POLITECNICO DI TORINO

Master of Science
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Master's Thesis

Digitization and optimization of production flow in a manufacturing company

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ABSTRACT

The present work proposed in the thesis aims at Introducing Digitization under the concept of **Horizontal Deployment** in a **Horizontally Integrated** company along with LEAN principles to improve the production efficiency. **Tecnovalvo srl** an Italian valve industry founded in 1956, is a market leader in the design, production and marketing of special valves for the chemical, petrochemical, pharmaceutical and similar industries. **SchuF**, on the other hand, is a medium-sized global mechanical engineering company based in Frankfurt am Main that specializes in the design and manufacture of process-critical valves to customer specifications. They are the market leader in the chemical industry for speciality valves.

Being the direct competitor to each other, manufacturing some similar valves, SchuF acquired Tecnovalvo in 2008 to penetrate the Italian valve market and increase market power via Tecnovalvo‘s historical customer base. Though they manufacture similar valves, their methodologies are radically different from each other. SchuF is much more forward by digitizing their entire flow process while Tecnovalvo is plowing through their good old work methodologies. Before the Integration, Tecnovalvo was contented with their own manufacturing methodologies, but after the Integration more orders started flowing in, inducing a need to ramp up the production in order to meet up with the demands.

In this thesis, we will be describing about the digitization changes brought into Tecnovalvo from SchuF through ERP in tackling three major issues, the challenges faced and the solutions provided to implant the changes in the employees standard process structure.

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Nomenclature

Abbreviations

SFIN	SchuF India
LATV	La Tecnovalvo
KOMM	Kommission (Order)
PO	Purchase Order
GRN	Goods Received Note

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1 Introduction

This chapter includes an explanation about the background and purpose along with the outline of the work done during the thesis.

1.1 Background and Theory

Company History – SchuF

In Frankfurt, Germany, Josef Frank and Ludwig Schwärzel formed SchuF in 1911. Originally named as "Schwärzel und Frank," the company supplied the rapidly expanding German chemical sector. The Lift Plug Valve was invented by the business and was granted a patent in 1914. In the 1920s, patents were issued for the Piston, Disc Rising, and Lowering Bottom Outlet Valve. In the 1930s and 1940s, SchuF targeted the coal liquefaction sector. Following that, a slew of new patents appeared, including:

- Dead space free polymer diverter valves
- Tangential sampling valves
- Polymer injection systems, forced or tangential flow diverter valves
- Special angle control valves
- Fire safe PTFE and glass lined valve
- the 2-in-1 Control Valve Used in a Heavy Oil Upgrading Plant and
- the latest innovation is the patent for our disc valves for the Process Analytical Technology (PAT).

In the post-war period, Dr. Josef Frank, the founder's son, began exporting. In the 1950s, he started in Basel, Switzerland, where he established the Basel standard. This was the first time a standard for bottom outlet valves was attempted. He began exporting to the Benelux and the United Kingdom in the 1960s, focusing on the chemical and pharmaceutical industries.

Wolfgang Frank, Josef Frank's grandson, began selling globally in the 1970s and 1980s. He established offices in the United Kingdom and the United States. At the age of 27, his younger brother, Dr. Martin Frank, became the managing director of the German parent business in 1984. In 1991, he oversaw the company's expansion in Asia as well as the establishment of SchuF's first manufacturing unit in Cork, Ireland. This increased the company's design and production capability by a factor of two. Dr. Martin Frank assisted SchuF in developing and manufacturing severe service control valves for PTA throughout Asia.

Brief Growth Timelines:

- SchuF Speciality Valves India Pvt Ltd, SchuF's third factory, opened in Coimbatore, India, in 2000. (SFIN)
- Before joining the SchuF Group in 2004, Fetterolf was a top US polymer valve specialist.
- In 2005, SchuF China Valves Ltd was established.
- In 2006, SchuF received its largest order for customized control, diverter, and isolation valves for the Chinese coal liquefaction process.
- Nicolas Frank, Josef Frank's great-grandson, succeeded his father Wolfgang as joint managing director of SchuF Ireland in 2009.

- In 2010, SchuF UK Ltd, a new production facility, as well as SchuF South East Asia Pte Ltd, a new sales office in Singapore, were founded.
- In 2015, SchuF Middle East opened its doors in Dubai.

Today, the company supplies valves to 65 nations throughout the world, having delivered over one million valves during its 100-year history.

Valve Products and Services:

The SchuF Group creates industrial valves for controlling, isolating, and diverting gases, liquids, slurries, and powders. Chemical, petrochemical, polymer, oil, gas, refining, and offshore industries all use their industrial valves, which are suited for demanding or harsh service conditions.

Drain and Sampling Valves:
- Disc Bottom Outlet Valves
- Ram Bottom Outlet Valves
- Flush Bottom Outlet Valve
- Sampling Valves

Isolation Valves:
- Lift Plug Valve
- True-Plug Valve
- Y-Globe Valves
- High Pressure Angle Valve
- Blowdown Valves

Control Valves:
- Angle Control Valves
- In-line Control Valves
- Automatic Recirculation Valve

Switching Valves:
- Diverter Valves
- SwitchPlug Valve
- ManiFlow Selector Valve

Spray Rinse & Injection Valves:
- Spray Rinse Valve
- Steam Injection Valves

Safety Related Valves:
- Line Blind Valves
- Changeover Valves
- Tank Emergency Shut-Off Valves (TESO)

Company History- La Tecnovalvo

La Tecnovalvo (LaTv) was founded in 1956 by Luigi Cassani and now, 56 years later is a leading company in the valves sector for chemical and petrochemical plants. The company which has been directed for over 25 years by the founder‘s son Guido Cassani, supported by a staff of skilled collaborators, has continually renewed itself and it is a landmark for engineering companies, also owing to it‘s choice of being a strong customer-oriented company, caring to fulfill their needs and often adapting the product to the plant requirements.

LaTv‘s product typologies are completely customized, such as diverter valves, reactor charge and discharge flush bottom valves available with disc or piston, the injection valves and the closing valves in various versions.

Product types:

- Diverters
- Gate Valve in incoloy
- Dosing Valve
- 4-Ways Plug Valve
- Jacketed Plug Valve
- Forged Ball Valve in Hastelloy
- Injection Valve
- Valve Group for Transport “On the Road” (T-PED).
- Injection Valve with Clamp.
- Flush Bottom Disc Type.
- Flush Bottom Piston Type.

The main factor bridging the manufacturing efficiency between these two companies is the Process Digitization. LaTv is not completely restructured in Digitizing their processes as they are partly caught up in their own traditional methodologies linked to Lean principles followed/following before the Acquisition. LaTv’s lean management was pretty strong owing to medium scale sector but Digitization was not up to date. Initially it was fine managing their orders with their own methods. But as more orders started flowing in, the paperwork increased, and they started facing complications in meeting the deadlines. The limits of what can be done have virtually been reached by the same lean that once altered working methods, the company started suffering from what can be called as “Lean Fatigue” thereby inducing a need for increased Digital transformation.

We live in a period when a single factor (such as COVID-19) has the potential to transform the global manufacturing economy's game plan. Digital transformation has been underway over the past decade, but it appears that not all countries and businesses are taking use of all of the opportunities it presents to develop new digital competencies such as "digital resilience." The importance of a digital transformation path to Industry 4.0 in manufacturing is greater than ever (*Bojan Lalic et al.,2020*). However, most businesses are having difficulty determining the best strategy for capturing the benefits of this digital promise. Choosing from the profusion of new alternatives afforded by digital technologies is, indeed, a difficult task. In most cases, it is difficult to know where to begin and how to prioritize a company's efforts and resources in order to achieve meaningful outcomes. While some firms have been able to achieve a 50 percent or greater boost in performance, many have become caught in a position where initiatives are carried out in silos, efforts are disjointed, and results are few or non-existent (*Bernd Schreiber et al., 2017*).

Integration of lean concepts into digital transformation has proved to be a highly effective approach of achieving radical simplification of the process, allowing firms to discover and use the most effective levers for the digital journey (*Bernd Schreiber et al., 2017).* When compared to their competition, companies that follow lean concepts earn comparatively high performance levels.

In a recent Arthur D. Little automotive research, the lean lifecycle was divided into three phases, with annual company growth rates estimated for each phase. The association between lean adoption and a major automotive productivity metric ("hours per vehicle") was investigated (*Figure 1.1*)

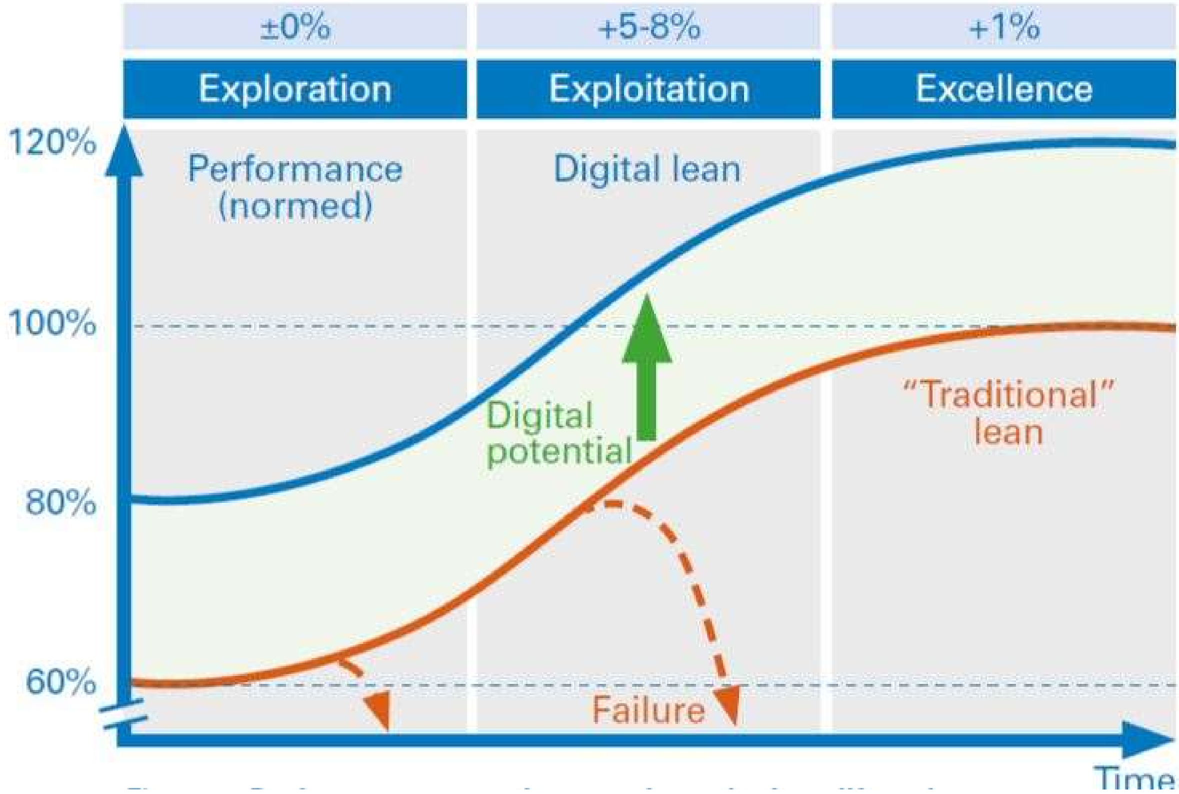

Figure 1.1: Performance growth rates along the lean lifecycle
Source: Arthur D. Little, the HARBOUR Report 2008

During the Lean Exploitation phase, performance growth of up to 8% is common. This lowers as performance increases, and in the Lean Excellence phase, it tends to stable at around 1%. Across all phases, digital technologies have the ability to create a further step-change improvement. Similar patterns have been observed in other industries (*Bernd Schreiber et al., 2017*).

ERP (Enterprise Resource Planning) is a solution that can help with digital transformation. It is a complete system with a single database that consists of several interconnected enterprise resource planning apps. Every application focuses on a specific fundamental process that is essential to run a business, such as manufacturing. ERP systems are complicated systems that are integrated with the newest technologies such as process automation and predictive analytics, despite the fact that they are utilized to run day-to-day tasks. Manufacturing companies have always treated each transaction separately since they are constructed around clear limits of certain functions that a given application is designed to handle. Transactions are no longer treated as stand-alone operations in ERP; instead, they are viewed as part of the business's interconnected processes. It is based on the idea that the sum of its components is larger than the sum of its parts (*Avraham Shtub & Reuven Karni, 2010*).

1.2 Purpose of the Thesis

The aim of the thesis is to introduce and exploit Digitization through SchuF's ERP called as **SMART** to help LaTv in solving three major problems they are facing such as **Time Management, Inventory Management and Estimation of Machining time**. The problems were categorized and analysed. Inside the processes related to the three problems, the non-value adding steps were again examined and questioned: "why this step needs to be processed and by what technology it can be automated". In this way the manual intervention was reduced to an extent by automating and digitalizing manual information processing and standard decision-making. The concepts supporting the analysis and implementation will be **Lean Principles, Horizontal deployment (Yokoten), Process Benchmarking type, Internal Benchmarking approach and ERP Implementation model**.

Smart is an on-premise, mid-market ERP software which was invented and used by SchuF all over their organisations. The entire process in the industry right from creating a quotation till delivering the product are handled through SMART. It is maintained by SchuF's IT department with centralised control in SchuF-India and SchuF-Ireland.

1.3 Thesis Outline

The Thesis is organized as follows:

Chapter-2 provides a brief brush up about the various Lean principles linked along with the Digital transformation implemented in this thesis.

Chapter-3 explains the various subject oriented theories related to the thesis, concepts supporting the implementation and also the tools which we used to analyze and develop solutions to the problem.

Chapter-4 presents a detailed explanation about Enterprise Resource Planning, models of implementation, it's role in Digital transformation along with a supporting case study.

Chapter-5 focuses on how we: Identified and analyzed the causes of the three main problems.

Chapter-6 presents discussion about how we developed the solutions for the problems on identifying the root causes.

Chapter-7 reports the conclusions developed during the thesis and also discusses about the challenges faced during the implementation of the solution.

2 LEAN MANUFACTURING

2.1 History of Toyota Production System

Although process thinking has been used in manufacturing since the 1450s, Henry Ford was the first to successfully integrate an entire production process. In 1913, he created the so-called manufacturing flow by combining consistently interchangeable parts with regular work. Ford was able to turn the whole company's inventory every few days, but the difficulty with this new production system was that it lacked diversity. This is exemplified by a famous sentence: “Any client can have an automobile (Ford T) painted any color he likes as long as it is black” (*Ford et al., 1922*). Other automakers attempted to meet the growing demand for variety by investing in larger, quicker machines. On the one hand, they reduced expenses per process step, but they also raised throughput times and inventories over time, with the exception of a few exceptional circumstances where all process stages could be linked and automated. After World War II, Kiichiro Toyoda, Taiichi Ohno, and other Japanese engineers took a look at the situation. They attempted to apply a number of small quick-win changes in order to maintain process flow while also providing a wide range of product offers. As a result, they went back to Ford's original ideas and developed the Toyota Production System (TPS), often known as Lean Production (*Holweg, 2007*). When asked what a Toyota Production System is, 80% of people will say it is a Kanban-based system, 15% will say it is a specific production system, and only 5% will get to the heart of the matter and say it is a system that "eliminates wastes" (*Shingo, 1989*). The phrase "lean production" was first used in 1988 in John F. Krafcik's article "Triumph of the Lean Production System," which was based on his MIT Sloan School of Management thesis. Krafcik created the term in his publication with the goal of contrasting the buffering production systems of Western companies with the innovative TPS that arose in Japan after WWII. The word refers to a production system that "does more with less," or uses the fewest resources possible to achieve the maximum level of efficiency and quality. Lean was first established in Toyota Motor Manufacturing, and it is a methodology that aims to eliminate wastes that do not add value to consumers (Muda) in order to boost factory productivity. Nonetheless, Taiichi Ohno, the father of the Toyota Production System, wanted to emphasize that Lean Production was only “a mere response to the state of the automobile industry in Japan after World War II” (*Ohno, 1973*), and that it was the result of a long period of trial and error to find a way to survive in the mass production competitive environment that had already been established in Europe. In fact, the war had severely harmed the Japanese automobile sector, and Ohno was hired to increase factory production, as efficiency was the key motivator at the time. Despite traveling to the United States with the intention of studying Ford's manufacturing process, he was intrigued by the logic of American supermarkets. When he returned to Japan, he combined the two pillars of Jidoka and Just-in-Time, which had already been applied by Sakichi Toyoda, to form the Toyota Production System. He realized that the only way to boost efficiency was to adapt the system to modern Japanese industry, because "mass production could never have operated under those conditions" (*Womack et al., 1990*). TPS is related with the name Lean because it uses half of everything in comparison to mass production: half of the human effort, half of the factory area, half of the tool investment, half of the hours required to produce a new product, and significantly less than half of the inventory (*Womack et al., 1990*). Unlike mass manufacturing, which relies on narrowly skilled specialists for design and unskilled (or at least semi-skilled) laborers for production, Lean employs multi-skilled workers at all levels. In addition, rather than purchasing expensive, single-purpose machines, Lean recommends manual and automated systems capable of producing high volumes with a wide range of products. From an organizational standpoint, the transition is from hierarchical to value streams characterized by appropriate degrees of empowerment, implying that duties must be delegated down the organization (*Krafcik, 1988*). Customer satisfaction and profitability are the two fundamental goals of lean manufacturing. Everything must deliver necessary value to the final client, which is why it is critical to comprehend what the customer truly desires and is prepared to pay for. A Lean organization recognizes the value of its customers and focuses its core activities on continually increasing it through a flawless value creation process with zero (or minimal) wastes. Lean can be defined as "a quest to add value" from a practical standpoint. Lean reduces the amount of human work, space, capital, and time required to manufacture products by removing wastes throughout the value chain (rather than at isolated points). “Companies are able to respond to changing client needs with high variety, high quality, low cost, and extremely short throughput times” (*Lean Enterprise Institute*) by eliminating wastes and errors. Furthermore, despite the fact that the traditional perspective of profit is based on the equation "selling price equals profit plus costs," Taiichi Ohno emphasized that this is not the optimal view. He began to think of profit as the difference between the selling price and the costs (*Ohno, 1973*). According to him, the selling price is the amount that a buyer is willing to pay for the product's perceived worth. As a result, profit is solely dependent on cost reduction. Once this section has been defined, it is evident that the greatest method to boost profitability is to minimize costs as much as possible, according to the Lean perspective. Furthermore, the continual research and elimination of non-value-adding operations, specifically those tasks for which the consumer is unwilling to pay, is the cornerstone of Lean thinking. Many parts of the manufacturing process can be eliminated, including how the original product is designed, how design conformity is ensured, and how to operate a completed plant (*Melton, 2005*). Waste reduction is not the main emphasis of any Lean implementation endeavor, but it is unquestionably a must-have. Ohno identified seven forms of wastes, or Muda, that are linked to a waste of time, money, or resources: product movement, inventory, physical motion of a person, waiting, over-production, over processing, and faults (*Liker, 1996*).

Type of Wastes	**Description**
Handling	Product movement between processes or from one area to another.
Inventory	Work in progress and finished items inventory (also raw materials).
Motion	While performing an operation, a person's physical movement is important.
Waiting	Time spent waiting for a product or machine to finish.
Over-Production	Producing more than the buyer has requested.
Over-Processing	Making activities go above and beyond what the customer expects.
Defects	Due to several process flaws, products were reworked or rejected.

Table 2-1: Seven types of wastes (Muda) (*Liker,1996*)

Furthermore, not only Muda, but also Mura and Muri must be taken into account. Mura is the waste of unevenness that causes Muda: if a corporation fails to smooth demand, it results in variance and volatility, which leads to inventory and other wastes. Muri, on the other hand, causes overburden, i.e., undue stress on employees and processes: this is produced by Mura (demand fluctuation), a lack of training, production system breakdowns, or the use of the improper tools

(*Womack, 2007*). Lean techniques allow an organization to achieve many benefits by preventing and reducing wastes: improved quality performance due to fewer defects and pieces reworked both in house and at the customer, fewer process breakdowns, more involved, empowered, and satisfied employees, improved supplier relationships, lower inventory levels and, as a result, a higher level of stock turnover with less space. The latter is a critical component of Lean, as it decreases the risk of obsolescence and allows cash to be returned to the business, in accordance with the general notion that "cash is king" (*Gardner et al., 1994*). Lean, on the other hand, is not something that can be implemented overnight. In reality, it necessitates the involvement and commitment of the entire business. According to a fascinating study conducted in the United States in 2007 and published in the Journal of Operations Management in 2009 (*Anand et al., 2009*), 74% of American manufacturing organizations that sought to implement lean principles were completely dissatisfied because the outcomes were intangible. Furthermore, associating the word Lean with Japanese businesses is not always accurate. Even though Toyota is the icon of Japanese industry, barely 20% of Japanese enterprises have successfully implemented lean manufacturing (*Goldratt, 1990*). This is in line with the concept of change management, which states that, first and foremost, a strong mindset and a strong culture must support the use of Lean methods. Regardless of the country or industry, the success of Lean Thinking and, as a result, Lean implementation is based on employee involvement and a willingness to change at any level of the company. Before the wastes, the philosophy must successfully establish the value for the client (*Womack et al., 1996*). Improvements in efficiency, which may lead to job losses, make people more resistant to change and more willing to fight its adoption (*Jadhav et al., 2014*). Even if shown, the enormous high-level topic of people and change management will be ignored in comparison to the Industry 4.0 ecosystem. The research that went into the dissertation focused on Lean's operational tools and techniques, as well as how they are sustained (and continuously enhanced) or disrupted in the emerging Industry 4.0 reality.

2.2 Lean principles

According to Lean methodology, the systematic elimination of these three causes of inefficiencies (Muda, Mura, and Muri) can only be accomplished by five acts, which Womack and Jones refer to as principles, and which serve as reference points for process rearrangement. The first step is to determine what value means to the customer. The value stream for each product is identified in the second step. The third principle states that a continuous product flow through the remaining value-added steps is required. The fourth action strives to a customer-pulled flow that can be maintained indefinitely. The final principle encourages people to strive for perfection (*Womack et al., 1996*). These actions must be repeated indefinitely, every day, as part of a continuous improvement cycle.

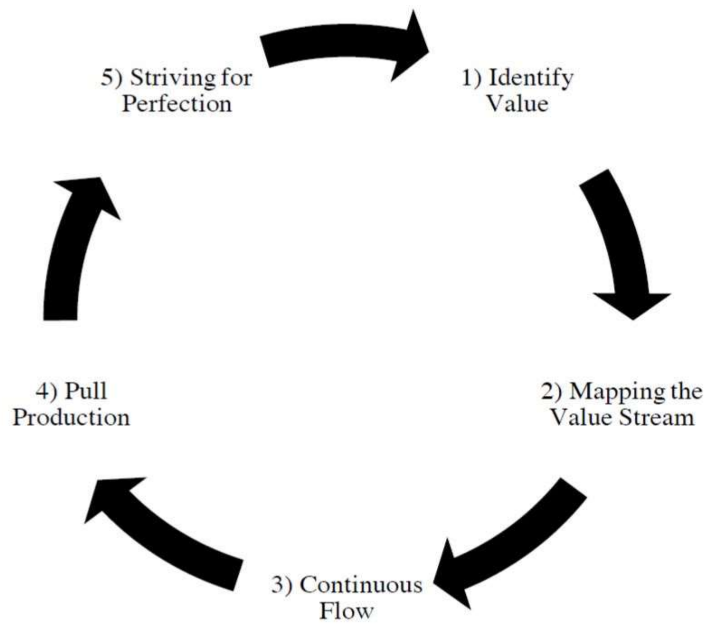

Figure 2.1: Five cycling actions for Lean implementation (*Lean Enterprise Institute, 2016*)

2.2.1 Value

The identification of the value is the first step in the waste elimination process. The client defines value, and it symbolizes what he or she is prepared to pay for; first and foremost, it is critical to identify precisely what is important to the customer. The major difference from the past is that the producer must understand and listen to the client rather than forcing what is more convenient for the manufacturer. In this regard, organizations employ techniques such as Brainstorming and Quality Function Deployment (QFD) to identify value-adding processes and make them as efficient and waste-free as feasible. In other words, by just looking for wastes, it is easy to make non-value-adding operations more efficiently (*Rother et al., 2003*). In most cases, the consumer does not want to pay for reworking, transportation, or time spent waiting (and other sources of wastes, *cf. Liker, 1996*).

The first principle's underlying premise can be summed up in the phrase "customer first" (*Walker, 1990*): Lean's mission and ultimate goal is to listen to the customer in order to comprehend what he or she genuinely wants and needs.

2.2.2 Mapping the value stream

After determining what is useful to the client, the next step is to map the Value Stream, which is made up of all the interconnected operations required to transform raw materials into finished products that provide value to the consumer (*Lovelle, 2001*). The value flow analysis reveals three types of activities: value-adding activities, necessary non-value-adding activities that must be maintained (or at the very least minimized or optimized), and non-value-adding activities that generate waste and must be eliminated. Another significant feature of the value stream is that it is examined from the perspective of the entire product rather than particular departments (*Howell, 2013*). To map it, Lean thinking advises using a visual tool called a value stream map, which takes into account the current and future condition of the flow (*Grewal, 2008*).

This second step tries to determine the process time and eliminate all non-value-adding operations by determining what effectively adds value for the client and what he or she is prepared to pay for within the process.

2.2.3 Continuous flow

Once the tasks that do not provide value have been eliminated, the remaining activities must be organized in a flow: the process must run without interruptions. The ideal flow is known as one-piece flow, however due to machine setups and the need to flow various product streams through particular machines or cells, this is not always possible. In general, tools ranging from Kanban to small machines and cell design are used to produce this flow. Everything that obstructs the flow is a waste, thus it must be recognized and removed; the process must be able to continue without interruption (*1988, Krafcik*). Furthermore, each component must adhere to the takt-time, which is the projected production rate for delivering the product to the customer, or, in other words, the production rate to meet the customer's request (*Myerson, 2012*). It is computed by dividing the total available time for delivering a product by the volume of product to be delivered (demand).

2.2.4 Pull Production

The fourth principle is the most important, and it has to do with how production is structured and carried out. Inventory is, in reality, one of the major wastes that must be removed. In the conventional metaphor of the boat, inventory hides the majority of a company's difficulties while also causing a slew of additional wastes (*Gupta et al., 2014*). A system should ideally only produce when a consumer places an order: output should be driven by actual market demand (*Spearman et al., 1992*). Kanban and supermarkets are used to accomplish pull production. Kanban is a straightforward and transparent mechanism for replenishing a required component, which is, of course, triggered by external demand. Only a small amount of goods remains in the workplace, and before it runs out, the operator issues a Kanban-card order that ensures just-in-time replenishment. Just-in-Time means having the appropriate components, at the right place, at the right time in order to assure a smooth pull production and deliver the proper result. Customer requests can be swiftly fulfilled with these tools, and components are made from standard parts or taken from a small stock that is supplied in the same way as supermarket shelves are restocked when customers buy things (*Kumar et al., 2007*). Of course, in order to be reactive when a product is required, a pull production requires a high level of visibility into the process; in other words, more visibility supports a more effective just-in-time manufacturing (*Myerson, 2012*).

2.2.5 Striving for perfection

It is feasible to prevent a large amount of waste in the organization's processes by completing the first four steps. The fifth principle, on the other hand, is more closely linked to the philosophy's ambition and the daily attitude that prompts its actual application. Lean focuses on the ultimate goal of achieving continuous perfection by paying attention to daily operations: the focus must be on the daily journey, not the destination. Being better than the competition isn't enough; the key goal is to provide value to customers by eliminating waste.

The term Kaizen, which is made up of two Japanese words: Kai, which means change, and Zen, which denotes perfection, can be translated as "constant improvement" (*Bhuiyan et al., 2005*). Kaizen is more of a mindset than a method for making improvements. In practice, it is each person of the organization's attitude, which must be motivated by the desire to improve every day performance through a never-ending cycle of excellence. It is necessary to build a collaborative and participatory strategy in order to actively involve each actor in the continuous improvement process by utilizing his or her competencies, experiences, abilities, and skills in the field. It is a mindset that focuses on what needs to be done rather than what could be done. The goal of continuous improvement is to improve little by little, day by day, through little yet consistent activities. This sentence may be effective in better explaining this concept: "it is better to have 50% instantly rather than 100% never" (*Bonfiglioli, 2001*). This idea is diametrically opposed to the solely Western paradigm of innovation and revolution. However, Kaizen alone is insufficient to achieve Lean's lofty goals: Kakushin (continuous improvement) and Kaikaku are also required (revolutionary or radical change). In fact, to achieve excellence, every company requires both radical and incremental techniques (*Yamamoto, 2010; Gasvaer et al., 2012*).

In most cases, managers must learn to see: to perceive the value stream, the continual flow of value, and the value being pulled by the client. It is reasonable to believe that the ultimate form of seeing is to bring perfection into full view: in this way, the improvement goal becomes obvious and concrete to the entire organization. As a result, no picture of perfection can be flawless. In a lean perspective, perfection is equivalent to infinity. Although reaching there is unattainable, the desire to do so motivates and provides a sense of direction that is necessary for progress down the route. Setting "specific deadlines to accomplish seemingly unattainable projects and then frequently meeting or exceeding them" is the difference between companies that have accomplished a lot and those that have accomplished little or nothing (*Womack et al., 1996*). Kaizen requires excellent engineering throughout the planning phase, as well as a high level of process control (like in Deming Cycle). Starting with the standardization of activities and processes, the Kaizen cycle measures them (in terms of time and resources used), evaluates all feasible improvement ideas, and only innovates when the process is saturated, standardized, and implemented. Of course, the cycle continues indefinitely.

2.3 House of Lean

Mrugalska and Wyrwicka linked each of the five concepts previously discussed to a step in the Lean implementation process in their article (*Mrugalska et al., 2017*). Following an initial phase in which a vision must be established and a team must be formed, the next steps are to identify products (value) and processes (value stream mapping), review the factory layout (continuous flow), choose an appropriate strategy (pull production), and conclude with a never-ending process of continuous improvement (strive for perfection).

The definition of the Lean paradigm is not restricted to these five actions, and it has been explained in a variety of ways. One of the most prominent depictions of the Lean paradigm uses a house as a figure. In 2004, Liker drew the most common lean tools in such shape for the first time (*Figure 2.2*). Just-in-Time and Jidoka are the two main pillars that support the roof of the house. People are at the heart of the home because they can see waste and solve problems while maintaining a constant improvement mindset. There are four primary principles that serve as foundations: standardized work, visual management, and leveled production (Heijunka), all of which are supported by a strong Lean mindset that allows the pillars to stand stably.

It is important to note that the goal of Lean Production is to eliminate waste, not only reduce it. The goal of Lean manufacturing is to achieve "the best quality, lowest prices, shortest lead-time, highest safety, and high morale" and is written on the ceiling (*Begam et al., 2013*). Because Lean thinking invokes the image of a structural system, the TPS diagram is portrayed as a house (*Liker, 2004*). A weak connection in the roof, pillars, or foundations will inevitably weaken the entire structure. Furthermore, each constituent is vital in its own right as much as it is required for the system's overall balance.

Figure 2.2: Toyota production system

2.3.1 Toyota way philosophy

In the literature, the concept that Lean is more than a set of tools (*Bicheno, 2004*) is dominant, as it may be considered a true philosophy (*Pettersen, 2009*). To be more specific, the Toyota Production System (TPS) is just one component of the Toyota Way's larger set of ideas and behaviors: it is designed to give workers the tools they need to keep improving their work. 14 management concepts might be used to summarize this system (*Liker, 2004*).

TPS provides the recommendations for driving the mentality shift that is at the heart of this culture revolution, which is underpinned by two pillars: continuous improvement and human respect. In truth, Lean is first and foremost a style of thinking, not a to-do list (*Shingo, 1989*). The major difference between Lean and buffering systems arises from the underlying philosophy: mass production aspires for good enough, whereas Lean Production seeks for excellence, which is entirely feasible with the Kaizen mentality. Furthermore, one of the most significant aspects of Lean is the involvement of all members of a company (*Womack, 2007*). When the workforce began to be considered the company's most valuable asset, as promoted by Juran, Deming, and other quality Gurus (*Juran, 1991; Deming, 2000*), everyone had to contribute to the implementation of the philosophy. Using the power of the organization's people to solve challenges, of course, allows for ongoing improvement.

Furthermore, Toyota Way has five core principles that are shared by all levels of the business and all personnel in order to ensure that consumers are constantly satisfied: Challenge, Kaizen, Genchi Genbutsu, Respect for People, and Teamwork are the five values (*Toyota Motor Corporation, 2003*). The phrase "challenge" refers to the pursuit of a long-term vision by confronting all challenges with the appropriate fortitude and inventiveness. Kaizen refers to a mindset of continual improvement, a never-ending quest for excellence (*Imai, 1986*). Genchi Genbutsu tries to identify the fundamental cause of an issue so that corrective action can be taken to achieve the goals. Respect entails valuing all stakeholders and attempting to understand and build a trusting relationship with them on a constant basis. Teamwork entails sharing learning opportunities and improving individual performance as a group.

Finally, it is evident that TPS (Toyota Production System) is not sufficient in and of itself; it must be combined with another TPS, namely Thinking People System (or, in other words, the Toyota Way), in order to create the third and most important TPS: the ultimate Toyota Profit System (*Mazzieri, 2015*). Of course, each firm must adapt this business model to the industry and its own operations in order to attain the Japanese philosophy's ultimate aim of cost, quality, and safety.

2.3.2 Stable and standardized process

It is crucial to realize solid and standardized procedures once a long-term vision has been defined, which is essential for the successful implementation of Lean philosophy. To promote improvement, it is first vital to maintain consistency in the four Ms: manpower, machinery, materials, and methods (*Ishikawa, 1976*). A thorough understanding of the situation is required to maintain process stability and avoid unanticipated deviations. Stability begins with standard work, a term that is intimately linked to two other key concepts: workplace organization and visual management, which is another pillar of Lean House (*Liker, 2004*).

The principle of standardization lies at the heart of Lean methodology. Standardized Work refers to the cornerstone of a method that allows the ongoing improvement of learning processes. It specifies how to execute a typical process according to best practices (*Dolak et al., 2004*). It entails dividing work into an ordered sequence of pieces that must be completed repeatedly: in other words, the process is separated into packages, each of which must be defined and completed in the same manner. Any type of deviation could lengthen the cycle time and cause quality problems. Instead, standardized work frequently strives to maintain consistently high levels of productivity, safety, and quality (*Pascal, 2002*).

These are the elements that must be present in order to achieve standardization: Standard Work in Process, takt-time, and work sequence (SWIP).

Takt-time, in particular, refers to the rate at which a production is completed. The word takt means "beat," "timing," and "speed regulating." It is the longest time window for producing a product in order to meet market demand; the goal is to follow the market's rhythm in terms of manufacturing (*Feteke, 2013*). Synchronization is the essential word: the production cycle must meet external demand in order to avoid both over- and under-production. Takt-time optimization seeks to eliminate wastes and inefficiencies throughout the entire process, as well as the danger of delays and excessive production. Furthermore, takt-time is distinct from cycle time, which is the time it takes to complete a cycle of a specific operation, as well as a function, a job, or a task, from beginning to end. It is the amount of time required to produce one unit of output (*Ducharme et al., 2004*). Considering the concept of synchronization, all jobs within an area or a production line must be finished at the same time. The fundamental concept is that the lines must be balanced (*Gurumurthy et al., 2011*). Following line balancing, each operator's job sequence must follow a regular procedure. This means that in order to produce the best quality results, each worker must perform the job in the same way every time (*Pascal, 2002*). Furthermore, ergonomics is linked to work sequence. In reality, the process must be set up so that the operator can do the tasks in the most ergonomically sound manner possible: workplace structure optimizes ergonomics. Finally, SWIP (Standardized Work in Process) is defined as the minimum process inventory required to sustain one-piece flow, which is another key Lean concept. These three parts work together to partition the entire process into subgroups, improve uniformity, and provide better understanding and control over the processes. In reality, "once a scientifically one optimal technique to execute a task has been established and frozen," "to improve a process, it is important to standardize it" *(Imai, 1986*).

2.3.3 Visual Management

The concept of standardization is commonly employed to make the concept of visual management more practical. Manage the shop floor with your eyes closed allows you to see the current condition of industrial processes using simple tools while enhancing the level of visibility for the process actors. The ultimate goal is to collect concrete data on results and progress in order to identify and address important issues in real time. (*Parry et al., 2006*).

Visual management methodologies could be utilized not only during the process execution, but also during the process analysis, allowing for continuous updating and the introduction of improvement actions to decrease wastes. It is feasible to define the status of a certain process element and propose a strategy for improvement using only a few intuitive pieces of information. Of course, as the process circumstances change, it occurs to avoid simple signals that are adequately computed and simply adjusted. Warning signals, stripes, cards, document holders, colored borders, and the use of graphic devices are all visual and useful instruments that stimulate operators and deliver essential information quickly. Everyone involved in the operation must be able to understand each component and its status at all times (*Womack et al., 1996*).

Visual management concepts are inextricably tied to the management in view proposed by the 5S technique for workplace efficiency in order to remove inefficiencies in the process (*Michalska et al., 2007*). Five S stands for the first letter of five Japanese words that represent the stages of execution of that methodology: Sort out (Seiri) means to separate what is beneficial from what is not. Seiton (Order) refers to the reorganization of what is useful in order for everyone to use it readily; Seiso (Shine) refers to keeping the workplace clean and orderly. Standardize (Seiketsu), which entails the standardization of workplace tasks and the dissemination of proper operative methods to all; Shitsuke (Sustain), which means adhering to a set of guidelines for each workplace. (*Peterson et al., 2001*).

5S is a methodology that supports Visual Management techniques and has a number of advantages, including the ability to make visible to anyone the system and people's behaviors that are not in line with objectives and pre-defined standards; to train people to have a cleaning and organizing attitude in the workplace; to continuously improve working conditions; to make the best use of available space; and to reduce waste.

2.3.4 Levelled Production

Another significant concept in the House of Liker is Heijunka, which means "production smoothing or leveling," and which, together with takt-time, represents the ability to be flexible while meeting demand by ensuring a fluid, consistent, and observable process. In the assembly process, Toyota defines it as “distributing the production of different body types evenly over the course of a day, a week, and a month” (*Coleman et al., 1994*).

Heijunka is another strategy for facilitating just-in-time production, and it is used to ensure that product inventory is proportional to demand variability, according to the Toyota Production System. In actuality, it is nothing more than the removal of Mura (workload variability), allowing the correct combination flexibility to adjust the production sequence more quickly. Heijunka also enables for the removal of Muri (overburden), which can lead to quality and safety issues. Furthermore, by pursuing just-in-time logic, the disruption of production flow is reduced by ensuring that components are available in the proper sequence and amount at the right moment. Heijunka's ultimate goal is to eliminate peaks and valleys in the production schedule in order to better organize the workforce and maintain a consistent process across time (*Huttmeir et al., 2009*).

2.3.5 Just In Time

Taichii Ohno discusses the two pillars of Toyota's production strategy in his book, which Liker designated as the two pillars of the house: Just in Time (JIT) and Jidoka (*Ohno, 1988*).

Beginning with the notion of Just in Time, it entails creating "the appropriate thing at the right time in the right quantity, according to the takt-time" (*Monden, 1993*). It has something to do with inventory elimination: zero inventory is described as a system in which a company stores no (or very little) inventory in storage, instead generating only what it needs to sell using a pull production method.

A production process that is fluid, consistent, and optimized, with a working cycle that is precisely planned and measured, and in which items move only when they are needed, decreases the expenses incurred by squandering time, materials, and capacity. Team members can concentrate on their jobs without being interrupted, resulting in higher quality, on-time deliveries, and customer satisfaction.

Toyota Motor Corporation poached the concept of Just in Time from a Ford approach known as "dock to factory floor," in which necessary components were placed near the manufacturing line on the factory floor without having to transit through the warehouse. The Kanban is the pinnacle of Just in Time management. Kanban is a plastic card that carries all of the information needed for the current production, including its stage and the following actions to complete the process (*Kumar et al., 2007*). The information about the units needed, such as number and type, is printed on a tag, a card that is transferred from a process operator to workers in prior operations in this system. Many operations in the facility are integrated in this fashion, allowing for greater management of amounts required by different production units.

The first purpose of JIT manufacturing systems is to continuously reduce and eliminate all wastes (*Brown et al., 1991*). Just in Time logic emphasizes the notion of Zero (Zero Objective), which entails the elimination of faults, queues, inventories, breakdowns, and inefficiencies. It is the most important pillar in pull production, which consists of a series of workstations with value addition at each one (*Spearman et al., 1992*). Companies strive to operate with a very low inventory level and a very high degree of quality and productivity based on this pillar (*Sugimori et al., 1977*).

2.3.6 Jidoka

Ohno came up with the idea of cutting costs by minimizing waste after working with an automatic loom that would halt every time a thread broke in order to avoid wasting resources or machine time. The loom was described by Ohno as "a text book in front of my eyes" (*Cusumano, 1985*), and this concept was included into the TPS. Jidoka, the House of Lean's second pillar, was the name given to it (*Liker, 2004*). Jidoka, in fact, promotes JIT methods since it ensures that defective pieces from prior processes do not flow into and interrupt a subsequent step (*Monden, 1983*).

Jidoka's goal is to give machines and operators the ability to recognize irregularities and stop the job instantly. It is also characterized as "automation with a human touch" (*Liker, 2004*) because the equipment can discern good from faulty parts without the need for human intervention. Each phase is monitored for quality: before passing the product to the next phase, each team member is accountable for performing quality checks. If a defect is discovered, it is addressed right away by stopping the production line if necessary. Indeed, Jidoka is defined as "the decision to halt and rectify problems as they arise rather than deferring their resolution until later" (*Liker et al., 2006*).

Andon and Poka-Yoke are also part of Jidoka. Andon is a basic board that displays the state of the manufacturing line and is easily visible across the factory. It promptly detects if and which operator has identified a breakdown; in fact, the operators are in charge of production quality and have the right to halt production if necessary to resolve the problem (*Parry et al., 2006*). Furthermore, Poka-Yoke is a Japanese approach for preventing the production of defective products (*Dudek-Burlikowska et al., 2009*). It is a simple yet effective technique to cut down on errors while maintaining a high level of quality. Poke-Yoke systems are divided into two categories: warning systems, which transmit a signal when a deviation from the standard occurs, and control systems, which cause a machine to halt automatically whenever a divergence from the standard occurs (*Shingo, 1989*). Typically, there exist gadgets that prevent (nearly) all operators from making standard workplace blunders. Jidoka is an important concept in Lean because it is critical to maintain a high level of quality throughout the whole manufacturing process. Even if each member is responsible for stopping the flow, this has no effect on the customer's delivery; in fact, productivity increases, idle time decreases, and the return on investment increases. Jidoka's ultimate goal is to make the problem evident and then provide an in-station quality. When a problem is discovered, the line is shut down until a solution is found. The Five Whys analysis is a possible method for identifying the causes and fostering a successful remedy (*Ishikawa, 1976*).

Furthermore, Total Productive Maintenance (TPM), which attempts to eliminate breakdowns, is linked to the concept of Jidoka and, to a greater extent, the prevention of errors (*Willmott, 1994*). The acronym TPM is made up of three words: Maintenance is an activity that aims to preserve the efficiency of plants through time; productive indicates that it aims to increase the productivity of the plants; and total refers to the workforce's full and active participation. TPM attempts to reduce delivery times in order to supply high-quality, low-cost products (*Wireman, 2004*). It is divided into pillars, each focusing on the elimination of a specific set of losses in accordance with the organization's goals (*Venkatesh, 2007*). All company roles, from operators to plant managers, are involved in the introduction of the pillars.

TPM focuses on the reliability of processes and the elimination of their breakdowns, and works through small groups of workers to achieve optimum efficiency. The major Key Performance Indicator for monitoring the results gained is OEE (Overall Equipment Effectiveness). It is the proportion of value-adding operative time (time spent using the machines) to total available time (*Ahuja et al., 2008*).

2.3.7 Waste Reduction: Problem Solving Approach

In order to achieve Lean final goal, illustrated in the roof of the house, the two above-mentioned pillars must be supported by the attitude of continuous improvement (*Liker, 2004*), already explained in the previous section of this dissertation (*cf section 2.2.5*). Kaizen requires not only people who are committed to it, but also a secret and strong desire to reduce waste. According to Liker, Lean Manufacturing is a mindset that, once followed, reduces the time between client order and delivery by eliminating waste causes in the manufacturing cycle (*Liker, 1996*). Another significant reference point for the effective adoption of Lean, which is directly linked to the problem-solving approach, is the practice of reducing wastes in the process until they are eliminated. TPS is not only a set of tools; it is also a mindset for problem solving that seeks to find and analyze a situation from several angles. Indeed, through leveraging cooperation, each person of the organization must be aligned with the business objectives and drive continuous progress (*Bhuiyan et al., 2005*). To put it another way, every member of the organization is important in the decision-making process and may contribute to Kaizen (*Imai, 1986*).

The underlying principle of continuous improvement through an iterative process created by William Edwards Deming lies at the heart of Lean Problem Solving (*Moen et al., 2006*). The Deming Cycle (PDCA) is made up of four steps that repeat themselves: Plan, Do, Check (of results), and Act. The execution phase (Do) follows the initial planning phase (Plan), in which activities are studied in order to identify the final target. The monitoring phase (Check) is the most important: it is when input is obtained and analyzed in order to detect variations and problems, and then possible corrective measures for improvement are organized. In the final phase (Act), these planned activities are carried out, which may be followed by re-planning and hence a re-start of the PDCA cycle.

Toyota developed the A3 Process, a structured approach to issue solving based on Deming's findings (*Sobek et al., 2008*). The goal was to come up with a simple technique that would have an immediate effect; to do so, all of the information needed to be written on an A3-size sheet. This allows you to concentrate on the knowledge you need to address the problem rather than becoming bogged down in irrelevant details. Another benefit is that it increases people's engagement by encouraging communication and participation: each actor is allowed to write on the A3 page if new information or problems arise. Background, Current Situation, Goal and Root Cause Analysis (Plan), Countermeasures (Do), Confirmation of the Results (Check), and Follow-up plan are the seven areas of the A3 model, which follow the PDCA cycle. Furthermore, various problem-solving tools such as Value Stream Mapping, Fishbone Diagram, and Five Whys support this structured and detailed approach.

To be more specific, Value Stream Mapping (VSM) is used to map the current scenario in order to determine where value is created for customers and then focus on areas that may be improved by eliminating non-value generating operations (*Rother et al., 2003*). The Fishbone Diagram (also known as the Ishikawa Diagram) is one of the most intriguing problem-solving tools since it allows you to identify all of the trigger factors until you find the underlying cause of the problem. The Five-Whys technique is used to uncover difficulties and continue suggesting remedies in order to dig deeper into the investigation of the reasons for each aspect. In reality, Kaizen requires that the rationale and advantages of all initiatives be carefully assessed prior to implementation of a specific improvement plan. This is why the Five-Whys technique is so important: before any proposed improvement can be implemented, it must be evaluated and questioned, progressing through the five levels of whys to ensure the ultimate result (*Ishikawa, 1976*).

The logic behind these techniques is based on the concept of Genchi Genbutsu, which literally means "going to the source"; instead of relying on information provided by third parties, it is necessary to evaluate all of the causes in order to analyze the root of the problem by understanding it completely and accurately (*Haghirian, 2010*).

2.3.8 People and Teamwork

In mass manufacturing, processes were designed to be repetitious so that even inexperienced people could do their responsibilities with ease. Workers in a Lean enterprise, on the other hand, have a greater number of jobs and responsibilities: they are better able to track each problem swiftly and determine the root cause (*Poppendieck, 2002*). The focus shifts to those who create value. The organization becomes more team-oriented, with a focus on the value stream rather than functional knowledge (*Womack et al., 1990*). The mindset of continuous improvement must be carried throughout the organization, with top management's support and the necessary engagement of employees. Companies must define common, clear, and quantifiable goals for them.

Respect for people is one of the core concepts of Lean, along with the motto Elimination of Waste, as numerous works of literature have pointed out (*Taleghani, 2010*). For management teams, respect for people is portrayed as a novel concept (*Cardon et al., 2015*). Of course, a shift of mindset is required when it comes to decision-making. In fact, the conventional autocratic decision-making process had to be overcome in order for the new Ringi decision-making process to emerge. It is based on a bottom-up strategy, in which more members of the organization are invited to endorse a decision, fostering collaboration in the search for the best solution to a problem (*Sagi, 2015*).

To properly adopt the Lean paradigm, people must be involved at all times. Prior to implementation, it is critical to instill the proper mindset throughout the organization (*Bicheno et* *al., 2016*). Internal resistance to Lean implementation is significant, and a shift in the company's culture toward a Lean approach is required. Of course, in order to support value creation for customers at all levels of the business, change management must be substantially customer-driven. Furthermore, in order to support the continuous improvement process, individuals must be engaged and continuously taught on each task, using a cross-trained approach company-wide, and through encouraging better team effectiveness. (*Marks et al., 2002*).

2.4 Application Fields

The deployment of a pull production system necessitates involvement in several operational areas, which is accomplished through the use of a set of tools and procedures that together form the heart of Lean production. Lean methodology is used in practice in a variety of ways to achieve different goals, including product design, process design, production management, workforce management, and supplier management. The goal of product design is to simplify the product as much as possible while also rethinking the engineering process in terms of overall expenses. This is accomplished by standardizing and modularizing components and procedures.

The process flow, the temporal homogeneity of the mix, and the operative regularity must all be guaranteed according to the process design. The process flow can be achieved through Group Technology, new layouts, production capacity splitting, and the development of dedicated or mixed-model lines. The operation regularity is achieved by process quality and the availability of means, while the temporal uniformity is achieved by lowering set-up time.

To speed up the production flow, production management requires perfect synchronization between production and market demand, as well as a simplified management system. These goals are met through leveled and synchronized production planning (Heijunka) and operative production planning, which includes a flat bill of materials, flow control by pull, activity overlapping, and Visual Management techniques.

It is feasible to act in the field of workforce management to achieve a high level of professional flexibility and decisional authority (through job enlargement and enrichment) and to adjust the workforce to market demands. In the final area of intervention, supplier management, it is vital to ensure delivery reliability and coordination. It is possible to reduce the number of suppliers and distances between them, to certify their quality, to form long-term partnerships with them, and to evaluate them based on cost-drivers and improvement trends. It is vital to be pulled by the market, which demands tiny batches with high variety and regularity in order to support just-in-time replenishments. Furthermore, pull production systems such as TPS, when combined with the above-mentioned just-in-time methodologies, recognize the Zero target (*Kumar et al., 2007*). For example, Kanban strives to minimize inventory levels; TQC (Total Quality Control) focuses on defect elimination; TPM aids in the elimination of breakdowns; and finally, Sekkei Kanri provides for a faster time to market (*Koudate, 2003*). Of course, the Zero method must be executed and completed on a daily basis with a Kaizen attitude.

3 Theories supporting implementation

In this chapter, the theories and concepts linked to the implementation of entire thesis will be explained in detail.

3.1 Horizontal Integration/Diversification

Horizontal integration is likely the most prevalent expansion strategy, as it seeks ownership or control of a company's competitors. Thousands of competitor mergers, acquisitions, and takeovers take place each year. Almost all of these deals are aimed at increasing economies of scale and facilitating the transfer of resources and capabilities. The five criteria below show when horizontal integration is a particularly effective method:

- Without being challenged by the federal government for “significantly” reducing competition, a business might acquire monopolistic characteristics in a certain area or region.
- In a booming industry, an organization competes.
- Economies of scale provide significant competitive benefits..
- An organization has both the financial and human resources required to successfully manage growth.
- Competitors are struggling due to a lack of managerial skills or a requirement for certain resources that an organization has. Horizontal integration would not be appropriate if competitors were performing poorly, as this would result in a drop in overall industry sales. (*Fred R.David & Forest R.David ,2017*).

3.1.1 Potential drivers for Horizontal Integration

Horizontal integration is the result of four possible value-creating drivers: exploitation of scope economies, stretching corporate management competencies, exploitation of superior internal processes, and boosting market dominance (*Lichtenthaler, 2005; Van de Voorde & Vanelslander, 2009; Johnson et al., 2015*). To begin, let's look at the first potential driver: economies of scope, which refers to increasing efficiency by leveraging existing talents and resources to enter new markets. This driver is most common in companies with underutilized resources. For the most part, the competences and capacities are not completely utilized. This permits the organization to apply such competencies and capabilities to other activities (*Rumelt, 1982*): for example, a hotel that only lets its guests to utilize its integrated fitness center is not maximizing the facility's potential. A fitness center has more potential capabilities than simply adding value to a hotel stay: in other words, it has the ability to be more than just a supplement to the primary business.

The second driving, corporate management competences stretching, is quite similar to the first driver, scope economies. Corporate management competences are stretched by utilizing the potential skills of talented people (*Lichtenthaler, 2005*). New activities can be implemented with the help of professional management. The logic is that by dispersing managerial skills across the portfolio of operations, they would be fully used.

The third driving, leveraging better internal processes, is based on the idea that internal procedures within a corporation might be more efficient than widely used external processes in a free market. This means that when a developing market's labor or capital markets aren't developed enough to meet demand, conglomerates or diversified enterprises can compensate for the lack of external resources by relying on their own internal processes. Even when a conglomerate's various business segments have no functioning relationships with one another, this phenomena makes sense. Conglomerates that are well-organized have the ability to mobilize assets, retrain employees, and shift managers. (*Lichtenthaler, 2005*).

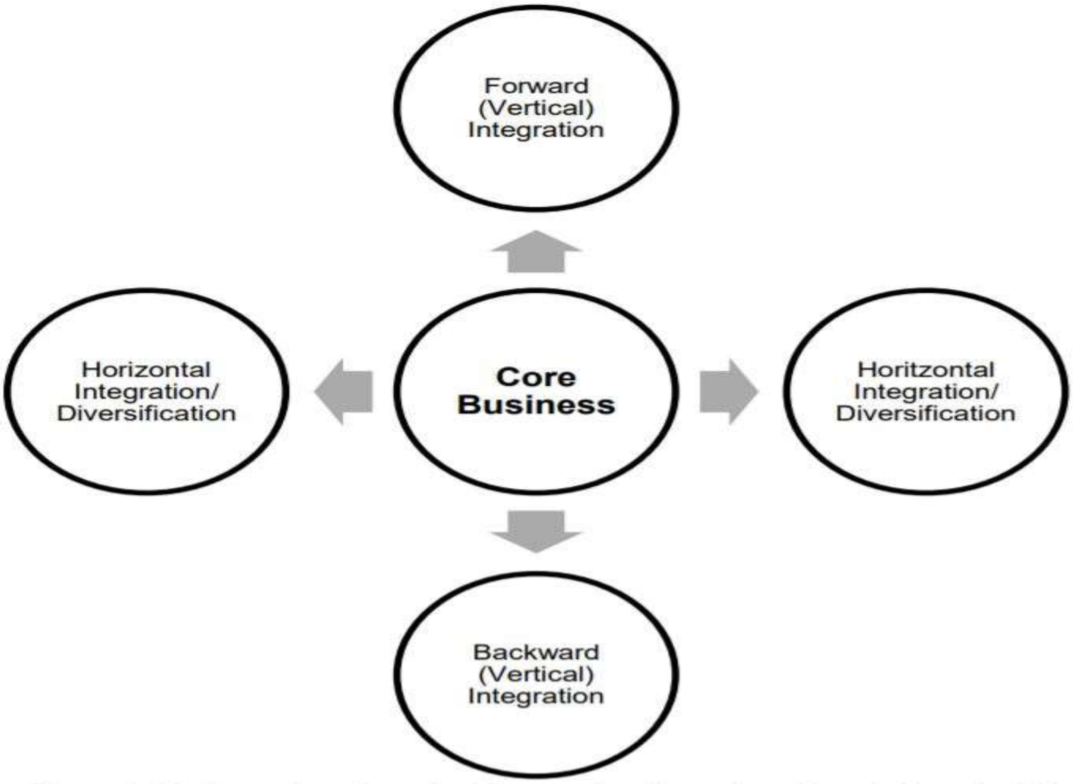

Figure 3.1: Horizontal and vertical integration
(*Van de Voorde & Vanelslander, 2009*)

The last driver, which increases market power, refers to an entirely different perspective: competitive advantage. Being active in a variety of markets may result in increased market power over the competitors (*Van de Voorde & Vanelslander, 2009*). Conglomeration allows 'business A' to be strengthened using resources from 'business B.' This allows the conglomerate or diversified corporation to gain market power: for example, prices in 'product market A' can be artificially kept low by subsidizing 'business A' with, for the time being obsolete, assets from 'business B.' By making strategic decisions, the diverse corporation is able to strike a balance between its many operations. There is one thing that all four possible value-creating drivers have in common. They occur as a result of horizontal integration's synergetic effect. This means that the activities' talents, capabilities, or assets complement one another, resulting in a combined surplus of advantages. The phenomenon of synergy occurs when the combined effect of two actions is larger than the total of the two activities individually (*Scott Morton, 2002*).

3.1.2 Effects of Diversification

The reasons for choosing a diversity strategy, as well as the impacts of diversification, are examined here.

Diversification tactics are employed by the great majority of organizations. Especially when the market or the business is experiencing satiety and, as a result, growth rates are slowing (*Lichtenthaler, 2005*). (*Ansoff, 1957*) links diversification with changes in the characteristics of the company's product line or the market in which it operates in one of the most well-known publications on diversification strategies. In contrast to market penetration, product development, and market development, Ansoff (1957) typified growth tactics with the other (*Figure 3.2*). Other forms of changes in product attributes and market structure emerge as a result of this (*Ansoff, 1957*). In practice, diversification refers to a company's expansion of both its products and markets. These additional initiatives may or may not be related to the company's present portfolio. (*Lichtenthaler, 2005*).

Figure 3.2: Growth strategies (*Ansoff, 1957*)

3.1.3 Diversification Strategies

A company can diversify in multiple ways, with as starting point its own current market and competences. According to Lichtenthaler (2005) companies can choose between three types of diversification strategies, based on growth stages: disruptive, pioneering and buy & build strategy (*Figure 3.3*). When a company is intended to enter an existing market, it implements a disruptive strategy (*Lichtenthaler, 2005*). Entering an existing market is possible in the situations of possessing the required competences or not possessing the required competences. In both, situations will be switched to a disruptive diversification strategy. However, this is in essence only possible when the company can gather a competitive advantage, which is exploited in a disruptive manner. The bigger the competitive advantage, the easier the entry to the market (*Adner & Levinthal, 2002*). Hence, the competitive advantage has to be sufficiently large to be from disruptive nature.

In a second situation, an existing market can also be targeted without having the necessary competences available, but where possessing this competences on the other hand is a requirement. In this kind of situation a buy & build strategy is recommended (*Figure 3.3*). This strategy implies that external capabilities are being attracted to achieve effective growth in competences: e.g., when

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the market is partitioned or when companies in that market are about to be restructured, the appropriate strategy is to incorporate these companies partially or to cooperate with them. These companies will be used as a growth platform, in order to enter the market and capture market share. The last option, pioneering strategy, is used when a company is about to enter a new market (*Figure 3.2*). Entering new markets occurs mainly when these markets are in an early stage. The diversifying company generally possesses the required competences. However, entering a new market without the necessary competences belongs to the possibilities as well (*Lichtenthaler, 2005*).

The three diversification strategies all relate to the current state of the business life cycle of the company. This implies that the used strategy is connected with the internal growth of the company. A pioneering strategy is often used in the early stages of the company's business life cycle: i.e., the emergence and growth stages. The buy & build strategy and the disruptive strategy mainly concern respectively the middle and later stages of the business life cycle.

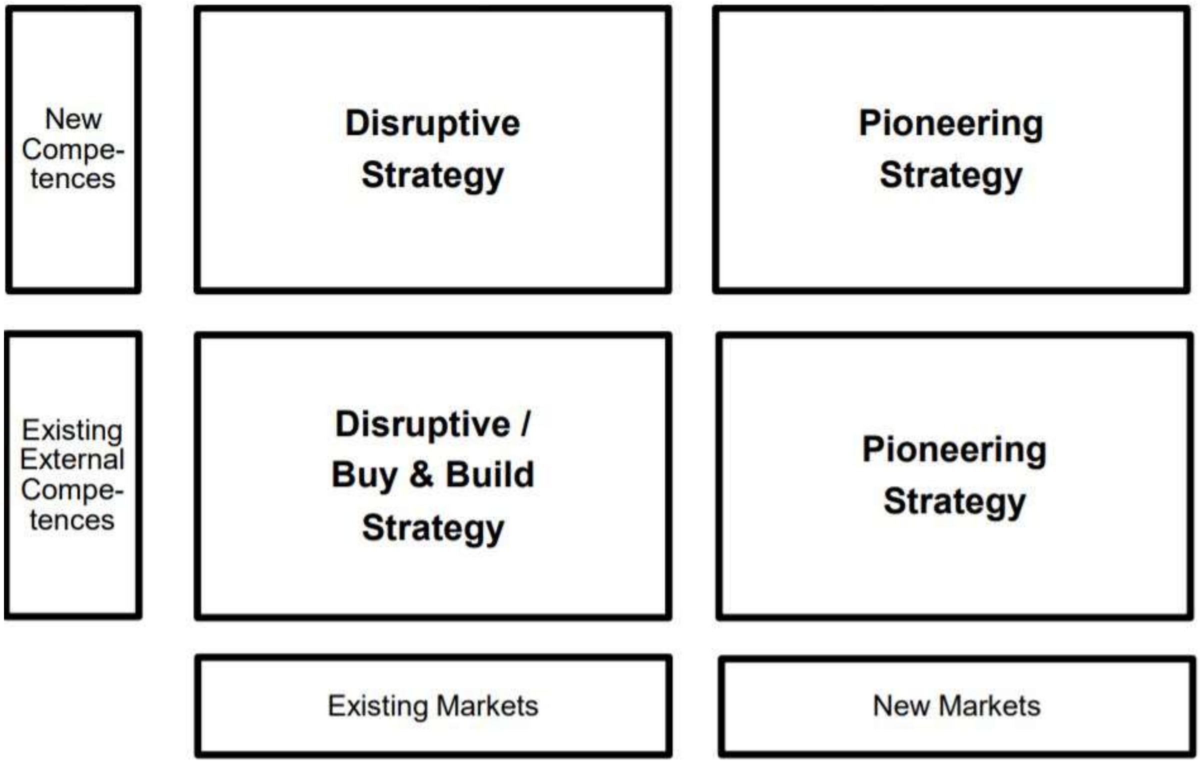

Figure 3.3: Diversification strategies
(*Lichtenthaler, 2005*)

3.1.4 Diversification effects

Several papers about economic performance of diversification arrive at different outcomes, due to the variety in measurement methods. Where strategic management literature is mostly based on the classification scheme of Rumelt (1974), literature concerning business organisation does not go beyond simple measurement of product diversity of a company's operations (*Choi et al., 2011*). Fundamental difference between both types of methodology is the distinction between related and unrelated diversification. The classification scheme of Rumelt takes the relative value of diversification into account, with respect to the core business: i.e., what is the correlation between the performance and the degree of diversification? By contrast, this phenomenon has not taken into consideration by researchers in literature concerning business organisation (*Montgomery, 1982*).

In order to develop his classification scheme, Rumelt (1974) identified the shortcomings of the previous diversification performance measurements and devised a method to counteract this phenomenon. He designed a categorical measurement which merges three critical elements: (1) the company's commitment with respect to diversity, (2) the company's competences that enable the diversification and (3) the degree of relatedness between the new and the old activities. Subsequently, he subdivided the diversified companies into nine different categories by using a range of quantitative criteria. With this categorisation it became possible to analyse a sample of diversified companies on economic performance. Concluding that companies with a diversification strategy that is restricted to a limited range of activities have shown significant higher performance than other types of companies within the study. Adding that the range of activities of these diversified companies all fall within the competence of the company: i.e., related diversified companies show better profitability compared to unrelated diversified companies (*Rumelt, 1974; Palepu, 1985; Choi et al. 2011*).

In practice switching to a diversification strategy is not easy. Companies struggle with finding new opportunities and preparing the internal organisation for this change in business strategy. First, the decrease of research & development (R&D) intensity, due to the reduction of budgets, is an important struggle which results in declining diversification intentions. On the other hand, increasing R&D budgets can lead to saturation of available technologies. This makes developing new innovations and thus entering into new business opportunities, to an increasingly scarcity. Furthermore, companies have trouble recognising potential future growth markets. Intensions may be clear, but the knowledge how to start and how to proceed in generating new business opportunities is lacking. Next to these internal struggles, additional difficulties are identifiable in the external environment: e.g., the barriers of entry have increased due to growth markets that become global in no time. This makes it more difficult to enter the market for companies that aim to diversify (*Lichtenthaler, 2005*).

Horizontal Integration examples:

Acquiring company	**Acquired company**
Amazon.com	Whole Foods
Porsche	Volkswagen
Daimler Benz	Chrysler
Kraft Foods	Cadbury
Quaker Oats	Snapple
Pepsico	Quaker Oats
Pfizer	Wyeth
Pfizer	Pharmacia Corporation
Glaxo Wellcome	SmithKline Beecham
AT & T	T-Mobile

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AT & T	Bell South
Mittal Steel	Arcelor
HP	Compaq
Oracle	PeopleSoft
Delta	Northwest Airlines
United Airlines	Continental
JPMorgan Chase	Bank One
Microsoft	Taleo
Microsoft	Yahoo!
Apple	AuthenTec
BP	Amoco

Table 3-1: Horizontal Integration examples
(*Strategic Management Insight*)

Advantages of the strategy:

- Lower costs- As a result of HI, there is now a single larger firm that can provide more services and goods. Greater economies of scale and efficiency result from increased output.
- Increased product or service differentiation- The combined firm will be able to provide more product or service features.
- Increased market power- A larger corporation has more clout with its suppliers, distributors, and customers.
- Less fierce competition- As a result of industry consolidation, there are fewer companies functioning in the industry.
- Integration with a company that produces the same items but operates in a different region or serves a different market niche might provide access to new markets and distribution channels.

Disadvantages of the strategy:

- M&A rarely adds value to firms; instead, it destroys it. Because projected synergies never materialize, M&As frequently fail and undermine the value of the companies involved.
- Legal ramifications- HI has the potential to create a monopoly, which many countries oppose due to a lack of competition. As a result, most larger mergers and acquisitions require government approval before they can take place.
- Reduced flexibility- Large firms are more difficult to manage and less adaptable when it comes to presenting new products to the market.

3.2 Horizontal Deployment (Yokoten)

Yokoten is a Japanese word that means "horizontal deployment." It refers to the technique of transferring positive kaizen outcomes from one area to another. Yokoten is a Japanese phrase that approximately translates to "everywhere." It implies "best practice sharing" in the Japanese lean method. The word was coined by Toyota to describe the horizontal movement of information and knowledge inside a company. Yokoten fosters data exchange within the company. Yokoten literally means "to spread across or proliferate." This is analogous to the natural process of saplings multiplying from a large tree to many new ones. The new trees will flourish in the right soil and weather. Each new tree, on the other hand, will grow and adapt to its specific surroundings in its own way. The trees are not clones, but they have their own personality. This is also true of Yokoten. It is not merely a case of "see and copy." Yokoten is more horizontal, or peer-to-peer, in that people are encouraged to go see for themselves and understand how another region implemented kaizen. At Toyota, Yokoten, there is an expectation that duplicating a good concept would be followed by kaizen. Within organizations, there is a wealth of untapped information. Over the last two decades, businesses have invested millions of dollars in knowledge management systems to fight this. Yokoten, as a knowledge management tool, organizes rather than individualizes knowledge. Yokoten is a two-way street that requires intentional effort from both those acquiring and expanding knowledge and those who could benefit from a better grasp of what it takes to succeed. People are more likely to be interested in what others are doing and how they are doing it if they see others succeeding. Sharing best practices is an important aspect of any organization's success. Individual experiences are important, but learning from the experiences, failures, and accomplishments of others is more easier and more successful.

Figure 3.4: Horizontal Deployment
(*Kaizen institute of India*)

Much of best-practice knowledge is unwritten, residing in people's thoughts and difficult to document. As a result, most best-practice initiatives incorporate two crucial elements: explicit knowledge, such as a best-practice database (linking individuals with information), and tacit knowledge-sharing mechanisms, such as communities of practice (connecting people with people). Communities of practice are groups of individuals who share a concern or a passion for something they do, and who learn how to do it better by interacting with one another on a regular basis. These two approaches are mutually beneficial. A database can provide enough information for a potential best practice user to locate it and determine whether it is worthwhile to pursue further. The greatest way to share best practices, however, is "on the job," therefore communities and personal interaction with those who have employed the best practice are essential. Yokoten is an important aspect of a lean culture's long-term performance, but it may also have a significant impact on short-term results. Yokoten is a multiplier of success. Senior executives must actively go visit, recognize good work, and insist that others go see as well. Management must organize effective kaizen project presentations and ask colleagues to attend and learn. Leaders of teams and departments must actively involve members in studying kaizen examples, motivating them to begin kaizen on their own. Yokoten must be added to project leaders' and continuous improvement specialists' checklists, and they must follow up diligently. Regardless of where you are on your lean journey, concentrating on the acquisition and transfer of knowledge and learning, as encapsulated in the Yokoten idea, can have a huge impact on the overall outcomes and success of lean programs. (*Anthony Manos & Chad Vincent, 2012; Mukesh Mare, 2013*).

3.2.1 Yokoten fit with Kaizen

The yokoten activity occurs in step 8 of the TBP (Toyota Business Practice) 8-step practical problem-solving procedure. Yokoten occurs in the Act (A) stage of the PDCA cycle. (*Masaaki Imai, 2012; Tracy & Ernie Richardson, 2017*)

1. Clarify the problem
2. Break down the problem
3. Set a target
4. Analyse the root cause
5. Develop countermeasures
6. See countermeasures through
7. Evaluate both results and process
8. Standardize successes, learn from failures

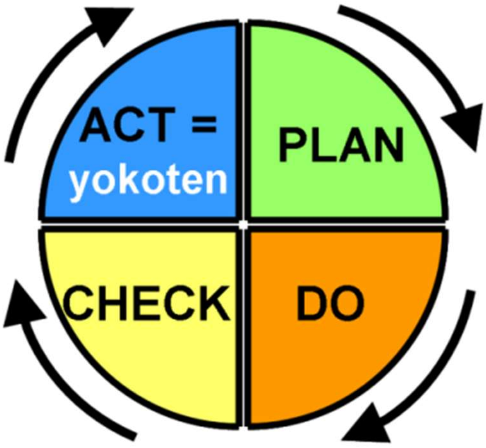

Figure 3.5: Toyota Business Practice
(*Masaaki Imai, 2012; Tracy & Ernie Richardson, 2017)*

3.2.2 Implementing Yokoten

"The answer to the question "How do you do yokoten?" is pretty easy and can be summed up in one word: "communication". Senior executives must actively go see, recognize good work, and demand that others go see as well. Management must organize effective kaizen project presentations and ask colleagues to attend and learn. Leaders of teams and departments must actively involve members in studying kaizen examples, motivating them to begin kaizen on their own. Project managers and continuous improvement specialists should add yokoten to their to-do lists and track it closely.

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Another Japanese term is frequently associated with the development of yokoten culture. It is called kaze toushi, and it technically means "ventilation" or "wind blowing through," but it refers to an organization's openness or ease of communication. When there is a lack of ventilation or information flow, yokoten does not occur. To accomplish yokoten, simply begin sharing improved methods and asking for help from others. As habits, norms, and incentives that obstruct the flow of information and the sharing of success and failure are identified, kaizen at the organizational or system level becomes a possibility. (*John Miller, 2020*)

3.3 Benchmarking

Benchmarking is a strategy that compares the performance of company processes and products to the best in the industry and outside of it.

Benchmarking is the process of looking for industry best practices that lead to better results. (*Camp, R.C,1989*)

3.3.1 Understanding the tool

When competing, comparing your own company to a competitor is critical. You never know how successful your market performance is or whether you accomplish one or more tasks better than your opponent if you did not have it. For example, 85 percent customer satisfaction may appear to be excellent for you or even the industry average, but what if some other companies (not necessarily competitors) attain a score of 97 percent? In this case, your 85 percent satisfaction percentage does not appear to be that impressive. Managers utilize benchmarking to better understand their situation and improve their company's performance.

Since the 1800s, firms have employed some type of comparison, which mostly comprised product quality and feature comparison. Until the late 1980s and 1990s, when Xerox launched the process benchmarking technique, this form of comparison was rarely used and did not become a valuable management tool (*Spendolini,1992*). This type of comparison proved to be quite advantageous, and Xerox, AT&T, and other corporations began benchmarking their operations against industry best practices. Benchmarking has evolved into a modern strategic tool, as shown in the table below:

1950-1975	Reverse engineering
1976-1986	Competitive benchmarking
1982-1986	Process benchmarking
1988+	Strategic benchmarking
1993+	Global benchmarking

Table 3-2: Benchmarking history
(*J. Blakeman, University of Wisconsin-Milwaukee*)

Benchmarking, as defined by Camp (1989), is simply "finding and implementing the best business practices." Managers can use the application to find best practices in other firms and adapt them to their own procedures to improve the company's performance. Without a question, the most crucial purpose of benchmarking is to improve a company's performance.

3.3.2 Other uses of the tool

- **To disclose successful business processes-** It's not always evident how high-performing firms get there. You can find the processes, abilities, or competences that contribute to an organization's success by studying and evaluating similar businesses, and then applying those practices to your own.
- **To make knowledge sharing easier-** The knowledge you've gained about other businesses can easily be transferred to your own.
- **To obtain a competitive advantage-** If a corporation incorporates best practices from other industries to its own, it can gain a competitive advantage. To attract attention and earn new clients, a small family-owned farm selling its own agricultural products online may use the same social media methods as internet blogs. This would be a novel technique to get clients, and it could result in a competitive edge, at least in the short term.

3.3.3 Popularity

Of all the corporate planning tools, this is one of the most well-known and widely used. According to a survey conducted by The Global Benchmarking Network (*Global Benchmarking Network, 2010*), businesses adaption of the technique ranges from 68% for informal benchmarking to 49% and 39% for performance and best practice benchmarking, respectively. In addition, Bain & Company's annual surveys (*Bain & Company, 2013*) show comparable outcomes.

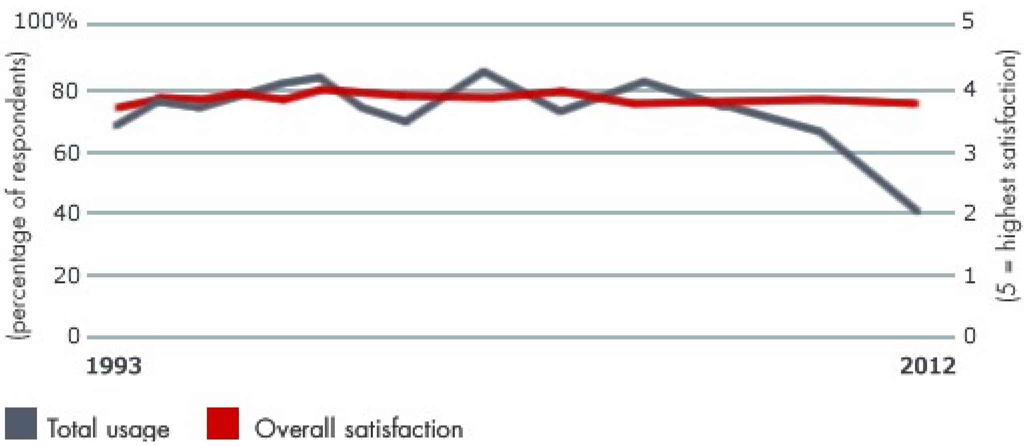

Figure 3.6: Benchmarking usage survey
(*Brain & Company*)

The graph demonstrates that, despite the tool's high level of satisfaction, its use has decreased from its peak in 1999. Despite this, benchmarking remained the world's fourth most popular business tool in 2013 (*Rigby & Bilodeau, 2013*).

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3.3.4 Types

There are different types of benchmarking the managers can use. Tuominen (*Tuominem,1997*) and Bogan (*Bogan & English,1994*) identified these 3 major types:

Strategic benchmarking:

Managers utilize benchmarking to determine the most effective approach to compete in the market. During the process, the companies find winning methods used by successful companies (typically outside their own industry) and apply them to their own strategic approach. It is also typical to compare strategic objectives in order to identify new strategic options.

Performance benchmarking:

It is all about comparing and contrasting your company's products and services. According to Bogan & English (*Bogan & English,1994*), the instrument primarily measures product and service quality, features, pricing, speed, dependability, design, and customer happiness, but it may also measure anything with measurable metrics, such as processes. Benchmarking determines how good our products and services are in comparison to those of our competitors.

Process benchmarking:

It necessitates examining other businesses that engage in comparable activities in order to uncover best practices that can be applied to your own operations to improve them. Process benchmarking is a different type of benchmarking than performance benchmarking, yet it frequently stems from performance benchmarking. This is because corporations first identify their products or services weak competing points, then focus on the main procedures to fix such flaws. For example, a company utilizing performance comparison discovers that its product ‘X' has better features, manufacturing quality, and design than a competitor's product ‘Y,' but is more expensive. The company then evaluates which procedures contribute the most to the product's cost and looks for ways to enhance them by examining similar but less costly processes in other organizations.

3.3.5 Approaches

Benchmarking can be done in four different methods, in addition to the categories. It is critical to choose the ideal path because it lowers the activity's costs and increases your chances of finding the "best standards" you can rely on.

Internal benchmarking:

The same operations and procedures are generally done by separate teams, business units, or divisions in large enterprises that operate in different geographic areas or manage many goods and services. As a result, procedures that function well in one division may perform poorly in another. Internal benchmarking is a method of comparing the work of different teams, units, or divisions in order to identify which ones are performing better and to share that information with other teams within the firm in order to achieve higher performance. It is most commonly used by businesses that have recently grown geographically but haven't yet established proper knowledge-sharing mechanisms between divisions. There is no need to employ internal benchmarking to find best practices if such mechanisms are in place.

External or competitive benchmarking:

Although some authors use these phrases interchangeably, there are a few distinctions. To begin, competitive benchmarking is a procedure in which a company compares itself to its industry's competitors. External benchmarking, on the other hand, searches both within and outside the industry for best practices, thereby includes competitive benchmarking (*Kulmala, J*). Second, competitive benchmarking, will only be used to compare products and services in conjunction with performance benchmarking. Strategic or process benchmarking will not be feasible solutions because finding a competitor willing to provide sensitive information will be difficult. Furthermore, external benchmarking is a better strategy to adopt because the chances of identifying the best practices are higher.

Functional benchmarking:

Managers of functional departments find it valuable to compare their functional area's performance to that of other firms' functional areas. It is simple to find the top marketing, finance, human resources, or operations departments in other organizations that excel at what they do and adopt their strategies to your own. Companies may now look at a wide range of organizations, even those that are unconnected, and instead of enhancing individual processes, they can enhance entire functional areas.

Generic benchmarking:

It refers to comparisons that "focus on good work processes rather than on the business practices of a particular organization," according to Kulmala (*Kulmala, J*). For instance, let us say your company wants to strengthen its marketing capabilities and compares itself to company "A". When you look at a company's "A" marketing procedures, you can see how successfully its human resources are managed utilizing "big data" analytics. This gives you an idea of how to set up a data collection and analysis team in your own firm to improve overall performance.

Comparing your procedures to commonly known best practices is another type of generic benchmarking. Every firm, for example, aspires to become a learning organization because learning organizations are better suited to face obstacles and react to market changes. You would be employing generic benchmarking if you compared your firm to some basic standards that would suggest that your company is a learning organization. The types and ways to benchmarking are summarized in the diagram below:

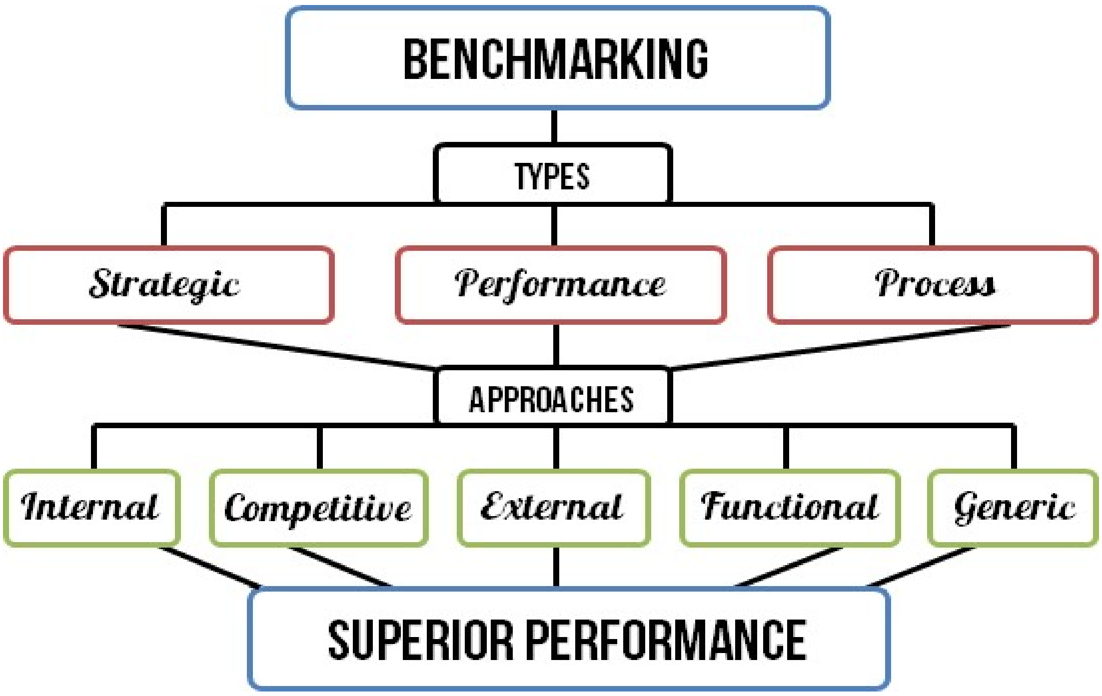

Figure 3.7: Benchmarking types and approaches

Advantages:

- Simple to comprehend and apply.
- It is a low-cost activity with a big payoff if done correctly.
- Contributes to the company's innovation.
- Gives you an understanding of how other businesses manage their operations and processes.
- Makes you more aware of your costs and level of performance in comparison to your competitors.
- Encourages collaboration among teams, units, and divisions.

Disadvantages:

- You have to find someone to benchmark with.
- It is not always possible to assign a metric to a procedure.
- It is possible that you will need to engage a consultant.
- If your company is not used to it, the start-up expenditures could be significant.
- Changes that are required to increase performance are frequently resisted by managers.
- Not all best practices will apply to your entire organization.

3.3.6 Using the tool

Organizations utilize benchmarking frequently, although no standardized process for conducting it has been created. Each company develops their own approach to utilize the tool. We present guidelines (*Blakeman,2002*) to make the procedure easier before revealing some of the examples.

Guidelines:

- Select only the products, services, or processes that are ineffective. Comparing the processes you excel in is a waste of time and money that won't provide the desired results.
- Define the metrics or procedures that will be measured. You will not be able to compare it adequately if you chose too broad procedures that cannot be assessed.
- Get your firm ready for change. To incorporate new best practices, your business must overcome opposition to change.
- Select the most qualified team. Although benchmarking is simple to implement, you should not entrust it to just anyone. Include the people who will be in charge of executing the modifications as well as those who are knowledgeable about it.
- Join benchmarking networks and use relevant software to make the process easier. Participating companies can identify benchmarking partners or obtain data for the metrics they need through a variety of benchmarking networks. This type of engagement speeds up the process by lowering the costs and time spent seeking for the relevant data.
- Even in unrelated sectors, look for the highest standards and ideas. Observing companies that are absolutely unrelated to your organization will lead to several valuable findings.

3.3.7 Benchmarking Wheel

The benchmarking wheel model, as described in the article "Benchmarking for Quality" (*Shah & Kleiner, 2011*), is a five-stage method developed after studying more than 20 existing models.

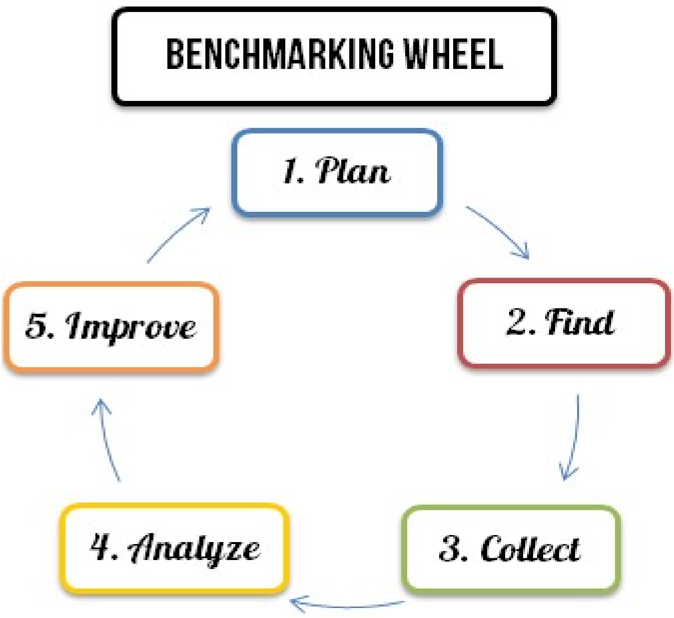

Figure 3.8: Benchmarking Wheel

It is quite straightforward and consists of the stages listed below.:

- **Plan-** Assemble a group of people. Define exactly what you are comparing and attach metrics to it.
- **Find-** Identify benchmarking partners or information sources from which you will be able to gather data.

- **Collect-** Select the methods for gathering data and collecting information for the metrics you had set.
- **Analyse-** Compare the indicators and determine the performance difference between your company and the observed organization. Provide the findings as well as suggestions for how to enhance the performance.
- **Improve-** Make the necessary adjustments to your products, services, procedures, or strategy.

4 Enterprise Resource Planning

This chapter presents a detailed explanation about Enterprise Resource planning, models of implementation its role in Digital transformation along with a supporting case study.

4.1 Introduction

ERP is described as a system for effectively planning and controlling the resources needed to take, create, ship, and account for client orders in a manufacturing, distribution, or service company, according to the American Production and Inventory Control Society (2001) (*Chen C,2003*). The seamless integration of all information moving through the organization, such as financial, accounting, human resources, supply chain, and customer information, can be accomplished through a software package solution given by vendors [*O'Leary, 2000*].

As a result, ERP software is all-encompassing since it allows you to manage all departments in one integrated system, from manufacturing to distribution and accounting. In this way, the method reduces operating expenses, makes day-to-day management easier, and allows for overall strategic planning of operations. It will enhance proper operation of corporate processes and increase profitability if personnel are properly trained on correct ERP (*Ross J-1998, Umble E-2003*). Modules are integrated and allow seamless data flow between modules, boosting operational transparency through standard interfaces. Because the project provides an opportunity to reengineer processes in accordance with the ERP model used, it is also an opportunity to revitalize the entire company for competitiveness.

4.1.1 ERP Overview

From material requirements planning (MRP) (*Orlicky, 1975*) to capacity requirements planning (CRP) to manufacturing resource planning (MRP II), ERP represents the most recent stage in the evolution and expansion of production planning and control systems for manufacturing businesses (*Wight, 1982; 1984*). Dow Chemical Company purchased its first ERP manufacturing module from SAP AG of Germany in 1988, and MRP II systems began to evolve into ERP systems (*Schaaf, 1999*). The Gartner Group of Stamford, Connecticut, coined the phrase "Enterprise Resource Planning" to describe systems that are designed to plan and schedule all of a company's internal resources. During the years 1988 to 1994, however, the phrases MRPII and ERP were used interchangeably. When SAP AG debuted R/3, its next-generation software, in 1994, the distinctness of ERP systems became even more apparent. R/3 also signaled a move in technology platforms from mainframe to UNIX-based client-server architecture, which has become increasingly common. Manufacturing and certain service firms began to invest heavily in SAP and its major competitors ERP systems, such as Oracle, Baan, PeopleSoft, and J.D. Edwards, in the following years. Because the activities associated with planning and deploying ERP are typically more expensive than the software package itself, consultants and systems integrators have jumped into the implementation industry with both feet. In 1998, the ERP-related revenues of each of the five consultancy and systems integration industry leaders exceeded $1 billion (*Escalle et al., 1999*). According to Advanced Manufacturing Research (AMR), one of the leading ERP industry analysts, the ERP market for software sales and auxiliary services will approach $50 billion in annual revenues by 2002. ERP systems are made up of a collection of software modules, each of which is in charge of gathering and processing data for a specific business function, or a group of related business functions. Accounting, master scheduling, material planning, inventory, forecasting, finite scheduling, distribution planning, and other ERP software modules may be included. An ERP system integrates all of a company's functions by allowing modules to freely share and transfer data (*Hicks and Stecke, 1995*). Furthermore, all data is centralized in a single relational database that is accessible by all modules, removing the need for duplicate entries of the same data. While large companies typically fund substantially for ERP and may implement a large number of available modules (*Chalmers, 1999*), smaller companies commonly take a piecemeal approach, beginning with a few modules or components of each module (*Ferman, 1999*). Customers and suppliers with network security clearance can use an external communication interface to access specific sorts of data.

4.2 ERP Benefits and implementations

Many industry publications extol the charms of ERP and its potential to provide multiple benefits to businesses who adopt these systems successfully. The capacity to integrate corporate operations is one of the fundamental goals for implementing ERP, as well as one of its main benefits (*Brakely, 1999; Davenport, 1998, 2000*). Customer satisfaction has also been proven to be aided by ERP implementation. NEC Technologies, for example, attributes its ERP implementation to increased order processing speed, improved invoicing, and substantially reduced customer support response times (*Michel, 1997*). ERP has also been shown to help businesses cut inventory costs, improve efficiency, and boost profits (*Appleton, 1997; Brakely, 1999*). Furthermore, ERP has been attributed with shortening production lead times (*Goodpasture, 1995*). Other potential ERP benefits include significant inventory reductions, breakthrough working capital savings, a wealth of information about customer wants and needs, and the capacity to view and manage the extended enterprise of suppliers, alliances, and customers as a single entity. However, it should be mentioned that not all businesses who have implemented ERP are happy with the results of their investments. Many companies regard their implementation efforts as failures. For example, the $5 billion pharmaceutical company FoxMeyer Drug just declared bankruptcy. According to FoxMeyer, severe issues were caused by a faulty ERP system, which resulted in excess shipments due to improper orders (*Bicknell, 1998; Boudette, 1999*). Dell Computer also ditched its ERP system, arguing that it was too rigid to accommodate their growing global operations. In order to understand why some businesses thrive while others fail in their ERP implementations, it is important to remember that, while ERP systems technological capabilities are well-established, putting them in place is not as straightforward as buying and installing software. Many people believe that, as with any advanced technology systems, management concerns, from strategy to implementation, are key roadblocks to ERP system adoption. The literature has stressed the importance and necessity of empirical investigations on technology planning and implementation difficulties.(*Chen and Small, 1996; Voss, 1988*).

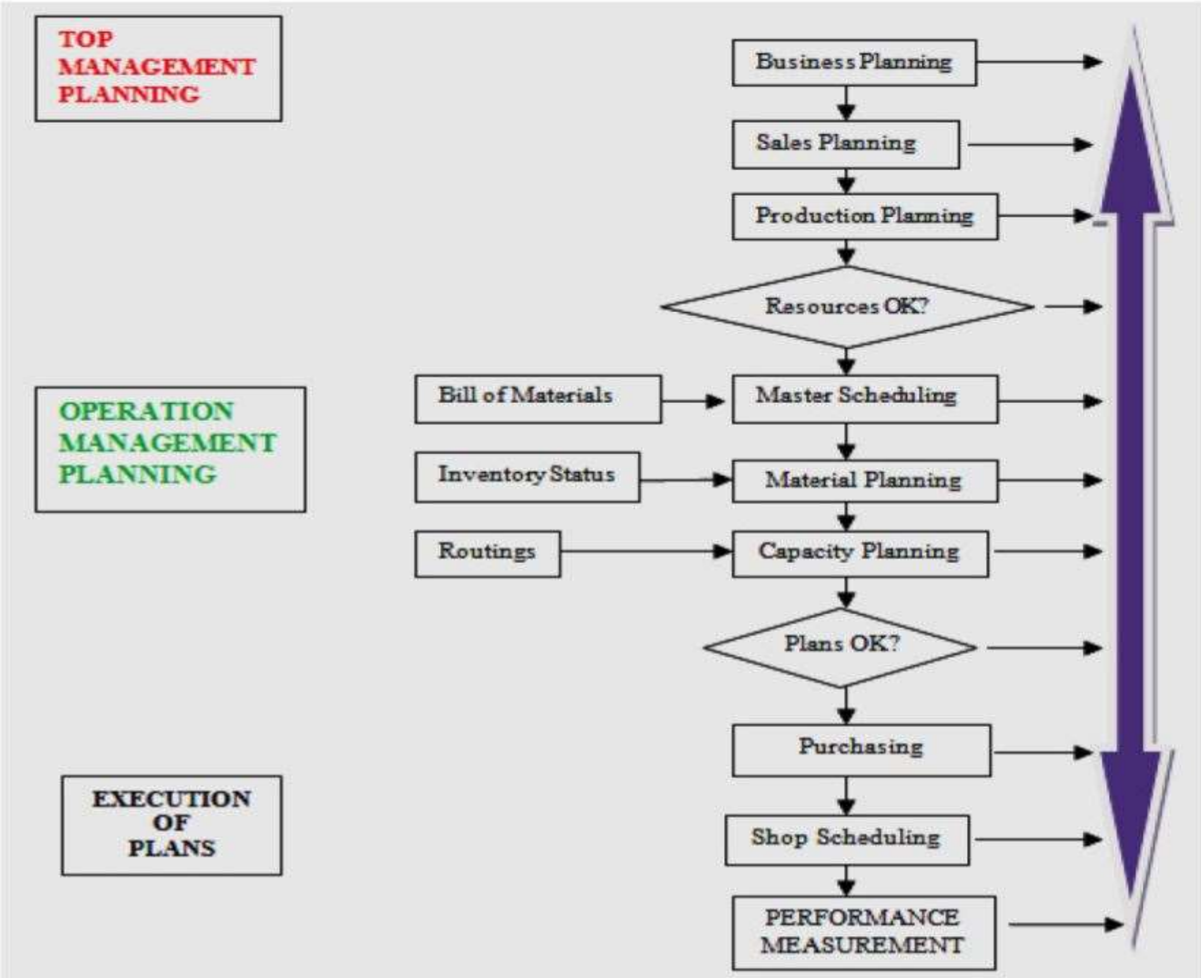

Figure 4.1: Standard ERP Flow chart

4.3 ERP Implementation model

Symix has devised four FOCUS models (*Angappa Gunasekaran, 2008*) for the manufacturing industry to correctly plan and manage its ERP deployment. Business Objective, Rapid, Supported, and Self-Directed are the four models (*Figure 4.2*). There are five phases and seven steps in the FOCUS approach. These steps and their order in the implementation process are depicted in *Figure 4.3*.

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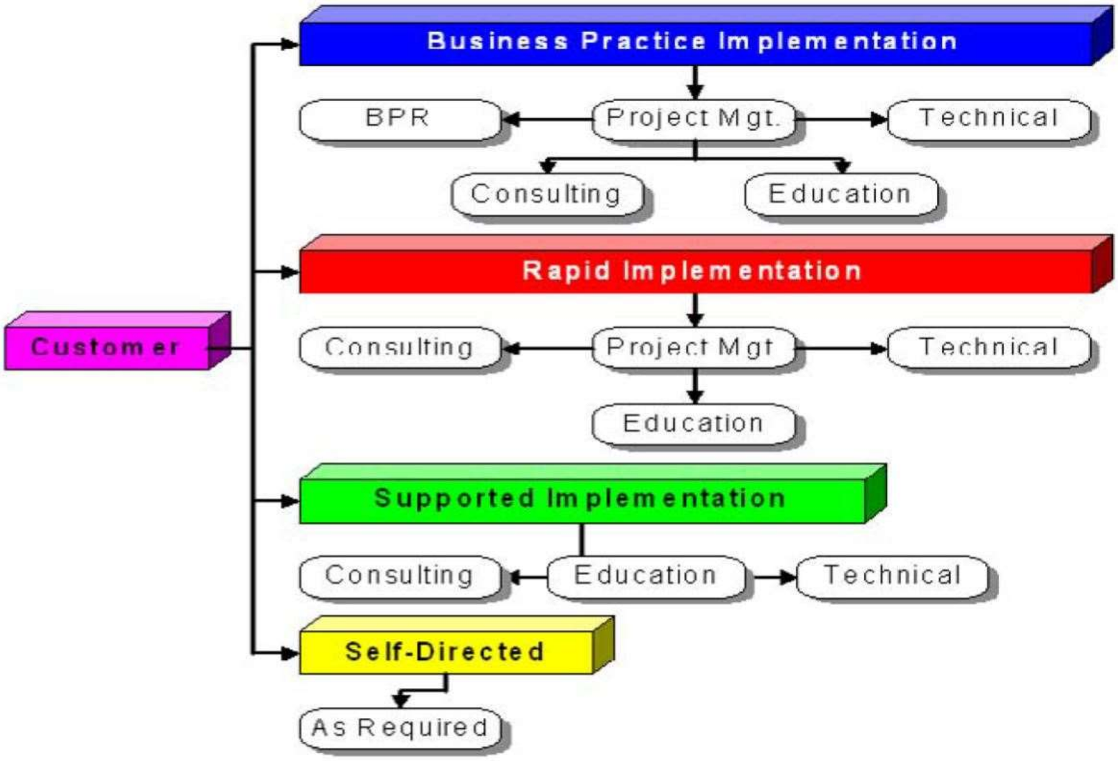

Figure 4.2: Focus implementation models

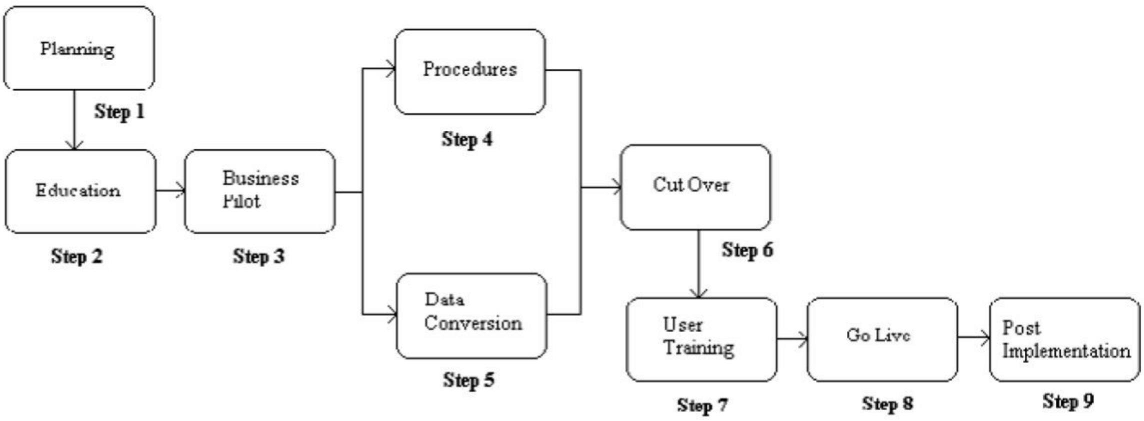

Figure 4.3: Focus implementation steps

4.3.1 Phase 1: Project and Education Planning

Step 1: Implementation Planning

Setting mutual expectations and developing a good working relationship with the customer begins with implementation planning. The consultant must exude confidence and meticulous control over the FOCUS methodology approach.

Step 2: Education Planning

Education is an important part of the FOCUS technique. It is a step in the process of preparing the implementation team. As students, the team members must have a clear knowledge of the education's goal and expectations. The team members will have a solid foundation to comprehend the ERP system and contribute meaningfully and constructively throughout the project after the training.

4.3.2 Phase 2: Business Pilot and Procedures

Step 3: Business Pilot (Conference Room Pilot and Business Simulations)

The members of the team are now starting to think about how they would conduct their business with an ERP system. This process is fraught with emotion, as it will be the ERP system's first genuine test drive, much like buying a new automobile. The users are likewise terrified of failing in this procedure. Following are the steps in the business simulation that the ERP consultant will direct and manage:

- The Process Planning Session (structure, dates, times, data, roles, etc.)
- Simulation Preparation (data elements and outputs).
- Activities for simulating a business system.
- Managing Open Issues and Other Subjects.

Step 4: Developing and Writing Operating Procedures

Individual and departmental processes are structured and controlled using procedures, which provide an overview of the business flow. Workflow diagrams are frequently used to develop procedures. Outline the lines of integration between and within departments as the initial stage in writing processes. Workflow mapping is used for this. During the business pilot, business procedures are normally finalized, and the procedure-building process begins. It is one of the project's most time-consuming jobs.

4.3.3 Phase 3: Cutover and Training

Step 5: Data Conversion

In order to convert existing data to the new system in preparation for the ultimate cutover, data conversion involves data mapping and actual conversion programming. Data conversion program specifications are created to safeguard and reuse current data while also reducing entry and validation processes.

Step 6: Cutover Planning

Cutover planning guarantees that the final system is fully functioning and meets the data requirements of the customer. The ordered specific procedures, responsibilities, and expected length of the cutover are all part of the cutover planning process. The necessary procedures are completed after a consulting session with the implementation team to define the various options and their associated benefits and downsides. Cutover planning also serves as a project checklist for determining the readiness of the organization to go online.

Step 7: End-User Training Process

The final preparation procedures before going online are user training and cutover. In order to establish the appropriate cutover processes, end-users must be trained and a conversion strategy must be created. These two efforts will ensure that the transition from the pilot to the cutover phase is as smooth as possible. In order to avoid a false start or a dangerous cutover with unskilled employees, both steps demand equal effort. Each phase necessitates its own set of processes and planning efforts. Companies that cross train will strive for efficiency in all duties from all members of the team or group.

4.3.4 Phase 4: Go Live

Step 8: Go Live Assistance

Having technical support for the final cutover is critical. This phase has a less organized aim than the others, but it is no less significant. It is utilized to make sure that any issues that develop during the final cutover are dealt with immediately and decisively.

4.3.5 Phase 5: Post Implementation

Step 9: Post-Implementation Review

A formal examination of the customer's system implementation is provided through the post-implementation review. It gives you a way to go over all of the implementation's functions and bring them to a close (i.e., training, functionality, business practices, and month-end closing procedures). It lasts for 30 to 60 days once it's turned on.

For more than 20 years, MAPICS consultants have used FOCUS implementation methods to successfully integrate clients ERP systems. FOCUS implementation models, like most vendor ERP implementation models, are quite beneficial since MAPICS has learned from experience to improve them.

4.4 Case Study

The case study (*Ignatio Madanhirea & Charles Mbohwab*) was conducted at a company in Cape Town, South Africa, that manufactures linen and uniforms for the hospital industry. As shown in

Figure 4.4, the organization's key departments were the Design section, Pattern making section, cutting section, production, and technical services section. Traditional techniques were explored to handle these operational difficulties, with a special focus on the Manufacturing Department, because the business was having trouble achieving delivery deadlines. To address the organization's recurring problem, an ERP system was recommended.

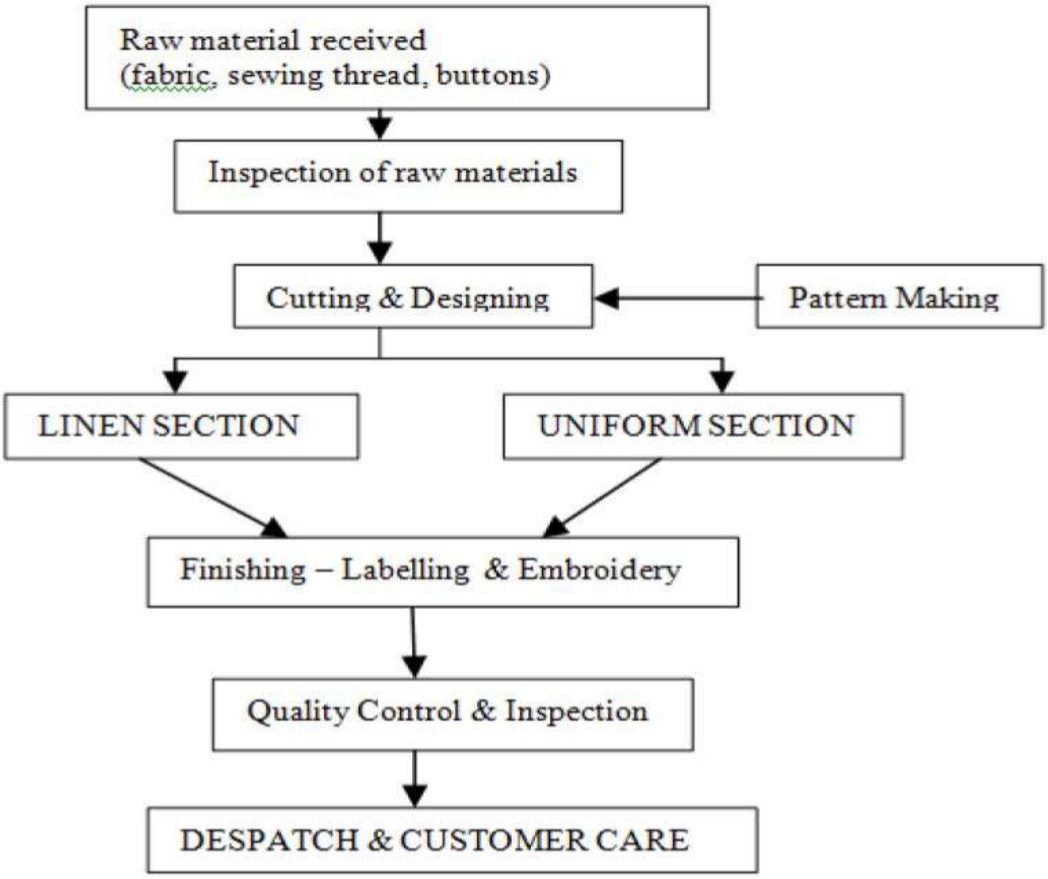

Figure 4.4: Hospitality industry manufacturing process

As shown in *Table 4-1*, the firm produced two main product lines for the hospital industry: linen and uniforms.

LINEN	**UNIFORMS**
Table cloths & napkins	Chef jackets
Curtains	Chef pants
Cushions	Chef caps
Kitchen cleaning clothes	Aprons

Table 4-1: Hospitality industry main product lines

4.4.1 Complications with traditional method (Without ERP)

For capacity requirements planning (CRP), the company used a conservative capacity lag technique. Customers were lost as a result of the inability to satisfy demand, as capacity was only raised after demand had increased. This resulted in delays in the manufacturing process, particularly in the uniform department. Because the activities are not totally automated, new contract workers were hired when demand increased. This meant that training had to be done on a regular basis, putting a pressure on manufacturing productivity because newly hired casuals would be unfamiliar with product needs.

Despite the fact that all of the computer machines were connected to the local network server, there were only a few of them, and a lot of paperwork would flow between departments, requiring a long time to process. The Quality Control Department, which was part of the Production Department, didn't have a computer, thus everything was done by hand. The Linen sector employed the majority of the full-time staff, with 25 people working one 8.5 hour shift every day. Due to human resource issues, records showed that this sector was consistently failing to produce products on time as specified on the Master Production Schedule.

		Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14
Scheduled available hours		4 462.5	5 355	5 355	6 247.5	6 287.5	6 300.5
Scheduled hours earned		3 037.5	4 725	4 725	5 512.5	5 512.5	5 565.5
Actual hours earned		4 412.5	5 310.5	5 226.3	6 225.2	6 238.3	6 268.5
Load		4 455.8	5 340.7	5 330.7	6 240.5	6 240.5	6 285.7

Table 4-2: Linen section production times

		Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14
Efficiency		89.2	89.0	90.4	88.6	88.4	88.8
Utilization		98.9	99.2	97.6	99.6	99.2	99.5
Capacity		3 936.8	4 727.8	4 724.7	5 513.1	5 513.7	5 516.7
Load %		113.2	113.0	112.8	113.2	113.2	114.0

Table 4-3: Linen section capacity data

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Product Type	Product Qty	Duration per product hours
Tablecloth	3	461
Napkin	1	495
Cushion	3	470

Table 4-4: Linen section: Quantity and duration data

Over a six-month period from November 2013 to April 2014, overage efficiency and utilization were projected to be 89.1 percent and 99 percent, respectively. The data for the Uniform Section is shown in *Table 4-2*, which was derived from time sheets and weekly individual reports. *Table 4-3* shows load percentages more than 100%, indicating that the load schedules in this sector were beyond the capacity of the available labor resources. As a result, the majority of the orders would be delayed, and needless costs such as overtime or recruiting more contract workers would be incurred as a result of the panic. This was due to the plant's capacity being exceeded by continual scheduling. The uniform area had a team of nine full-time employees who worked an average of 8.5 hours each day and were unable to meet deadlines.

		Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'14
Scheduled available hours		1 963.5	2 363.5	2 258.5	2 306.5	2 606.5	2 606.5
Scheduled hours earned		1 400	1 658	1 569.2	1 696.8	1 696.8	1 950.5
Actual hours earned		1 564.5	2 009.5	2 065.5	2 098.2	2 264.5	2 363.5
Load		1 645.5	2 020	2 005	2 039.2	2 071.8	2 185.2

Table 4-5: Uniform section production times

		Nov'13	Dec'13	Jan'14	Feb'14	Mar'14	Apr'1
Efficiency		89.5	82.5	76.0	80.9	74.9	82.5
Utilization		79.7	85.0	91.5	91.0	86.9	90.7
Capacity		1 400.6	1 657.4	1 570.6	1698.0	1 696.5	1 950.4
Load %		117.5	121.9	127.7	120.1	122.1	112.0

Table 4-6: Uniform section capacity data

Product Type	Product Qty	Duration per product hours
Chef jacket	3	45.8
Chef pant	4	15
Chef cap	10	88.5
Apron	2	30

Table 4-7: Uniform section: Quantity and duration data

Based on the six-month averages in *Table 4-6*, efficiency and utilization are projected to be 81.1 percent and 87.5 percent, respectively. The data for the Uniform Section is shown in *Table 4-5*, which was compiled using time sheets and weekly individual reports. *Table 4-6* shows that the load percentages are above 100%, indicating that the resources could not handle the load assigned to them in the Master Production Schedule (MPS). Again, more workers are required in order to increase capacity.

When compared to the Linen sector, the Uniform section exhibited lower efficiency and utilization. This was attributable to internal inefficiencies in activity coordination, which resulted in uniform deliveries being delayed.

4.4.2 ERP Installation

The computer hardware structure had to be upgraded to Pentium 4 (P4s) with enormous capacities, which were compatible with ERP software, in order to employ ERP software. Additionally, the number has to be expanded in order to significantly reduce paper work and promote faster information flow and decision-making processes. Competitive software could be purchased from Oracle at the time of the study, but Oracle had to initiate specialist training for shop floor personnel and supervisors.

Because the work schedule was beyond the Linen section's capability based on load percentages, capacity had to be increased. As a result, a number of additional workers must be computed in order for the section to be adequately capacitated for the current demand. Hiring four more permanent employees would be a long-term solution. To solve the problem at Uniform Section, capacity had to be increased by employing 1 more temporary worker for 6 days a month to match the workload. The reduction of any resource wastages in the form of material, energy, inventory, faults, or wasted capacity is another area where ERP could help, thanks to labor control and work-in-progress control. The reduction of product cycle time could be accomplished by minimizing the amount of time spent waiting and processing.

Waiting time can be cut by better coordinating material flow (for example, intermediate and completed products) in the Uniform Section, while processing time can be cut by carefully balancing changeover times and inventory costs. When installing an ERP system, it's critical to cut cycle times. It is accomplished by eliminating setup times and delays, aligning Technical Services maintenance with production operation schedules, and optimizing space to better utilize people, equipment, and workstations.

4.4.3 Conclusion

The project developed an ERP implementation framework, and it was demonstrated how the implementation will improve the manufacturing system's operational efficiency at this linen manufacturing firm. Employee efficiency improved thanks to the ERP system, which allowed data and information to be gathered and updated in one place, eliminating the need for duplication of work and resource waste. The improvement in communication and collaboration among all departments resulted in increased operational efficiency. Inventory levels were updated online, allowing informed decisions to be made in order to meet product delivery deadlines. ERP necessitates enterprise-wide agreement to re-engineer essential business processes by utilizing software to automate information updates and incorporate best practices to promote faster decision-making, lower costs, and increase managerial control for increased organizational competitiveness.

4.5 Types of ERP

The deployment of Modern ERP systems can be in any number of ways: (*Sap-Insights*)

- In a public or private cloud.
- On premise.
- In a variety of hybrid settings involving many ecosystems.

Here are some of the high-level advantages of each to assist you decide which implementation choice is best for your company.

4.5.1 Cloud ERP

The software in cloud ERP is hosted on a provider's cloud computing platform. The supplier is in charge of the system's upkeep. There is also the option of using a public or private cloud, which is gaining popularity due to its inexpensive initial expenses.

4.5.2 On-Premises ERP

This is the classic software deployment model, in which you have complete control. The ERP software is installed in your data center at your preferred locations. It is the duty of your staff to install and maintain the hardware and software.

4.5.3 Hybrid ERP

The hybrid approach is for companies that desire a combination of both to satisfy their business needs. Some of your ERP systems and data will be on the cloud, while others will remain on-premise. This is sometimes referred to as two-tier ERP.

4.6 ERP at any size

ERP is not solely for multinational corporations. Small, midsize, and big enterprises can all benefit from ERP solutions (*Sap-Insights*). To suit specific business requirements, you can also receive industry- and company-specific capabilities.

4.6.1 Small business ERP

Small business ERP software may help you move beyond spreadsheets and efficiently handle all element of your expanding firm, from sales and customer interactions to finances and operations. Small business ERP software is often hosted in the cloud, is simple to set up, and is built to scale with your company.

4.6.2 Mid-Market ERP

Built-in analytics, easy deployment, and best practices for 35 various business processes – financials, HR, supply chain management, and more – are now available in ERP software targeted for mid-market enterprises and subsidiaries. Midsize ERP software enables growing firms to scale and compete without the complexity and cost of larger ERP systems.

4.6.3 Enterprise ERP

To modernize processes, large businesses with global or subsidiary operations require a comprehensive, market-leading ERP system with embedded AI, machine learning, analytics, and intelligent automation. Depending on the business need, ERP systems can be deployed on-premise, on the cloud, or in a hybrid environment. They can work with existing databases or, in the best-case scenario, run on newer, more powerful in-memory databases.

4.7 Key benefits of ERP

Higher productivity	Streamline and automate your essential business processes to enable everyone in your organization to accomplish more with less.
Deeper insights	Get fast answers to mission-critical business problems by eliminating information silos and establishing a single source of truth.
Accelerated reporting	Business and financial reporting can be completed more quickly, and the results can be shared more readily. Act on data in real time to boost performance.
Lower risk	Increase business visibility and control, assure regulatory compliance, and anticipate and avoid risk.
Simpler IT	You may simplify IT and make work easier for everyone by utilizing integrated ERP systems that share a database.
Improved agility	You can swiftly recognize and react to new opportunities if your operations are efficient and you have access to real-time data.

Table 4-8: ERP Benefits

5 Problem Identification and Analysis

This chapter focuses on how we: Identified causes for the three main problems, defined solutions and methodologies to adapt to the solution so that the problems will not repeat in future.

5.1 Identifying and defining the problem

After a tour around LaTv's plant visualizing their work methodologies and meeting with the company's manager regarding the various issues they are facing, I was able to get a rough picture about the reason behind the issues by linking Latv's methodologies with SFIN (*visual management*, *cf section 2.3.3*). We then segregated the problems into three categories:

5.1.1 Time optimization

LaTv was way behind in their overall valve manufacturing duration comparing to SFIN though they manufacture almost the same valves.

We listed out the most common valves both the companies manufactured without any modifications and did a time study comparing their manufacturing stages (*Internal benchmarking, cf section 3.3.5*). There were 27 standard activities in manufacturing a valve. Comparing the duration of each stage one by one, we figured out there were two activities: "Material ordering and In-house machining" for which the time deviation was way beyond the estimate. The case was same for almost all the components. Hence, we decided to point our focus in these two stages and analyze the cause behind it.

5.1.2 Inventory Management

The next challenge faced by Latv was in managing their Inventory. Inventory is a point where most of the major wastages within an organization is hidden (*cf section 2.2.4*). As per the SchuF methodology, the Inventory Management is completely handled through their ERP-Smart. Right from the time, the raw materials enters the factory till getting converted into the finished product, the entire material handling processes are carried out through the ERP. Even if one process is skipped in the middle, it may lead to wrong stock figures. LaTv was facing this problem of misleading stock figures. Though they claim that entire process was followed as per the procedure, they were facing the error in their stock values.

As per SchuF procedure, a designer completes designing a valve and creates the required Bill Of Materials based on size, price, material and operation conditions of the valve in the ERP as shown below:

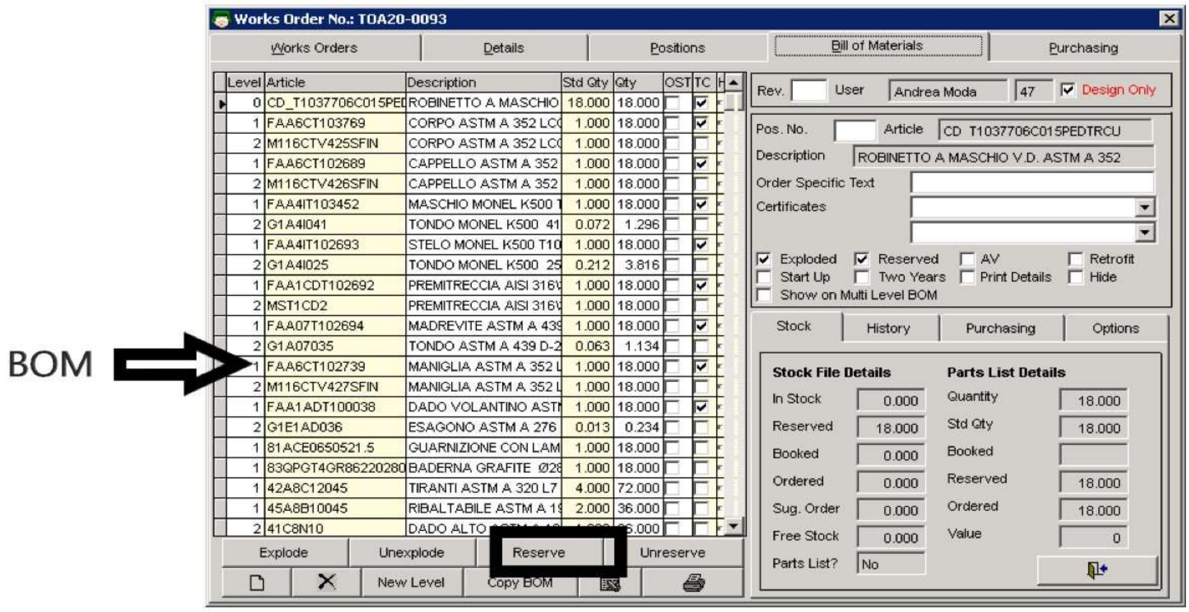

Figure 5.1: How to Reserve

Once the BOM is created and finalized, the project engineer reserves this BOM i.e. the materials listed in the BOM along with the quantity required will be reserved in the stores for this order. If the listed materials or the required quantity is not available in the stores, a requisition arises and will be notified to the purchase department who then places the order for the requirements accordingly.

For LaTv, the material requisition is not popping up for some orders if the reserved material is not in stock, because of which the store manager had to check the stock manually and place order accordingly and sometimes ends up placing order for items already on stock (*Inventory waste*, *Muda, cf Table 2-1*) thereby increasing the complexity of the process (*Over-processing*, *Muda, cf Table 2-1)* , which in-turn lead to excessive time, cost and overall store process delay.

On discussing the issue faced by LaTv with the store manager of SFIN, I realised the problem maybe in either skipping or not following properly two stages in the entire store processes called "creating GRN (Goods Received Note)" and "Booking out the materials to use". Both processes are carried out through the ERP. So, the problem lies in missing out certain points within the two process.

LaTv sometimes order materials from other SchuF branches, if the others have extras in stock, rather than purchasing from third party suppliers. It depends on the material and shipping cost of the component. I decided to track the purchase order of such items right from the time they are created and closed to trace and conclude the cause. I took one open purchase order placed to SFIN from 2019, i.e TPO19-0420/1 as shown below. As we can see (*Figure 5.2*) 11 quantities of Valve

BODIES (casting) were placed order and the delivery week is showing as 0 (means it is not delivered yet).

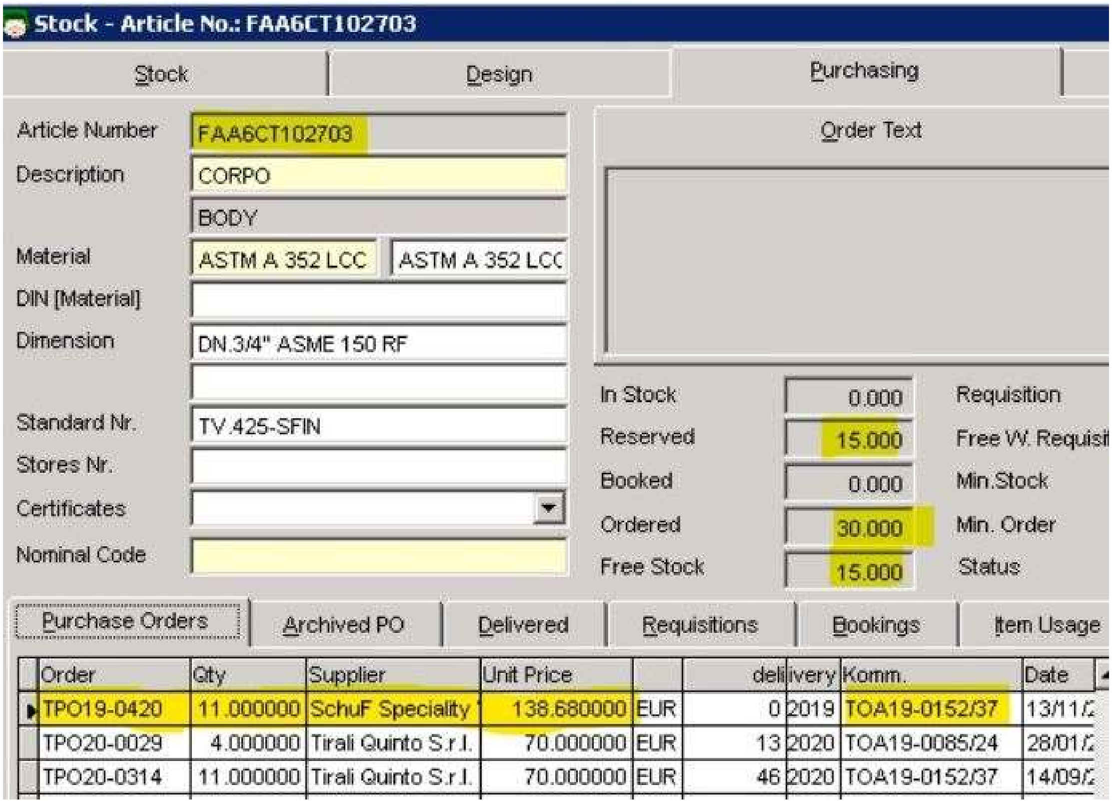

Figure 5.2: LaTv PO status

By checking the status of the item in SFIN's SMART (*Figure 5.3*) it was showing that the items were already shipped:

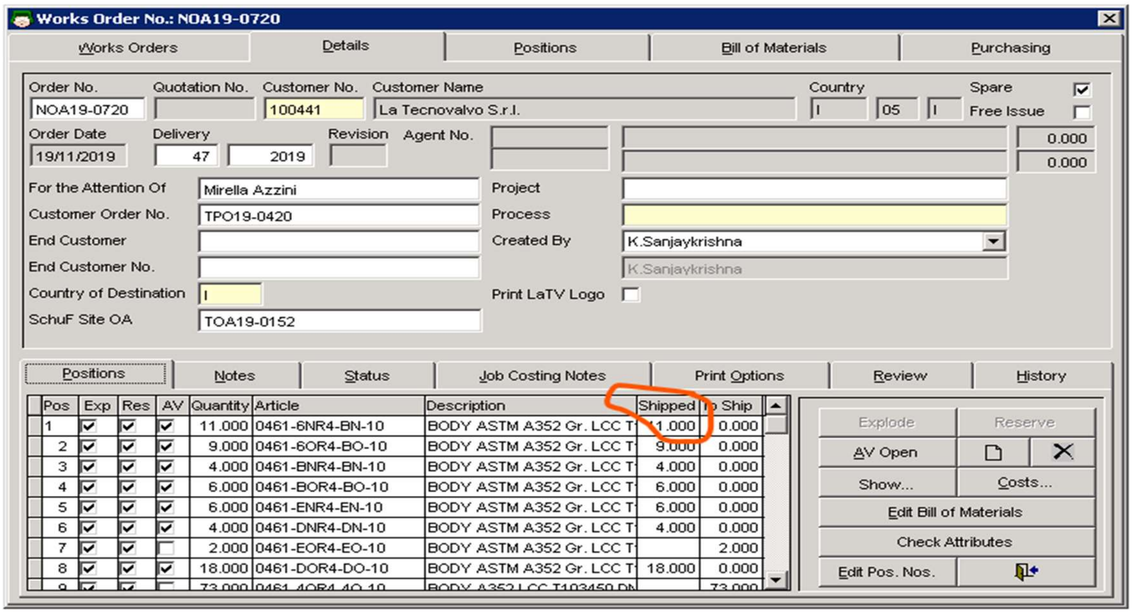

Figure 5.3: SFIN PO Status

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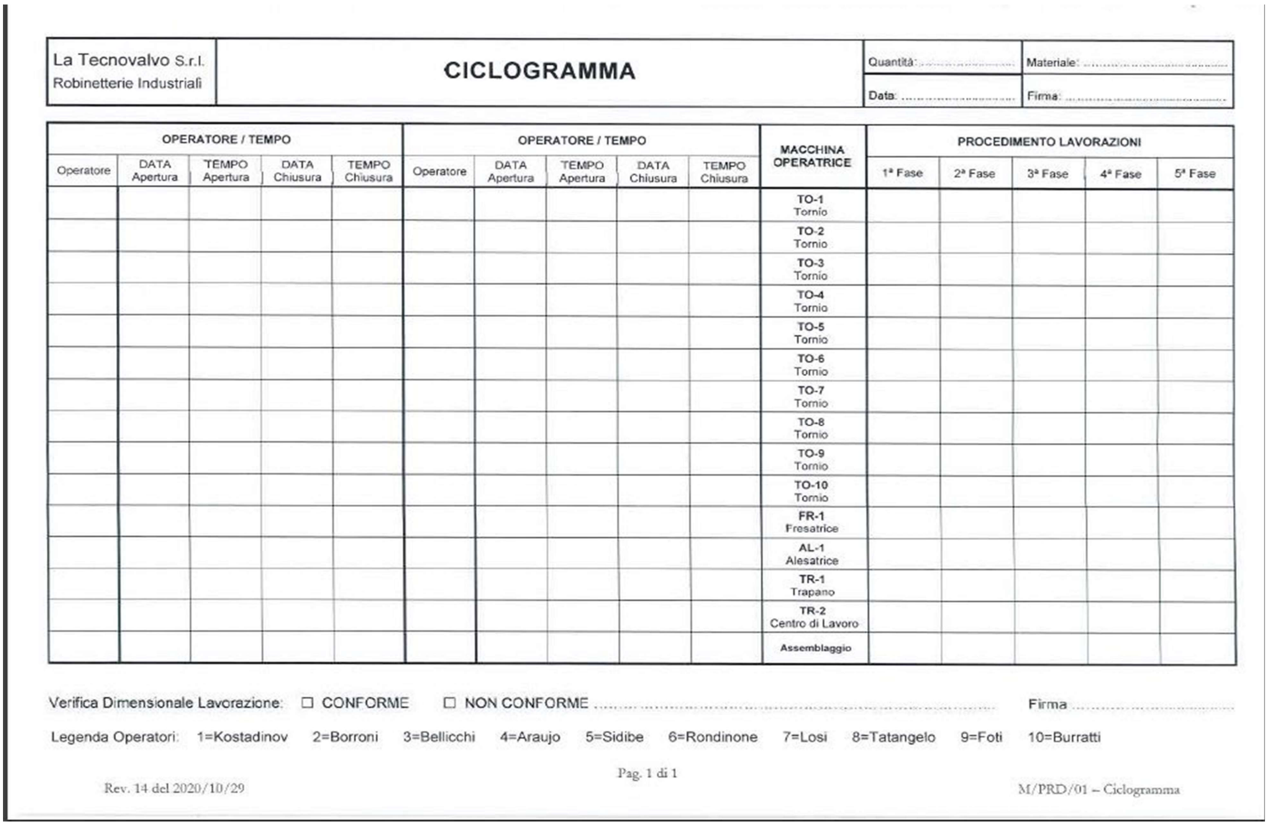
This gives an insight that the item was received but not recorded in LaTv's smart, Hence GRN was not created thereby aligning with the words of Store manager from SFIN.

5.1.3 Estimation of Machining Time

There was a massive time deviation in the overall machining process in LaTv. On analyzing we realized LaTv is still adopting their traditional method in recording the time taken for their machining activity. As per their traditional method, once a worker completes his machining process, he writes them down manually in a sheet called Ciclogramma as shown below:



La Tecnovalvo S.r.l. Robinetterie Industriali	CICLOGRAMMA	Quantità:	Materiale: ....
		Data:	Firma: ....

OPERATORE / TEMPO					OPERATORE / TEMPO					MACCHINA OPERATRICE	PROCEDIMENTO LAVORAZIONI				
Operatore	DATA Apertura	TEMPO Apertura	DATA Chiusura	TEMPO Chiusura	Operatore	DATA Apertura	TEMPO Apertura	DATA Chiusura	TEMPO Chiusura		1ª Fase	2ª Fase	3ª Fase	4ª Fase	5ª Fase
										TO-1 Tornio					
										TO-2 Tornio					
										TO-3 Tornio					
										TO-4 Tornio					
										TO-5 Tornio					
										TO-6 Tornio					
										TO-7 Tornio					
										TO-8 Tornio					
										TO-9 Tornio					
										TO-10 Tornio					
										FR-1 Fresatrice					
										AL-1 Alesatrice					
										TR-1 Trapano					
										TR-2 Centro di Lavoro					
										Assemblaggio					

Verifica Dimensionale Lavorazione: ☐ CONFORME ☐ NON CONFORME .... Firma ....

Legenda Operatori: 1=Kostadinov 2=Borroni 3=Bellicchi 4=Araujo 5=Sidibe 6=Rondinone 7=Losi 8=Tatangelo 9=Foti 10=Burratti

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Figure 5.4: Ciclogramma

Here the worker enters his name in "Operatore" column and the working hours next to the respective machine he worked under "Macchina Operatrice" column. If multiple workers are involved, the sheet gets passed on to everyone and they enter the data as required. In the end, they add up the total duration and conclude it as the Total time taken to machine the valve.

As the process is manual and stressful (*Muri, cf section 2.1*), there are many chances of not entering the exact time value. It depends on the precision in capturing time via stop clock or any other accurate recording means. The margin of error keeps increasing as more workers gets involved in the machining process because some components had to be machined in different machines and hence this leads to increased paper work and margin of error (*Over-Processing,Muda, Table 2-1).* Sometimes they miss out this process completely and fill it up in the end based on assumed values.

Above listed are the three major problems hindering the production efficiency.

5.2 Analyzing the problem

Though LaTv and SFIN manufacture almost the same valves, the above enlisted problems were not an issue for SFIN, things were running smoothly from their end. So, I realized the problem is in LaTv's work methodologies or processes. I decided to compare LaTv's working methodologies with SFIN and discuss the projected issues with colleagues of SFIN (*Implementing Yokoten, cf 3.2.2*)

Linking the puzzles, I realized the root-cause for all these issues pointed out to the direction of "not utilizing the ERP in its most efficient manner". The main glitch is, they are still caught up in the transition phase from their historical methods to SchuF's standardized methodologies (*Diversification effects, cf 3.1.4*). LaTv was completely unaware of many processes that can be implemented via Smart which will solve their problems. Knowledge sharing through horizontal deployment *(Yokoten, cf section 3.2)* is a tool I decided to use and fill in the missing puzzles.

6 Developing Solutions

The idea proposed was to Internal benchmark LaTv with SFIN and deploy the missing puzzles via Knowledge sharing with the help of colleagues from SFIN, because SFIN is much more efficient in their valve manufacturing duration and flow process hence I decided to benchmark and point out the lag in different stages and processes.

6.1 Time Optimization

I visited the plant in India when I was there during the pandemic lockdown in Italy and explained my ideas about implementing this process to the COO of the company. During this discussion he introduced me to a new tool in their ERP called **Order Tracking**, which helps in optimizing the valve manufacturing duration in each stage. This method was adopted and used only in SFIN and it was showing a very good result. Linking to the concept of Horizontal deployment (*Yokoten*) and knowledge sharing, I decided to chip out this successful implementation from Schuf India and execute it in Latv.

6.1.1 About Order tracking module

What is Order tracking?

A tool/option used in the ERP system of India to optimize production time. It was programmed inside the ERP using the concept of **Critical Path Method** where all the activities required to manufacture the valves are listed out, standardized and linked in network manner (*cf section 2.3.2*). Durations are planned and fixed as per the historical data for each type of valves. Some valves require special processes and additions as per the customer requirements, for which certain manufacturing activities/processes are made as options and linked into the path network. These options can be selected based on the requirements and it gets added into the path network and the duration gets adjusted accordingly.

6.1.2 Concepts related to Order tracking:

- Early Finish Time- It is the earliest completion time of an activity.
- Late Finish Time- It is the Latest time an activity can be completed, beyond which the project will encounter a delay.
- Early Start Time- It is the earliest time at which an activity can be started.
  (This is not viewable in smart)
- Late Start Time- It is the latest time at which the activity can be started.
  (This is not viewable in smart)
- How is Early start time of an activity determined? It is calculated based on Early finish of its predecessor activity.
  ES(Activity) = Maximum EF (Immediate Predecessor)

- Sometimes an activity will have more than one predecessor, in such case the maximum EF of predecessor is calculated.

- How is Early Finish Time of an activity is calculated? It is calculated by summing up Early start of that particular activity & its duration.

  EF(Activity) = ES(Activity) + Duration (Activity)

- Slack- Slack denotes the flexibility available in the project to carry out other activities.

  (or)

  Slack can also be termed as the duration by which an activity can be delayed without affecting the overall duration of the project.

  Slack Calculation?
  Slack can be calculated in two different ways:

  LS(Activity) - ES(Activity)

  (or)

  LF(Activity) – EF(Activity)

  For critical activities the slack will be = 0

  How is Late Finish Time & Late Start Time of an activity calculated?
  Late Finish is calculated using a method called “Backward Pass Method”
  Here,

  Formula1- LF (Final Activity) = Maximum EF(Final Activity).

  Formula2- LS(Activity) = LF(Activity) – Duration (Activity).

  Formula3- LF(Activity) = Minimum LS(Successor).

6.1.3 Activity description

Mentioned below are the list of standardized activities involved in valve manufacturing process:

Activities	Description	Department in charge
OA- Order Acknowledgement	Creation of Order Acknowledgement after the sales order is approved	Project
Design In	OA passed onto design department to process FA, i.e. any clarifications to process FA drawings are clarified	Project
FA- For Approval	Creation of ‘For Approval’ drawings, parts list etc.	Design
V-Order	Time taken to send V-order i.e. place order to the	Project

	foundry for castings and other such long lead delivery items.	
Approval	Time taken by the customer to provide approval for FA drawings.	Design
FC- Finally Certified	Time taken to create Final Certified drawings, update any corrections in parts list etc.	Design
Picking list clearance	Time taken to clear picking list, i.e. to clarify what all required items are available in stores and what all to items to place order from external supplier.	Project
Materials Ordering	Time taken to place order for the materials unavailable in stores.	Purchase
Trims Receipt	Time taken for the trims to arrive in stores with purchase receipt.	Purchase
Brought-In Receipt	Time taken for the brought in to arrive in stores with purchase receipt.	Purchase
Castings Receipt	Time taken for the Castings to arrive in stores with purchase receipt.	Purchase
File to production	Time taken to move the valve file (drawings and other required files) to production.	Project
Process planning	Time taken for process planning dept to plan the manufacturing process.	Production
Job Preparation (Yoke/Body)	Preparing the body and yoke to manufacture by getting approval from quality.	Stores
Preparation (Trims)	Preparing the Trim items to manufacture by getting approval from quality.	Stores
Preparation (Bought inns)	Preparing the Bought inn by getting approval from quality.	Stores

Sub-contracting inn	Time taken for subcontract items to arrive and being ready.	Vendor development
In-house machining	Time taken for machining all the components.	Production
Painting	Time taken to paint the valve.	Production
Assembly	Time taken to assemble the valve.	Production
Final Inspection	Time taken for inspecting the valve.	Quality
Packing	Time taken to pack the valve.	Production
Dispatch	Time taken to prepare the valve for dispatch.	Production
Heating Jacket	Time taken to machine heating jacket.	Production
Radiography (Machining)	Time taken for Radiography testing (gets added under in-house machining).	Production
Third party inspection	Time taken for third party to come over and inspect the valve.	Quality
Inspection release note	Time taken for third party to release the inspected note, the valve can be dispatched after this.	Quality

Table 6-1: Acivity description

Valves are segregated and grouped based on their size and type. For example, let's say "Changeover Valve- until size 4", their manufacturing time and process are same. Above 4" size, the process time in certain stages will vary. The delivery duration is fixed based on the historical information as these valves have been delivered for years. In this way we do not have to create time frame for each valve.

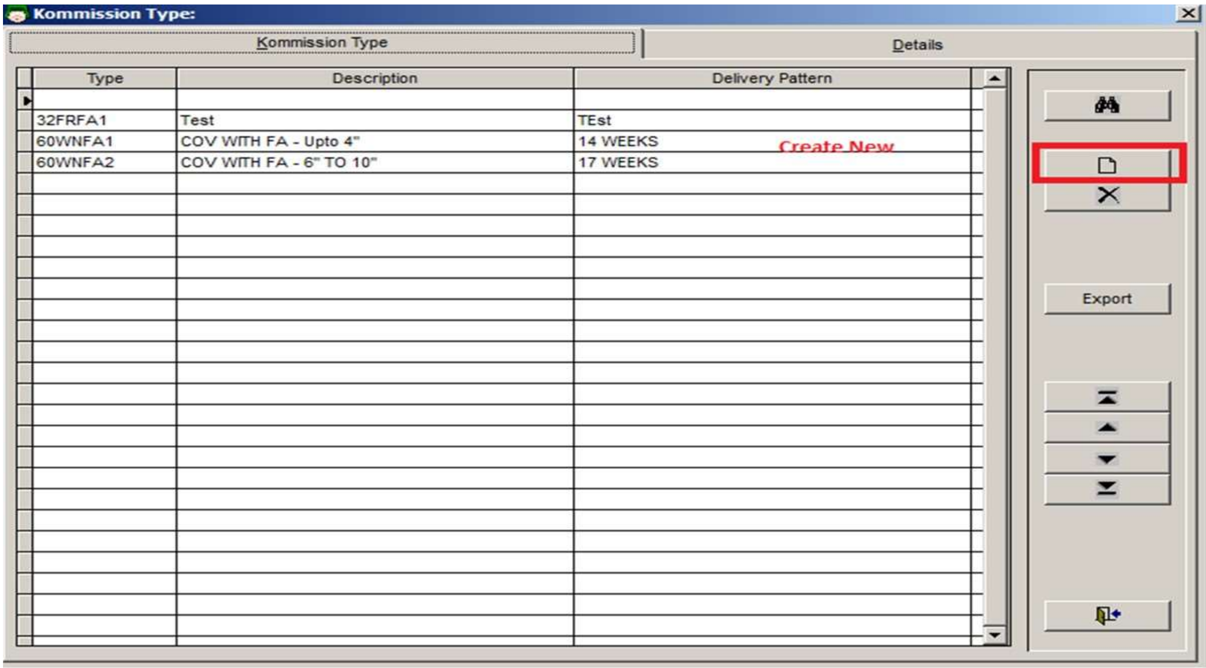

Figure 6.1: Creating new Kommission.

The valve manufacturing process/stages are standardized. For each category of valve, the duration for each stage in days as per the pre-delivery pattern are entered and saved in the database. The stages are programmed in such a way that they are linked to each other via Critical Path Network i.e. modifying one activity duration will affect its predecessor and successor's duration.

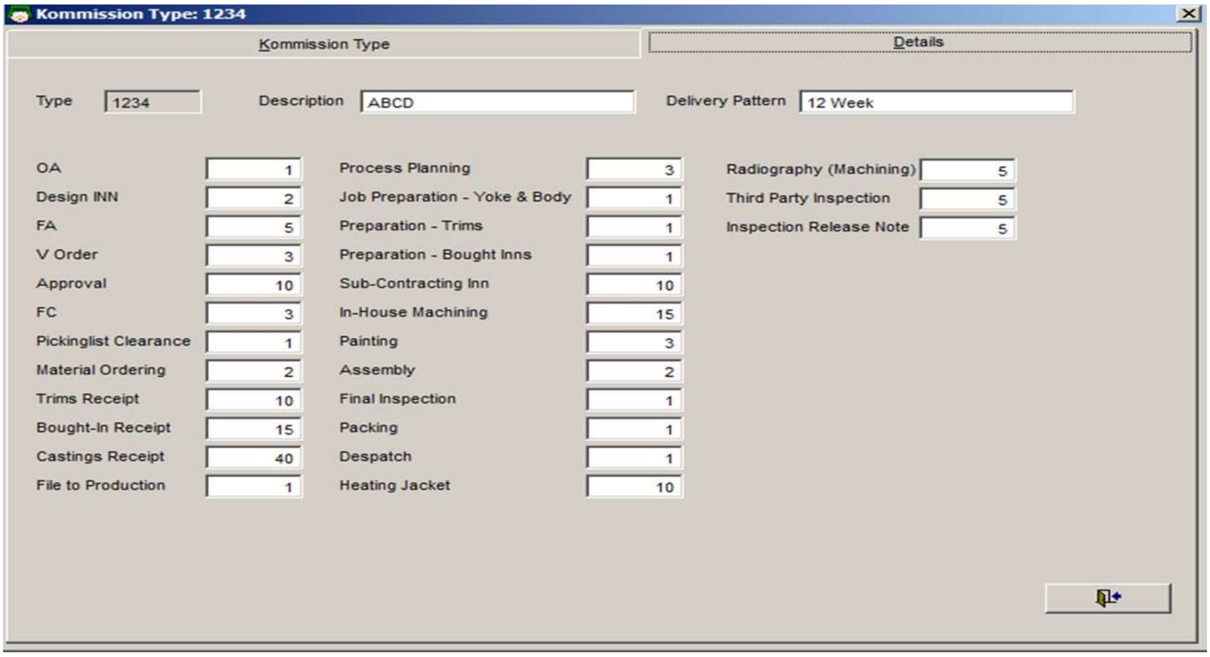

Figure 6.2: Creating time plan

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6.1.4 Order Tracking procedure

- select the order tracking option.

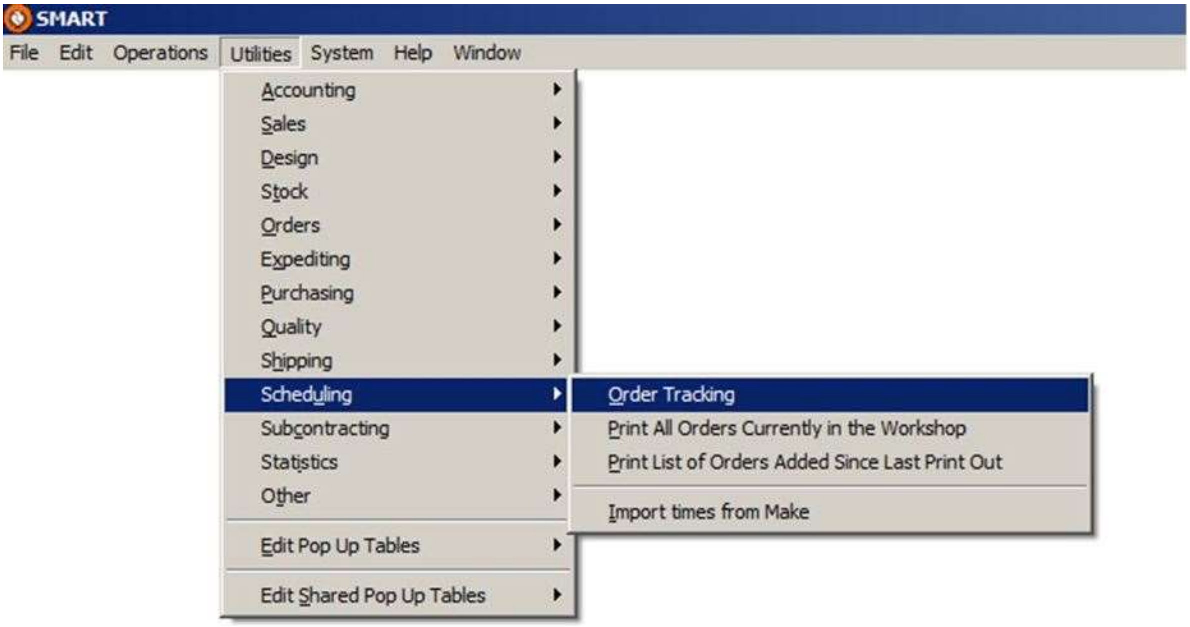

Figure 6.3: OT-Step 1

- Select the Komm.no that needs to be scheduled.

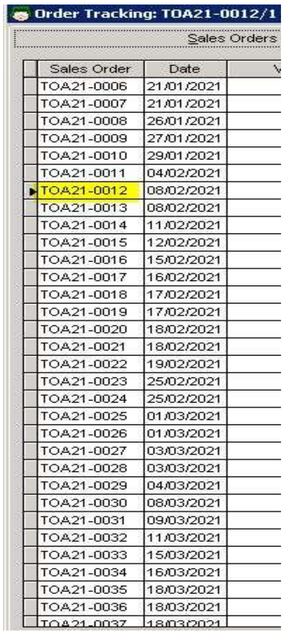

Figure 6.4: OT-Step 2

- Insert * in the "Type tab" and click on enter.

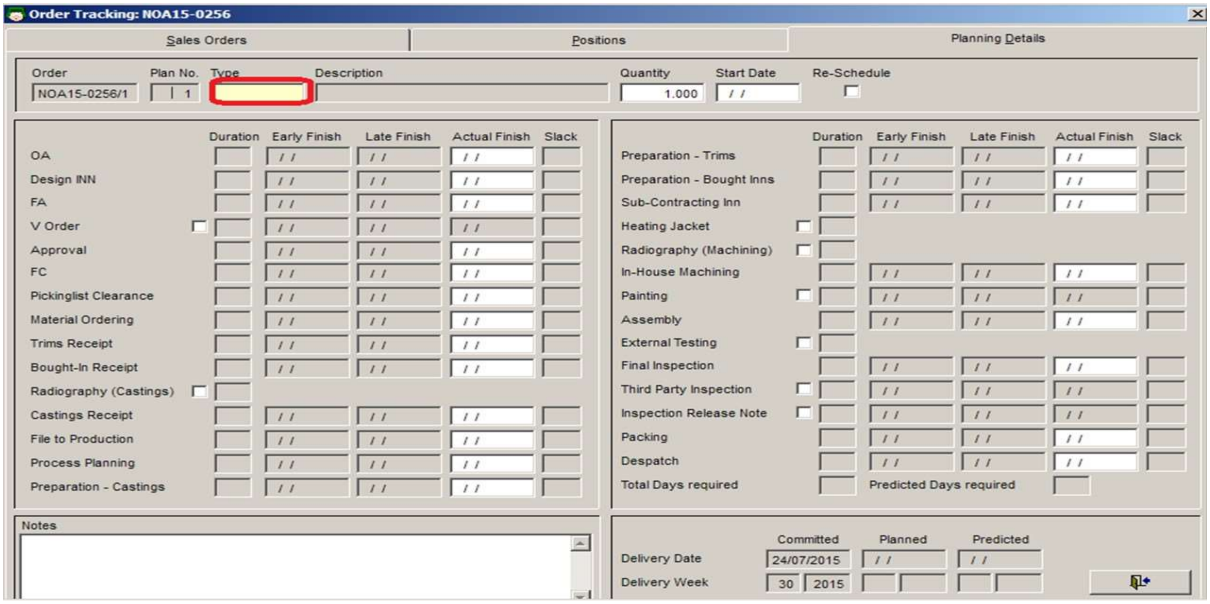

Figure 6.5: OT- Step 3

- A list opens up showing the valve types for which order tracking module is created and stored before. Select the appropriate valve type and size. If there is no plan available, we have to create one and link it to this order.

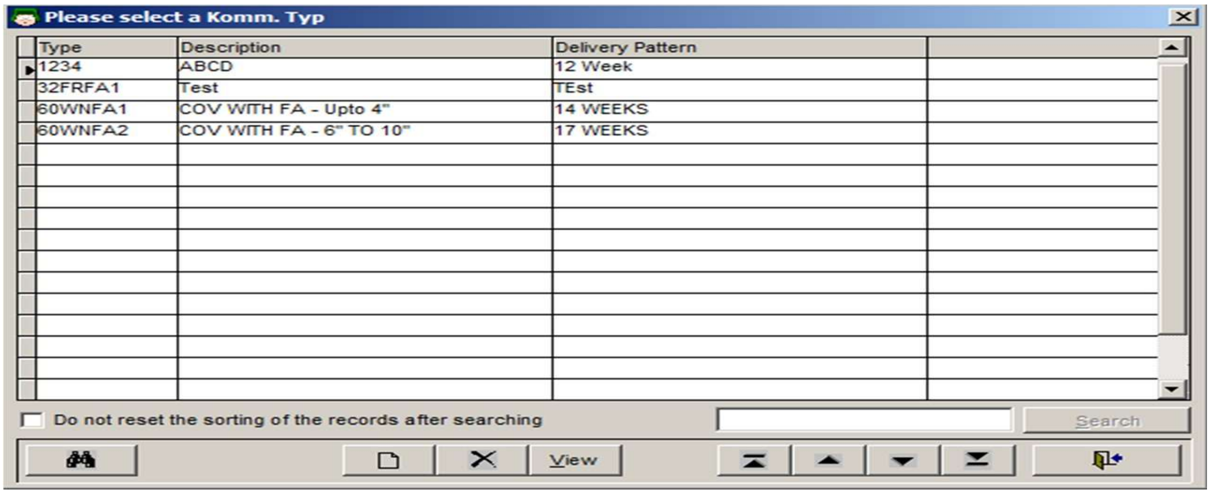

Figure 6.6: OT-Step 4

- An order tracking window opens up linking the pre-fed data from the database with the Kommission. Enter the start date as the as the date when the sales order is created. Based on the start date, the early and late finish date of each activity will be displayed as shown below.

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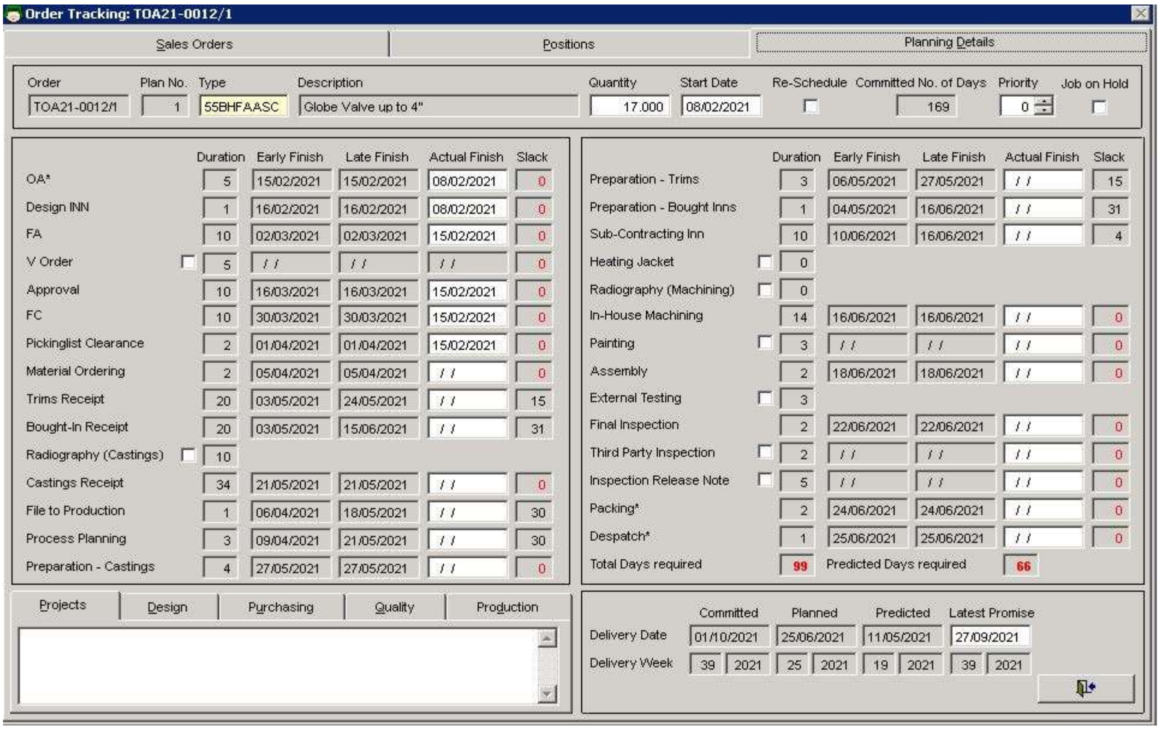

Figure 6.7: OT-Step 5

There are some check boxes which needs to be checked based on the project demand while planning. There are two different types of functions which the check boxes do:

a) Activity check box – Example: V-order, Painting, Third Party Inspection & Inspection Release Note. On selecting, these activities are turned alive and accommodated into the planning.

b) Duration adder Check Box – Example: Radiography (Castings), Heating Jacket, Radiography (Machining) & External Testing. On Checking these, the duration of these activities are added to their appropriate mother activity. Say For ex: On checking radiography (Machining), 10 days are added to In-house Machining activity.

6.1.5 Tracking the project schedule

By comparing:

Committed delivery week vs Predicted delivery week→ Use this while the project is on-going and once the user has started feeding the Actual Finish Date.

Committed delivery week vs Planned delivery week→ Use this during initial Planning.

6.1.6 Re-scheduling the project

Re-scheduling can be done at any stage. By checking the re-scheduling check box, all duration field is turned editable and based on the critical path, one can edit the duration of activities.

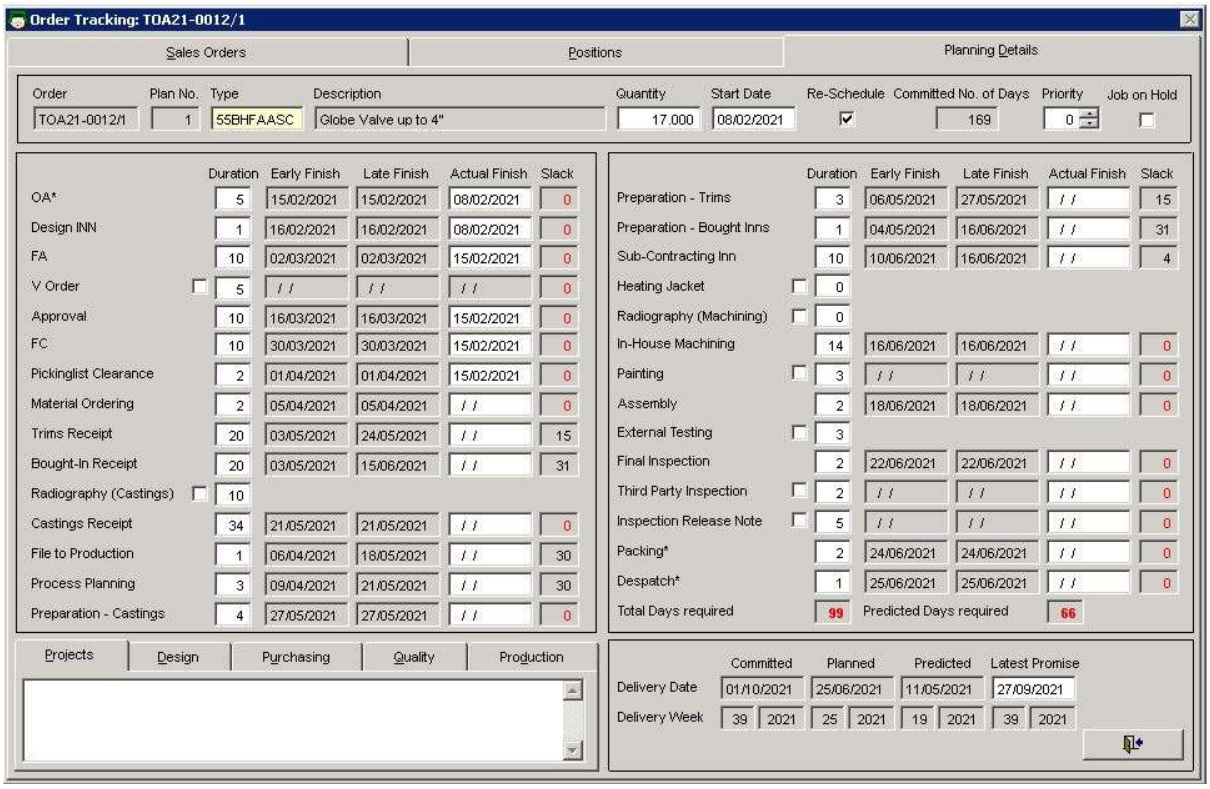

Figure 6.8: Project Re-scheduling

Once edited the check box must to be unchecked. This will start re-calculating and a new plan is established as Latest promise plan.

6.1.7 Critical Path

The critical path is the longest sequence of activities in a project plan which must be completed on time for the project to complete on due date. An activity on the critical path cannot be started until it's predecessor activity is complete. If it is delayed for a day, the entire project will be delayed for a day unless the activity following the delayed activity is completed a day earlier.

The critical path is OA➔Design INN➔FA➔FC➔Picking List➔Material Ordering➔File to Production➔Preparation - Castings ➔ In-House Machining ➔ Painting ➔ Assembly➔ Final Inspection ➔Third Party Inspection ➔ Inspection Release Note ➔Packing ➔ Despatch. Activities for which the Slack is zero fall under critical path.

6.2 Inventory Management

I decided to study the store handling processes completely with the help of colleagues from SFIN, create a sequential documentation regarding them and compare it with what LaTv is following to get a deeper picture about the issue leading to the cause and standardize the stages related to the cause (*stable and standardized process, cf 2.3.2*).

6.2.1 Creating Goods Received Note

Once an ordered material enters the company premises, purchase department will check whether the material is as per the "Purchase Order". Then they check if the material matches the quantity, supplier etc. Once done, they inform to the quality department to inspect the materials received. Quality dept inspects the material and check if it meet all the requirements as per the Purchase Order (Ex: Dimensions and various other technical requirements as per the PO) and drafts a mail to the stores with an "Incoming Inspection Report."

Now the material is brought into stock through SMART by converting the Purchase Order of the received material to GRN. Only then the received material will be reflected in the ERP. Once the GRN is created, the Purchase Order will be archived. In this way, we can see which PO's are still open.

Figure 6.9: GRN Process flowchart

The open purchase order can be exported from SMART in an Excel file format as shown below. With this option I realized that some Purchase Orders created long back are still not converted to GRN, they are left open without archiving.

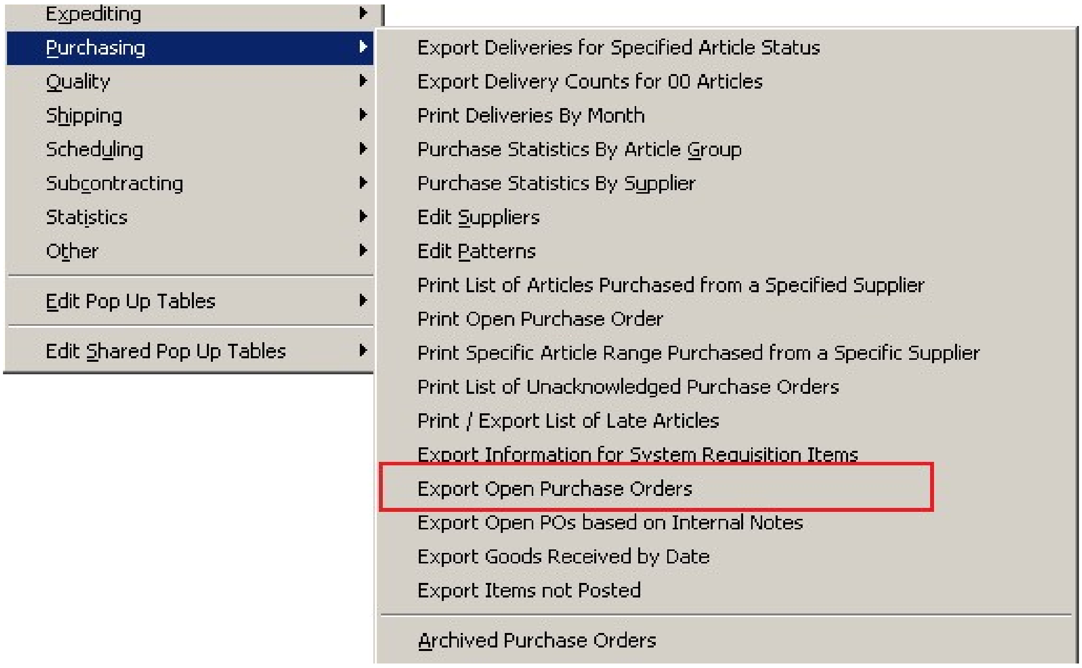

Figure 6.10: Exporting Open PO's from SMART

PO No.	*Order Date*	*Supplier*	*Article*	*Description*	*Komm No.*
TPO19-0420/1	20191113	SchuF Speciality Valves Ir	FAA6CT102703	CORPO ASTM A 352 LCC T102703	TOA19-0152/37
TPO19-0420/2	20191113	SchuF Speciality Valves Ir	FAA6CT102706	CORPO ASTM A 352 LCC T102706	TOA19-0152/42
TPO19-0420/3	20191113	SchuF Speciality Valves Ir	FAA6CT102688	CORPO ASTM A 352 LCC T102688	TOA19-0152/38
TPO19-0420/4	20191113	SchuF Speciality Valves Ir	FAA6CT102699	CORPO ASTM A 352 LCC T102699	TOA19-0152/43
TPO19-0420/5	20191113	SchuF Speciality Valves Ir	FAA6CT102698	CORPO ASTM A 352 LCC T102698	TOA19-0152/36=4;40=2
TPO19-0420/6	20191113	SchuF Speciality Valves Ir	FAA6CT102718	CORPO ASTM A 352 LCC T102718	TOA19-0152/39

Figure 6.11: Open PO's

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This means as marked in the *Figure 6.9*, the last two steps are not followed strictly. So, if GRN is not created it means materials are not brought into the stores via SMART but it is present inside the stores in reality. Hence why the stock values are misleading i.e. Materials are ordered, received but not updated in the ERP.

6.2.2 Booking out the materials to use

Another process which is not strictly followed is, Booking out the materials through ERP. Once all the materials and components to manufacture a valve are received and recorded, the project engineer reserves the respective items for that particular valve (*Figure 5.1*).

To start the manufacturing process, the store manager has to Book out the raw materials reserved for the particular valve through SMART. Only if booking out is carried out properly, the material quantity gets adjusted in the ERP stock count and there will also be a record of what all materials and components are being used from the stores for a particular valve. This can also help in the price calculation of raw materials along with their quantity.

Booking out is carried out in three ways:

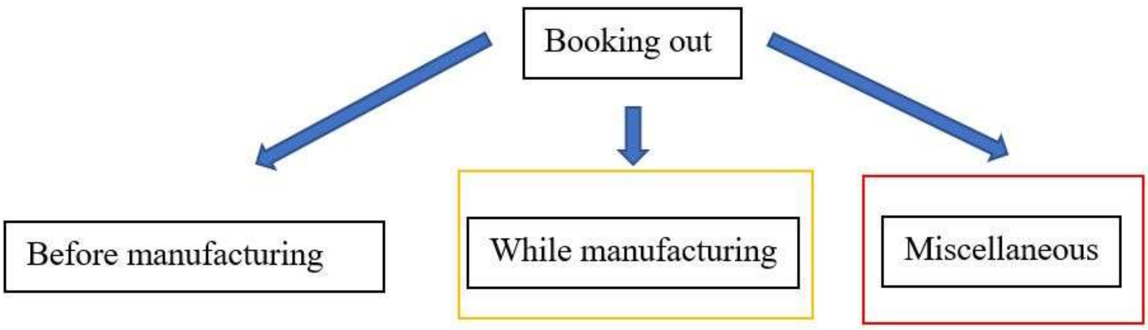

Figure 6.12: Booking out process

Before manufacturing:

These are all the primary raw materials booked out initially to begin the manufacturing process. It includes the main body casting, bar stock or any raw materials needed to commence the manufacturing process for the valve.

While manufacturing:

These are all the components needed while machining the component. It includes the consumables, connecting parts, fasteners, and other bought inns. These are booked out only when needed because of the possibility of mis-placing or loosing them.

Note:Bought inns are items which are not machined In-house but procured separately from suppliers

Miscellaneous:

These are all the extra components which are not included in the Bill Of Materials. It includes extra fasteners, re-work and defective items. They are included in the overhead costs.

On analyzing these three subdivision processes, I realized that materials/components that fall under ‘Before booking’ category are almost showing perfect stock count in the ERP. But the stock count of components that fall under the rest two category are showing deviations especially the ones related to “Miscellaneous”. Based on this we realized the two process to be monitored here are “Booking out-while manufacturing and Booking out-Miscellaneous”.

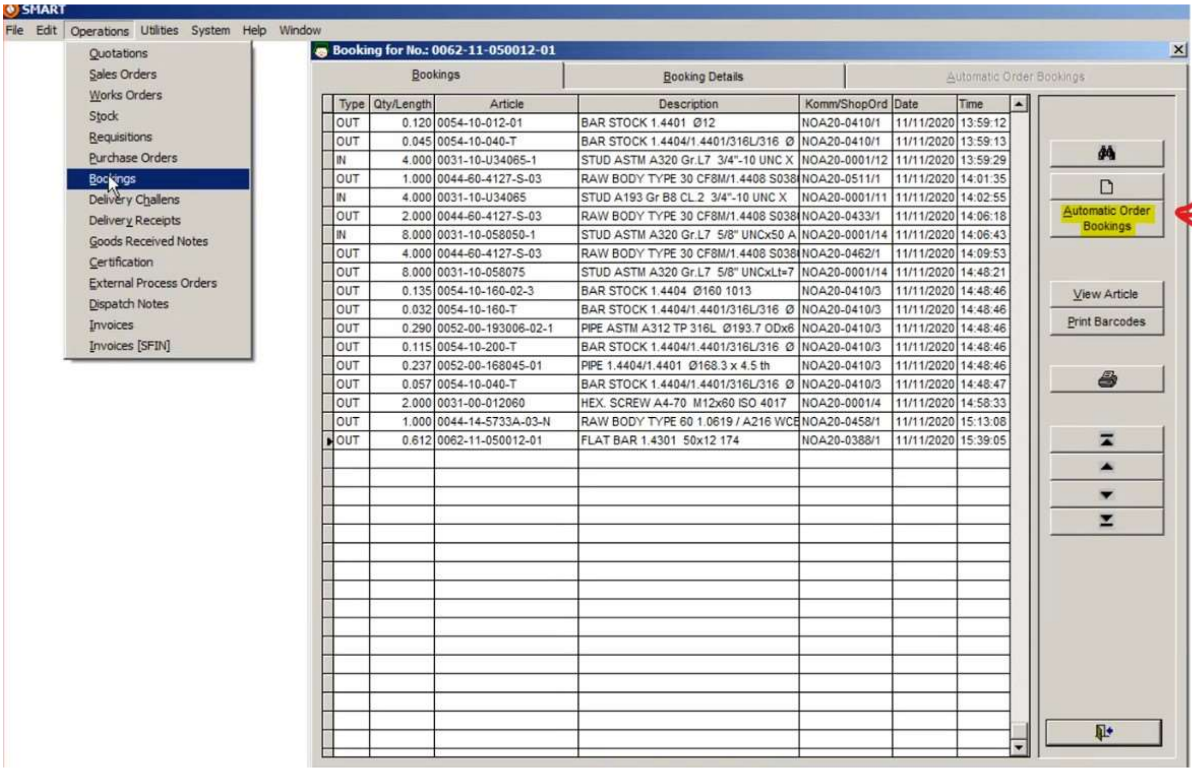

Figure 6.13: Booking out- Miscellaneous

In the above figure (*Figure 6.13*), you can see three items which are not yet Booked out. On enquiring we figured out they belong to either “while manufacturing” or “Miscellaneous” category i.e. items which are updated in the BOM while the manufacturing is in process. This concludes that when the store manager hands out items from the Inventory during these two phases, sometimes they miss to make a record of it in the ERP.

To pinpoint the exact step which is the root cause for this problem is tedious because as per the storekeeper’s knowledge, they claim they are following the procedures properly. So, the best way would be to sit next to them and learn how they are carrying out the process, then take the necessary corrective actions. To do so is not possible in the current pandemic scenario owing to the travel restrictions.

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Hence, I decided to create a step-by-step documentation of the store-related ERP processes, highlight the two phases and distributed to the responsible personnel so that I can collect a feedback from them regarding where and what they are missing out.

Going through the documentation, they were able to refine the process again and figure out where exactly they were going wrong. Those processes are also the ones that is linked to the above two highlighted stages "While manufacturing" and "Miscellaneous".

Based on the above analysis, it was very evident that the materials moving out of the Inventory while and after machining are sometimes missed registering through SMART i.e. when workers are requesting additional materials which are not recorded in the Bill Of Materials before, the store keepers are giving it out sometimes without registering the items in the ERP. In that way, the materials keep showing in stock even though they are moved out. Hence why, requisitions for materials which are not in stock are not popping up because as per the ERP, the materials are in stock but in reality, it is not.

6.3 Estimation of Machining Time

Discussing the particular complexity with SFIN, I came to know they clock the machining time using a software which is sort of like an extension to SMART called "TIME COLLECTION". They feed all the necessary data inside the software to calculate the machining cost and time. The workers have to follow a simple step by step procedure with precision and the machining time will be recorded accordingly. Let's see the idea in much more detailed format.

6.3.1 About Time Collection

TIME COLLECTION is linked to SMART in such way that the data fed into TIME COLLECTION will be reflected in SMART. We feed in the necessary data required either through barcode scanner or by manually typing the respective attribute related number. The data required to feed are: Employee's name, working cost/hour (this will be based on their years of experience and expertise), various machining centers available, cost of operating the machines/hour (based on cost/unit of electricity), various categories of operations. These various attributes are indicated by a number as well as barcode as shown below:

Cost Centers

No.	Cost Center Name
100	Assembly
101	Testing
102	TOS Boring Machine
103	Mill Machine
104	Bomac CNC Large Lathe Mac
105	Band Saw cutting machine
106	Matra CNC Lathe
107	Bridgeport CNC Machine Ce
108	Manual lathe machine

Figure 6.14: Cost centers

Setup
Design Rework
Rework
Programming Time
Production Time
Incorrect Material
Customer Change

Figure 6.15 Operation codes

Time Collection - Production Employees 2021-03-29

EVER ARAUJO (101)
FABIO SCAINI (102)
GABRIELE LOSI (103)
SOULEYMANE SIDIBE (104)
MATTEO TATANGELO (105)
KOSTA KOSTADINOV (106)
MICHELE RONDINONE (107)
THOMAS BELLUCCHI (108)
MIRKO BURRATTI (109)
ROBERTO BORRONI (110)
MATTEO FELLETTI (111)
N/A (112)

Figure 6.16 Employee name codes

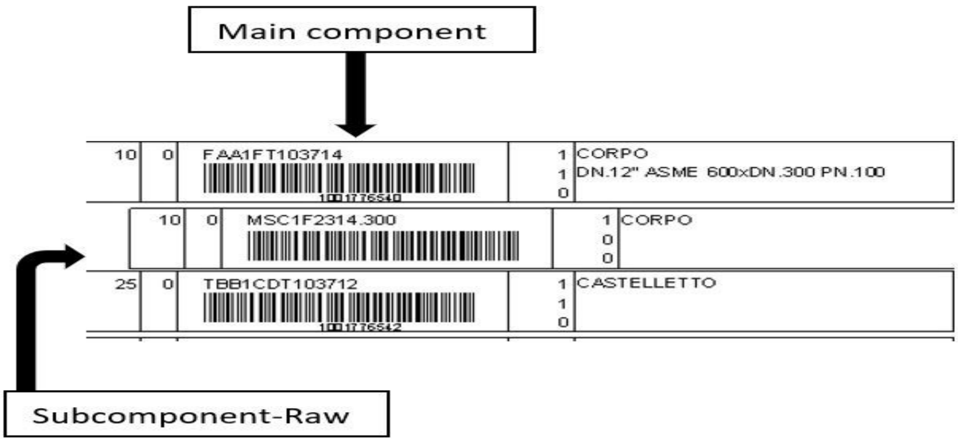

Figure 6.17: Component codes

By taking the printouts of all these three pdfs, the workers can now implement the process by feeding the below shown commands in a sequential manner.

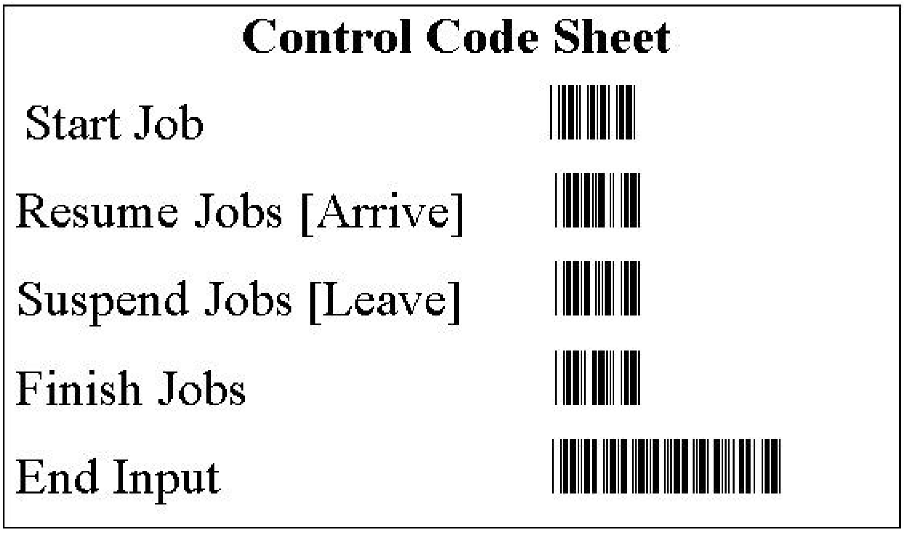

Figure 6.18: Control codes

6.3.2 Step by step procedure to feed the data

- Connect and check the barcode scanner functionality.
- Open the TIME COLLECTION software, click on the option "online time collection". A window opens like below (*Figure 6.14*):

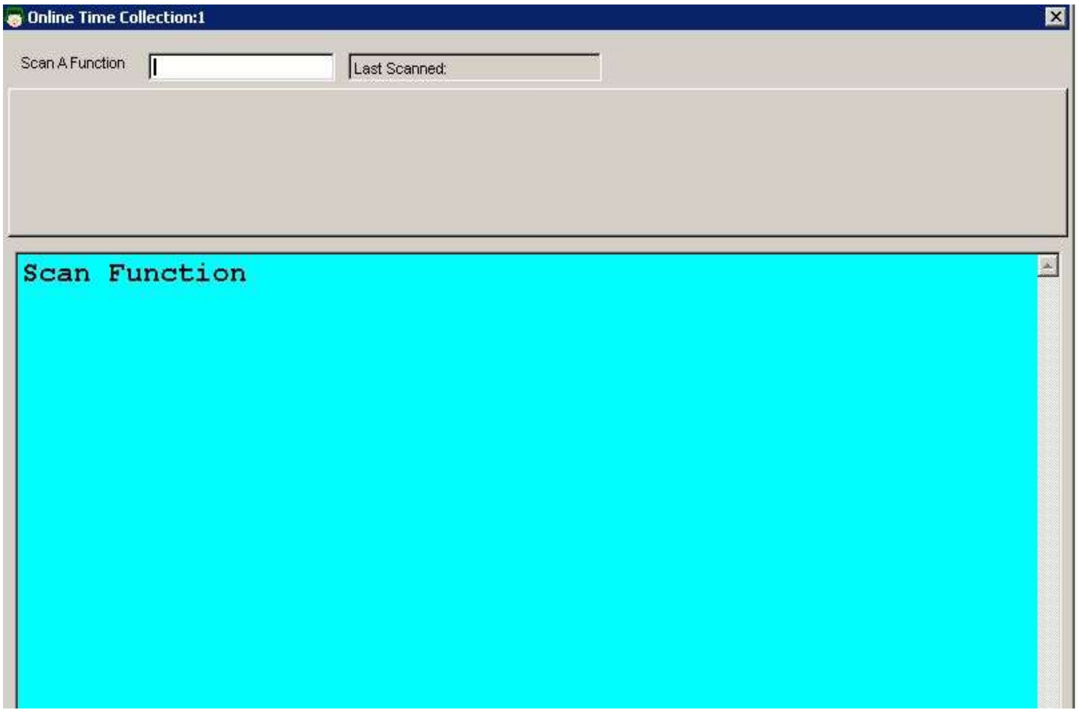

Figure 6.19: Time collection window

Now we can either Scan the function from the pdf using barcode or enter the number (Ex:100-Assembly, *Figure 6.14*) manually. The moment you enter one function, it keeps asking the following other sequential functions.

Note: Job indicates the particular component to be machined

To Start a new operation:

- START Job: Scan START function (*Figure 6.18*).
- Employee ID card: Scan the name of employee who initiates the operation (*Figure 6.16*)
- Cost Centre name: Scan the name of machine where the machining is carried out (*Figure 6.14*).
- Work type: Scan the type of work (*Figure 6.15*).
- Article Number of the Item: Indicates the main component that needs to be machined (*Figure 6.17*).
- End Input: Scan END function (*Figure 6.18*).

Now the machining time gets initiated.

To End an operation:

- FINISH Job (*Figure 6.18*).
- Employee ID card
- End Input

Now the machining time will be stopped.

To Suspend a job:

- SUSPEND Job (*Figure 6.18*).
- Employee ID card
- End Input

This function is used when you want to pause the operation i.e. when an employee wants to take a break or continue the operation the next day.

To Resume a job:

- RESUME Job (*Figure 6.18*).
- Employee ID card
- End Input

This function is used to resume the suspended job.

7 Results and Discussion

In this chapter, we will be discussing the results after implementing the solutions and also the challenges faced in adaptability within the organization.

7.1 Time Management

When the upcoming orders are linked under this tool, the management can export an excel anytime and can see the processing stage of every valve i.e. in which stage a valve is, which activity is in delay, for how many days and which department is in-charge of the delayed activity. If the activity is in red, means it is in delay and the one in green is as per the planned schedule (*Figure 7.2*). This helps the management in taking necessary corrective actions in the delayed stage and frame a solution for the bottleneck in future ensuring the production is adhering to takt-time (*cf section 2.2.3*).

This tool also helps in knowing, how many pending orders are there to be delivered in a month or week and also what all activities are in delay for each specific department. The management just have to filter the date before exporting the excel (*Figure 7.2*).

This also helps the managers of individual department to have a clear picture about the progress within their own department. As you can see below, if you choose to export the excel for an individual department, the activities related to them will be exported for every valve linked under order-tracking and necessary corrective actions can be taken before the promised delivery date.

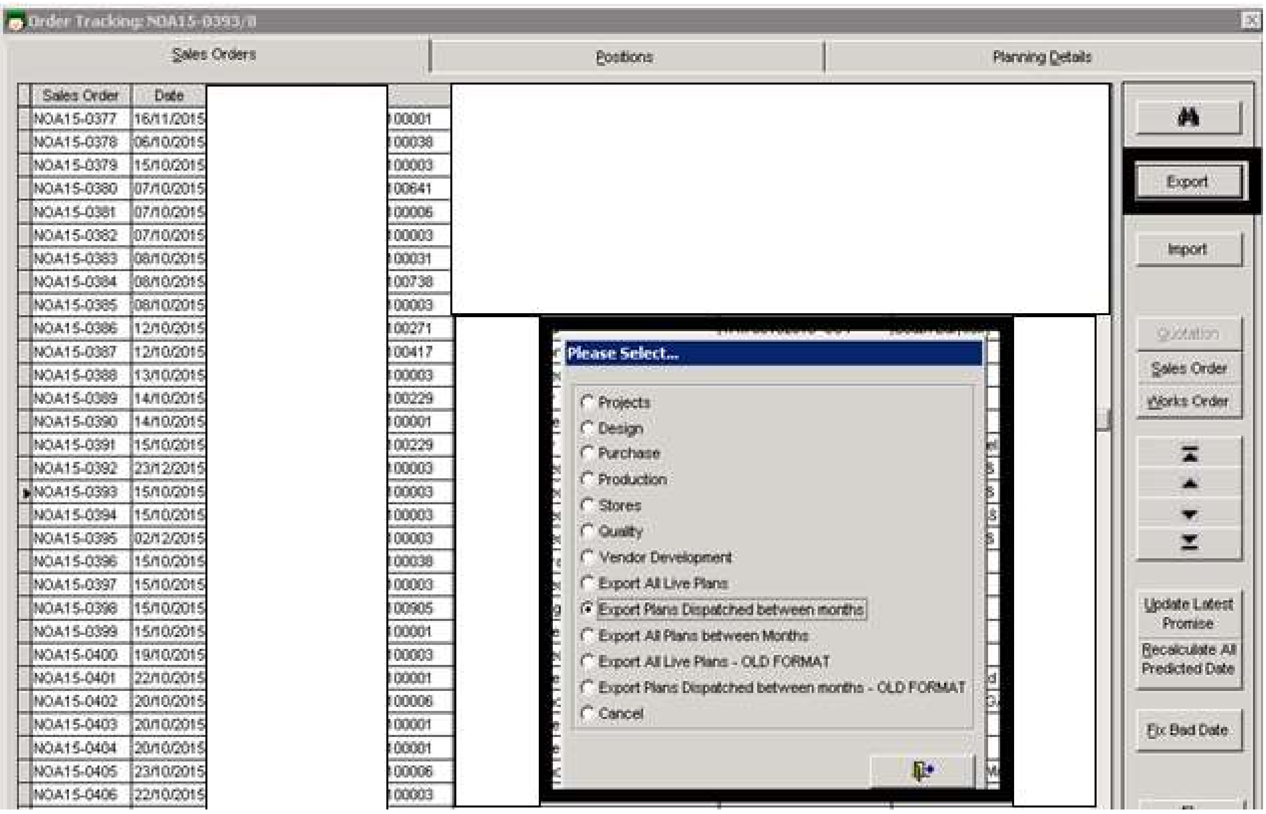

Figure 7.1: Order Tracking Result

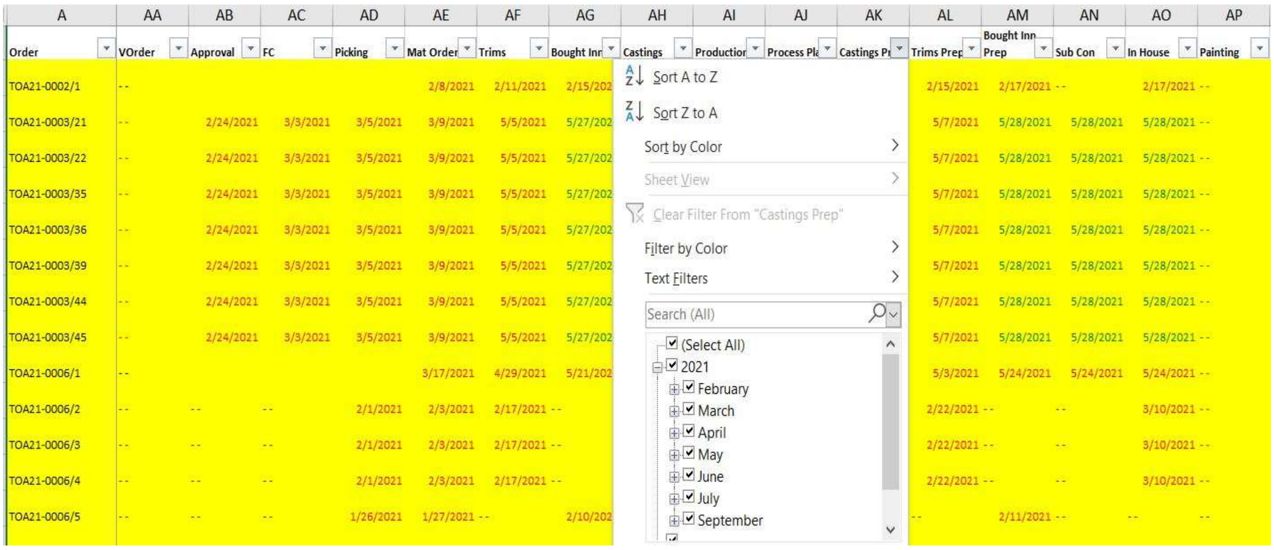

Figure 7.2: Order Tracking Excel

7.1.1 Challenges faced

Training and adaptation:

The primary challenge was to offer training to the various departments involved in using this tool. Initially there was a little bit reluctancy because the tool increases the transparency and time constrain for the entire departments within the organisation, also it points out exactly which stage is lagging. Though it increases the bureaucracy, the advantages that comes out of it had to be highlighted out to win the approval of all the departments involved.

Duration allotment:

SFIN had already created stagewise timeline for almost all the standard valves available. Though both the companies manufacture almost the same valves, the experiences of the employees, machining capacity and process flow efficiency varies considerably, so we have to tailor the stagewise timing based on the Latv employee's feasibility by modifying slightly the master timings framed by SFIN for some non-standard valves.

LaTv also has some standard valves which only they manufacture, tailored specifically for their own customers. To establish an efficient standard time frame for these valves, we had to refer the historical documents and study the time taken for various activities. Then we took the most efficiently time-scaled valve in the most commonly delivered category and standardized the activity duration with tolerances. In this way, we finalised a standard plan for some standard valves. There are still some categories of valves pending for which the plan will be established and tested in the coming days.

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7.2 Inventory Management

GRN were created for the "In-Process" komms (*Figure 6.11*) and all materials in Inventory were made to be reflected in SMART. This corrected the stock value figures close to approximate because some materials for which orders placed, are related to komms that are already manufactured and delivered. The materials linked to the dispatched orders may or may not be in the inventory. For such cases linked to delivered orders, a list of PO's created for the past 3 months were exported from SMART and the status were made to be updated by checking manually in the stores whether the materials are still in the inventory and if so how much delivered quantity is left over and then updated in SMART accordingly. In this way, some more inventory figures were corrected.

Next the Booked in/out list (*Figure 6.13*) were exported from SMART, and the materials for which the status shown as IN are checked and booked out based on the status. This removed the used materials from Inventory thereby making the Inventory value even more precise.

7.2.1 Challenges faced

Training and adaptation:

To avoid this glitch in future, employees are requested to follow the procedures related to the two process with extra precision and care. The store manager is requested to monitor the process stringently.

At the end of every week, the store managers are requested to check whether the Purchase Orders of received materials in that week are archived and if GRN are created accordingly.

Identify the root cause:

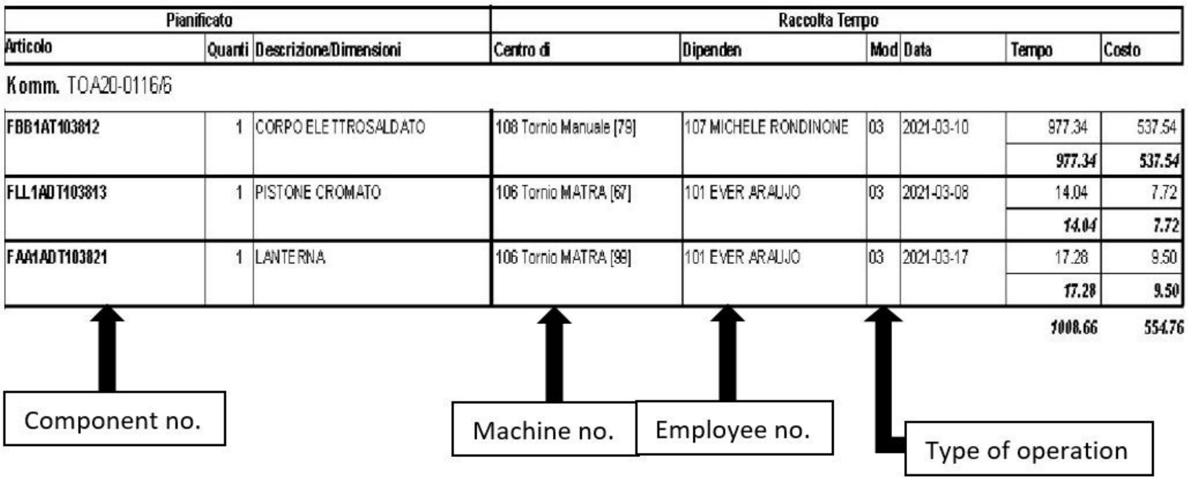
Store related processes have many procedures involved within it. When the company first proposed me the problem they are facing, it was difficult to figure out "what went wrong and where." So, I had to divide and categorize the processes, then study them one by one to arrive at the most appropriate conclusion.

To study the process, though I was given access to their Intranet source to study the flowchart related to stores, I needed a much clearer picture. Hence, I decided to get help from the store manager of India to explain me visually via skype, sharing his screen the entire process related to stores. After gathering this information, I had to document the process sequentially by clubbing them under various category with simple words for easy understanding in both English and Italian as blue-collar workers are much feasible in understanding the process in Italian. Then highlight the stages linked to the issue faced along with solutions to tackle it in future.

The store related process also had some responsibilities related to the Project department. So, I had to get help the same way from a colleague working in project department as well and document it accordingly.

7.3 Estimation of Machining time

By adapting to this methodology, the organization can Record the time taken to machine each component and also can club together to see the result of total machining time taken for an entire order along with the cost as shown below (*Figure 7.3*). This also saved drastically the time taken to record the machining duration with high level accuracy.



Pianificato			Raccolta Tempo					
Articolo	Quanti	Descrizione/Dimensioni	Centro di	Dipenden	Mod	Data	Tempo	Costo
Komm. TOA20-0116/6								
FBB1AT103812	1	CORPO ELETTROSALDATO	108 Tornio Manuale [79]	107 MICHELE RONDINONE	03	2021-03-10	977.34	537.54
							977.34	**537.54**
FLL1ADT103813	1	PISTONE CROMATO	106 Tornio MATRA [67]	101 EVER ARAUJO	03	2021-03-08	14.04	7.72
							14.04	**7.72**
FAA1ADT103821	1	LANTERNA	106 Tornio MATRA [99]	101 EVER ARAUJO	03	2021-03-17	17.28	9.50
							17.28	**9.50**
							1008.66	**554.76**

Figure: 7.3: Smart Times Result

7.3.1 Challenges faced

Adaptability:

The workers in the shopfloor were finding it a bit complicated to adapt with precision because of the no. of sequential procedures and the precision to be maintained while recording. Sometimes they forget to clock out the timing, so the duration keeps getting added without a pause (*Figure 7.4*).

Komm	Pos.	Emp.Code	Emp.Name	Cost Center	Start date	End date	Start Time	End Time	Total[Hrs]	Total[Mins]
TOA20-0094	2	101	EVER ARAUJO	106	3/1/2021	3/1/2021	11:53:55	16:58:58	3.9175	235.05
TOA20-0094	2	101	EVER ARAUJO	106	3/2/2021	3/3/2021	9:13:43	16:59:19	30.426667	1825.60002

Figure: 7.4: Smart Times Adaptability issue

As you can see from the above tabulated result, the duration for this component had exceeded 30 hours because the clocking was executed without any pause from 2nd march- 3rd march i.e. the respective employee had forgot to use the “SUSPEND” function to pause the machining and directly executed the “FINISH” function after the entire machining gets completed the next day.

If a machining activity is not getting completed in a day, it should be paused using “SUSPEND” function, resumed the next day with “RESUME” function and then should be terminated with “FINISH” function once the machining is completely done using the particular cost center.

Software glitch:

After feeding the required data and initiating the time recording test, the duration was not getting recorded at all. There was programming issue because the initial set up was not activated. This was rectified with the help of the IT dept.

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