companywide, both preventive and predictive. The strength of this methodology is the involvement of figures from different levels, from management to operators, including also planning and design teams. The latter are responsible of designing machineries that would require less and rapid maintenance. A dedicated team of maintenance, made of conscious and skilled operators, is defined and is given autonomous decision power. In addition, TPM provides a system of programmed maintenance, with data gathering on the reliability of the machinery, that will plan preventive interventions based on the data analysed.

1.3.6 *Poka-yoke* and Visual Management

Poka-yoke literally means error proofing and refers to devices created to avoid the possibility for an operator to make mistakes. Each poka-yoke device has its own standard form that summarizes the problem addressed, the emergency alarm that will sound in case of mistake, the action to be taken in an emergency. Also, it is provided with a system that confirms the error-proof method is operating correctly and the quality check in case the fool-proof method breaks down. There are two types of inspection *poka-yokes*: those that shut down the process upon finding a defect and those that warn the operator through an alarm (Liker, 2004). For example, a poka-yoke device could require putting back a tool in its holder after each time has been used, otherwise the line will stop and an alarm will sound. The purpose of *poka-yoke* is eliminating error incidence thereby making the process more robust.

Visual management is another tactic put in place to increase transparency of the process. Visual control is a powerful tool in order to avoid that problems are hidden, thus preventing mistakes to progress along the production process or machinery to keep on operating in a low-quality condition. Signals, lights and displays are placed within the working area in order to give clear information about performance or detected mistakes. An andon, for example, is a

visual management tool that highlights the status of operations at a single glance and that signals whenever an abnormality occurs. It is an overhead sign board with rows of numbers corresponding to workstations or machines; it can be used also to display the status of production in terms of the number of units planned versus actual output (Lean Enterprise Institute). The goal of visual management is the transfer of information, the communication over working standards, the locating and visualizing the status of working stations.

Techniques as *poka-yoke* and visual management satisfy the principle of *Jidoka*, according to which no bad quality parts are allowed to progress down the production process.

2nd Chapter: Lean Healthcare

In the recent years, the concept of quality in healthcare has risen attention, therefore care facilities are evolving their offering looking at the patient experience and safety. In this direction, health services are transmuting into curing processes, considering the patient flow within the hospital as a continuum, where complexity and heterogeneity of care are the main pillars of this new healthcare vision. Together with the increasing complexity, healthcare is facing severe reduction of capitals, generating offering cuts. In a context like this, one way of assuring quality without squandering finances, rather focusing on improving current resources, is represented by lean thinking applications (Bracci, 2014).

After the remarkable impacts regarding costs reduction and quality enhancement obtained in manufacturing companies, where lean thinking has been applied, curiosity has attracted healthcare companies as well. Clearly though, a system generated in a manufacturing environment faced multiple divergences when applied in a service sector, where different goals and requirements persist. A first diversification aspect concerns the object of processes, which in manufacturing is a good to be transformed while in healthcare is a patient to be cured. Designing a process to be applied on people requires adaptation to the single cases, rapid answer to variability and strict compliance to the attainment of the results foresaw. Consequently, the avoidance of defects possesses in healthcare a stronger impact, given that the concept of discarding defectives cannot be considered an option. Additionally, the strict attention that healthcare services must pay to patient's needs goes beyond the concept of customer satisfaction in manufacturing sectors. Here, services must be customized according to single patients requirements and attention over their satisfaction is one of the main drivers of competitive advantage. Service industry has been the next frontier of Lean applications, where scepticals thought the system wouldn't had been effective given the different criteria characterizing this sector. Yet Lean principles have proven to be the answer of the diverse business models shaping the service sector, achieving significant results also in the healthcare service. The core values of strict attention to quality and pursuit of zero defects, brought by lean thinking in manufacturing, are the alignment between lean philosophy and healthcare. As will be reported through this chapter, many lean applications have proven to be effective

within this environment, thus leading to the diffusion of a new tendency named Lean Healthcare.

2.1 Healthcare system

Healthcare system is marked out by distinguishing features not following the common business rules. The characterizing aspects are the following (Nicosia, 2017):

- Information asymmetry, since the specialists possesses knowledge that is hardly transferable to the patient. Being the patient in a situation of knowledge inferiority, he/she must totally rely on the doctor's competences. There is no condition for a "rational choice of customer", as it has been called in economics, where the decision among alternatives is based on the evaluation of all the influencing factors;

- Variability of the patient conditions, since patients affected by the same disease, handled with the same therapy can show different effects. In some branches of healthcare, where research has not reached a complete understanding of the disease, variability has even greater impact, becoming a natural factor to take into consideration;

- Externalities, being those intrinsic or external factors that influence the status of the patient and that cannot be controlled neither by the doctor nor the patient himself/herself. One example could be second-hand smoke, which we normally breathe without being aware of and that potentially affects our wealth condition.

- The distinction between patient and customer distorts the normal relationship buyer-seller because patients will choose where to be cured only according to the quality of the service, setting apart the price variable which, in normal conditions, affects the decisional process. Since usually who is paying for the health service, being the customer, doesn't match with the patient, this asymmetry reflects in a lower sensitivity of patients over price together with a higher sensitivity over quality.

In Italy, as in other occidental countries, healthcare sector is facing more and more restrictions and complexity. Demand is continuously increasing given the ageing of the population; the

higher life expectancy together with the reduced birth-rate causes an incremental incidence of old population who generally requires greater amount of healthcare services. Previsions state that the percentage of people over 75 will increase with a 0.9% annual rate (C.R.E.A. Sanità). Demand is increased also because of the greater reliance of the population on healthcare. Nowadays frequent checks and inspections have become a well diffused practice for the majority of people. On the supply side innovation is making a big step forward, but still new technologies and medical solutions remain expensive, especially in the pharmacological sector. The lack of economic expansion, especially in Italy, has negatively influenced the healthcare system, causing a restriction of funds reserved to healthcare and a lowering of quality levels (Rosa, 2017). The combination of all these aspects is jeopardizing the sustainability of the national healthcare system.

2.1.1 Inefficiencies embedded in the Healthcare system

Healthcare system worldwide is not only threatened by the reduction of funds, indeed malfunctions entrenched within operations are the first cause of a low quality service.

When entering an hospital, it is evident at a first glance the amount of waiting a patient will be subject to; every office or counter generally has its own queue. Waiting is a crucial aspect in healthcare, in primis being the slack of time between reservation and the actual execution of any health service. Usually waiting time is even greater than the actual duration of the visit or clinical performance and it negatively affects the whole perception of the service.

Inefficiencies substantially reside in operational failures, defined as moments where an employee is not provided with the supplies, equipment, information or people needed to fulfil the task. These activities waste at least 10% of caregivers' time, thus delaying the care service and contributing to safety lapses (study conducted at two American hospitals by Tucker et al., 2013), ultimately contributing to hospital's poor performance. A common response to operational failures is to "work around", meaning that employees devise alternative procedures to address a blockage in the flow of their work. Although workarounds are effective in the short term because they facilitate task completion, they prevent from removing the underlying causes, therefore enabling the recurrence of operational failures.

The difficulty relying behind the elimination of operational failure is that they manifest as small-scale problems, therefore their impact is considered limited. Nevertheless, it exists a wide-ranging set of small failures that, accumulated, generate a considerable impact. For their small-scale nature, they are proved difficult to address in practice since attention is directed only to large scale problems, but the persistence recurrence of failures can generate greater problems when reaching the last steps of the process. For example, an incomplete information about an insurance coverage can be of low importance to the front office, while can be detrimental to the administrative office, that according to the kind of insurance must adopt different actions to be reimbursed.

Operational failures not only negatively affect the time consuming perspective, in addition, the massive workload of employees who continuously face duplication of information, processing of wrong or missing data and accumulation of documentation leads them to burnout (Tucker et al., 2013). Stress creates extra pressure in getting the job done and it is the perfect environment for mistakes proliferation.

Compounded to the culture of healthcare environments, activities are disconnected and employees have specific knowledge about what they actually do, the rest is invisible to them. Connected to this cultural division, there are two major consequences. The first is that employees are not aware of what information or activity is needed to the following step in order to be fulfilled. The second problem is the difficult cooperation among professionals, which, given the positional knowledge, is fundamental to fulfil an analysis of the root causes and prevent the repetition of failure occurrence (Lean Enterprise Academy, 2006).

According to Jones and Mitchell who analysed the British national healthcare system, the major failures characterizing the healthcare service are the following:

- Errors hardly investigated and often repeated;
- Unclear Responsibilities and lack of communication among staff members;
- Unnecessary work is embedded in routines and keeps on being created;
- Disconnections of processes given by the organizational setting based on departmental silos.

Lack of visibility, confused responsibilities, unnecessary work, disconnections, extra workarounds are all small scale failures that add up to one another. The more complex things become, the greater is the chance of mistakes undermining quality of the service and harming safety of patients (Lean Enterprise Academy, 2006).

Most of the cited failures are consequence of a major problem existing in today's healthcare organizations: the absence of process definition. Having a good quality service offered through an inefficient process is the first source of waste. Best practices are not defined, therefore employees do not have guidelines about how to operate. This leads to variability in acting even in the same department or job position; every employees has his/her own way of fulfilling the tasks and, when shifts happen, the major problem is understanding what the prior operator did. Definition of standard procedures prevents variability, therefore generates alignment between operators occupying the same position and between activities within the same process. These are some of the most common mistakes that can be observed in hospitals and other healthcare facilities and that are causing low quality services and inefficient resources utilization.

Concerning Italian healthcare system, according to the survey of the National Institute of Statistics (Istat), in 2017 it has been positioned among the firsts in the European scene in terms of quality of the curing system offered. Nevertheless, for 45.1% of the Italian population, quality of regional healthcare service has decreased in the last years. What is the reason of this asymmetry? In Italy there exists a great number of professionals offering high quality services, in parallel there is a wasteful management of this excellences that deteriorates overall perceived quality by the patients.

According to Istat, about 5.4 million Italians receive prescriptions of drugs, visits or inspections which result useless (Nicosia, 2017). This is the consequence of the diffused culture among citizens for which the quality of the curing system is strictly connected to the number of health services performed; the two parameters are instead not related, oppositely the quantity could negatively affect the quality.

Another aspect endangering the perceived quality level in Italy is the underestimation of clinical risks, resulting in damage requests from patients that in 2017 amounted to 2.5 billion euros per year. Inappropriate spending results also in hospitalization, where CEIS report 2018 estimated that 14% of ordinary hospitalizations are inappropriate, generating a yearly waste of

1.5 billion. Another typology of waste is the excessive reliance on pharmacological drugs or diagnostic procedures performed in order to reassure patients (Nicosia, 2017). Looking at these data, it is evident how the healthcare sector is invaded by wasteful procedures embedded in the way of thinking of healthcare workers as well as patients themselves. Once the effects caused by small inefficiencies have been evaluated, healthcare companies understood an action was necessary. By looking at other industries and studying the successful cases, strategic actions have been applied also in the healthcare sector, in order to improve the business model and performance to guarantee a satisfactory service for patients (Tucker et al.,2013).

2.1.2 SSN vs Private healthcare

When analysing healthcare system it is useful to distinguish public from private service, since the two are based on different organizational structures and are driven by distinct requirements. Given the large differentiation within the national healthcare services of each country, the analysis will take into consideration the Italian case.

Italy is one of the few countries where healthcare is delivered mainly by public providers financed by the government itself. Despite the availability of public service, the number of citizens who commit to private structures is constantly increasing.

Nowadays, in Italy, is possible to distinguish three main types of health facilities:

- National Healthcare Service;
- Private accredited facilities;
- Private facilities.

The Italian National Health Service (*Servizio Sanitario Nazionale*, SSN) is organised by the Ministry of Health and administered on a regional basis. It is financed by general taxation that provides universal coverage, largely free of charge at the point of service. The central government defines the basic national health benefits package, which must be uniformly provided throughout the country, assuring healthcare service coverage under the SSN provision of Essential Level of Assistance, called LEA (Livelli Essenziali di Assistenza). The central government allocates national funds to the regions, which, through their local health

authorities (LHA), are responsible for organising, administering and delivering primary, secondary and tertiary healthcare services as well as preventive and health promotion services (Mossialos et al., 2016). Regions are allowed significant autonomy in the definition of the local structure of the system; assistance levels of care are based on the specific needs of the regional population and financial resources are split according to regional requirements. The goal of public healthcare is the satisfaction of the demand coming from citizens instead of the remuneration on invested capital, the latter being the goal pursued by companies in other sectors and by private healthcare as well.

Even though SSN strives to be universalistic and comprehensive, it can't finance the whole set of healthcare services required by Italians, indeed services not included in LEA have to be paid by patients together with a good portion of pharmaceutical costs (Toth, 2016).

In Italy, next to the public segment there are over 400 private hospitals of which 80% are accredited by the SSN. To assure sufficient healthcare capacity, the local health authorities buy care services from these accredited hospitals (Tforg, 2016), outsourcing about one third of the demand to private providers.

Accreditation is the necessary requirement for an healthcare facility to be an accountable provider of the SSN. Accreditation ensures equity, among private and public providers, over tariffs and remuneration of suppliers (Ministry of Health). Accredited providers, like public hospitals, are granted public funds to deliver health services, which will be reimbursed by the LHA of the patients treated, being regional authorities financially responsible for the health services delivered to their resident population (Fabbri and Robone, 2010). The refund process is based on the pricing of each individual clinical episode, classified according to Diagnosis Related Groups (DRG). Accreditation is based on a contractual agreement, that has to be renovated on a yearly basis by the regional authorities, where types and amounts of admissions are defined, as well as tariffs (Fabbri and Robone, 2010). Patients are indistinctly admitted in publicly financed care facilities, either being public or private accredited, within or outside the residential region. Since patients are unaware of treatment costs, their choice strictly depends on perceived quality, distance of the facility, hospital specialization and waiting time.

The remaining 20% of the 400 private structures are only authorized private organizations, meaning that they are given the authorization by the SSN to provide healthcare services, but

they are not accredited. Thus, private organizations are assigned a limited amount of services to offer but are not publicly financed, therefore tariffs are set by the organization itself. The authorization process concerns all structures (private and public) that are allowed to offer healthcare services within the Italian healthcare system. The authorizing entities are the regions, which define, according to minimum thresholds of structural, organizational and technological requisites, whether or not to authorize organizations.

In 2017 the private sector in Italy accounted for 26.0% of the total healthcare expenditure, facing a steady rise since 2007, when private expenditure registered 22.5% (CREA Sanità).

Of all the private spending, a small portion refers to the costs of supplementary insurance policies, while the major portion, about 88%, covers the costs of services demanded to private providers, since the SSN does not finance them (Toth, 2016).

The reason of the increasing reliance on private healthcare by Italian citizen is found in the consistent inefficiencies affecting the SSN, which reduced the overall level of care perceived by patients. The long waiting lists, disorganization in administering patient flow, duplication of exams and controls, together with a general malfunctioning of the entire system are some of the core problems diffused in public hospital settings (Rosa, 2017). Because of the long waiting lists, 10 million Italians more address private healthcare in order to avoid waiting. In the public sector, waiting can go up to a few months for consultations, tests and elective surgery, while the waiting times in the private sector generally do not exceed a few weeks. This results in an increased private spending, that in 2017 faced a 3.2% incremental value respect to the previous year (Nicosia, 2017).

The crucial problem in public healthcare are the diminishing financial reserves, since containing health costs is a core concern to the central government, as the Italian public debt is among the highest within industrialized nations (Mossialos, 2016). Therefore, the central government can impose recovery plans to regions with healthcare expenditure deficits, by revising the diagnostic fees, reducing number of beds and human resource through limited turnover.

Distinction among the different health providers categories hold diverse implications when applying a lean transformation. In case of public healthcare facilities, the main concern is the reduction of waiting times, together with an optimization of resources given the shortage of

financial supports. Lean applications in public healthcare must have a wide scope so to involve the majority of departments through a structural rearrangement of the hospital (Rosa, 2017). Improvements in the public sector are usually driven by incentives from the SSN rather than being a choice of the directional power. Indeed in 2017 the national healthcare system allocated a majority fund of 0.1% to the LHA that started requalification projects in order to spur attention over the necessity of improvements (Rosa, 2017).

The case of private healthcare instead, is characterized by a different scenario. The strength of private healthcare relies on the efficiency of the service offered to the patient, to the disadvantage of the organization's efficiency. Sure enough, private facilities are usually underutilized, given that a slack capacity guarantees better flexibility in accommodating requests, even in the short-term. Moreover, private organization stress the attention not only over patient, because a great concern for private healthcare are also the specialists. The latter are an important source of revenue, therefore private organization tend to satisfy their needs together with the needs of patients. These aspects greatly impact on the goal and KPIs of a lean implementation project .

2.2 Lean Thinking applied in Healthcare

Lean philosophy has been for the first time applied in healthcare at the end of 2000s, when some American hospitals tested the application of lean principles, so far only applied in manufacturing sectors. The motivation to undertake a lean evolution came as a response to the financial deficit that healthcare started to face in those years, together with problems connected to endless waiting lists and general dissatisfaction over operational practices.

Since then, Lean application has spread rapidly throughout the field, becoming today one of the key management strategies in healthcare environments aimed at improving efficiency and quality of the service (Black & Miller, 2008)

The reason of the successful match between Lean management and the healthcare system relies in the alignment over the core objectives. In healthcare, more than any other business, attention over the patient and the quality offered to the patient is the central focus and the main attribute of competitive advantage. In the same way, lean thinking advocates improving the service from a customer perspective, patient in this case, having a process that follows

his/her requirements, rather than having a patient adapt to a series of steps (Black & Miller, 2008).

Another common feature is represented by the involvement of first line employees, because, from a lean perspective, this is the most efficient way of improving processes and eliminating wastes; from an healthcare perspective, it is fundamental to spur employees motivation as it is one of the main drivers of perceived quality by the patient. As a consequence, has been proved how workers are more willing to sustain lean transformations rather than other projects, since they are participant and proactive to the definition of new ideas and solutions (Bracci, 2014). The occidental world is characterized by a top-down decisional system, where solutions are asked and approved by the top management before being implemented. Japanese instead, prefer a bottom-up approach, where line operators are the ones bringing solutions and testing themselves their applicability and effectiveness. Thus, operators are continuously testing the system and correcting it anytime they discover a problem; not only more defects can be discovered, also the time of action is drastically reduced (Nicosia, 2017).

Besides alignment in the core principles, lean transformations are preferable because they do not require a consistent financial support to be implemented, therefore being in line with the shortage of financial resources characterizing the majority of care facilities. Additionally, lean approaches are flexible, meaning that they are adaptable to different context, according to the wideness and complexity of the project scope.

There are also critical aspects to evaluate when implementing lean thinking in healthcare, one of which being variability. Health services are for their nature variable, thanks to the different reactions of individuals to treatments, to the fluctuating necessity of care and to the unpredictability of events. If we think of an hospital, there are usually peaks in the Emergency Room at weekends because of accidents, while Mondays are usually the staffed days of ordinary cases (Nicosia, 2017). Surely healthcare must be ready to hold and satisfy demand, therefore it requires to be set taking into consideration the variability factor. It is true, though, that variability generates waste, since it requires overproduction in offering. At the same time, it is demonstrated how, even in healthcare, demand can be foreseen in the short-term to a certain degree of approximation. An analysis conducted by Nicosia, 2014, over the historical data of a large-sized hospital, showed that demand is predictable on a day to day basis, even for emergency cases. Request peaks happen in precise days of the week and specific months

during a year, also according to climate conditions (Nicosia, 2014). Surely this sector will preserve some degree of variability, but the innovation is that hospitals can actually plan in advance, at least the non-emergency cases. In England, the NHS has studied fluctuation in emergency accesses and programmed hospitalization, the former being unpredictable respect to the latter. Yet, data showed that there is greater variability in the programmed hospitalization rather than in emergency cases. This is due to an inefficient planning of surgeries, that are usually under each single specialist's control rather than being managed by the hospital itself (Nicosia, 2014).

Another critical aspect is the traditional culture widespread in healthcare environments. A strong unbalance in powerful positions characterizes this sector; the consequences are a difficult homogeneity in acting and a strong diversification between employees. The real problem is faced when different actors are asked to collaborate within heterogeneous teams or are asked to modify their way of working. Usually these processes encounter strong resistance (Bracci, 2014).

Finally, a determinant factor is represented by the lack of commitment, resultant of a weak directional power unable to spur motivation. What frequently happens in healthcare facilities, is that directional power is given few recognition when referring to operational changes, even if holding strategic importance. Therefore the support of top management over a lean transformation will not imply motivation among operators in participating and proactively fulfilling the activities. The latter is a crucial aspect to the successful implementation of a lean project.

As will be better explained in the following paragraphs, lean thinking in healthcare represents an operational approach that affects both the technical and the social sphere, by modifying processes, at the same time, values and ways of acting of employees. The goal is value maximization from a patient perspective and a deep efficiency of processes through an accurate elimination of waste. Redesigning care processes following a lean perspective guarantees more safety and accessibility to healthcare (Federsanità). Ultimately, lean transformations pose the attention toward operators' needs for balanced workloads and better working environments, together with an eye over the organization's needs for greater revenues and costs reductions (Federsanità).

2.2.1 Lean framework for healthcare implementation

Lean implementations in healthcare have been classified by Radnor & Walley (2008) into two categories: rapid improvement events and long-term strategic events.

Rapid improvement events (or Kaizen events) are cases in which Lean philosophy and tools are applied to operational processes of specific departments. Usually they have a short-term scope, one or two weeks, and they address waste reduction and quality improvement of a limited part of the business. Kaizen events start with a planning section where participants meet together to evaluate the current state of the process and study the possible future condition. This approach is applicable either to primary processes or support and administrative processes. Primary process kaizen events can be, for example, the reduction of the length of stay, waiting time or incidence of untreated patients in an ER process. An example of a support process improvement is the application of the 5S tool to improve spaces utilization and material storage. The positive aspect of Kaizen events is the rapid achievement of significative results, however their sustainability over time results limited, especially when lean thinking is not connected to the strategic view of the company (Bracci et al., 2014).

Long-term strategic events are the cases where lean becomes part of the company philosophy, settled as the guiding principle of strategic decisions and spread at all levels and departments. Long-term events begin with the definition of a new strategic view where lean improvements are formalized as part of the strategy. The purpose is a fundamental redesigning of organizational procedures in order to develop process capability of producing uniform and replicable outcomes, to empower employees and make them responsible of the continuous improvement. The ultimate goal is the sustainability of the improvements over time, achievable when lean thinking is internalized in the employees values and in the company mission. Even if scientific literature states the importance to adopt a systematic and long-term approach when implementing lean thinking, the majority of studies and experiences focus on single process, short-term improvements. Based on this differentiation, implemented projects are not all clearly classifiable as strategic events or kaizen events, but they move in a continuum between the two approaches. A lean project can start as a kaizen event then evolve in a strategic project with a long term perspective (Bracci et al., 2014).

In the report OASI 2013 it has been introduced a conceptual framework that analyses and interprets lean management approaches in healthcare, as shown in Fig. 2.1. In this framework, four main areas have been identified, defining, for each of them, analysis dimensions and their operationality.

Area	Analysis Dimensions	Operationality
Lean as organizational strategy	nature of the driver	endogenous/ exogenous
	action scope	wide/ narrow
	number of initiatives	high/ low
	field of intervention	clinical/ administrative
	project structure	temporary or dedicated team
	label	inherent to the context or the company identity or generic lean
Toolbox	methodologies and tools used to support the improvement	diagnostic tools (D), redesigning tools (R), monitoring and standardization tools (S)
Human Capital	lean educational activities	provided/not provided
Performance Measurement	KPIs	process-oriented, efficiency, effectiveness, customer satisfaction, employees motivation

Fig. 2.1 – Conceptual framework of lean implementation projects (OASI 2013)

Within the area of "Lean as organizational strategy" there are variables that identify the perimeter and scope of the project. These are:

- the nature of the driver, which can be endogenous, when it is required by the top management in order to improve quality and efficiency of the service, or exogenous, when external funds are settled or regional institution require it;

- the action scope, which defines the number and width of the objectives the company wants to pursue through the lean project;
- the number of initiatives, referring to the amount of projects and activities planned, defined in a qualitative way (high or low);
- the field of intervention, defining whether the project refers to clinical processes or administrative processes, or both;
- the project structure, which distinguishes cases where teams are fully and permanently dedicated to the lean project and cases where people are only temporarily involved in the project;
- The label of the initiative, that usually recalls the objective of the project or the field in which it will operate. Can also be a generic lean project.

The toolbox area defines the methodologies and tools used to support the improvement. These can be distinguished between: diagnostic tools (D), referring to process mapping tools as VSM or Spaghetti diagram and 5why's for the analysis of inefficiencies; redesigning tools (R), which help organizing activities like A3 and are useful to the actual modification of processes and layouts like 5S and kaizen events; monitoring and standardization tools (S), like visual management, kanban and poka-yoke to spread clear information about the functioning and the results obtained (Carbone et al., 2013).

The human capital section refers to the presence of educational activities aimed at spreading lean concepts and philosophy, together with programs aimed at increasing employees' capabilities.

The fourth area of performance measurement defines the KPIs used to assess the status of the improvement. Indicators can be process-oriented (like the identification of inefficiencies), can evaluate customer satisfaction or employees motivation, or either levels of efficiency and effectiveness.

2.2.2 Prerequisites for a successful start

Like any other project, lean applications require some degree of planning and setting of a favourable environment in order for the project to bring significant change. Three essential features to the successful implementation of lean methodologies in healthcare are the following (Bracci, 2014):

- Education. Operators engaged in the project must be knowledgeable of the concepts and values of lean thinking. A deep clarification of lean tools and practices is required in order to have proactive employees participating in first person to the attainment of the project goals. The strict reliance over first line operators sustained by lean thinking makes it extremely important to spend time in the education phase, in order to start the project with prepared and motivated participants.

- Team. The definition of a lean team can be a facilitator during the implementation phase, spreading the vision and helping in the correct fulfilment of the results expected. Also, once the project has been implemented, the difficult step concerns the sustainability of the improvements obtained. Indeed, lean practices must be continued over time in order to implement the concept of continuous improvement on which lean philosophy is built. To guarantee such maintenance, the definition of a lean team, permanent inside the company, is a strategic tool that facilitates continuous attention over the core concepts.

- Leadership support. Top management must believe in the successful opportunity embraced with a lean transformation and communicate its engagement through events. Leaders play the role of sponsors in a practical sense, by removing obstacles entrenched in the organization, and in a theoretical sense, by communicating and favouring knowledge development over lean concepts. In order for employees to actively sustain the project, a strong support by the leadership represents a critical success factor.

Once knowledge has been diffused and motivation has been settled, what remains to be determined is where to start the project. According to lean philosophy, rather than pointing at

the big problem, is better to start by focusing on the small inefficiencies which are easy to identify and fast to remove. This because immediate results generate satisfaction and set the basis for the major effort required for strategic improvements. Starting from eliminating operational wastes guarantees a leaner structure over which to implement the major changes. Additionally, the achievement of the first, even small, results generates greater interests among not-involved personnel, widening participation. In order to rapidly achieve results is fundamental to promote transparency in acting; indeed, to be improved, performance must be measurable and comparable with best practices. The aim of transparency is not to judge single operators performance, but to ameliorate the overall results obtained. Transparency is achievable through diagrams and visual management tools, easy instruments that clarify the state of the process and spur the diffusion of the results obtained (Bracci, 2014).

Having guidelines is helpful to concentrate effort on useful activities and to understand in which direction pursuing the analysis. Reasoning in a Lean way, before starting any analysis, it is useful to define which are the most common wastes that characterize processes within an hospital, focusing on their removal first. The following is a list of the main wastes according to Ohno classification of *muda* (Nicosia, 2017) adapted to the healthcare sector.

1. Overproduction: hospitalization longer than required; redundant or unnecessary preoperative exams.

2. Stockpile: underutilization or non-utilization of resources like beds, machinery or operating rooms; storage of medical drugs or materials.

3. Transportations of goods or information: movement of clinical folders or other documentation; medical report collection; bringing test tubes to the laboratory.

4. Waiting: missing synchronization between operators; patient waiting during the hospital journey; missing information that prevent the smooth proceeding of activities.

5. Movement of people: healthcare professionals moving within the hospital to perform their activities; workers moving to deliver documentation or materials.

6. Defects: lack of time strictness; incorrect diagnosis or treatments; privacy violation; wrong data collection.

7. Processes not defined: lack of efficiency in process design with consequent duplication of activities; variability in the way workers manage an identical situation.

2.2.3 Lean principles and tools in healthcare

The set of tools offered by lean applications remains unchanged respect to manufacturing applications. Nevertheless, their applicability can assume different meanings or be directed to different goals. The same happens with lean principles, which are distinctive of the approach therefore remain untouched. It is opportune, though, to describe lean principles applied in healthcare, firstly because their impact assumes slightly different meaning, secondly because using the appropriate language of the sector is a facilitator to the understanding process. Lean principles, introduced by J.P. Womack and D.T. Jones, translated in healthcare language are the following (Bracci, 2014):

- *Value* relies in providing the required cures to patients so to recover their health within a brief period of time and in total safety. Value also consists of all those activities which are useful to satisfy patient needs beyond the curing process;

- *Value Stream* means identifying the process through which the patient receives health services. Given the variability of the curing processes, it is useful to define family of patients according to their diseases. To identify the core patient, having demand data, the patient with the most frequent disease passing through the major number of steps will be recognized as the core patient;

- Once the process is defined, the next step refers to the elimination of muda and the creation of a continuous process, named *flow*. The removal of interruptions within the process implies a redesigning of the process both in the layout and in the way activities are performed, so that all steps are synchronized and proceed at the same pace. In healthcare, this principle obtains even greater attention because it guarantees readiness in responding to patient's needs;

- *Pull* means providing services according to the external demand and it is opposing to push strategies. In an hospital following a push strategy, patients can be received in the first step of the process independently from the availability of the following steps,

therefore generating queues in the system. On the contrary, in a pull organized hospital, services are provided when fully available therefore guaranteeing a continuous and complete curing process to the patient;

- *Perfection*, in healthcare like in manufacturing, is a goal that spurs employees to continuously correct the process by reducing mistakes. Kaizen is what drives the company to a systematic perfection of processes; indeed the goal is not revolutionizing with huge improvements, rather meticulously improve even the trifles that hold smaller impact but easiest correction.

Referring to the third principle of flow, it is important to stress out that it doesn't refer only to the patient flow, rather to a combination of flows which ultimately guarantee that of patients. According to J. Black (2008) in his book "The Toyota way to Healthcare Excellence", in any hospital or clinic there are seven critical flows to take into consideration. Those are the following:

Patient flow. The whole progression of the patient through the hospital from the first arrival to the final discharge is considered the patient flow. By analysing the complete flow of a patient, it is evident that numerous stops and waiting affect transitions between consecutive activities. A careful design of processes could facilitate the flow of patients and reduce length of stay at the hospital.

Clinical flow. Specialists, nurses and staff move inside the building in order to accomplish all their tasks. The movement of workers must be minimized to assure that time will be spent in patient care rather than in transfers from a department to another. The layout of the building is a critical aspect that affects the efficiency of clinical flow.

Pharmaceutical flow. Drugs and medications are continuously moved from central storages to departmental storages and finally to carts ready to be dispensed. The pharmaceutical flow must be orchestrated in order to have the correct amounts of the correct medicine at the right time in the correct location. This is possible through a digitized system that tracks movements and utilization of pharmaceutical goods.

Medical device flow. Disinfectants and other medical devices are necessary consumables that must be present in numerous areas of the hospital. Their flow reflects that of pharmaceutical goods, but requirements and utilization are different.

Information flow. While the patient passes through the process inside the hospital, an amount of information is registered and transferred among the departments. It is of extreme importance that information is complete, reliable and ready when required, otherwise lack of information could be the cause of delays, mistakes or inefficiencies. A well-organized information flow requires an information system that registers and displays the right data at the right moment.

Medical equipment flow. Healthcare relies more and more on technology and innovative devices, therefore their utilization is of fundamental importance for specific healthcare activities, especially in surgery. Their movement is another parameter to consider and coordinate when planning surgeries or examinations. In order to optimize their flow, a right sizing of the equipment is required together with a designing that favours easy transporting without risking damages.

Lean methodologies that will operate toward the achievement of flows coordination, among other lean objectives, can be classified according to their scope of action in the healthcare setting. Tools can be distinguished within three classifications:

- Diagnostic analysis tools include *VSM*, *Spaghetti Diagram*, *Makigami* which permit the mapping of processes, together with *5why's* and *FMECA* (Failure Mode, Effects and Criticality Analysis) that are tools used when determining the causes of inefficiencies;

- Re-organization tools are the ones used when planning activities like *A3* and *Kaizen* events, or the tools aimed at modifying layout with *cell design* and re-organizing spaces like *5S*;

- Monitoring and standardization tools are used to control the status of the process, to share information about results and to show evidence of mistakes occurrence. These are *Kanban*, *Poka-Yoke* and *Visual Management* tools.

2.2.4 Hospitals based on care pathways

In the majority of hospitals and clinics, patient assistance processes are organized over a vertical single-specialization management. This means that each department is characterized by operational excellence, still excellence remains restricted to single activities and does not extend to the process in its entirety. Everyday activities, like the support of hospitalized patients while in bed, are left aside in the run over excellence, therefore exhibit lack of efficiency and effectiveness. A cause of that is the absence of a responsible for the whole patient process through the hospital, thus there is no univocal definition of how to fulfil the entire process step by step. Activities are fragmented and focused on singular success accomplishment, at the same time connections between them are characterized by inefficiencies and glitches. In the current organization, it is normal to daily face different levels of variability in the seriousness of patients conditions as well as in the therapies required. Fixing the standard level of assistance on an average value means that assistance could result poor for certain patients while being in excess for others. This approach generates two effects respectively named “roof effect” and “floor effect” (Nardia et al., 2011).

Roof effect defines situations in which a user with high requirements is served by a low offering system. The user will tend to stress the offering to its highest levels but still will be unsatisfied of the final outcome. Here are represented patients with serious diseases that won’t receive the necessary assistance, being the latter fixed at a standard average level. Floor effect takes place when a user with low requirements is given a high level service; in healthcare it refers to a patient that receives more assistance than required, resulting in a waste of resources employed in unneeded activities.

The model of a differentiated intensity of hospital care is an organizational model where sectors are dedicated to patients with homogeneous needs of care. Different care pathways are defined according to parameters of clinical instability and assistance complexity. Evaluation of those parameters is performed by analysing diagnosis, vital signs, physical features, laboratory exams, personal factors and prognosis of the patient. Based on clinical instability, the patient will be assigned to the hospitalization department that best fits his/her treatment needs. While in a departmental and verticalized organization patients are assigned according

to the nature of the disease, with care pathway is given major relevance to the clinical condition and the level of dependency of the patient. Assistance complexity defines the curing treatment based on the amount of work required and the intensity of the treatments. Care pathways hospitals require both a revision of healthcare processes and a requalification of the offering so to guarantee the continuity of care. The efficiency of assistance and treatments along the path is crucial to the suitability of hospitalization and the possibility of a rapid discharge (Croce, 2012).

In the care pathway model, given the significance attributed to assistance complexity, the nursing component acquires greater relevance. In this sense, the model identifies the new figure of the Case Manager. This figure refers to a professional nurse who is responsible of complex curing processes. His/her role is about coordinating assistance toward the whole patient flow, from admission to follow-up after discharge. Is the case manager that takes responsibility of the patient and directly follows him through each step, collecting information to share with the nursery staff that takes care of the patient. Additionally, case manager has an important role as instructor of both the nurses and the family of the patient; he/she is responsible of procuring the nursing staff with the adequate indications about how to treat the patient, at the same time he/she shares with the patient family information on how to deal with the disease and the follow-up activities (Iemmi, 2012).

Evaluation over the effective impact of the case manager figure has shown positive results. Indeed, nurses, patients and doctors show greater satisfaction when care pathways and case managers are defined, contextually quality of assistance increases given the continuity of the treatment, while length of hospitalization is reduced, as well as costs (Iemmi, 2012). Responsibility of the case manager is also the definition of the professional resources to assign to patients; assignment of resources follows the principle of correct utilization and optimization, together with the maintenance of high quality levels.

Care pathways are distinguished among three main levels (Iemmi, 2012):

- *Intensive care* refers to cases of intensive or sub-intensive therapy. This sector needs to be centralized and multi-purpose;
- *High care* includes hospitalizations characterized by a high degree of assistance and short length of stay, but patients are liable to develop complications and need a close

monitoring. This sector is the most common one, where most of the cases merge, therefore it is determined by high degree of variability and complexity;

- *Low care* is the sector dedicated to post-acute care. In this level there are low assistance cases and low complexity.

Each of the three levels defines a care setting. Wards are distinguished according to care settings and can host patients from different operating units. In this scenario, patients are in custody of the care setting where they are located, for the assistance dimension, while connected to the operating unit that is responsible of the treatment and medical dimension. For this reason, hospitals organized over care pathways recognize a double hierarchy: medical component and nursing component, connected to each other in a matrices way. From an operational point of view, there is a double taking charge of the patient both from the medical and nursing side, as well as a double discharge.

Hospitals based on care pathways are distinguished for their attention over the central role of patient that translates into an accurate planning of activities and timelines and efficient management of information. The logic is simple: patients, once defined only according to their main disease, in the old system needed the collaboration of external professionals to evaluate complementary pathologies; with the care pathways system, patients are located in the level of assistance that better express his/her mix of pathologies, therefore external professionals are allocated to the care pathway becoming internal resources to the treatment path (Croce, 2012). This new system has been a response to the increasing incidence of patients affected by multiple pathologies requiring a complex level of assistance and therapies.

The care pathway model, in order to be successfully implemented, requires a new healthcare organization that achieves a progressive evolution from a vertical management based on departments, to an horizontal management of multi-department processes. This evolution requires specialists, nurses, operators to be collaborative and create multi-professional teams of work. In this sense, it is fundamental to spur integration through the definition of a common goal and the use of collective tools that permit to observe others' performance, assess the status of the process and diffuse uniform operative standards. Stressing the concept of collaboration is extremely important in healthcare organizations since they are referred to

as “professional bureaucracy” where employees are strongly identified in their own discipline, own language, own values and own practices, therefore prefer to work independently (Iemmi, 2012).

Another important factor to the efficient assistance of patient through a treatment continuum is given by the informatization of the clinic folder which permits a rapid and complete consultation of the patient documentation and description of the hospitalization steps.

The model of care pathway has been an answer to the requirement of resource optimization lately characterizing healthcare. The scope of the model reaches also other aspects of optimization like an efficient organization of the therapy trolley, the documentation required for the ward round, the drugs storage and the drug administering process. The care pathway model represent a strong shift in the way of thinking in healthcare, which is strictly correlated to the lean approach to optimization. Indeed, viewing care service as a continuum process recalls the lean concept of value stream, which sets the basis of lean thinking. Also, the interconnection of multiple actors creating multidisciplinary teams of work is an aspect that characterizes lean healthcare. For these reasons, the care pathway model is considered an innovation that adopts a lean perspective.

2.3 Lean Healthcare applications

Steven Spear advocated the diffusion of lean principles in healthcare by spreading knowledge over the advantages introduced applying the methodology. Indeed, in his publications, he showed how to reduce deaths and infections provoked by an inefficient hospital management (Bracci et al., 2014).

What encouraged healthcare organizations to introduce a lean revolution has been the necessity to respond to financial deficits, problems connected to long waiting lists and a general dissatisfaction among employees (Bracci et al., 2014). The results of hospitals or private facilities that implemented lean when the concept was still new, reported great achievements and enthusiasm that generated interests over the concept. In 2001, Virginia Mason Hospital was involving in a lean healthcare application; the company stated the importance and effectiveness of striving for a continuous improvement, which is achievable only through an organizational and strategic development at every level.

In 2004 in Wisconsin, the healthcare facility of Thedacare started a Lean program devolved to the redesigning of processes. Through a Value Stream Mapping, evidence of the criticalities has been spread among the company personnel, in this way each one was participating to the elimination of wastes and to the improvement of procedures, performed during Kaizen weeks. The 5S approach has been applied in order to render the spaces efficient to their utilizations and the tools homogeneous, building optimized warehouses and drugs supply management. After a year implementing Lean methodologies, has been clear to the organization that a successful application is achievable only by working in teams and having a strong and recognized leadership. Moreover, is fundamental the standardization of procedures and working spaces, with a process view rather than proceeding for single activity (Bracci et al., 2014).

The firsts applications in Europe took place in England in the late 2000s, thanks also to the creation of a Lean Enterprise Academy. The Royal Bolton Hospital pioneered the use of lean thinking in the NHS, focusing the effort over the concept of mortality reduction. Then lean applications have been spread to all aspects of quality improvements and the project has been reinvented in the Bolton Improving Care System (BICS), a permanent institution that recognized Bolton Hospital as the leader of lean healthcare implementations (www.boltonft.nhs.uk).

In Italy, the introduction of Lean principles within the healthcare system has taken place in 2007. Since then, great results have been explored, indeed the attention over this methodology of waste elimination and quality enhancement has spread in numerous projects. In the following sections, some of the major projects introduced by Italian companies have been explained, so to understand the variety that a Lean implementation project could attain and the variety in the results and effort required.

2.3.1 Ospedale Galliera di Genova

In 2008, Galliera Hospital has implemented a multi-year project to diffuse lean thinking within the company. The project has been named G.E.N.O.V.A. (Galliera Empowerment by New Organization and Value Analysis) and it was aimed at redesigning the hospital according

to the care pathway model, together with a substantial requalification of the structure and the efficiency of activities.

The lean project has seen the identification of a Lean Galliera team composed of 20 members, staff from the diverse departments of the hospitals; this was already a significant change given that, for the first time, inhomogeneous actors have been grouped together (nurses, doctors, administrative). Processes have been distinguished according to pathologies and analysed through Value Stream Mapping in order to reduce length of stay at the hospital. For example, the gastroenterology process, has achieved a reduction of 23.6% in the hospitalization length: in 2010 the structure treated 704 patient with an average length of convalescence of 11.39 days, while in 2012 the patients treated were 710 with an average length of 8.82 days in bed. The reduction in time didn't affected negatively the quality of the service, instead it reduced the waiting and downtimes, therefore guaranteeing better service to the patient. Lean principles have been taught to two thirds of the company employees through multiple formation programs held during the following 5 years. Part of the lean project was also the optimization of the operating block, where results show that a reduction of overtime work by 90% has saved 1.2 million euros on a yearly basis, offering same quality and same amount of services, at the same time saving 40% of space utilization.

In the following years, lean applications involved visual management installations in the wards, aimed at monitoring the status of hospitalized patients and the progression of therapies. Today Galliera Hospital has extended the care pathway model to all departments.
Other achievements are the 47% increase in Day Hospital activities, entailing a reduction in hospitalization costs. Also the incidence of postponed surgery has decrease by 45%. All these numbers have been publicly announced by the board of the company that faced 1.5 million euros savings in management costs on a yearly basis (Nicosia, 2017).

2.3.2 Istituto Clinico Humanitas di Rozzano

At the beginning of 2012 Humanitas Clinical Institute has introduced a lean unit in its organogram, with the aim of improving efficiency and quality while reducing wastes. The lean unit started its project by spreading the culture among employees; indeed what the company was requiring was a cultural transformation first, where workers were the key players, responsible for the improvements to come (Perella, 2018). Since June 2012, over 550 staff members have been taught about lean principles and how to apply them. In viewpoint of the *Kaizen* approach, every year the Institute promotes a Lean Project Award where employees are presenting their improvement applications. Employees from every department are participating to lean projects development, thus reflecting how lean culture has become part of the DNA in Humanitas. Listed below are some of the project implemented and awarded during the yearly Lean days (humanitas.it).

- "Un rx torace al giorno non leva il medico di torno" is a 2015 project aimed at eliminating the practice of performing unnecessary x-rays. Specifically, Intensive Therapy patients subjected to heart surgery were undergoing a chest x-ray on a daily basis with the purpose of controlling their status. Thanks to the project, a curing plan has been defined according to the real clinical necessity, therefore x-rays were carried out only when actually detecting adding information useful to the diagnosis.

- "Giù le mani dalla mia medicazione" is an improvement addressed to the medical treatment of patients undergone to shoulder and knee arthroscopy. An inspection and correction of the protocol defining the treatment details has entailed a reduction in the risk of contamination.

- "Fast & Light" is a project directed over the simplification of operational activities. Previously to the project implementation, the utilization of mattresses preventing bed sores was a time consuming activity because of the inflation in and out before and after utilization. Applying lean thinking, the activity has been considerably shorten by using a movable coverage that prevents from inflating the mattress each time. With a simple and effective action, time of the activity has been shrunk without affecting the quality of the service.

- In 2018, Humanitas won the Lean Healthcare and Life Science Award with the project "Rx torace? No, grazie". In order to control the rightful positioning of the PICC (Peripherally Inserted Central Catheter), patents had to wait on average three hours before being submitted to the x-rays control. The project introduced new guidelines in order to reach the same result by substituting x-rays with an intracavitary ECG. The major advantage brought by this new methodology is that it can be performed right after positioning the catheter, therefore the patient can directly start the therapy. The study has been conducted through a pilot project tested over 1200 patients, confirming the effectiveness of the methodology and the incremental quality offered to the patient, with a reduction of waiting times of about 73%.

2.3.3 AOUS - Azienda Ospedaliera Universitaria Senese

G.O.A.L.S. (Gruppo Operativo Aziendale Lean Senese) is the name of the lean office introduced since 2012 in the hospital of Siena. The team operating in the office is composed of heterogeneous figures, from engineers to nurses, doctors, and administrative. The function of this team is to improve company processes in terms of efficiency, effectiveness and safety, by developing lean projects and spreading knowledge in order to spur employees to elaborate their own projects. Periodically the team meets with the top management to evaluate the proceeding of activities, the alignment with lean principles and to share common goals to pursue.

The strength of the team relies in their operability: they are always on field checking how the structure performs by directly looking themselves through gemba walks. AOUS has been nominated in 2013 one of the best six companies in the Italian scenario that successfully implemented Lean thinking in healthcare. In addition, the company every year organizes a Lean Day where projects are presented and awarded. During the Lean Day 2017, 35 projects have been presented, thanks to 400 employees actively participating in their implementations. Few of the most appreciated projects are the following:

- "PPU: Il prelievo all'ora che vuoi tu" focused on the reduction of waiting time for patients requiring blood exams. By analysing the demand, it has been possible to calculate takt time and realign the offering to the effective demand. Contextually, through an activity of demand management, patients have been asked to come at

different times during the day so to level demand and avoid peaks. This resulted successful by making aware patients of the unnecessary fast before blood exams (the necessity to fast before exams is not supported by empirical evidence) primary cause of patients coming all early in the morning. Results show a reduction of 13% in 2017 in the waiting time of patients respect to November 2016.

- "Il nuovo PS" is a project oriented over the reorganization of the emergency room. It proposed a division of spaces in three main areas, each according to a different intensity of disease (high, medium, low intensity). The goal is to shrink waiting times before taking charge of the patient. Employees will be flexible to work in either one of the three areas according to demand, therefore applying resource optimization.

- "Ordinando..con il Kanban!" promoted a redesigning in the layout of wards. Drugs and materials have been centralized in a single storage, where orders are managed according to kanban. The new layout permitted to free up space; also, savings amounted to €42.000 because of the reduction of urgent orders of about 86% and a 60% reduction in time spent to emit an order.

2.3.4 Fondazione Poliambulanza di Brescia

During Kaizen Award Italia 2017, Poliambulanza has been the winning company with a project aimed at enhancing the surgical process through a lean healthcare view.
The awarded project has been settled to increase the productivity of the surgical processes by better managing the allocation of the critical resources, which are operating rooms and hospitalization beds. The patient flow from reception to discharge has been cleaned of the major wastes and reorganized following standard procedures. Greater attention has been paid over the patient's needs, indeed, levels of assistance have been improved. Also logistics of surgical materials have been reorganized based on a pull system, with orderings planned via kanban methodology.
The Hospital is pursuing dimensional growth and a continuous quality improvement of the services offered. The great innovation has been the increased synergy between different specialists, fostering a multidisciplinary approach to process management that, ultimately, has driven the company towards resource optimization.

Among the numerous projects introduced by Poliambulanza multidisciplinary teams there is "Clean & Lean", that brought a reduction of 30% in necessary time to clean and sanitize common spaces and operating rooms; another project is "Lotto per il letto" which focused on a better management of beds utilization, solving the problem connected to underutilization and overbooking of beds.

2.3.5 Clinica San Francesco

In 2016, the Hospital of San Francesco implemented a new Healthcare Integrated System (HIS) in order to improve information management and operational fluency, together with a better compliance to privacy and reduction of clinical risks. The informatization process has been conducted by Afea s.r.l. that implemented its integrated system. Additionally to the implementation of a new HIS, San Francesco required lean consulting with the aim of eliminating wastes embedded in the processes. Afea, together with Telos consulting, has planned a kaizen week where processes have been analysed following a lean approach. The variety of patients cured at San Francesco was impossible to be represented in a single process, therefore a pilot process has been considered according to the level of complexity: the most complex and complete process resulted the orthopaedic patient with prosthesis. The action plan was divided into a first section of Value Stream Mapping where consultants, together with first line operators, analysed the current state of the process, considering an end-to-end dimension. Following, consultants approached a Gemba walk aimed at collecting data and verifying the current status, before proceeding with the articulation of a future state map. What resulted from the analysis was that informatization through an integrated system already represented the solution to numerous wastes like duplication of information, missing documentation and lengthy operations. With the elimination of unnecessary steps, the future state process showed a considerable reduction in terms of process length and resources absorption, guaranteeing a greater level of quality with fewer utilization of resources. After the successful results obtained in the orthopaedic process, the company decided to extend the lean approach in a second Kaizen week, to deeply analyse another critical process: the doctors compensation process. A similar process analysis through VSM has been accomplished, where the narrower scope permitted a deeper focus on details. The compensation process faced a reduction in the execution time from 40.5 hours to 13 hours. Proceeding with kaizen

implementations, recently the clinic of San Francesco has implemented a new lean project aimed at optimizing the planning activity of surgery rooms. The reliance over kaizen week applications is significant of the fact that the company perceives the value brought by lean healthcare (www.clinicasanfrancesco.it).

3rd Chapter: Lean Thinking applied in a surgical process

During the 6-month internship at Afea s.r.l. I had the opportunity to evaluate the performance of different public and private healthcare facilities, through analyses aimed at implementing the HIS offered by the company: H2O. An evidence, common to the majority of healthcare companies, is the presence of wasteful procedures, lack of optimization of resources and inefficiencies in the processes offered to the patient. Through the implementation of an integrated information system, results show an accurate management and storage of information together with a reduction in printed document. Also, procedures become faster and compliant to privacy requirements, with a reduction in clinical risk in terms of prevention of mistakes about patients' information or missing documentation. What is left out of the action scope of implementing H2O is the profound modification and optimization of processes, that remain contaminated of waste. Why this happens? An HIS implementation is not seen as an opportunity to discuss about the effectiveness of procedures, rather is the substitution of a support tool, decided by the top management that rarely accurately informs and involves employees in a proactive way. Usually, first line workers are subjected to the HIS substitution, without taking advantage of the possibility to ameliorate their way of working. Afea introduced this dimension through *3d project* making workers actively participating to the project and being the first suggesting improvements. Still companies proved not to be ready for a major change. The topic of the internship has been the development of a parallel approach aimed at improving customers' procedures from a process optimization perspective, which, added to the informatic improvement brought by the new HIS, completed the mission of the *3d project*. For this purpose, it has been chosen to apply *lean thinking*, given the increasing attention attained by this method especially in healthcare environments. Given the participation of Afea in a precedent experience of lean application, the company proactively supported the implementation of a lean process optimization project, providing the mentoring of a Lean consultant and planning educational events for the diffusion of lean principles through the whole company employees.

Aim of the pilot project is to determine the effectiveness of lean applications and the alignment with Afea's core business in order to introduce this approach in the company offering. It has been chosen to apply a lean transformation in a private company, where attention over patient experience and comfort possesses greater relevance. The choice is in line with Afea's objectives given the majority of private customers addressing the company. The customer chosen for the implementation of the pilot project has been the facility Casa di Cura Villa Donatello, firstly because of the interest demonstrated by the top management, secondly because of the narrow dimensions, that facilitated the execution of the pilot project and prevented dispersion of the analysis. Moreover, at Villa Donatello employees are open-minded and keen on innovation, in line with the dynamicity of the facility that has recently faced a great modification moving into a new structure. Definitely, their disposition to change, together with the good relationship between the facility and Afea, have been two determinant factors that oriented the choice over Villa Donatello.

This chapter will present the private hospital Villa Donatello and describe the beginning phases of the project, from the definition of the project scope to the first applications oriented over the current state analysis. Tools used during the project will be described before referring to their implementation and procedures will be backed up by images for a clearer understanding of the project execution.

3.1 Lean in Surgery

The process definition phase has been driven by literature review, where greater focus is posed over the application of lean thinking in surgery. Explanation of this is that the process of undergoing surgery is, for an healthcare facility, a main revenue driver (Hearn, 2016). Accordingly, surgery represents one of the most articulated managerial challenges given the interconnection of flows and resources necessary to a correct satisfaction of an operation. Indeed, the main activities required to accomplish a surgical operation are (Bracci, 2014):

- the patient must be carried to the operating room ready to undergo surgery, which implies previous activities of intervention planning and pre-operative exams execution;

- the surgical and anesthetic team must be present in the correct room in the exact order in which they are require to treat the patient. A determinant role is played also by the support team of nurses who help the specialists accomplishing their tasks;
- the operating room needs to be sanitized and correctly organized with the useful tools, machineries and materials;
- availability of the bed for hospitalization has to be ensured in advance, requiring a planning activity of beds occupation parallelized to the surgical planning.

Although the complexity of this business process, there is also a significant opportunity of improvement, since even the detection of a small waste or inefficiency could generate great returns for the stakeholders of the process, being patients, operators and the company itself. Some common areas to look for waste in a surgical process are the preoperative phase, the supply and inventory process and the scheduling process (Hearn, 2016).

In the Preoperative process, a factor to consider is the number of days prior to surgery required in order to obtain all exams results before the day planned for surgery, avoiding delays. At the same, a key consideration refers to the patient's distance from the facility; it can be perceived as a low quality service, to a patient living far from the facility, to drive twice to the structure because of exams. Therefore, most of the times, exams are performed by external providers or inside the private hospital in the morning of the surgery day, even if this procedure could cause delays. Part of the pre-operative phase is the readiness of the surgery room which holds as much impact as the patient readiness in the efficient flow to undergo surgery. There are some precise times that affect the surgery start and must be maintained under control:

- Room set-up time: reflects the time in which the room is ready to receive the patient and is supplied with the necessary equipment and personnel. In turnover situations, it reflects also the time required to perform a sterilization;
- Patient arrival time: is the time required to bring the patient from the wards to the operating block. It is affected by the readiness of the patient to undergo surgery, which implies a good health state and a preparation of the area interested by the surgery. Patient arrival time is influenced also by the presence of nurses available to carry the

patient to the operating block, activity that usually takes some time depending on the distance between the two physical spaces.

- Draped and ready time: is the moment in which the patient's surgical site has been signed and prepared for surgery, considering also the complexity of the positioning;
- Physician arrival time: the time when the surgical equipe is ready to start operating;
- Anesthesia time: depending on the kind of anesthesia and on the reaction of the patient to the treatment, anesthesia absorbs some time before the surgery start.

Those must all be considered as preparation activities to be scheduled prior the start time of the surgery, in order not to generate delays, though their coordination is sometimes difficult to obtain.

The supply and inventory process concerns both the core supply of materials that are common to the majority of surgeries, and the specialty equipment. For core materials, usually stock levels are above request because of fear of remaining without, therefore generating high inventory levels. Specialty equipment, instead, is usually shared between multiple rooms causing a natural strain on the efficiency of the system because their availability is limited. In order to saturate machineries without incurring standstills it is fundamental not to overlap surgeries requiring the same machinery, evaluate the option of buying a second machinery in case of high utilization or optimizing the downtimes of machineries, such as the sanitizing process.

Concerning the scheduling process, it is important to evaluate the effectiveness of having a block schedule rather than a non-block schedule or an hybrid solution. A block schedule has fixed room spaces dedicated to specific surgeons or physicians groups. On the contrary, a non-block schedule will take surgeries as they are requested and place them where there is empty space. The hybrid schedule is a mix of the two solutions when behaviors of surgical equipes differs substantially. The choice of the schedule configuration depends on a series of factors such as volumes of the surgeries performed by the physician group, on-time start rate, the recurrence of events. The scheduling process involves also bed management, that in numerous cases is the critical variable of the process, being the number of beds fixed according to the authorization given by SSN, in some other cases it can be critical because of lengthy hospitalization stays. Above all, it is to consider that most of the times, requirements

of the surgeon are opposed to the requirements of the facility, therefore keeping the delicate balance between the needs of both is a crucial job (Hearn, 2016).

3.2 Casa di Cura Villa Donatello

The care facility Villa Donatello is a Private Institute, owned by the Unipol group, that offers diagnostic and therapeutic services both in hospitalization and outpatient regime. Together with the ordinary hospitalization service, Villa Donatello offers also Day Hospital and Day Surgery for health services that can be performed within a day-time.
Elective hospitalization is distinguished among two areas, medical and surgical, the latter representing the majority of the facility offering. Concerning the medical area, the specialties offered are Internal Medicine and Oncology. For the surgical area specialties are listed below:

- General surgery;
- Plastic surgery;
- Thoracic surgery;
- Vascular Surgery;
- Gynaecology and Obstetrics;
- Ophthalmology;
- Orthopaedics and Traumatology;
- Otorhinolaryngologist and Urology.

A distinctive feature of Villa Donatello refers also to the hospitality comfort, which detains great impact for the majority of patients, who can choose among three levels of comfort. The facility guarantees also continuity in the presence of a service doctor that monitors the condition of hospitalized patients.
Concerning the outpatient regime, the facility offers over 30 specialties for visits and outpatient surgeries. The outpatient service is based on a multidisciplinary approach, with a strong integration among diagnostics, therapeutics and rehabilitation processes. Aim of the private hospital is that of developing sanitary paths that follow the patient from diagnosis, through rehabilitation, to follow-up, having a team of professionals coordinated and sharing a univocal view of patient's needs (villadonatello.com). The offering of Villa Donatello has

been enhanced by the availability of outpatient surgery in the fields of Ophthalmology, Odontology, Physiotherapeutic rehabilitation and Cosmetic dermatology.

3.2.1 Relocation: the new building at Sesto Fiorentino

The structure, located in the centre of Florence for seventy years, in October 2018 moved to a new location in Sesto Fiorentino (Fig.3.1), an historical building known as Villa Ragionieri.

Fig.3.1 New building of Villa Donatello (ww.villadonatello.com)

The facility today is equipped with new machinery that allow the execution of advanced procedures. The majority of the offering has been moved into the new location in order to unify the offering, though the old building of the hospital is still in use for some outpatient services, given also its strategic position in the city centre. The relocation has been necessary because of the increasing number of patients addressing the private hospital and the need for a requalification of machineries given the high quality service that the facility offers. Indeed the historical building in the centre of Florence was facing difficulty in embracing the higher

number of patient and offering them the level of quality that has always distinguished the facility, therefore they opted for an expansion.

The concept driving the structure of the new building is that of the "open hospital" where the facility creates bounds with the territory, with citizens and research and development departments. In this direction, the facility offers a service of integrated domestic assistance which guarantees the opportunity of receiving any kind of report directly at home, together with the Fast-aid outpatient clinic that operates as emergency room for non-critical patients.

Today the institute possesses four multi-specialty hospitalization wards for a total of 128 beds and 8 surgery rooms provided with the machinery to perform every kind of surgery, favouring the mini-invasive kind. The facility is provided also with an advanced diagnostics centre with nine specific rooms for: CAT[7], x-ray, BMD[8], MRI[9], ultrasonography, angiography and mammography. The facility offers service also for urgent surgeries, indeed operating rooms are operative 24/7, as well as the diagnostic centre, the laboratory and the cardiologist consultancy. Safety standards are satisfied thanks to the availability of three intensive therapy placements. It is therefore provided with the necessary supports to guarantee hospitalization for urgent pathologies. The facility nowadays offers also a specialized ophthalmology centre provided with advanced machinery like Femtosecond Laser, which is the new paradigm in modern refractive surgery. The ophthalmology centre has its own divisional structure inside the facility, with its own surgery rooms, therefore guaranteeing efficient setting and equipment of rooms together with continuous availability.

Surgeons at Villa Donatello are external professionals and amount to 300 specialists operating in the facility. The rest of the personnel is employed and is organized as follows:

- 9 operators working at the registration desks and 3 operators at the invoicing desk
- 11 operating block nurses and 16 ward nurses
- 12 social health operators: 2 at the operating block and 10 at the wards
- 1 nurse for the preoperative phase
- 4 radiology technicals
- 3 emergency doctors and 5 anaesthetists

[7] Computerized Axial Taxonomy

[8] Bone Mineral Density

[9] Magnetic Resonance Imaging

3.2.2 Villa Donatello Surgical Process

The surgical process at Villa Donatello represents the major business line of the company in terms of profits. A peculiarity of the surgical process in Villa Donatello is that patients, regardless of the surgery typology, follow the same path through the hospital, while differentiation relies in the contents of the curing process. As a consequence, there is no necessity of narrowing the scope to a single patient type (i.e. cardiologic, orthopaedic, ect.) but we can refer to a generic surgical patient. Clearly some variation in the process exists, given the presence of particular cases and relative urgencies (Villa Donatello doesn't have the emergency department, therefore most of the demand is planned in advance), but those can be avoided by focusing on the most common episodes, according to historical data. We already said that, according to lean thinking, processes must be considered from patient perspective, hence they must represent the patient flow through the facility from the first contact to the final discharge. Translated into Villa Donatello background, the process starts with the doctor inserting the planned intervention into the surgery list and ends with the discharge of the patient. Going deeper in the definition of the subject matter of the analysis, from the patient perspective, a typical surgical process at Villa Donatello is characterized by the following steps (Fig. 3.2):

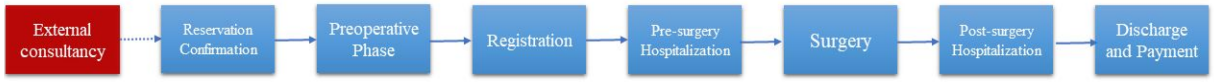


Fig.3.2: Main steps of Villa Donatello surgical process (Patient perspective)

The reservation step is carried out by the surgeon who, after an external consulence with the patient, addresses the private hospital to reserve a surgery room availability. This activity requires the surgeon to fill out a form, named MPR (Modulo Prenotazione Ricovero), which will be sent through email to the operators of Villa Donatello so that they can insert the reservation in their planning. Once the reservation is inserted in the planning, the first contact of the facility with the patient is through phone call to confirm the reservation. A patient with confirmed reservation, before undergoing surgery, needs to be checked in order to evaluate the eligibility of the patient to be operated. The pre-operative phase consists of a set of exams,

including anesthetist consulence, ECG and cardiologist consulence plus blood exams, to which a series of additional exams can be added. Pre-operative exams are performed within a few hours then the patient can go back home. Usually a week later, patients arrive at Villa Donatello for surgery and, after being registered for recovery, they are given an hospitalization bed, where the patient can be prepared before surgery. Then, surgery is performed and the patient remains in the surgery block until the effect of anesthetics are vanished and pain is limited within a threshold value. The patient is brought back to the ward where he/she is controlled to guarantee a condition of stability through the adoption of therapies and additional exams. Once the patient is ready to be dismissed, he/she receives a dismission certificate and passes at the reception desk to pay for treatment and stay.
Related to the patient flow above cited, there are a number of activities which do not involve patients in first person but are necessary to the successful prosecution of the patient flow. Among these we have the surgery planning, which represents the pacemaker of the whole process; this means that the surgery planning consequently determines the planning of the other activities downstream and upstream.

3.3 Project scope

The pilot project represents the first lean implementation to which Villa Donatello has been exposed, therefore a short-range application has been preferred, limiting the action scope to a single process among the Clinical offerings. For this reason, it has been decided to address the surgical process, leaving for a future analysis the other business lines of the facility. Also, boundaries of the project are given by time constraints, for which a kaizen week approach has been preferred. Indeed the project involved staff from Villa Donatello for a total of 7 days, during which clinical, administrative and directional employees interacted with me and two co-workers. Days have not been consecutive in order not to impact on the operational efficiency of the private hospital in one side, and, in the other side, to have time for elaborating information collected during the days spent in the facility. The definition of the project scope has considered the interest of the facility to enhance the surgical patient journey through the hospital, in terms of perceived quality of the service. Also, another perspective taken into consideration, parallel to the patient perspective, has been that of operators. Within

the project scope has been included the goal of optimizing activities from operators perspective, backed by the belief that people are able to guarantee a higher level service if they are satisfied of their job first. Related to the definition of the project scope are the identification of the activities performed during the project and the people involved; these aspects are described in the following sections.

3.3.1 Activity Planning

Completing the definition of the project scope, activities have been distributed over time in a sequence of consecutive steps to be performed. The plan of activities has been firstly developed together with a consultant of Afea, then it has been presented to Villa Donatello's directional team for approval. The schedule of activities is described below:

1. Kick-off meeting with Villa Donatello directional staff for the definition of the project and the goal to be achieved. The intentions of the staff over the project have been considered in order to shape the project structure to the requirements of the facility. In this phase, activities have been decided and fixed on a timeline.

2. Gemba walk, a direct observation of the process step by step, getting beside operators to understand how they work and how the patient moves and interacts along the process.

3. Presentation of the project, to involve participants and share with them knowledge about lean concepts and values, the project objectives and activities. Most importantly, participants have been informed of the important impact they could make on the results and the necessity of a proactive participation to the successful implementation of the project.

4. Value Stream Mapping (VSM) of the current condition guided by the interested operators who have been asked to carefully describe their activities and highlight criticalities of their tasks. Data about performance metrics, times of availability of the service and demand volumes have been collected and added to the analysis so to guarantee a complete definition of the current state condition.

5. Identification of the inefficiencies and evaluation of possible corrective actions to be implemented, together with a deeper analysis of the factors resulted critical to the optimization of the overall process.

6. Definition of the future state by performing a second VSM activity, where it is shown the objective condition of the process and the modifications to be applied in order to obtain that final state.

7. Structuring of an Action Plan by determining the sequence of corrective actions to implement in order to achieve the future state. Activities have been prioritized starting from the easiest one to realize, so to obtain an progressive optimization of the process and a relative adaptation of operators and patients to the improvements applied.

During the execution of the first activity, the plan has been presented and submitted for confirmation to the spokesperson of the private hospital, being the Chief Medical Officer (CMO). Following her directives, the presentation of the project has been postponed after the Gemba walk because the definition of the key users was preferably to be performed after the observation of employees. By looking at how people work, it has been possible to select some key users according to their working position and experience in the position covered.

3.3.2 Definition of the Lean team

The definition of Villa Donatello employees to involve in the project has been an activity performed after gemba walk. Indeed, as requested by the CMO, the choice of the best fitting members was to be conducted by the project developers after a direct observation of the staff while working. The aim has been involving those employees keener on change and proactive on participation beyond routinary work activities. Once pioneers are involved in the project, the goal is to have them spread enthusiasm over Lean Thinking approach, therefore embracing more interested people for possible future applications. During gemba there has been the opportunity to get in contact with the majority of operators involved in the surgical process, and to start transmitting core values of the lean philosophy. The response of employees over the possibility of optimizing the working procedures has been positive and they showed active participation from the first phase of gemba. The choice of the key users

has been driven by the necessity to involve at least one member for each of the process steps, at the same time containing the number of participants in order to simplify the accurate progression of the project. Strategic to the correct implementation of the project has been the involvement of the Chief Executive Officer Dr. Alberto Rimoldi, whose support has guaranteed value and general curiosity over the project from the whole staff of the private hospital. Also, peculiar to the implementation of the project has been the continuous presence of the Chief Medical Officer Dr. Silvia Galli, who has supported and followed the project from the first steps. The support of the CMO spurred participation of employees and helped in organizing the multiple phases of the project, assuring the presence of the required people. Another important presence to mention has been that of Roberto Ricci, responsible of Villa Donatello informatic systems. His support to the project has been essential in the collection of historical data, in furnishing the required materials and in meetings planning. The other actors involved in the project are:

- The administrative manager, accountable of the strategic planning of the facility and of the periodic control of financial and managerial aspects. The administrative manager is an important stakeholder when considering an improvement of processes towards efficiency and effectiveness.

- The wards coordinator, responsible for the insertion of surgery reservation and planner of the operating schedule. The wards coordinator manages also the ward organization and the nursing staff.

- The front office coordinator, responsible for the registration of the patient both in preoperative and hospitalization phase, the down payments for hospitalization and the delivery of certificates and folder copy.

- The PO responsible, who organizes all the preoperative exams from the booking to the actual execution and collection of the results.

- A back office operator involved in the check for folder completeness and filing operations in order to store all clinical documents.

- The nursing supervisor who controls the nursing staff and coordinates patient assistance during the pre-surgery and post-surgery hospitalization.

- A surgery room nurse who organizes the spaces within the operating block, provides materials required and sets the rooms for surgery.
- A Back office operator responsible for invoicing, insurance coverages and balancing for accounts.

The team is composed of 11 different actors combined in a multidisciplinary team. Impressive has been their collaboration and interconnection, an aspect difficult to obtain in an environment based on a departmental structure.

3.4 Grasping the situation: Current State Analysis

From April 10th, activities in Villa Donatello started to involve personnel into the implementation of the lean project. Once accordance with the CMO and the directional power of the private hospital has been obtained on how to proceed, the project started with the analysis of the current condition. In order to appraise the real situation, a Gemba walk has been performed as a first step analysis. Then, personnel has been involved in the project presentation, a speech conducted in order to spread lean thinking principles and objectives of the project. The aim of the initial meeting is to communicate the necessity of having employees actively participating in the project, expressing themselves opinions and suggesting corrections. Participation is indeed one of the main drivers for the successful implementation of the project. Next to the presentation, the project started with the core activity of value stream mapping (VSM), one of the most common tools of the Lean set. The aim of VSM is to represent the whole process on a visual scheme so to have a complete understanding of the links between activities and assess the critical points. The current state analysis ended with the appraisal of current problems affecting the process flow which have been pinpointed together with employees and shared to the CMO. Data about the performance levels of the facility have been extracted from H2O, their current HIS. Since Villa Donatello is using Afea's product since 2009, it has been possible to extract historical data about the facility offering, limiting information to the last two years.

3.4.1 Gemba walk

Gemba is a Japanese term that means "the real place" and refers to the place where value is created along the value stream. According to Ohno, gemba means going on foot to see how things happen inside a company, observing procedures, communication and peculiarities that differ according to single operators. It is a useful activity to conduct because it permits to get in contact with the reality of how work is done and a direct evidence of the inefficiencies embedded in the procedures. Indeed, an external look can appraise particulars hidden and taken for granted by the people always working that way. The strong power of performing a gemba walk is the opportunity to ask operators why they perform that way, finding that most of the times the answer is "because I have always done it that way". From the inside is most of the time difficult to question how thing are done, especially because usually wastes are stuck in the most banal procedures. Instead, from a first look, even banal procedure are carefully analysed, in this way it is possible to appraise the real current state of operations, fundamental step in lean thinking. Go to see is a vital part of the change process because it permits to understand transitions that would be hidden in an office performed analysis with papers and spreadsheets. Gemba allows walkers to gain valuable insights on how to reduce existing waste and allows to discover where improvement opportunities exist. The goal is to find out what is really happening and not what is suppose to happen or whether people are following procedures or not. Also, by going in the working locations around the facility, there is a natural engagement with the staff, who gets a first glimpse of what the project will be. Opportunities of improvement come also from line operators who are the ones actively involved and daily observing the state of operations, therefore their commitment is fundamental.

Gemba walk in Villa Donatello has been performed as a first activity in the field without any previous contact or knowledge about the hospital operating processes. This guaranteed an external opinion not affected by the considerations of staff members about current problems. Gemba walk has been a three-day full observation of the hospital's surgical process from operators and patients perspective. Together with patients, the surgical process has been traversed from the moment in which a patient enters the facility for pre-operative exams, to the moment in which he/she is discharged. During the path, patients have been asked about

impressions and opinions referring the quality of the service. The answers have revealed a good perceived quality of the curing service in contrast to some critics about the timing of exams and surgery, often postponed respect to the fixed time. From the operators perspective, it has been observed how they fulfill tasks in different offices and departments, from front desk to surgery room and wards, in order to understand the support flows of information and materials, together with the communication between staff members. Observing the process through the operators perspective has offered the opportunity to analyse also those steps which do not involve the patient in first person, obtaining therefore a complete visualizing of the flow of activities belonging to the surgical process of Villa Donatello. During the last day of gemba, criticalities perceived by operators have been collected together with documentation used in daily operational activities.

During the three-day observation, notes have been gathered following the standard questions of the Gemba Walk spreadsheet for each of the process steps. An example is reported in figure 3.3 referring to the Hospitalization admission step. Information collected during Gemba concerns:

- The length of each activity (in terms of process time and elapsed time), taken by actively measuring three times the execution of the same activity, then calculating the average value;
- The number of people performing the same activity and the operating window;
- The flow of paper documents and information during each step;
- The completeness and accuracy of information obtained by previous steps;
- The presence of criticalities that prevent the right fulfillment of the task or require reworking;
- Comments of patients and operators about the comfort perceived and the ease of operationality.

	QUESTIONS	DATA	COMMENTS
1	How many people work on this step?	Each shift is covered by 2 people. Total of 4 operators	Beatrice, Valentina, Lidia, Isabella
	How many people are shared resources, meaning they work elsewhere as well?	In the same office they carry out multiple tasks.	Cha MPR insertion; call patients; documents preparation; PO registration and payment; hospitalization registration and down payments; insurance coverage; Ophthalmology invoicing
2	What % of time do people have available to work on this step?	The office is opened from 6.30 to 20.00 from Mon to Fri, from 6.30 to 13.00 on Saturdays. Office is closed on Sundays	Even if they are performing other activities, as soon as the patient arrives for hospitalization, the serve the patient right away. Only if there are other patients there can be waiting of maximum 10 minutes
3	How much time elapses between the moment work is made available to you and the moment when you pass it to the next step?	10 to 15 minutes	Copy of the ID, privacy form, insurance coverage, hospitalization registration form, clinical folder first page with admission number and document for the ward
4	How long would it take to complete this activity if you could work on it without being interrupted or without waiting?	7 minutes	
5	What % of units received at this step is complete and accurate?	95%	Two days before hospitalization, operators check the completeness of the documentation required. Mistakes can refer to the accuracy of some patient records.
6	Do you have to set up anything (equipment, etc.) before doing this step?	Two days before they check documentation and call the patient to inform of the arrival time. Also they prepare all necessary documents to facilitate registration	
	If so, how long does that take?	2-3 minutes	
7	What system is being used for this step?	H2O	In H2O the patient is admitted and forms are printed in order for the patient to sign them
	How do you track needed information (reports, spreadsheets, etc.)?	Everything in this step is tracked in the system	
8	What issues or barriers to flow make this step painful or time consuming?	The lack of insurance coverage confirmation	If the patient takes in charge the procedure to activate an insurance coverage then the day of hospitalization arrives without an active coverage, either the surgery is postponed or the registration desk is asked to activate it

Fig. 3.3: Gemba Walk spreadsheet

The analysis of the data gathered during gemba has been essential to the fulfilment of the following project step, being the value stream mapping (VSM). Hence, direct observation guarantees a vision of the whole process, something that usually operators are unaware of, because they focus on their area of expertise.

3.4.2 Value Stream Mapping: analysis of the AS-IS condition

Prior to undergo VSM, a collection of data has been carried out so to have a general understanding of Villa Donatello's figures. Demand fulfilled in 2018, together with the first half of 2019, has been extracted and records show a levelled amount of demand during the whole year (Fig. 3.4), exception for the summer where demand is halved. Surgical demand is significant respect to the medical one, that reaches about 150 patients per quarter. The annual offering in 2018 has been of 1.697 surgical patients, meaning 5,4 registrations per day; the peak has been 6,15 daily registrations in the period April to June 2018, while the same period this year has faced a reduction in demand, receiving 5,2 patients a day.

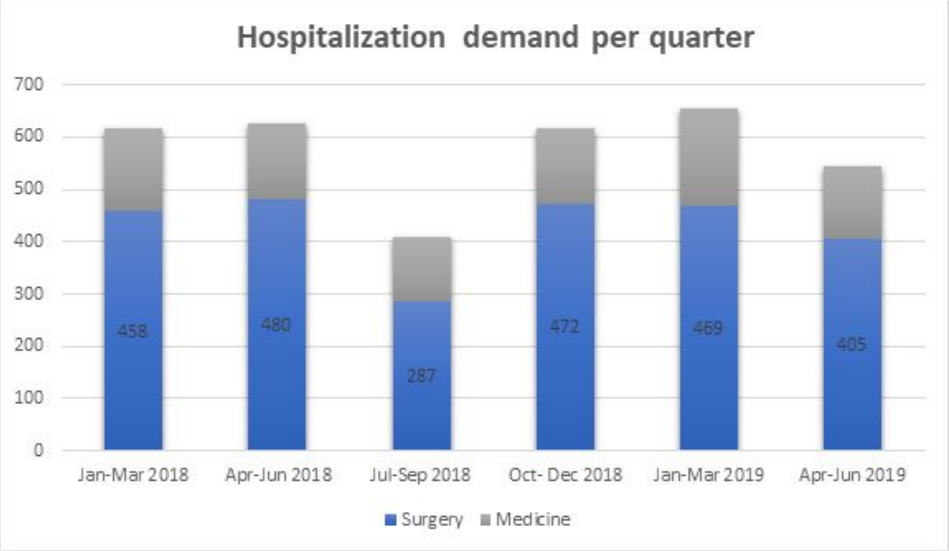


Fig. 3.4: Data extracted from H2O about hospitalization demand

When referring to surgical patients, attention has been posed only over those patients that follow an ordinary regime hospitalization. This guarantees greater homogeneity in the process definition, since Day Surgery (DS) and outpatient surgery (CHA) follow a shortest and easiest process which diversifies from ordinary patient ones. In order to address the more complete process, ordinary hospitalization has been chosen, also being the most frequent surgical process in the facility. Even though all surgical patients follow the same path, regardless of the specialty they belong to, data about the numbers of ordinary hospitalizations divided according per specialty have been extracted so to have an idea of the most significant surgery types (Fig. 3.5). In 2018, Orthopaedics results the most common specialty, followed by General Surgery and Urology.

Specialty	Ordinary Hospitalization
General Surgery	450
Plastic Surgery	16
Vascular Surgery	53
Orthopaedics	654
Gynaecology and Obstetrics	138
Otolaryngology	71
Urology	315
Total	**1.697**
Intensive Therapy	90

Fig. 3.5: Hospitalization sorted by specialty (H2O extraction of 2018)

After data collection, employees have been asked to represent on a visual scheme all process steps, detailed with information about their duration, input/output, communication with other departments and eventual devices support. VSM is a powerful tool because it permits a visual representation of the whole process, enabling causes-effect analysis of the interconnections among activities involved in the process.

There are multiple approaches to VSM as well as different structures. Approaches differ for the goal they are addressing; there are maps aimed at identifying the interconnection of a process with softwares or devices, there are maps directed over the transitions of a company with external entities, there are maps showing all the company business, as there are maps representing a single process within a company business. Different approaches require different designs and different information to be contained. However, even VSM built with the same approach can differ on how information are displayed and on the level of detail. In the current lean project has been chosen to adopt the model of VSM developed in 2015 by Henrique et al., who proposed their own model after having performed a literature review of the previous developed models. The distinguish feature of the new VSM model is that it is composed of parallel swimlanes containing flows regarding information and materials, added to the central flow of the patient. In this way, the new model is able to take into account all the flows that directly affect the duration of the treatment of the patient on a single map (Henrique et al.,2015).

The representation of the current state VSM is reported in the attachments A1 to A5, which are digital formats of what has been done with post-it attached on the wall (Fig. 3.6). The VSM process has been composed of multiple steps, from a general representation to the detailed one, starting from the definition of the activities without any information, then adding data about each single step. For each activity, in the grey box is expressed the activity performed, in the white box is expressed the actor and in the blue box have been collected data about:

- Process time, refers to the time required to perform an activity. It includes only the value-adding parts of the activity;
- Lead time, goes from the availability of the patient to undergo a step to the availability of the same patient to the consecutive step.
- C&A, meaning the percentage of completeness and accuracy of the information inserted during the activity.

Triangles in the map signal the existence of waiting, with the amount expressed in the timeline. Information flows are identified by green lines connecting the activity with the source where information is placed or extracted, being a software, a program or paper. Yellow lines represent materials flow while blue lines identify verbal connections with the patient (calls or emails). In the bottom part of the map there are yellow notes about the procedures followed in each activity and red notes identifying wastes observed during the process. Finally, there have been included smiley faces, stating the perception of both patients and operators during the steps of the process and improvement opportunities, in the green boxes at the bottom part, that came out as ideas during the progression of the AS IS mapping. The process has been articulated into five sections.

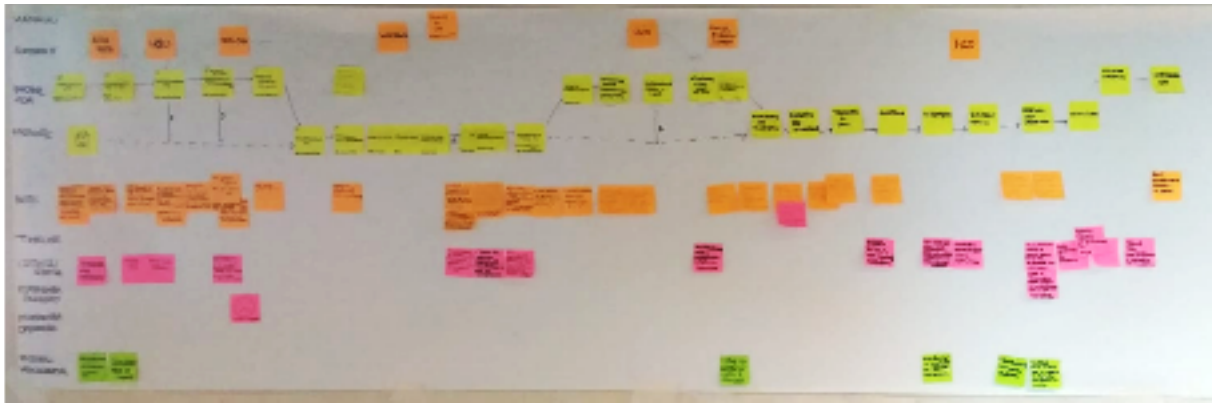


Fig. 3.6: Value Stream Mapping activity at Villa Donatello

1.Reservation

Is the surgeon that directly contacts Villa Donatello to fix a precise time slot and room availability for surgery. In order to accomplish reservation, the Doctor must interact with the Nursing Supervisor that confirms the operating room availability, then fill a form, called "Modulo Prenotazione Ricovero (MPR) with some compulsory information about the kind of surgery and the patient data. Most of the Doctors fill the MPR through the facility website, so that a mail is directly sent to the users who need the information. The procedure, though, is not followed by all surgeons, indeed 60% of doctors still prefer to call and communicate information verbally, requiring operators to fill the MPR form for them. Once MPR is in the mailing system, there are three operators responsible to insert the reservation in H2O, the current information system; usually is the wards coordinator that fulfills this task. Insertion usually requires reworks because of missing information by the surgeon. To complete reservation, employees in the front office call the patient to insert additional records in H2O, to assign a doctor to the surgery and to specify an entry time. In this way, reservation is perfected and is ready for the next step. Solvent patients, not covered by assurances, usually request an estimate of the hospitalization cost, therefore they are contacted by the estimates Responsible who inserts additional patient records herself, hence the front office will perfect the reservation without calling the patient again. The reservation step can be concluded in two days as in 20 days, depending on how much in advance the surgeon fills the MPR.

2. Pre-operative process

A patient with perfected reservation is called by the preoperative (PO) Responsible who submits a questionnaire to the patient about medical history and current health condition. During the call, the PO Responsible fixes the day of the preoperative exams and communicates the date to the patient; usually exams are done 1 week before surgery and PO planning is performed 10 days before PO execution. The call has a duration of 7 minutes on average. Once the call is concluded, the PO Responsible proceeds by sending an email to the patient with the list of exams to conduct at Villa Donatello and enters H2O to register the day of the PO and exams. In this phase there is a strong reliance on the mailing system because patients with previous exams, done less than three months earlier, can avoid repeating them, therefore they communicate it by mail to the PO Responsible attaching the medical report.

The day before PO exams, operators of the front desk prepare the clinical folder with all the information they have about the patient. On the day of the PO exams, patients arrive with a one-piece flow mechanism, since they are scheduled every 30 minutes. This guarantees almost a continuous flow, avoiding long queues. The first step is the registration desk, where the patient is required to sign some agreements for information disclosure, third party distribution, cost of hospitalization, folder request; nothing is registered in H2O. The registration takes 6 minutes to be performed, then the patient is received at the PO office where the responsible gives information about the surgery preparation, and about the preoperative steps. Preoperative exams usually involve: blood exams and ECG, cardiologist consultancy and anesthetist consultancy. Often, patients perform also a radiology exam which, together with the cardiologist, are the only visits with a fixed reservation time. The other exams and consultancies are performed when available. Once the patient carries out all the exams, turns the folder with medical reports to the PO responsible, then pays for the exams at the registration desk. The registration desks knows which exams have been performed by the patient only by receiving the "Modulo esami preospedalizzazione" paper document, through which reservations are updated in H2O, then payment is permitted. A full pre-operative path takes on average 2 hours then the patient goes back home. At fixed times during the day, blood exams are delivered to the laboratory, where within 24 h results are ready on SYNLAB, software for laboratory analyses. The day after, blood exam results are inserted in the clinical folder of the patient, then the anesthetist checks the folder in order to give eligibility for surgery. When the folder is provided with all results of the preoperative exams, the PO responsible will bring the folder to the ward, so that nurses will have the necessary documentation when the patient will be hospitalized.

3. Surgery planning and bed management

Every friday, the wards coordinator, together with the CMO, the anesthetists coordinator, the PO responsible and the nursing supervisor validate the planned surgeries for the following week. Through the visual planner they appraise the current state of operating rooms, they check if patient documentation is complete and if requirements to undergo surgery are all settled. The core activity of the surgery planning is the definition of personnel and the organization of shifts. Usually surgeries are not modified in day and time, since they keep the surgeon availability as a priority. Anyway a minimum optimization in the surgery planning is

performed in order to saturate the open rooms instead of opening new ones, and in order to minimize the number of nursing staff.

Two days before surgery, time of entry for hospitalization is organized and patients are called to be informed of the time they are required to be at Villa Donatello. The call is performed by the operators of the registration desk, after having checked that the documentation is complete, otherwise they also worn the patient if something is missing (for example insurance coverage in case of insured patient). It has been highlighted by operators the dissatisfaction expressed by patients about the continuous calls and notifications they receive during the process. The day before surgery, bed assignment is performed through an excel file, by coping information about patients already registered in H2O. The excel form is printed in multiple copies to be distributed to different operators; in case of variations, the nursing supervisor must call everyone that received the printed excel file to warn about the change. Bed management is possible a day in advance because of the wide availability of beds which are never fully saturated. in fact, of the 24 beds dedicated to surgical patients, 13,95 is the average utilization of beds (based on data of 2018). The last step of the planning process is the delivery of the clinical folder to the ward, after a check for completeness of the PO part.

4. Registration and surgery execution

The day of the surgery, patients are received at the registration desk; the activity lasts on average 7 minutes. During registration, identity of the patient is checked, privacy agreement is signed and the patient is assigned an hospitalization number univocally recognizing the event. Done with registration, operators of the front desk notify the ward of the patient arrival; the patient reaches the second floor of the structure where the surgical ward is located. At the ward, nurses have the list of entrances of the day together with patients' folders with information of the preoperative exams. When the patient enters the ward, identity is checked again, then the patient is brought to the hospitalization room. Here nurses evaluate vital signs of the patient and prepare him/her to undergo surgery. Preparation involves evaluation of the patient health condition, verification that he/she followed the pre-surgery procedure and check of eventual allergies or ongoing therapies. In the meanwhile, at the operating block, nurses are setting the room ready for surgery, providing the necessary tools and equipment. Equipping the room and sanitizing it requires 30 minutes. Usually 30 minutes before surgery start, nurses inform the ward to bring the patient at the operating block. In the recovery space, prior the

operating room, patients are controlled by the anesthetist who sets the machinery ready to perform anesthesia. An average of 10 minutes are necessary to perform anesthesia, but this value varies consistently according to the type of anesthesia; also, anesthesia cannot be performed until the surgeon is present at the operating block. Then, surgery starts and, depending on the kind of surgery, time of room occupancy can vary from 1h to 3h. Meanwhile the patient is operated, in the surgery room materials, tools and people orchestrate to succeed the surgery. Here it is appraisable if the room preparation has been efficient, therefore there is no requirement to exit the room, otherwise there are continuous in and out from the room. As soon as the surgery is completed, the patient is brought to the recovery space where he/she wakes up from anesthesia then the state of health is checked again. At the same time, nurses clean the operating room and set the room ready for next surgery. When the patient is waken up and values are stable, the nurse calls the ward to inform that the patient can be picked up and brought back to the hospitalization room. Usually in 10 minutes a ward nurse arrives and takes the patient; in order to exit the operating block, a form containing information on the patient state of health after surgery must be filled (Scheda di dimissibilità).

5. Post-operative phase, discharge and invoicing.

Patient back to the ward is submitted to the therapy decided by the surgeon, who visits the patient and determines whether and after how long the patient can be dismissed. Hospitalization have different durations depending of the surgery typology, nevertheless data show that on average hospitalization length lasts 2.5 days (Fig. 3.7).

	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Avg.
Avg. hospitalization length	3	4	3	3	3	2	2	2	2	3	2	2	**2.58**

Fig. 3.7: Average hospitalization length (H2O statistics of 2018 data)

During hospitalization, the patient can necessitate additional exams or visits, which are requested by the surgeon and reserved by ward nurses. In the wards there are usually 3 nurses, 2 healthcare workers and a service doctor who have to monitor the situation of all patients hospitalized in the surgical ward, who usually amount to a maximum of 16 patients.

Materials used for medication or other services during the stay at the ward are registered because they will be charged to the patient. Anyway, registration is on paper, inserted in the clinical folder. When the patient is scheduled for discharge, undergoes a last check at the ward then empties the room and reaches the payment desk at the ground floor, where operators know of his/her dismissal therefore organize documentation in advance. Nevertheless, in order for the patient to pay for surgery and hospitalization, charges of the materials used must be inserted in H2O; this task is performed for the most part by the responsible of folder check, since at the wards charges are never registered in H2O. Not always payments for the patient are ready, so it happens that the patient is asked to wait on average 15 minutes, time required by the folder check responsible to charge all materials and services used and check folder completeness. In the 20% of cases, charges cannot be inserted in H2O, hence the patient goes home without paying. This happens because the responsible of folders check works only until 2 pm, so patients discharged after that time won't be able to pay contextually; they will be asked to come back to the facility to pay in the following days. Finally, the patient exits Villa Donatello. The discharge procedure takes up to 30 minutes.

Once the whole process has been mapped, activities have been classified as value-adding (VA), non-value adding (NVA) or essential non-value adding (ENVA), by placing respectively a green dot, red dot or orange dot on top of the activity. In identifying activities as value or non-value added, it is important to keep in mind that from the patient perspective, some activities which are not in direct contact with them cannot be perceived as value adding, while they are extremely important for the prosecution of the process, hence they are classified as essential non-value adding. An example is the sanitization of the surgery room, which is hidden from the patient perspective that only perceives the waiting in case activities are not parallelized.

3.5 Criticalities emerged

During the current state mapping, each of the key users expressed the problems faced when performing his/her tasks. By sharing current problems with all key users, has been possible to understand the root causes generating those inefficiencies and highlight them in the swimlane of the VSM containing wastes. These inefficiencies represent the starting point to the definition of a future state condition. Once criticalities have been recognized, through the implementation of the *5 whys* practice, root cause analysis has been performed in order to understand which actions could be effective to the permanent elimination of the highlighted defects. The main wastes identified are explained in the following sections.

3.5.1 Not univocal reservation process

The first step of the process is a crucial task given the importance of the information contained in it, which triggers all the other process activities. The MPR system is a solution that guarantees access to all surgeons operating in the facility, since it is accessible everywhere from Villa Donatello website. It permits a rapid insertion of the necessary information about the surgery and the patient, that only the surgeon knows, and it is efficiently connected through mail to the staff who needs to be informed about it. The criticality about the MPR system is that it is not univocal for all surgeons. Indeed only 40% of the times the MPR is filled on the website; the majority of the surgeons find easier to call the wards coordinators to communicate her few of the mandatory information, others directly leave papernotes. This variability in the reservation procedure generates necessity of reworking, especially when important information are missing, and increases the risk of losing reservations delivered on paper.

Additionally, the wards coordinator, responsible of inserting reservations in H2O, wastes a great amount of time, since she has to collect reservations from different sources and most of the time she needs to call back the surgeon to ask for complete information about the reservation. The C&A value for the reservation process is 70%, therefore 3 out of 10 times the wards coordinator contacts the surgeon because of missing data, which are mandatory to save the reservation in H2O. Another inefficiency connected to the MPR system is that of the massive dispatching through email. Once the document is filled, it is automatically sent to

nine staff members, even though the responsibles for the insertion of the registration are only two of them. This happens because operators find easier to work with the information contained in the printed MPR instead of searching the reservation in H2O. Moreover the printed document permits to write down notes on it, being information easily recallable. Front-office operators, responsible for the reservation perfectioning, find useful to have the MPR because they can organize reservations according to priority, which is given by a combination of factors, so they are aware of which reservation to complete first. Operators using information contained in the MPR document, usually print it, hence each MPR generates up to 9 paper documents that most of the times are thrown after use; only one of them remains in the clinical folder.

3.5.2 Low utilization of material resources

When experiencing the patient journey, it stands out the flowing of the patient in certain steps, one of them is the ward assistance. As soon as the patient is admitted, he/she reaches the surgical ward where a nurse is waiting to accommodate the patient and to start the preparation to surgery. Definitely it represents a good quality service from the patient perspective, at the same time it holds some implications from the facility perspective. Indeed, fast assistance is a consequence of a balanced dimensioning of the ward staff that is usually composed of 3 nurses, together with 2 healthcare workers and a service doctor. At the same time though, the rapid service is a consequence of the limited number of patients hosted.

In the facility there are 24 beds ready to host surgical patients but of them, on average, 12 are used, generating a high incidence of waste for non utilization of resources (Fig. 3.8).

	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Avg.
Avg. beds utilized	14.77	16.36	15.26	16.00	15.48	10.66	6.17	5.55	6.37	15.22	10.48	10.15	**11.87**
Beds saturation	61%	68%	63%	66%	64%	44%	25%	23%	26%	63%	43%	42%	**49%**

Fig.3.8: Bed saturation (H2O statistics of 2018 data)

It is true that a security reserve is necessary to respond to peaks in demand, but a saturation of 49% is a level much below the optimal value of 75%, which guarantees also a slack for urgent

demand. Having 12 empty beds means for Villa Donatello a considerable waste; considering that the price for a day utilization of the room is 280€, twelve empty beds generate a daily waste of 3.360€ which means a 1.226.400€ on a yearly basis. Clearly, having 24 patients to manage instead of 13, requires a wider team of nurses to guarantee the same level of assistance, but considering the additional profits made, there are wide margins for payment of additional nurses as well as healthcare workers to clean the rooms. Nevertheless, unused rooms require anyway a certain level of maintenance, otherwise they won't be available for use once required. A similar waste has been observed even in the operating block, where of the 4 rooms available, on average 3 are used with a saturation of 52% each. If the excess capacity in hospitalization beds generates economic loss, this problem is tripled when talking about operating room.

In numbers, the cost for an hourly utilization of an operating room is 650€; if the unused rooms was at least saturated at 50% as the used ones, there will be an additional 5.5 hours utilization (operating time from 8.00 am to 7.00 pm), amounting to a daily revenue of 3.575€. Hence, on a yearly basis, Villa Donatello will gain 930.000€, considering that surgery is performed only during weekdays. Here as well, there are various costs connected to the utilization of an operating room, from machinery utilization, cleaning services and additional personnel to the increment in material requirements as in all the other activities belonging to the surgical process.

Waste of non utilization of material resources in the operating block affects, not only operating rooms, but also the recovery room which is not used (Fig.3.9).
The room is equipped with three emplacements for post-surgery patients who require control before returning in the ward. Its location, aside from the operating space, guarantees a quiet and sanitized environment in one side, but requires the monitoring of dedicated staff in the other side.

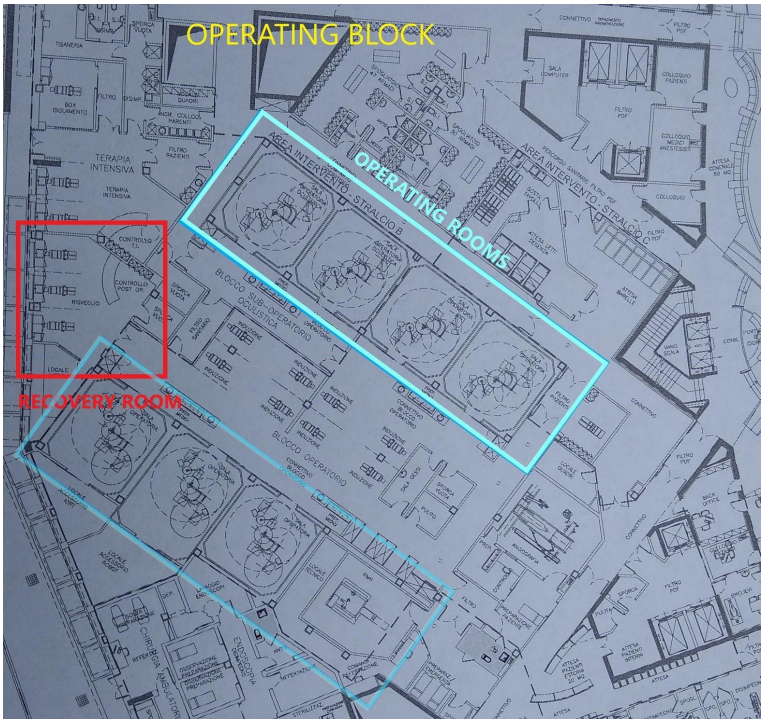


Fig.3.9: Villa Donatello operating block (villadonatello.com)

Nurses have to control and set-up operating rooms in the meantime, therefore there will be necessity of additional staff to use the recovery room. Given the stable conditions in which the majority of patients exit the operating room, it results unnecessary to have a resource fully dedicated to the monitoring of post-surgery patients. As a consequence, nowadays patients remain in the connective space between operating rooms where patients are also prepared for surgery. This generates an optimized use of human resources but, at the same time, a waste of space since the room is never used.

3.5.3 Overtime due to delays in surgery timing

The surgery planning at Villa Donatello mainly reflects the directions asked by surgeons in terms of timing and resources required. This happens in the majority of private hospitals since surgeons are not employees of the facility, rather they rent operating room availability together with the service offered by the facility where they chose to operate. As a consequence, surgeons are important stakeholders to the private hospitals and needs of the surgeons must be satisfied as much as needs of patients. Therefore it happens that a surgery room is booked only in the afternoon or for an early surgery in the morning then a late surgery at closing time. Even if a planning like that is not efficient from the facility perspective, it is

strictly respondent to the requirements of surgeons, hence it is beneficial to the relationship of the facility with its professionals. Another consequence of having freelance professionals working in the facility is that they are never fully present in the structure, rather they arrive only when their patients are about to be operated.

The inefficient planning together with the last minute arrival of surgeons, frequently generate delays in surgeries. When delays happen, overlappings can take place as well as shortage of resources, which, scheduled to follow a patient at the time, they end up with two patients to be taken charge simultaneously. Given the dimensioning of resources according to necessity, it happens that a delay in a surgery provokes a delay in all the following surgeries. When the delay occurs during a shift, it generates overtime work, given that nurses involved in a surgery are required to be present until complexion.

At Villa Donatello, delays in the operating block happens with a frequence of 70%, mostly because of surgeon delays, and 40% of the times they generate overtime. Overtime represent a burden for the facility that is forced to pay more for resources who perform the same activities with the same effort, where the final result is a lower quality experience for patients affected by waitings. Adding to the less satisfactory experience of patients, it is to be considered also the less quality perceived by relatives who arrive with the patient at the facility and wait outside the operating block to receive news about the surgery results. Waiting is perceived by relatives as something that is not going well during surgery, hence they could worry because of the longer time required and will disturb other employees to get information about the surgery situation.

3.5.4 Complex booking of radiology exams for inpatients during PO

The facility uses the integrated software H2O through the whole surgical process, from admission to discharge of the patient, still integration with other softwares are necessary along the path. Retains particular attention the integration with the departmental software of radiology, Suitestensa, which is required to communicate with H2O for the scheduling of exams both during preoperative phase and hospitalization post-surgery. The transfer of information to book an x-ray exam during the preoperative phase is composed of the following steps:

1. the PO responsible opens H2O in the section of the patient coming for PO and inserts an x-ray exam choosing time and room.
2. the day before the execution of the exam, at the front desk operators check the patient reservation for PO exams and, in case of an x-ray booked, they assign a professional to the booked request. This because, from the day before, operators know which doctor will be present on that day, and assign the exam to the doctor, by registering it in H2O.
3. on the day of the PO exams, the radiology registration desk is asked to check possible x-rays exams booked for preoperative patients and confirm them so that the information is actually displayed on the x-rays machinery and technical staff performing the exam are aware of the reservation, knowing when to call the patient.

In reality, those passages are rarely followed, mostly because the radiology front desk is busy with outpatients that come in the morning to perform radiology exams. As a consequence, it happens that the PO patient waits outside the x-ray room but he/she is never called to undergo the exam. In these occasions, the PO responsible must contact the radiology front desk and ask for the approval of the booked exam in Suitestensa.

The procedure required to book an x-rays exam results too complex because of the three passages required and because it involves three different actors that must manage the booking in three different times. The result of this complexity is a waste of time for patients that uselessly wait to be called for the exam, postponing the rest of the activities planned in the preoperative phase. Also it results in a waste of time for the PO responsible that has to check on patients whether or not they have been submitted to radiology exams and, in the worst case, reach the radiology front desk to solve the mistake. This situation affects the facility 30% of the times, generating a waste in time and a waste for movimentation, since the patient moves through the facility to ask for clarifications and the PO responsible move through the facility to correct the mistake.

3.5.5 Charges registration and clinical folder completeness

A critical inefficiency concerns the charging activity. With charging it is meant the registration in the information system of all the materials and services used by the patient through the process. Charges can take place during the ward hospitalization as a consequence of therapies and drugs administered to the patient, or because of additional services required,

like a meal or a bed for a partner. Charges are to be considered also in the operating room since during surgery all materials, prosthesis or other devices used are to be paid by the patient. At Villa Donatello what constitutes inefficiency is the lack of a punctual charge registration that generates a wide set of reworking. First of all, when the charge is not simultaneous to the administering, it requires the operator to keep track of the utilization hence to write on paper information about the products used. This happens in the operating room especially for special materials that must be traced on paper in order to have evidence of the administering in the hardcopy of the clinical folder.

Of greater concern is the complete absence of charging from the wards, which are provided with the necessary tools to perform the activity pertaining to them. Consequences of this shortcoming affect the activity of clinical folders check for completeness and the invoicing activity. About the clinical folder check, it is a task performed when the patient is dismissed, necessary to file documents, to ask for insurance refunds and to guarantee a copy of the complete clinical folder to patients who request it. The activity, if performed with complete information, has a process time of 2 minutes, while in reality it takes 8 minutes for each folder. 99% of the times there is lack of ward charges, therefore the operator is obliged to consult the therapeutic records in order to understand what has been administered to the patient and insert it in H2O. The procedure becomes even more complex if the dismissal time has already been registered in the system; in those cases, the operator is required to cancel dismissal time first, then insert charge, finally typing again the dismissal time, which must correspond to the previous one. Most of the times also extra services are missing while rarely there are missing charging from the operating room, cases that are signaled with a red dot on the folder.

The ultimate problem generated by the lack of charges registered in H2O is the impossibility for the invoicing office to let the patient pay for the service. Indeed, once the patient is dismissed from the ward, he/she reaches the payment office in the ground floor to settle the debt before leaving the structure. When charges are not registered, the patient is asked to wait until all charges have been reported into the system, then the patient is allowed to pay. When cases like this happen, the patient is dissatisfied of the waiting he/she has to bear before payment, while the operator who checks the completeness of the folder is overburden with the request of a fast check. The most critical occurrence is the fact that at Villa Donatello there is

only one operator responsible for the completeness checking of clinical folders, who works on a 6-hour schedule from 9.00 am to 3.00 pm. This means that when the responsible completes her shift, the unchecked folders remain without charges. If a patient is dismissed after 3.00 pm, there is no possibility to have the charges registered in H2O, so the patient is sent home, to be recalled days later to come back at the facility and pay. The responsible of the folder check is a critical resource, exposing the facility to the risk of accumulating work if that resource is absent for a longer period of time. This critical aspect not only affects the patient experience which is deteriorated in the final step, also creates disorder to the facility operations and balances, which 20% of the times remain unpaid because of this inefficiency.

3.5.6 Manual operations and extensive communication required

Another problem emerged during the mapping phase concerns the massive utilization of the mailing system and phone calls. Nowadays Villa Donatello's staff receive by mail essentials information for the surgical process, being first the MPR, then eventual PO exams carried out externally or the bed management schedule. Given the essentiality of the information contained in the mail, operators rely extremely on the mailing system and are continuously checking for new information received. To give an amount, the facility receives 10 to 15 MPR on a daily basis, this alone generating 90 to 135 mails. Also receiving different kind of information all together in the same device without any previous filter in the contents, generates confusion and possibility of losing information.

The problem connected to the massive communication affects also the patient experience, indeed patients are called from 3 to 5 times during the journey to receive clear information or updates about times and procedures to follow. Something that for some patients can be perceived as a valuable paying attention to the patient's needs, for the majority has been perceived as an excessive disturbing, since some of the calls are also lengthly to collect records and data.

Finally, a criticality is represented by the great amount of printed documents on which the facility relies. Nowadays Villa Donatello's main documentations are all printed on paper, together with a wide range of sheets that are printed only for operational purposes then are thrown away right after use. The support of the integrated information system is used only in

part respect to the capabilities offered by the system. The wide set of documents printed on paper and not inserted in the system is reachable only through the hardcopy of the clinical folder, hence folders must be kept in the local storage for a year then sent to the central storage. Storage of paper documents represents a waste of space and of time required to recall a specific document.

4th Chapter: Results and future developments

Having a multidisciplinary team focalized on the mapping of the whole process has guaranteed the opportunity of an articulated exchange of information, doubts, criticalities and hints for possible improvements. The strength of the cross-functional analysis is that doubts of a person are clarified by another and vice versa, building a constructive discussion were actual problems are identifiable because shared by the majority of actors.
Once the mapping has been concluded, attention has been posed over the wastes observed, which have been questioned and analysed carefully to understand the real reason generating them. A root cause analysis has been performed together with operators, through the application of the *5 whys* procedure. Understanding the real causes is a demanding activity since most of the time answers can be of the kind "the system requires it", "I've always done it this way", "I find the procedure easier to accomplish". It is required to tackle the problem from different perspectives and to match opinions of different actors. When the root causes have been discovered, the natural propension has been that of opting for possible improvement actions, each person giving his/her own suggestions. By collecting this information has been possible to draw the future state map and define the corrective actions to implement.

In this final chapter the future state map will be presented by taking into consideration the criticalities mentioned in the previous chapter and explaining how those wastes can be removed or reduced. In addition, other smaller criticalities not previously mentioned have been inserted in the future state because, even if of smaller relevance, they can facilitate operability of everyday activities and the avoidance of their continuous repetition can ultimately lead to a substantial gain. Then, by comparing the current state with the future state, has been possible to define which corrective actions are required in order to reach the optimal state. Clearly the solutions proposed hide different involvements, hence they have been splitted over time according to feasibility and effort required to put them into practice.
Finally, the purpose of the thesis is not limited to the implementation of the pilot project, rather the goal is to spread interest over Lean practices in an environment that is extremely needy of such improvements. To this purpose, in the last paragraph opportunities for future

developments have been introduced, either addressed to Villa Donatello or in general to the healthcare world.

4.1 Improved process: Future State

The definition of the future state has been an elaboration of the current condition, where the criticalities emerged have been reduced or solved by applying the collected ideas of improvement, after a study about their feasibility and action scope. A root cause analysis has been performed to get to the actual problems generating wastes, then has been possible to generate corrective actions and define a feasible solution of what could be the future process in Villa Donatello once countermeasure will be applied. After the elaboration of the countermeasures to adopt, the definition of the future state map has been the next step. The diagram representing the current condition has been changed according to the modifications proposed, hence obtaining the optimal solution diagram. The target condition is represented in the attachments A6-A9.

4.1.1 Root cause analysis and proposed countermeasures

Through the lean practice of the *5 whys* it has been possible to deepen the analysis to the root causes generating the previously identified inefficiencies. Listed below are expressed the root causes and countermeasures for each of the wastes to be corrected.

1. Multiple reservation procedures

The reason behind the acceptance of different alternatives for the request of a reservation relies in the attention paid over surgeons needs. Being the specialists freelance professionals, they are important stakeholders to the facility, hence they are granted a degree of freedom that guarantees them the opportunity to choose which is best alternative for them to place a reservation. It is true though that the MPR procedure has been introduced in order to ease the reservation activity for surgeons that can insert their request independently from where they are, by entering the facility website. The problem of surgeons not using this system is that most of the times they do not possess all the requested information so they prefer to write on paper or to call so that the reservation is valid even though they communicate the few

information known. It is also true that surgeons have not been informed of the importance of adopting a unique system, at the same time they are not aware of the facilitation that the MPR offers them; in case of lack of required information the surgeon must be contacted numerous times; also missing information about the surgery requirements can translate in inefficient material preparation for surgery. The countermeasure to adopt in order to have all surgeons use the MPR system are:

- simplify the filling procedure of the MPR by requiring a limited number of information (the 15 information required today can be reduced to 10);
- integrate the MPR insertion directly to H2O so that information is automatically registered in the system. This solution eliminates the waste of time to copy information from paper to H2O and also prevents from the dispatch of multiple emails that stuff the mailing system;
- educate surgeon to the utilization of the MPR system.

Using a unique and integrated procedure means freeing up time, reducing the risk of mistakes and reworking of uncomplete reservations. At the same time it permits to have a better control of the procedure and a direct visualization in the information system.

2. Inefficient utilization of TuoTempo notification

Villa Donatello has implemented a system of notification for patients to remind of the exams or consultancies they have booked. Two days in advance they receive a text with the location and time of the exam. This has been a solution implemented especially in occasion of the new location, for which it was required to remind patient not to show at the old building. However the notification system provided by the software TuoTempo is still useful in order to prevent no-show caused by forgetfulness. The problem is that notifications are set up to send a text for each of the exams booked, regardless of cases in which a patient has multiple exams booked. Also the notification system does not distinguish cases of outpatients from inpatients, therefore text are sent even to hospitalized patients for which exams have been requested. The major problem though is the misunderstanding that the notification system provokes during the preoperative phase; patients are reminded of the times for each of the exams they have to undergo, but they are not reminded of the earlier time they have to show at the facility to

fulfill activities prior exam execution, time that has been told them by the PO responsible a week before. As a consequence 40% of patients are late during PO. The cause of this inefficiency is to be accounted to the software which is not accurately set. In order to guarantee a satisfying service to the patient, the notification system must:

- avoid notifications to hospitalized patients;
- group notification for multiple exams in a single text;
- send a summarized notification for the preoperative phase with the time of the arrival at the facility and a reminder of the exams to undergo.

The correct management of the notification system could add value to the patient experience, while today the inefficient notification risk to negatively affect the patient perception of the facility organization.

3. Management of the reservation perfectioning

A criticality referring to the operability during the process is that of the reservation perfectioning. Today, front-desk operators have the responsibility to complete reservations in H2O by calling patients and asking additional information required to the facility in order to move forward with the surgical process. A common criticality that operators sustain is that of organizing reservations according to priority so they are aware of which reservations to perfection first. At the moment, operators print all MPR and put them in order based on the information contained in the MPR together with the advices given by the responsible of the registration insertion. Priority is given by a set of values:

- date of the surgery
- medical equipe
- criticality of the patient situation

Priority is fundamental to consider given the variability in the reservation procedure, indeed some MPR are filled and registered a month in advance, while others are available only few days earlier. This is the first reason preventing a flow in perfectioning according to the date of MPR insertion in the system. Another reason is the presence of medical equipes who require their patients to be ready for surgery, with all preoperative exams done and checked, two weeks in advance, while usually the standard procedure is preoperative are fulfilled a week

prior surgery. A third reason is the presence of critical patients, who require careful and lengthy preoperative exams because they are affected by serious disease therefore attention over their preparation to surgery must be at high levels and performed in advance. All these considerations today are verbally managed and in part are residing in operators' knowledge. The problem connected to this procedure is the fact that often perfectioning is not immediately fulfilled, hence the PO responsible is not able to schedule PO exams in time, given the strict necessity to manage only perfect reservations. The problem manifested by the front-desk operators is that of not having a clear prioritization mechanism, that prevents from relying on memory or on taking notes on paper. The solution to this unoptimized procedure is that of implementing a prioritizing mechanism in H2O so that once reservations are inserted, there could be the possibility of giving a level of priority based on a set of parameters a priori set. This will guarantee the absence of forgetting information given that everything remains registered in the system and prevents from printing all the MPR only for operational use, therefore reducing the paper used and the emails received. Indeed, if management is assigned completely to H2O, there is no need of receiving MPR documents in the mail anymore, also because all the information written in the MPR has already been reported in the information system.

4. Radiology exams during Preoperative

A wasteful procedure that affects patient journey during the preoperative phase is that of radiology exams. The standard procedure in PO consists of blood analysis, ECG test, cardiologist consultancy and anesthesiologist consultancy; often though, 70% of the times, patients are planned also an x-rays exams, commonly the thoracic one. In these cases, the procedure to book an x-rays for preoperative exams results lengthy and inefficient, requiring three steps to be performed by three different operators in three different timespans. The result of this inefficient procedure is that patients most of the times are not displayed in the system used by radiologists, Suitestensa, hence patients are never named to undergo the exam and remain waiting for about 30/40 minutes. The cause of this is that not all the steps are performed, so the uncompleted procedure is useless. In detail, the never performed activity is that of accepting the booked exams on the day of the PO from the radiology front-desk, given the busy location that in the morning has to manage a conspicuous amount of outpatients' exams. A solution to simplify the procedure of radiology exams is that of permitting the

validation of the booked exam directly to the technical staff performing the exam. In this way, radiology front-desk is exempted from the activity that generated disorders to their normal schedule, instead technical staff, meanwhile waiting for the first patient to come, has the time to accept booked exams so that they appear on the machinery and the patient can perform the exam on time. According to this solution, booking of radiology exams for PO patients are to be inserted by the PO responsible then require to be accepted by technical staff on the day of the exam; patients won't be subject of useless waiting and the PO responsible is relieved from the resolution of cases where patient are not submitted to radiology exams.

5. Stockpile of operating rooms and hospitalization beds

Definitely the incidence of unused resources reflects the major inefficiency characterizing the facility's surgical process. In general, the hyper or under utilization of operating rooms generate in both cases a costly waste in healthcare and determine a negative experience both for patients and for staff members (Federsanità). At Villa Donatello the problem is consistent given that saturation barely reaches the 50% meaning high wastes for the company business. The cause of this incongruence between the available offering and the effective demand is given by the difficulty of attracting new professionals. Indeed in the surgical process are not patients who choose Villa Donatello but are the specialists that bring patients to the facility. It is more difficult to attract specialists rather than patients, and because of this difficulty Villa Donatello is affected by a great level of under utilization. A countermeasure could be an extensive marketing action aimed at attracting specialists. Possibilities are the offering of preferential treatments, which will be an action benefitting also the surgery schedule if the incentive is focalized in certain days or times during the day. Another marketing action could be the adoption of high technological solution for surgery that may attract surgeon who ask for high quality machinery. An ulterior solution can be the participation to promoting events which guarantee greater visibility to the private hospital.

Otherwise, if the increase in demand results difficult to obtain, an alternative solution will be that of redesigning the unused spaces to create additional services or to cover activities which are over-saturated. For example, an operating room can become a recovery space given its closeness to the connective space, or an additional storage if the one already present is full.

Concerning bed utilization, the problem is still the same, in fact an increase in surgeries will determine an increase in hospitalizations, therefore the countermeasure matches with that of operating rooms. Additional spaces, like the unused recovery space, can be instead reused for other purposes, for example be transformed in intensive therapy locations, given that today there are only three beds in the existing intensive therapy.

6. Overtime in the operating block

In the majority of cases (80%), overtime happens at Villa Donatello as a consequence of surgeons delays. The remaining cases are to be blamed to crowdy moments at the ward that takes more time to bring the patient down at the operating block or to patients that are not ready to undergo surgery because of health disorders hence are needing a lengthy preparation for which the surgery can be delayed. The problem connected to overtime is that it generates additional costs which are useless since they do not produce any additional outcomes to the facility. Considering that the hourly cost for a resource in the operating room is 14€, and that overtime is paid 30% more, each hour of overtime costs to Villa Donatello 42€. Overtimes affect on average 8 hours a week and every surgery requires at least two nurses to be present. Hence, on a weekly basis, the facility bears 672€ of overtime, meaning 34.944€ in a year, which in practice is the cost for an additional resource. This cost though represents a waste for the company because it doesn't add any additional value to the patient. Instead, delays in surgery, as already said, negatively affect the patient experience. For this reason, overtime must be reduced as much as possible. Countermeasure applicable to obtain this result are first of all a better planning of surgeries, by placing operations in the morning or the first half of the afternoon so that the shift is covered. This option though is not auspicable since are usually surgeon that fix the time and the late surgeries are widely requested by professionals that are busy with their private outpatient service during the day. An effective countermeasure is that of preventing the surgeon to arrive late by deducting overtime cost from the surgeon revenue, from a certain amount on. Another solution could be that of incentivizing surgeons to occupy earlier operating windows by guaranteeing a lower price to their patients.

7. Unoptimized surgery planning

Fixing surgeries according to surgeon requests leads obviously to an inefficient scheduling and inefficient rooms utilization. It is true that the facility is provided with a surplus of rooms hence there is no requirement to aggregate surgeries one after the other in the same room, anyway an efficient schedule can translate in an optimized management of resources, both material and human resources. Since the prerogative in planning remains that of accommodating the surgeon in choosing the date that best satisfies him/her, there is limited opportunity to optimize the schedule once reservations are inserted. The action that instead can be implemented is organizing the schedule in a previous phase to the reservation. This means allocate room availability a priori to surgeons that reserve the same timespan with a recurring trend. By looking at the last year reservations, it is possible to study the trend and find possible recurring surgeons. According to frequency, allocations can be assigned on a weekly as on a monthly basis and, in case the surgeon assigned to the timespan is not operating, it is still possible to reserve the slot to another specialist.

8. Lack of charges from the wards

Chargings are often critical activities in hospitals because they refer to activities performed by health professionals who, most of the time, want to stay away from the administrative part. What results is that charges are always postponed, generating not few problems of incongruence or mistakes. At Villa Donatello there are nurses in the operating block who register charges almost simultaneously to surgery, while there are nurses at the wards that do not take into consideration the necessity of recording charges in the information system. The consequence of this inefficiency has already been explained, being the inability of letting the patient pay, in case of solvent patient, or to ask for refunds to the insurance company in case of insured patient. The root cause of the problem is the disregard that health professionals pose over administrative matters, which prevents them from performing an accurate and punctual charges registration because the activity is considered useless from their point of view. This, in the past, led to wrong registrations of charges where patients was debit of a whole package of drugs in cases when they have been administered of a single dose. Because of fastness and inaccuracy in performing the activity, in most cases it was required more time to adjust already registered charges rather than inserting them from zero. Hence the facility

opted for unburdening ward nurses from this activity and assigning it completely to the responsible of folder closing. The decision has proved not to be effective given the great amount of disorder that generates and the negative effect on the patient experience. The solution to this situation is:

- re-assign the task to ward nurses by providing them a clear and easy charging registration system, which prevents them from making mistakes and from waste too much time in insertion;
- create sets of charges according to therapies, where materials are already selected in the right quantities. Clearly quantities can be dimensioned based on a common value, that amounts must be regulated according to the specific case. It is important to remove package selections since in a short stay hospitalization it is uncommon that the patient will be administered a whole package of drugs;
- educate ward nurse over the relevance of a punctual and accurate charge registration so that the activity will be performed with the right amount of attention and carefulness. Diffuse the importance of having charges registered before the patient discharge so that the patient can flow from the ward to the payment office without any waiting;
- facilitate the research of additional drugs to be charged based also on their active ingredient, considering that usually nurses think by chemical composition instead of drug names.

9. Manual management of therapeutic administration

At the wards, nurses are used to fill an excel document with information about the patient situation, the administering done and the ones to be carried out in the brief time, the doctor's requirements, particular situations that affect the patient. All these pieces of information are typed everytime a shift happens. The time required to fill this format is about 1 minute for each patient, that considering an average of 13 patients means 13 minutes every shift. Not a relevant waste of time for sure, still on a yearly waste means 236,6 hours that could have been used for other purposes, given that the same information has already been written in the clinical folder so the excel document represents a double insertion. The major criticality here is given by the possibility of missing some important information. Since the activity is done almost when shift happens, can be that the nurse is in hurry and fills the document with less

accuracy. Given the strict reliance that nurses attribute to this document, completeness is extremely important. The root cause of this procedure is the necessity for nurses to directly understand the situation of the patient, because otherwise they should have leaf through the whole clinical folder to absorb the relevant information. A solution to this waste of time and risk of poor assistance is the adoption of an electronic clinical folder which, once information is inserted, gives the possibility to filter data according to necessity. By adopting an electronic clinical folder, nurses activities are optimized under multiple points of view, from management of the medical cart used for administering to the reminder of therapies or warnings in case of drug interactions. Also, by having all the information in the electronic system, it is possible to quickly recall whatever kind of data, avoiding the leaf through or the double insertion to facilitate operability. The use of an electronic clinical folder can solve also the problem of clinical folder storage and recall, as well as the elimination of all the movimentation required to move the folder in different departments during the process.

10. Missing functionalities in H2O

There are also few criticalities that are strictly connected to H2O operational settings. The first one is the impossibility to work in the same operative report simultaneously. This is a logical constriction given the relevance of the document which cannot be altered by multiple people because of the risk of losing information. It is true though, that the operative report is composed of tree sections to be filled respectively by the surgeon, the nurse and the anesthetist, who usually complete their sections as soon as the surgery ends. Hence, it will be possible to separate the three sections in order to permit the simultaneous compilation and prevent waiting of professionals who otherwise are obliged to postpone the activity.

Another activity which is not yet used at Villa Donatello is the automatic maintenance of the register of drugs loaded and unloaded, which is nowadays done manually by the nursing supervisor. This activity brings a waste of time for the employee that has to modify drugs in the different registers according to the effective availability in the pharmacy. By setting this option in the information system, drugs, correctly configured in H2O, can be set unavailable by the pharmacy therefore generating an automatic modification of all those registers containing that drug, and substituting it with an equivalent in terms of active ingredient.

4.2 Action Plan

The solutions proposed in order to bring some improvements to the surgical process of Villa Donatello can be classified in operational modifications of small and strong impact, software implementations or integrations, software adoptions, and management actions. Given the different efforts required to implement each of the countermeasure proposed, it has been decided to extend their implementation on a timespan divided into three main categories: short, medium and long term. In the short term are placed solutions that can be activated within the first month of activity. In the medium term are placed those improvements that can be put in place within a year time, because maybe require other actions to be taken first or simply because their impact is stronger and organization is required before implementation. Finally, in the long term horizon have been included those countermeasures that probably will be implemented in more than a year time; usually long term actions require change in the company vision or in the organizational setting, require some study to be performed first and, even once implemented, their impact is gradual, hence first results can be appraised after some time. All these proposed countermeasures generate an impact over the overall company performance, over the level of quality perceived by patients and satisfaction perceived employees, over costs of the structure, over levels of safety and control.

4.2.1 Short-Term solutions

Solutions that can be implemented first are the ones affecting the operability and generating a limited impact. Indeed, in line with lean principles, the removal of wastes has to start from the easiest tasks, those that usually are not even taken into consideration because of their small influence. The advantage of starting from the easiest tasks is that of obtaining rapid results and an increase in employees' motivation to put greater effort on wider impact solutions. Also, this incremental approach permits to deeply clean processes from wastes preventing the settling of small inefficiencies.

Included in the short-term solutions are:

- Unique reservation procedure

- Management of TuoTempo notification system
- Efficient radiology exams booking
- Synchronous charges registration

These activities involve different actors therefore there won't be a great impact in the operability of each of them. The fast obtainment of results is strictly dependent on how operators comply with the new procedures. Also, it is to be considered a learning time during which operators appraise how to fluently perform the task; once this time is concluded, then results and gains can be visible. The impact of these changes will affect the perceived quality of the service by patients thanks to the optimized notification system and the removal of waitings during preoperative exams and the final payment. Also employees will put in practice more standardized and optimized procedures that will prevent continuous reworks and mistakes.

4.2.2 Medium-term solutions

Among the medium term solutions are placed those interventions that require prior actions before implementation. These activities can be started in a brief period of time but their complete implementation is reachable only after time. The solutions inserted in these category of the action plan are:

- Prioritization system for reservation perfectioning
- Overtime prevention mechanism
- Master Surgical Schedule

Concerning the prioritization mechanism, it is to evaluate with the information system provider the best alternative available which is suitable to the actual necessity. Some configuration may be required as well as some developments in case the current system is not provided with the functionalities to fulfill this task. Then, as the system will be set with the prioritizing mechanism, operators will start introduce this new procedure to their routinary activities. Clearly passing from a paper management to a digitized one, there are important variances affecting the task completion, hence the complete passage may require some time in which the paper documents are still used.

Concerning the overtime avoidance, the difficulty in its application relies in the education of surgeon to the new procedure. This activity may encounter great resistance from the surgeons side and in order to be effective required the facility to spread knowledge about the new procedure and interest over its successful implementation. From the moment of the first application to the moment in which all staff members and specialists are working according to the new procedure, some time and effort is surely to be considered.

The last medium term action refers to the optimization of the surgery planning.

In order to improve the organization of surgery with all the activities and resources required, it is possible to opt for a Master Surgical Schedule (MSS) which is a preallocation of operating room spaces to specific specialties or surgeons. Indeed a priori planning of surgeries allows a more organized structure because of the reduced variability. Therefore, the planning of resources becomes an "easy task of repetition" since surgeries repeat every week/month in a similar pattern. It is to consider though, that the opposite situation of not having a preallocation of spaces guarantees greater flexibility to adapt according to demand. So it is needed a tradeoff between the two solutions, according to the levels of flexibility required by the facility and the impact on the quality perceived by patients. To combine the necessity of flexibility and stability, it is also possible to adopt an hybrid solution, where some specialties or surgeon will be assigned to specific spaces and specific rooms, while others could remain unassigned, enabling their allocation according to effective demand. This can be a useful solution in case of great variability in surgeon request for surgery, meaning that there some surgeon are usually recurring while others are extremely variable.

Having a MSS means adopting a block schedule which holds also the advantage of aggregating similar typology surgeries, hence reducing the preparation time for devices and tools, the organization of staff required and the surgeon that is concentrated on the same typology of intervention. This implementation of a MSS is an activity of strong impact, mainly because it modifies the pacemaker activity, as it is the surgery planning in Villa Donatello, hence its impact will be propagated indirectly to the majority of the process activities. Additionally, a change in the allocation of surgery greatly impacts the offering for specialists, since the steady surgeons, often operating at the facility, will be favoured and assigned the room spaces they prefer, while the occasional surgeon will be penalized by the occupancy of room spaces even if they reserve surgery in advance.

4.2.3 Long-Term solutions

Inserted in the long term solutions are the implementations that introduce variations in the company business, which may involve a change in strategy and a change in the company mission. Such changes require a deeper analysis and a definition of a specific strategy in order to determine the correct procedure to fulfill them. For this reason, they may require more than a year to be implemented. In this category have been placed the following corrective actions:

- Increase saturation of resources
- Adoption of the electronic clinical folder

In order to fulfill the increase in saturation of both operating rooms and hospitalization beds, it is necessary to increase demand; this is obtainable by attracting more patients or, better fitting to the case of private realities, attracting more or well-known surgeons. Saturation of beds should be at a 75% level in order to obtain a satisfying level that takes into consideration to accommodate eventual emergences (Bracci, 2014). The increase in demand surely requires an extensive marketing action, for which results are appraisable only after a while. Even though an increase in the amount of surgeries will imply a redimensioning of the facility staff, the structure is capable of offering a greater amount of services, therefore not taking advantage of this disposability traces an important limit for the company.

Otherwise an alternative solution is to redesign the structure by eliminating excess overproduction and allocating it to different purposes according to necessity. Another option could be to consider an increase in the offering variety, getting authorization for other specialties or procedures.

About the adoption of the electronic clinical folder, it is a concept that goes beyond the adoption of the software permitting such service, therefore has been added to the long term actions. In fact, the goal of adopting an electronic clinical folder is that of completely removing paper documentation and being lean in managing all the considerable information on an integrated platform. Hence, the time required to reach a situation like this is definitely a long time horizon, because it reverses the way of managing each kind of information within the facility. Considering that today at Villa Donatello, 80% of activities are done on paper, the digitization of such information will be gradual and extended over time. Digitizing and

working with the support of technology instead of paper documents requires also a substantial change in mindset, which is usually the most difficult changement to pursue. The result of such optimization, though, will be a private hospital working in a lean direction, with savings in paper printed, savings in copying and movimentation activities, together with a safer management of sensitive information, therapies, administering, and a better monitoring of patients condition.

4.3 Opportunities for future developments

The current lean project at Villa Donatello has been limited to a narrow scope, hence multiple opportunities of improvements have not been taken into consideration. Even though, it has been proposed to the company the possibility of fulfilling future projects focalized on aspects that have not been involved this time, or only involved in part.

Opportunities for improvements have been noticed in the operating room setting, since during surgery the nurse had the necessity of exiting the room numerous time to find equipment that was not provided within the room. This not only is a waste of time for the nurse that is already busy with activities regarding the surgery and has to move around the block to obtain the required materials, it is mostly a cause of clinical risk because it could affect the sterilization of the operating room. A cause of this inefficiency can be the unoptimized layout within the operating room, where useless materials occupy the shelves that could instead be used for required materials. The layout can be analysed and optimized through the *5S* lean procedure which operates in the reorganization of spaces through the removal of useless stuff. Working in an optimized space can represent a value added feature for surgeons who operate in those environment where cleaning, innovative machinery and organization are the competitive factors.

Another cause of the lack of materials in the operating room can be the inefficient management of ordering system, so that materials that run out of stock have not been reordered in time. This could open an opportunity to apply lean thinking in the logistic world of drugs storages, pharmacies supplies and ordering system and local storage management.

Finally, given the enthusiasm and the participation of employees during the project, has been embraced the possibility to develop a new innovative lean project with which participating to the Lean Healthcare and Life Science Award 2020.

Conclusions

The thesis aimed to address the improvement opportunities hidden in the surgical process of a private hospital. Through a lean thinking approach has been performed a direct observation followed by a mapping of the whole process in order to understand the current inefficiencies embedded in the activities along the process. The private hospital Villa Donatello shows a great attention to the patient experience and comfort, at the same time, organization of the whole process lacks of efficiency during numerous phases. Repetition of tasks, workarounds, delays are some of the wastes affecting the company procedures. The main waste has been recognized in the non utilization of material resources which represent an important burden to be reduced. Indeed, current saturation level in the operating rooms amounts to 52% in the open rooms, which are usually three out of four rooms available. Hence the total saturation calculated over the complete set of surgery rooms amounts to 39%, a value that hides conspicuous wastes and costs for the facility. Unsaturation affects also hospitalization beds, which show a utilization of 49%, another value that is much below the optimal value of 75%. From a patient perspective these inefficiencies can be of low relevance, yet increasing saturation means offering greater amount of services, permitting a wider number of patients to obtain their curing service in a brief timespan.

Even operative inefficiencies, that are hidden to the patient experience through the hospital, can reveal a beneficial impact to patients, whom information are carefully managed and respectful of privacy requirement. The beneficial impact reflects also the increased level of organization as perceived by specialists choosing to operate at Villa Donatello.

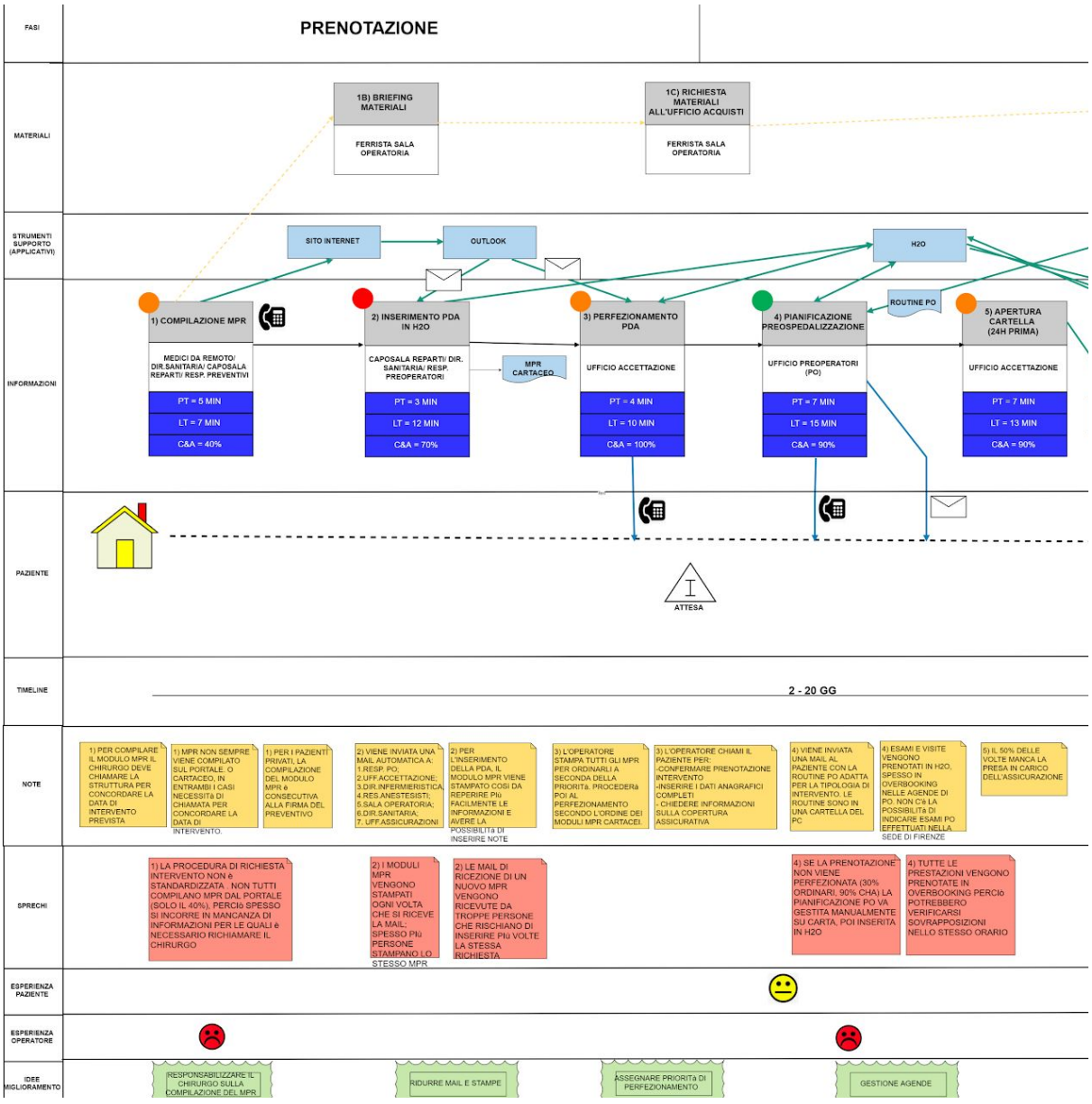
The proposed countermeasures, developed after an accurate analysis of the root causes generating the current inefficiencies, will be proposed to the facility as an action plan to be implemented. Clearly, results of the lean project cannot be assess in this framework since the countermeasures will be applied at Villa Donatello from September on, date in which the presentation of the results has been fixed. So far, the firsts achievements refer to the resolutions that have been applied right after value stream mapping, regarding the inefficiencies generated by lack of communication or information asymmetry. These, given the simplicity and immediacy of the solutions, have not been included in the study, yet they

represent the first successful result obtained by applying lean principles. The wish is that by implementing the future state countermeasures, Villa Donatello will get closer to lean thinking methodologies. Indeed beyond the project execution, aim of the project has been also focusing the attention over lean practices applied in healthcare and the possibilities of improvements that this sector can gain from projects like this one. The pilot project can be the start to the continuation of lean projects within the facility given the wide possibilities available, one of which is the management of drugs logistics.

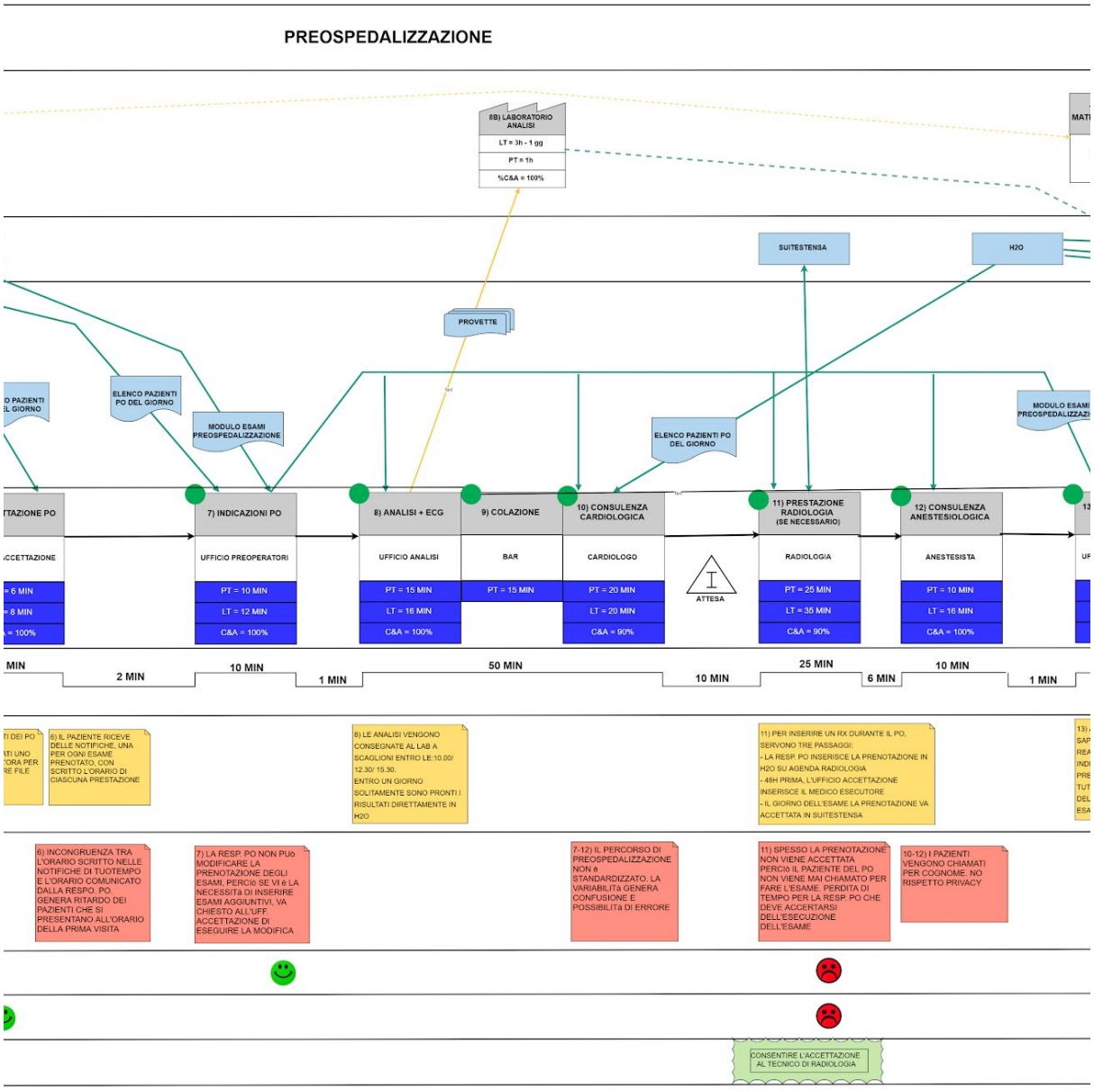
Finally, the ultimate goal of the thesis is that of bunding the lean approach to the analysis performed by Afea during the HIS implementation projects, in order to sustain the idea of the 3d project. Intention is that of giving an higher value service to clients companies approaching an HIS improvement project, by increasing their profitability and ameliorating their control over the processes belonging to the company offering.

Attachments

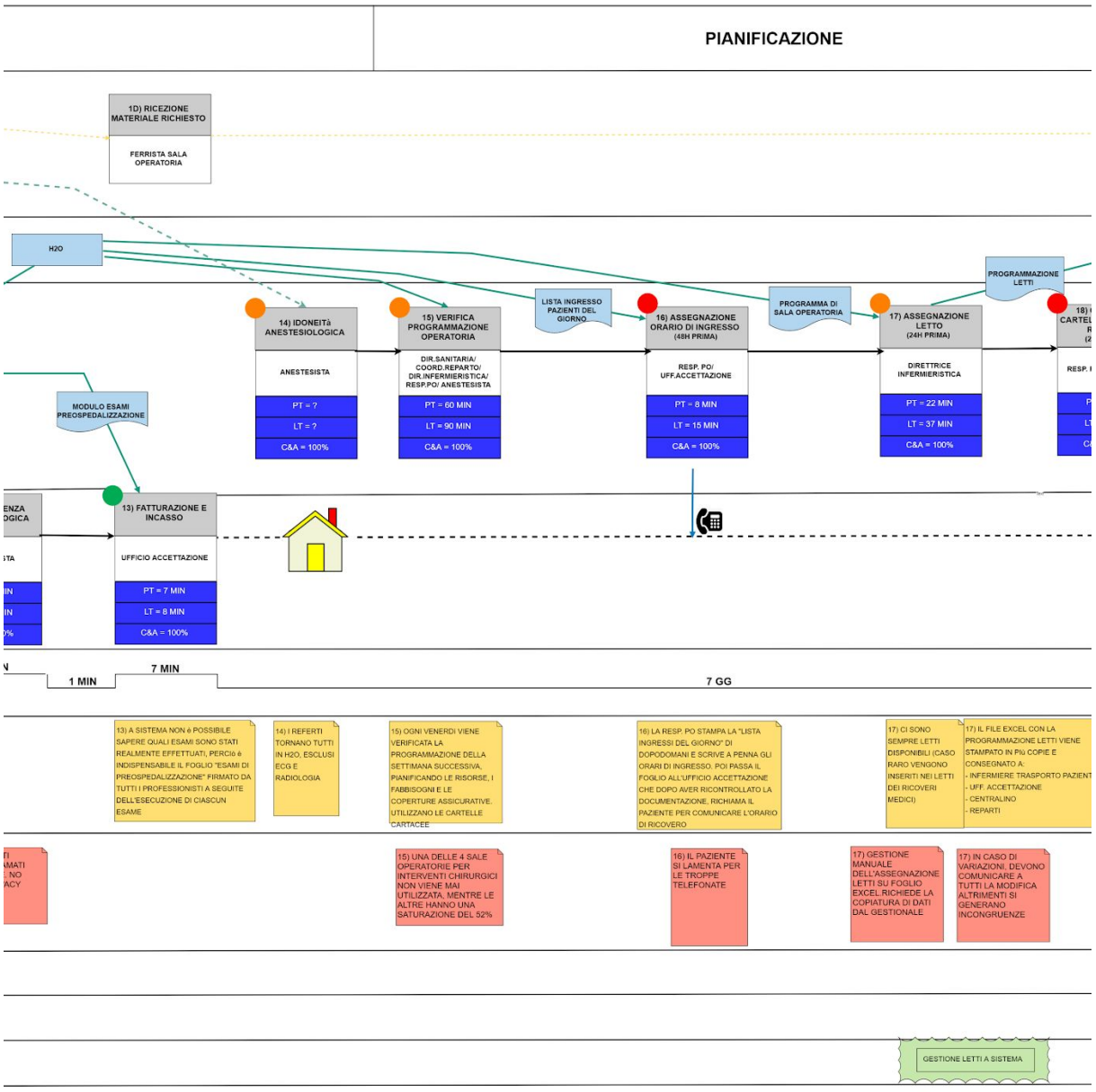
A1 - Value Stream Mapping of the AS IS condition (part 1)



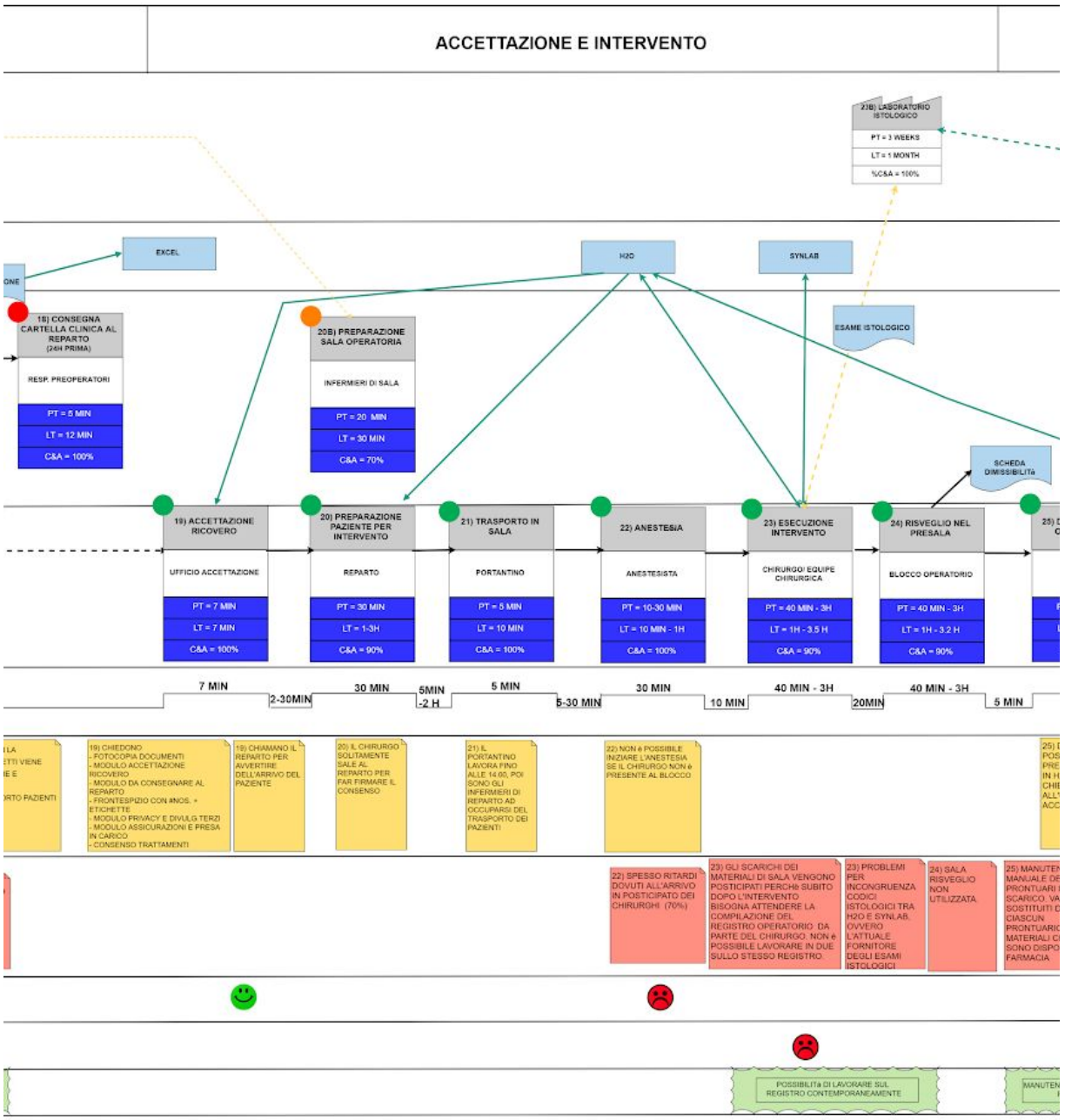
A2 - Value Stream Mapping of the AS IS condition (part 2)



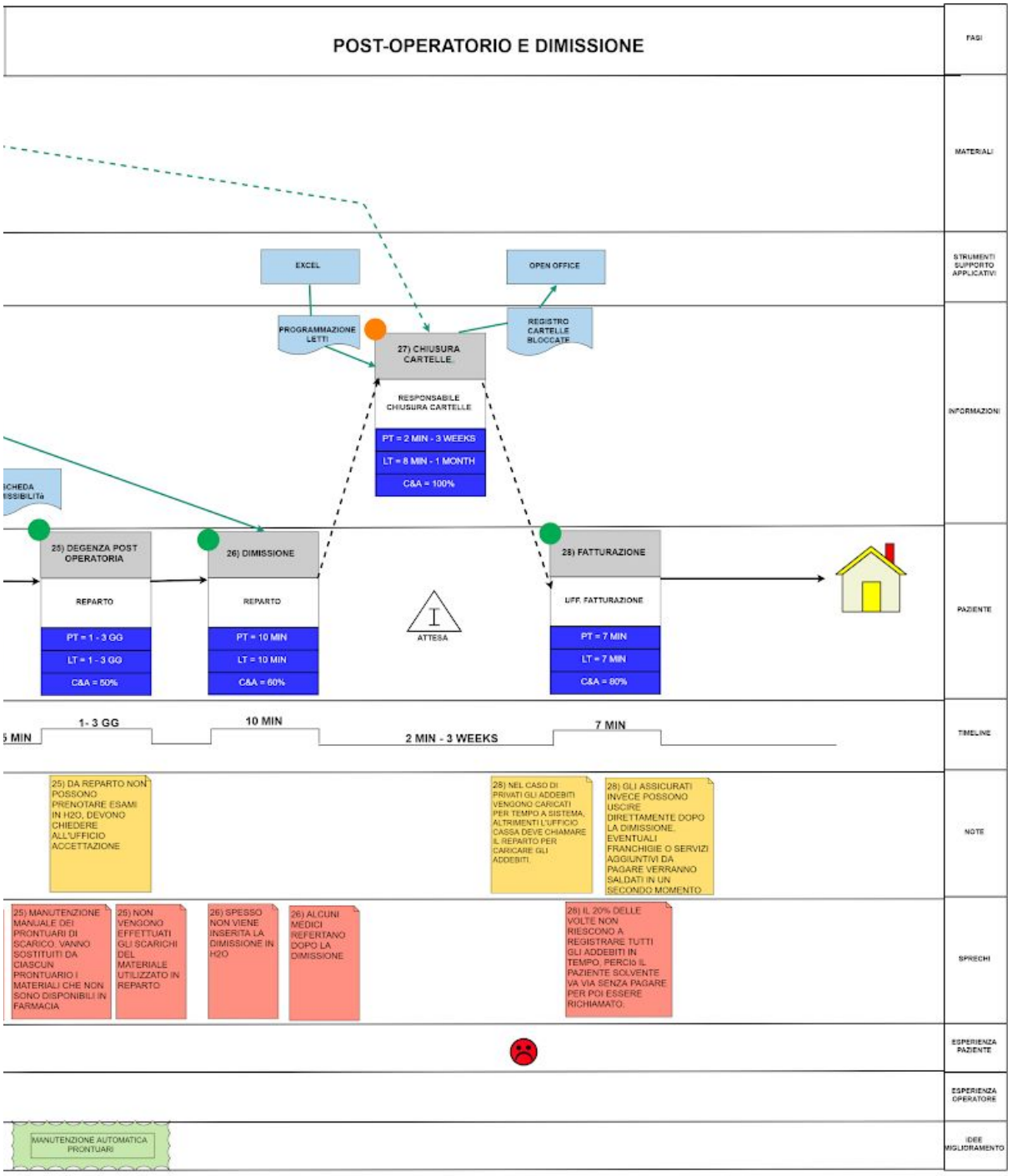
A3 - Value Stream Mapping of the AS IS condition (part 3)



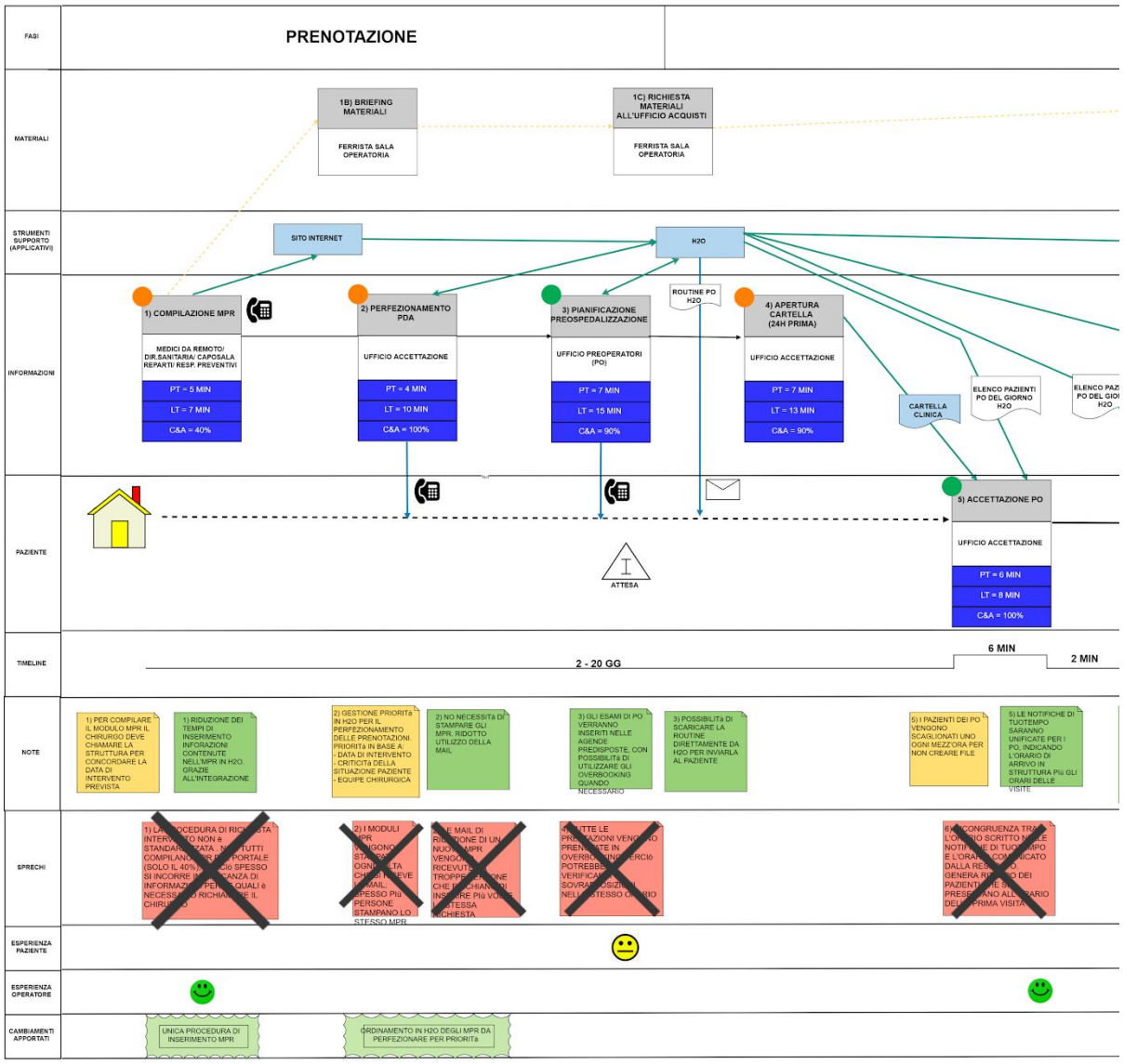
A4 - Value Stream Mapping of the AS IS condition (part 4)



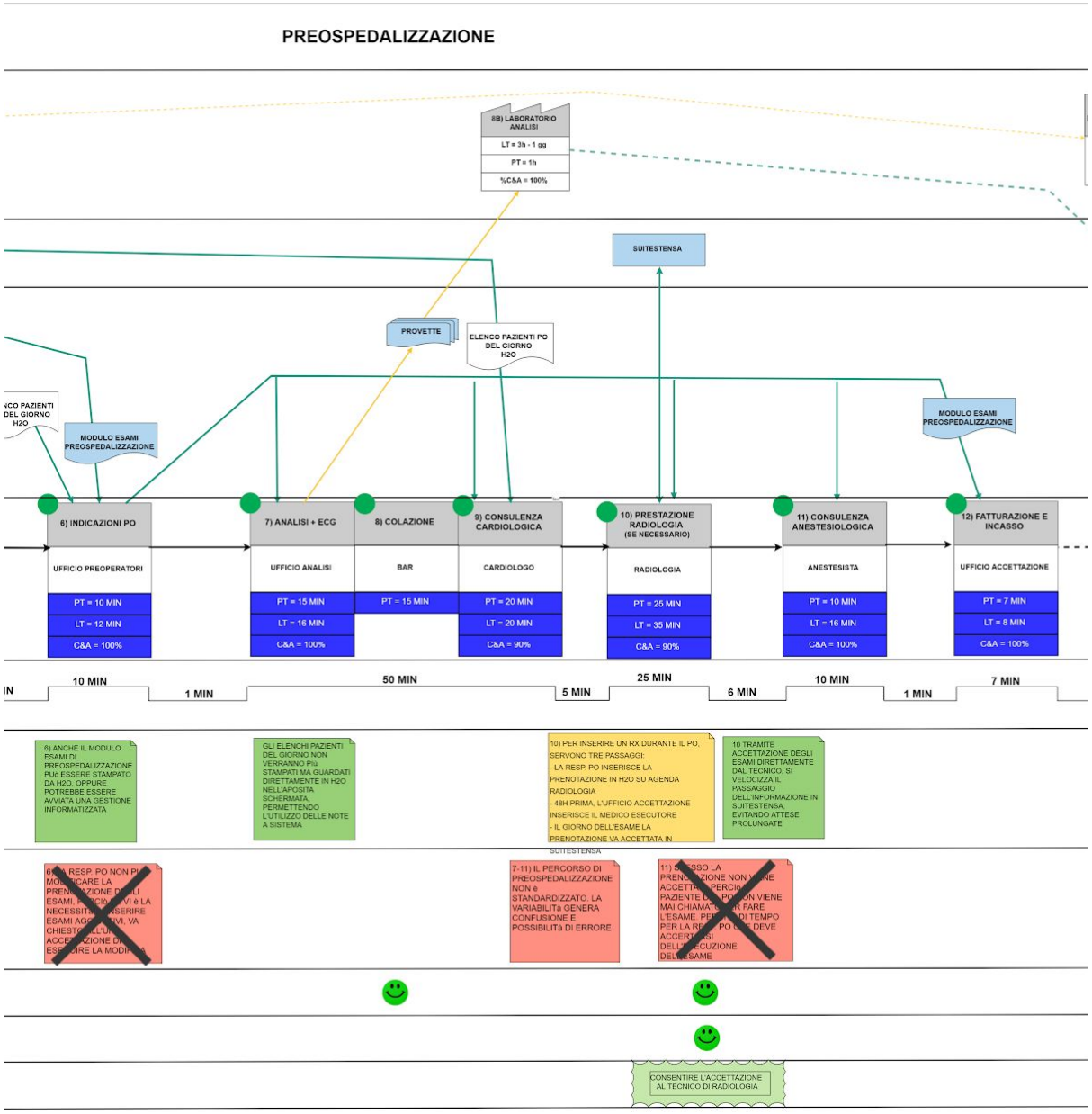
A5 - Value Stream Mapping of the AS IS condition (part 5)



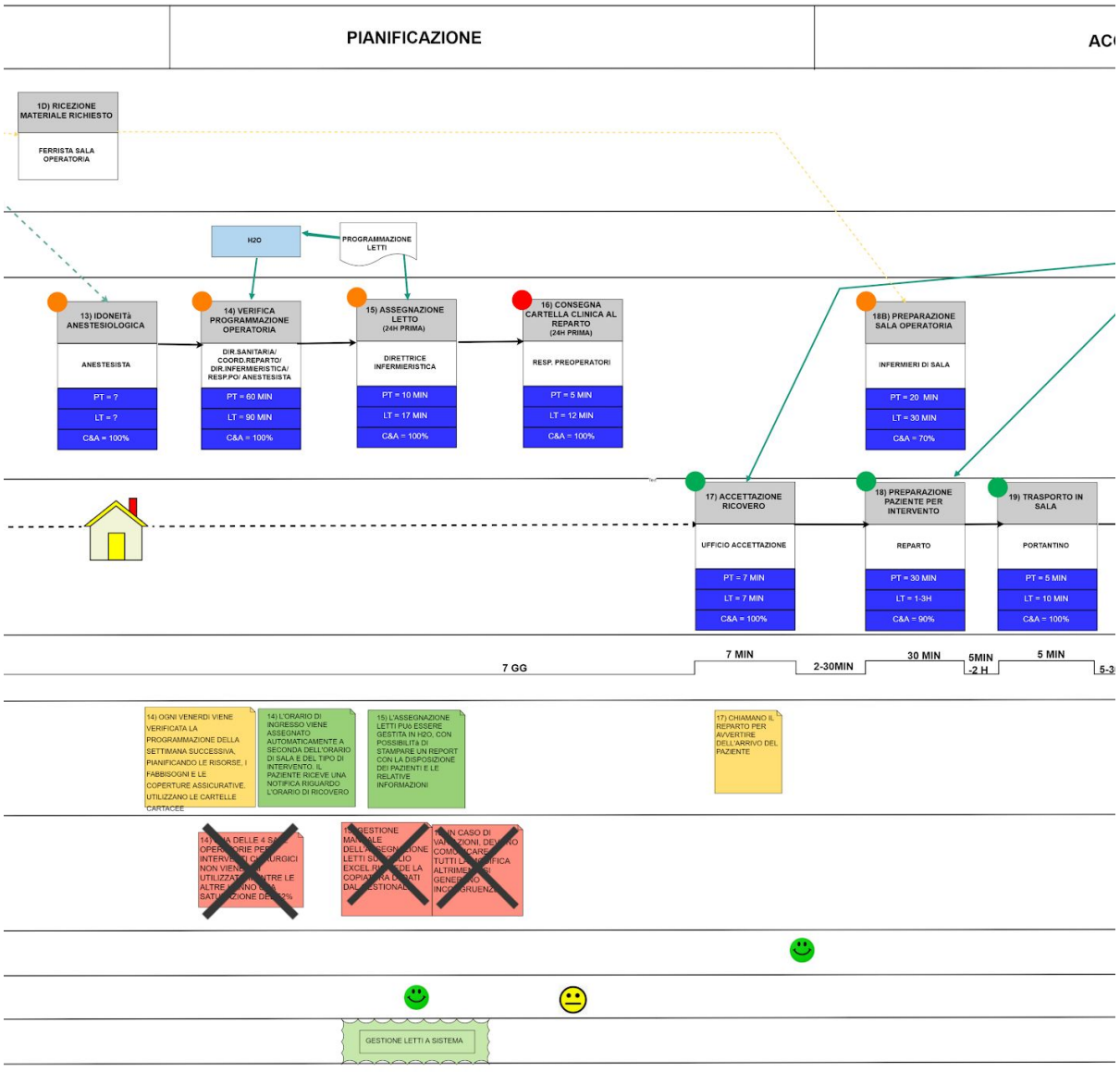
A6 - Value Stream Mapping of the Future State (part 1)



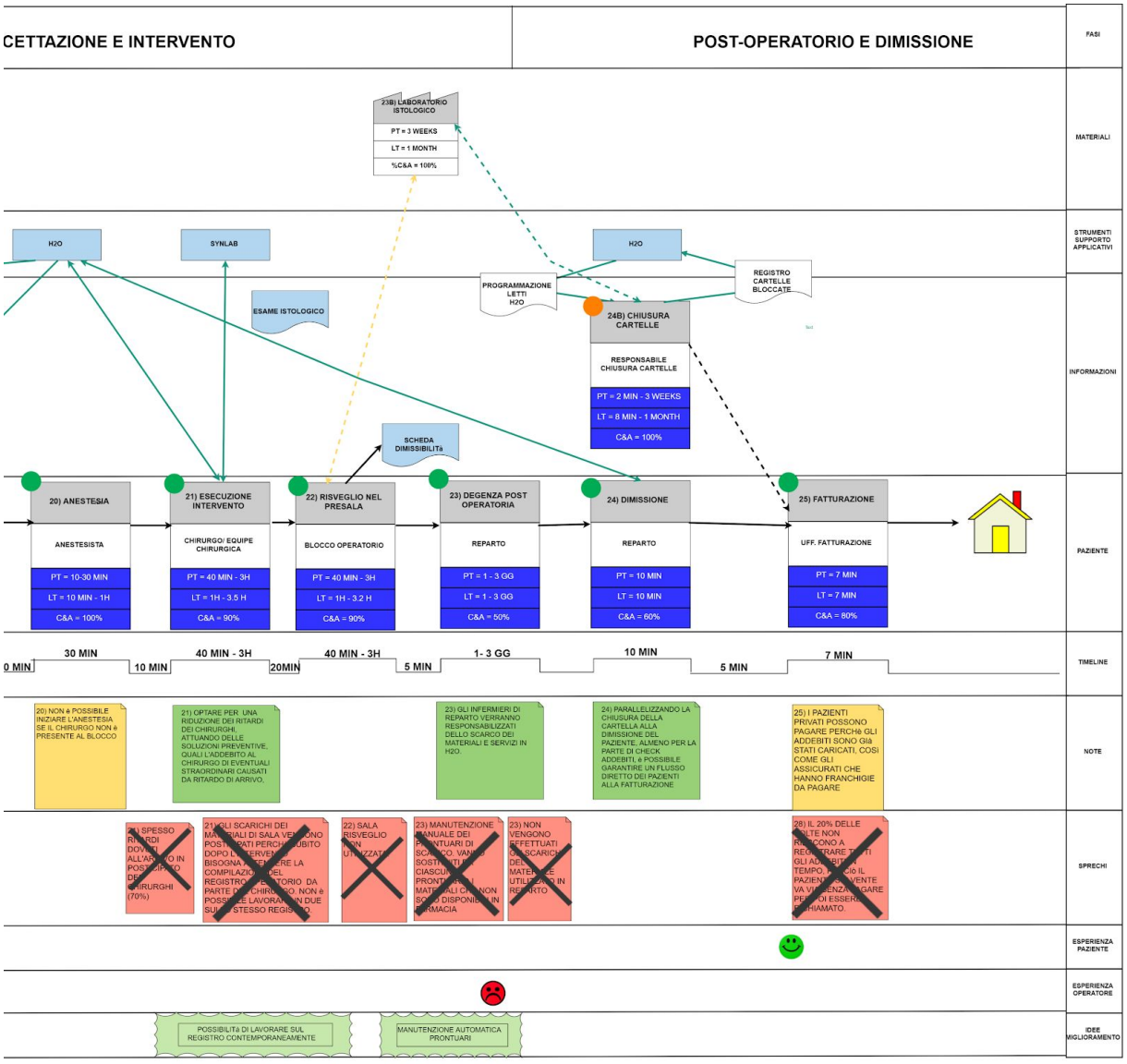
A7 - Value Stream Mapping of the Future State (part 2)



A8 - Value Stream Mapping of the Future State (part 3)



A9 - Value Stream Mapping of the Future State (part 4)



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