A Kind of Lean Approach for Removing Wastes from Non-Manufacturing Process with Various Facilitiese

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Abstract—It is important to identify and remove the wastes not only from manufacturing process, but also from non-manufacturing process. In the last several decades, significant research achievements and practice benefits have been achieved about removing wastes from manufacturing process. Since the 1990s, some researchers and lean practitioners have paid more attention to removing waste from non-manufacturing process. Based on the authors' research work and industrial practice, the paper introduces a kind of lean approach for removing waste from non-manufacturing process. In its case study, the order handling process in a value chain is described with respect to a factory and its downstream Distribution Centers (DCs). The paper proposes a lean approach solution for creating the improved order handling process, and analyze how great improvements in performance can be achieved. As a result, the significant achievement has created a win-win scenario for both the non-manufacturing process in a factory and non-manufacturing facilities (like DCs) across the value chain. It demonstrates that improvements have been made by removing waste from the non-manufacturing process that takes place within a factory as well as with external participants through the whole value chain. Likewise, the proposed lean approach has helped the case companies to achieve greater levels of efficiency and more benefits. Finally, some conclusions are drawn.

Index Terms—Non-manufacturing process, Value chain, Removing wastes, Lean approach, Optimized order handling process, Win-win scenario.

I. INTRODUCTION

LEAN approaches have been widely used in modern manufacturing process improvement of reducing non-value-added (waste) activities by Womack [1], Krafcik [2], Pettersen [3], Friel [4], and Ivezic [5] etc. Significant benefits made from such lean practices have been reported in recent years by Bamber [6], Campbell [7], Ohno [8], Morteza [9], Dimitris [10], Federica [11], Souza [12], and Gandhi [13] etc. Since the 1990s, more and more researchers like Rajashekharaia [14], Stoll [15] and Mann [16] have been focusing their interests on reducing non-value-added (waste) activities in the non-manufacturing process. Due to the specific characteristics of the non-manufacturing process, the key challenges today are not only to improve the techniques of the non-manufacturing process itself, but are also related to many other factors in the industry, since the non-manufacturing process is also undergoing changes with respect to personnel behavior, communications, culture shocks, and uncertainty throughout the work flow. All of these factors may lead to unclear issues, misunderstandings, incorrect information, and corrupted information throughout the whole value chain. In contrast to the manufacturing process, the non-manufacturing process takes into account the knowledge, information transparency, and communications regarding time and quality for all participants in the whole value chain.

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The paper is organized as below. Section I is introduction. Section II reviews the key wastes in the non-manufacturing process, which could be non-value-added activities or waste activities. The challenges of adequately dealing with waste in the non-manufacturing process are also discussed. Section III is a case study about the order handling process in the non-manufacturing process. The order related process and its work flow in a value chain are described with respect to a factory and its downstream Distribution Centers (DCs). Great improvements have been made by removing waste throughout the process, thereby affecting both the internal functions of the factory and its external participants throughout the value chain. The proposed lean approach for optimizing the order handling process have been applied in a pilot factory and its DCs, and great improvements in performance have been achieved. As a result, the significant improvements have resulted in a win-win scenario for both manufacturing (factory) and non-manufacturing facilities (like DCs) across the value chain. The proposed lean approach has helped the case study' company to achieve greater levels of efficiency and more benefits. Section IV draws conclusions and give out its future research.

II. DEVELOPMENT FROM LEAN APPROACH TO LEAN THINKING

The present study is about applying a kind of lean approach in non-manufacturing process to reduce waste, and obtaining a better understanding of the wastes both in manufacturing and non-manufacturing process.

A. Brief Background about Lean Manufacturing

Several predecessors in particular (Whitney in 1799; Taylor in the 1890s; Frank Gilbreth and Lillian Gilbreth in the 1890s) developed the lean thinking concept already more than one hundred years ago. Then, in about 1910, Henry Ford introduced the flowed lines to the mass production concept [17-19]. After the World War II, Mr. Taiichi Ohno from Toyota Motor Company began to incorporate Ford production and other techniques into an approach called Just in Time (JIT). The successful story became popularized with the publication of the book *The machine that changed the world: the story of lean production* by Womack, Jones & Roos [20-21]. Since then, lean manufacturing was regarded as a novel management philosophy in the 1990s.

When Womack and Jones further developed 'lean thinking' in a follow-up study [21], it became increasingly clear that more and more manufacturers had also obtained benefits as a result of lean implementation. According to Liker [22-23], as well as Michael [24], there are essential fundamental principles need to be followed, and then these principles can create a culture of continuous learning and improvement in the manufacturing process. More researchers have suggested more extensions to lean thinking since then.

B. Apply Lean Approach for Non-manufacturing Process

In the past, many researchers focused more on lean implementation in manufacturing process. Recently, the necessity of lean thinking in non-manufacturing process has attracted more attention of increasing numbers of practitioners. In particular, two questions are emerging in the literature:

- How are people wasting time and money during the work process?
- What kind of waste exists in non-manufacturing process?

Here, "waste" is defined as a non-value-added activity, regardless of whether it is generated by manufacturing or non-manufacturing process. Ohno, the first one defined the lean concept, also developed many lean tools while working for Toyota. When Ohno was asked "what he was trying to accomplish with lean", he famously replied:

"All we are doing is looking at the time line from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes" [8].

Based on this simple, accurate and excellent definition of "lean by Ohno, we can begin to address exactly what waste is, how it can be identified, and how it can be removed from the workplace as a means of improving management practices and enhancing value-added work.

To identify and remove the non-value-added wastes, Ohno categorized 7 types of waste (see Table 1, waste type 1C7). Others have since proposed additional types of waste (see Table 1, waste type 8), including waste related to people. To remove waste, prior studies focused mainly on the manufacturing process in facilities. Currently a number of lean practitioners are working on how to identify and remove waste from a manufacturing company, since it is easy to trace the material flow, then the waste generated by the manufacturing process is easy to identify, and then can imagine how value is being added at each step. They are mainly concentrating on the factory workshop, but the lean concept is not just used in a manufacturing context. Hence, since 1990s some researchers and businesses have been focusing more on non-manufacturing process in facilities using the same lean concept. In the past years, many attempts have been made to identify waste activities in non-manufacturing process. Based on the different applications over the years, Liker included eight different types of waste in his book *The Toyota Way fieldbook: a practical guide for implementing Toyota's 4Ps* [22-24]: 14 Management Principles from the Worlds Greatest Manufacturer (2004). In recent years, lean practitioners have continued their efforts of identifying waste in non-manufacturing process. Even though the research and practice of identifying and eliminating waste from non-manufacturing process is still young compared with the practice of addressing waste in manufacturing process, the benefits of removing the identified waste in non-manufacturing process have already contributed to reducing the waste flow and saving money for businesses. Similarly, we summarized 7 major categories of waste activities in non-manufacturing process (included here in Table 2).

For long time, those types of waste mentioned above have existed in many businesses engaged in non-manufacturing process. In the next section, we illustrates a case study regarding waste removal in non-manufacturing process. It not only describes the waste types identified in the case company related to the above-mentioned categories with respect to the non-manufacturing process, it also clearly demonstrates the ways these types of waste which have negatively impacted the business, and how the business in question has tried to identify them and remove them from the work process.

C. Impact of Poor Performance of the Handling Process

In order to identify and remove wastes in non-manufacturing process, the main challenges facing the order handling process was the too long time between entering an order from one DCs and confirming it with the factory, i.e. Time of Entry To Confirmation (TETC). When the "ball was in the hands of the Order Handling Department," it often required a great deal of time to resolve the issue. In terms of requirements, the target of TETC should be met "within 24h" or, more accurately, "no later than tomorrow." This issue was crucial for both the factory and its DCs because the order must be completed in Enterprise Resource Planning (ERP) system before the next step in the value chain could be undertaken.

However, regarding an actual situation (see Fig. 1), approximately 60% of the orders took TETC more than one day

TABLE I
FACTORY & OFFICE AREA WASTE EXAMPLES*

#	Waste	Definition	Examples
1	Over Manufacturing	Keeping M'cs (Manufacturing cells) busy; batch size rules; push manufacturing	Unclear or missing work instructions; weak induction & job training;
2	Waiting	Waiting for materials; Schedules & work orders; in M'c cycle time	Unnecessary email circulation
3	Transportation	Moving materials in or out of the work cell	For information or instructions
4	Over-Processing	Work above customer's requirements (unclear standards); unnecessary inspections; no standard work Standard Operation Procedure (SOPs)	Manual process documentation; process handoffs; responding to problems
5	Inventory	Material Requirements Planning (MRP) 'push' manufacturing; batch size rules to limit changeovers	Weak process; no standard work SOP's; over-circulation of & excessive use of e-mails
6	Spoilage & Rework	Defective input materials; weak process capabilities; no maintenance	Weak forecasting; Bill of Materials (BOM) errors; MRP lead-time errors
7	Motion	Ineffective workplace ergonomics; movements within the work cell	Inaccurate system data; master data errors; Inventory adjustments
8	People Potential	No people development plans for all levels; lack of inclusion; no communications plan	Ineffective workplace ergonomics; movements within the office

* Source: Introduction to 8 Lean Wastes (Losses), prepared by Johnson [25-26].

TABLE II
CATEGORIES OF WASTE IN NON-MANUFACTURING PROCESS

| #	Waste	Definition	Examples
1	Communication barriers	Any barrier to the flow of information that can come from not knowing who to ask for it	Information sent to the wrong person who does not need it and does not know who needs it
2	Poor tools	Any information created to facilitate a handoff between value-adding steps that does not add customer value	Information withheld to increase the information holder's power at the expense of another or for other motives
3	Useless information	Any information created to facilitate a handoff between value-adding steps that does not add customer value	Language barriers and poor translations
4	Waiting	Any delay in developing or receiving knowledge and information	Misunderstanding for some reasons
5	Discarding knowledge	Any capability in which knowledge is lost for a certain reason.	Computerized information systems are difficult to use
6	Multitasking	People work on more than one open task concurrently. From science, people cannot divide their	Incompatible or out-of-date systems that require data to be re-entered by hand or converted between information formats.
7	People Potential	Time equally between different tasks	Tools that do not add any useful information or knowledge about the customer.
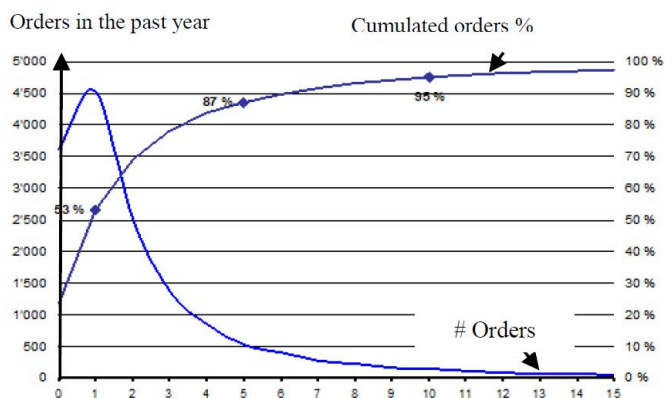
Fig. 1. Key performance: TETC for order handling

within 5 working days, and 95% within 10 working days. These poor rates of performance have negatively impacted both the factory and its DCs, because they resulted in longer delivery times from the factory to DCs, and then from the DCs to the end customer in the value chain. In order to shorten this time period, firstly the factory needs shorten the time spent on clarifying orders during the handling process between the factory and DCs, and also needs improve the First Pass Yield (FPY) for orders performance by optimizing the order handling process. The project team found that a great deal of time was spent on those wasted activities, for instance too much time spent on checking those unclear orders for some reason or another, too much time spent on product rework because of some mistakes, misunderstanding the order, or rescheduling production because of the unexpected changes.

to be processed, sometimes even as long as one week. More specifically, Fig. 1 shows that approximately 53% of the orders for all countries in past year were confirmed either the same day or by the next day (target), while 87% were confirmed

III. Case Study: Removing Waste From Non-Manufacturing Process With Various Facilities

A. Brief Problem Definition

The value chain of the case study, i.e. non-manufacturing process with various facilities (factory upstream and DCs downstream), can be described as Fig. 2. The factory in Germany has realized Assembly to Order (ATO) manufacturing for most standard products (transformer parts). The direct customers received their ordered products from those DCs of the factory throughout the world.

In factory, it was focused on its manufacturing process improvement before, and has achieved some benefits from application of lean approach on its manufacturing process, for instance, it set up a supermarket for ATO manufactory model, and its manufacturing lead-time for ATO product was just 1-2 working days. However, the pre-manufacturing time has brought a big problem for the factory. In details, the factory and its DCs tended to spend a long time on orders handling, from 1 day up to 1 week, as a consequence has lost a great deal of time between handling orders and managing export sales internally in the factory upstream and communicating the information to the external DCs downstream. Additionally, a great deal of time was also spent on waiting the delayed shipment of Finished Goods (FGs), which was the result of many unexpected changes like after-order confirmations. The unexpected changes also disrupted the upstream manufacturing process. These problems made it difficult for both the factory and DCs to deliver their product to the End Customer (EC) on time, all participants of the value chain were suffered from the long time on the bad order handling process.

In order to improve the non-manufacturing process together, French DCs was selected as a piloted DCs to be involved in the project because it was one major DCs according to orders. French DCs was also happy to join the improvement project because it has been suffering poor performance on order handling process for several years.

To address the existing problems of the non-manufacturing process, the case company defined the goals for the optimized order handling process as follows:
- Improve the office process by decreasing waste, re-work, and uneven flow;
- Achieve a shorter reaction time to DCs and end customers;
- Reduce the unnecessary and streamline the handling of late change requests;
- Optimize the order handling process to achieve a win-win scenario for both factory and DCs.

B. Actions and Achievements in the Improved Handling Process

To seek for a lean approach solution of shortening the order handling time, the project team and the experts from both the factory and DCs decided to have a brainstorming session on Root Cases Analysis (RCA) of the problems. Goldratt [27] used a tool called Theory of Constraints Thinking Process (TOC TP) to identify the root causes of the problems, which
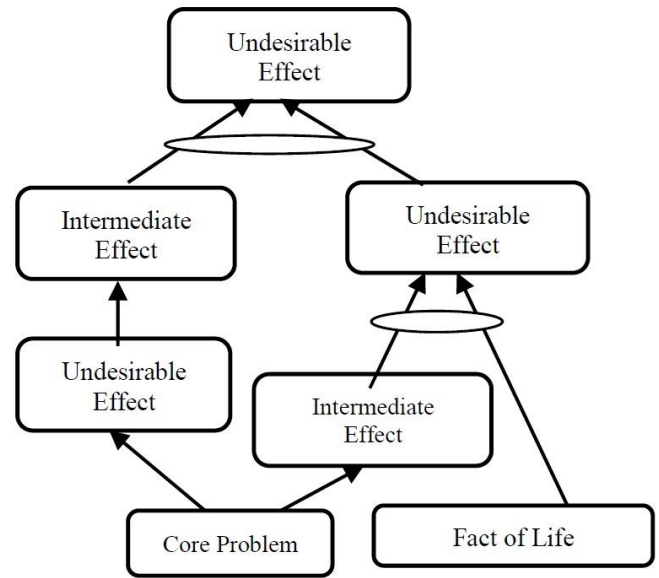

Fig. 3. TOC thinking process and CRT process

is a powerful tool for uncovering the root causes of problems. One process in TOC TP is to devise a Current Reality Tree (CRT) which must be used for RCA. When using the CRT process, the project team must follow a process to collect Undesirable Effects (UDEs) and construct a CRT (Fig. 3) together to help identify Root Causes (RCs). After several brainstorming workshops to construct CRT, a number of critical root causes were identified and agreed upon by project participants. As shown in Fig.4, the most important problem was "Lot of non-value add in Order delivery time", a numbers of UEDs were shown wastes through order handling process, and related RCs were identified on bottom, which the project should take suitable actions to eliminate.

Then, the project team grouped these root causes into different categories: communication, tools, internal and external process between the factory and DCs, and product-specific know-how. Each category was listed by its root cause and its impact on related Key Performance Indicators (KPIs).

Table 3 illustrates the RCA tool and related KPIs that the group defined, together with the different categories. To optimize the order handling process and then shorten the order handling time, the participants from the factory and DCs identified certain categories of waste, which is summarized in Table 2:
- Communication barriers: such barriers caused the significant misunderstanding, and then the re-work and clarification afterwardstoo much rework and clarification brought wastes according to Table 2;
- Poor tools at both sites: the lack of adequate tools causes more human errors and more manual work to correct those errors, which caused more time to process orders according to Table 2;
- Useless information: such information wasted the worker's time with respect to the value chain. As lacking of same understanding, both factory and DC spent too much time for clarification. Both sides thought some feedback from the other
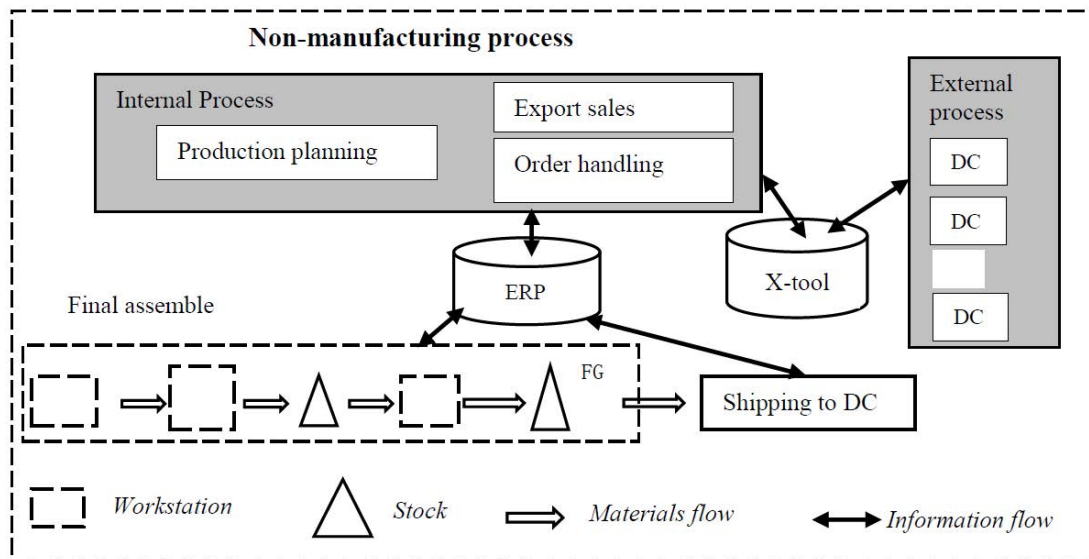
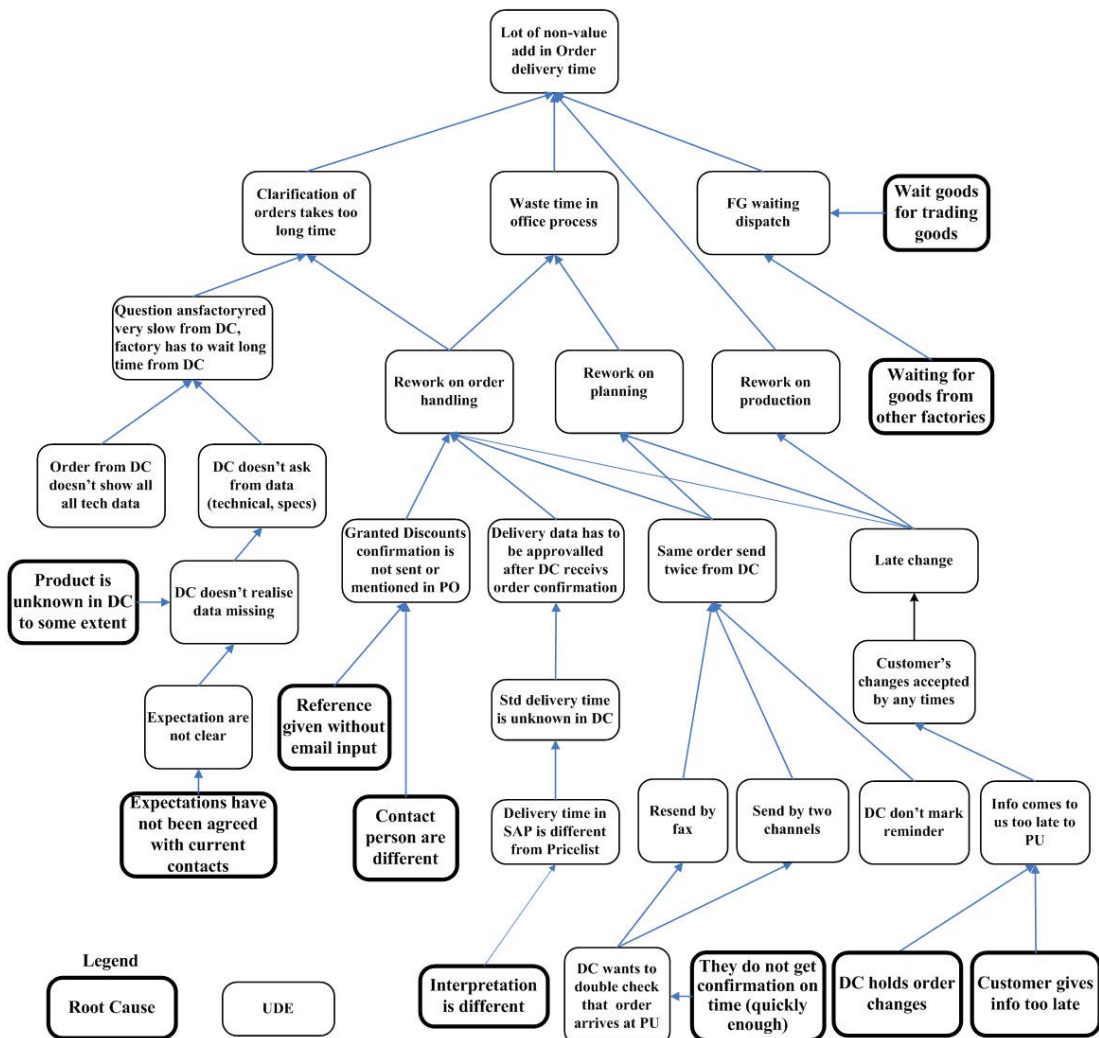Fig. 2. Value chain of case company together with its DCs

Fig. 4. CRT to identify root-cause

side were useless and didn't help their handling orders, even   wastes more time;

TABLE III
RCA OF TOOLS AND RELATED KPIs

UDE ID	RC	Category	KPI
1	Lack of understanding from both	Communication	CLR, TETC
2	Time spent agreeing on inspection date	Communication	ICLR, TETC
3	Informal info flow in DC sales	Communication	CLR, TETC
4	General problems between factory and DC discussed and solved Ad Hoc	Communication	CLR, TETC, FPYO
5	Misunderstanding of terms, i.e. delivery dates	Communication	CLR, TETC, RDTM
6	Time spend clarifying terminology	Communication	CLR, TETC

- Waiting: too much time is wasted by the delayed delivering products to DCs and ECs, due to many reasons, such as rework, poor tools, clarifications, etc.

Regarding the waste types identified above, the participants proposed the correspondent solutions based on their analysis of the root causes. Certain solutions were proposed to improve communication, for instance a common terminology was created (from standard to incoterms, delivery dates, and so forth). Participants defined how to change the information internally as well as between the factory and DCs, and also how to approach and sustainably solve any future problems; participants set up a regular meeting for workers from both sites (factory and DCs) to help establish a mutual understanding of necessary process for DCs and factory. The solution enhanced the communication, and reduced waiting times, the required clarifications and rework during the order handling process; likewise, it reduced the number of unexpected changes in delivery times after the order had already been placed.

In order to improve the tool's capability to support the order handling, a special X-tool was devised to support the factory and DCs for order handling. The X-tool was optimized for use in the value stream, for example, it helps the DCs downstream as well as the export sales and order handling departments upstream to make less human errors and resulted in less waiting, less rework and less clarifications. Moreover, the ERP system, X-tool, and other databases were integrated and improved to make the various systems and tools more compatible. Workers began to use the same data source and the same synchronization schedule.

In order to reduce the useless information which is created to facilitate a handoff, but does not add any customer value, the participants in the study defined and agreed on certain standardized work procedures and necessary documentation both internally within the factory and DCs. The responsible people could use the standardized instructions or documentation, which resulted in much less useless information and saved time of all workers involved in the operations.

To reduce the waiting time of order processing, certain communication actions were improved, participants helped optimize the available communication tools, and the factory and DCs provided the responsible people more training on product-specific know-how, how to handle orders more smoothly.

In brief, the above proposed solutions were implemented cooperatively in the factory and the French DCs to improve their operations, which included some specifically defined actions according to the proposed solutions. The detailed actions (how and what) were defined by the leading people responsible for overseeing their implementation at particular phases of the operation.

C. Defining the Performance Measures

Key Performance Indicator (KPI) is a type of performance measurement, which relies upon a good understanding of what is important to the organization. For example, Overall Equipment Effectiveness (OEE) is a set of broadly accepted KPI to reflect one manufacturing process's success. Unfortunately, there exists no common KPIs for non-manufacturing process yet, so the project team and the case company discussed and agreed the 4 KPIs to illustrate the project's achievements of resulting from an optimized order handling process at both the factory and the selected DCs downstream, which were defined as below:

Definition 1 (Time of Entry to Confirmation, TETC): the period of time between the entry order and order confirmation (day);

TETE=Date of order confirmed - Date of order entry

Definition 2 (First Pass Yield of Orders, FPYO): the sum of all orders that can be processed without any extra effort (%);

FPYO=(# orders of passed without any extra effort) / $\sum$# all orders monthly

Definition 3 (Ratio of Delivery Time Modification, RDTM): the number of delivery time modifications / sum of all orders (%);

RDTM= # orders of modified of delivery time / $\sum$# all orders monthly (%)

Definition 4 (Number of Clarifications, CLR): the number of reported actions needed to clarify information (#).

CLR= $\sum$ # clarified or reworked orders monthly

As an agreement between the factory and selected DCs, the detailed actions in terms of what/when/who/how had been defined with respect to RCA and implemented at both sites. The project team monitored the major issues related to the order handling process, and then reviewed the project's results after several months. Those KPIs had improved dramatically, as shown in Table 4 and Fig. 5.

D. Benefits

The lean approach solutions has helped the factory and its DCs achieve the visible and significant improvements, for example resulting in the huge amounts of waste removal, which were shown in Fig.5.

It was obvious that without removing waste during the order handling process, the factory and its DCs were absolutely unable to reach so good performance rates. The tangible benefits, i.e. direct cost savings, from those saved hours on order handling process of the factory was about 30,000 Euros

TABLE IV
KPI MONITORING

Month	TETC(day)	FPYO(%)	RDTM(%)	CLR(#)
Jan	4.15	83.00	25.50	1420
Feb	4.1	83.00	24.30	1010
Mar	3.95	83.00	22.50	1200
Apr	3.85	83.00	22.20	1180
Jun	3.8	86.00	20.20	1180
Jul	3.75	85.50	20.10	1060
Aug	3.8	85.50	22.80	1080
Sep	3.75	87.00	18.00	950
Oct	3.75	90.00	12.60	690

per month during piloting phase. Those saved hours could handle more orders and contribute for the increasing profits. As a result, the order delivery time is reduced about 30%, Finish Goods (FG) is reduced about 25%, annual orders was increased about 25%, so its annual revenue was increased about 15 million Euros. There was also intangible benefit from the pilot project. The participants of the whole value chain have learnt to apply lean thinking for other non-manufacturing work, to make further improvement together, and to get win-win scenarios.

The superior outcomes of the project have motivated the local team from the factory and DCs. At both sites, workers have learned how to work more closely with one another, and how to implement lean concepts and principles to reduce waste in non-manufacturing process. These were valuable achievements for the project team, and they will contribute to ongoing continuous improvement in the future. For example, the local factory has decided to apply the lean approach for more DCs, and the DCs selected for the case study would like to continue to implement lean approach measures within its own process, and even cooperate with its end customers to make continuous improvements.

In summary, the lean approach solutions have applied to non-manufacturing process of the case company, and achieved very good benefits. Lean approach solutions can be used not only in order handling process improvement, but also have extended to more non-manufacturing processes, including the identification and removal of waste throughout the whole value chain:

- With respect to Ohno and other lean practitioners, identify the waste generated across the value chain, not only the internal waste;
- Optimize the process throughout the value chain, not just an individual process;
- Maximize the value of participants' relationships throughout the value chain;
- Strengthen the cooperation and communication between all participants of the value chain in order to achieve win-win scenarios;
- Improve the tools both internally at both the factory and DCs, and externally in the whole value chain;
- Define some proper KPIs to reach some defined targets in order to optimize the non-manufacturing processes;
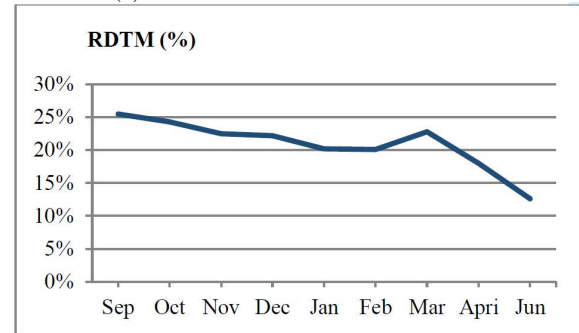- Change management should be one part of the project.
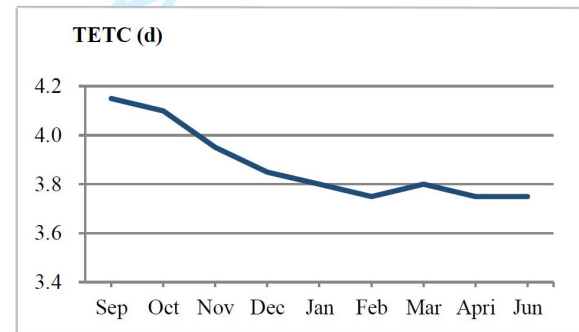
TETC= Time of Entry to Confirmation: Time period between entry order to order confirmation (day)
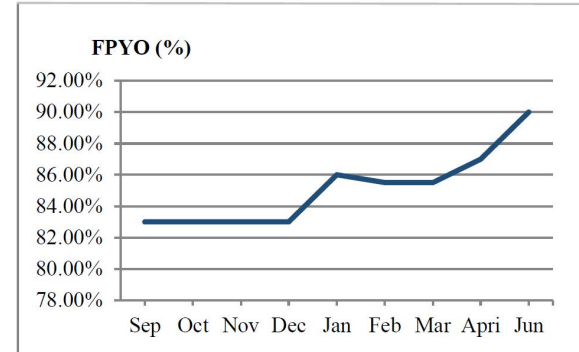
FPYO= First Pass Yield of Orders
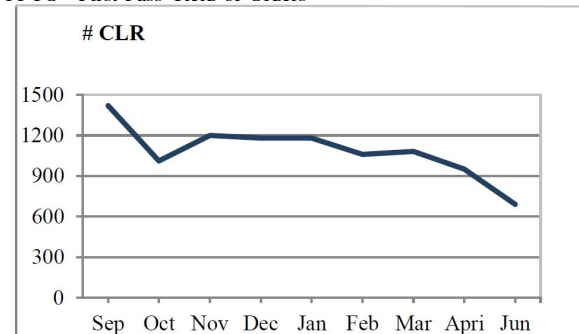
CLR= Numbers of Clarification: Number of reported actions for clarification (#)

RDTM= Ratio of Delivery Time Modification: Sum of delivery time modifications /sum of all orders (%)

Fig. 5. KPI performance's trend

IV. CONCLUSIONS AND FURTHER RESEARCH

A kind of lean approach is presented to optimize the waste removal in non-manufacturing process, which is one of the most important issues that a manufacturing company faces. The paper proposed the lean approach solutions to identify and

remove non-value-added work or waste from the work flow. The case study of the lean approach focused on how lean practice was implemented in the case company's particular factory and its DCs to achieve a win-win scenario by removing the wastes throughout the whole value chain.

In terms of further research, the lean approach application in non-manufacturing process could be extended:

- Expanding the relative application to different specific non-manufacturing process, such as the service sector or R&D, or even in Human Resources (HR), Information Technology (IT) areas if a manufacturing company would like to improve its relevant process and remove wastes accordingly.

- It is still a problem to define adequate KPIs for intangible benefit achieved from non-manufacturing process improvement. Compared with KPIs for lean approach improvement on manufacturing, it is not easy to measure all benefits for achievement from non-manufacturing process. This issue still needs research effort to explore suitable approach to measure the intangible achievement by non-manufacturing process improvement.

- Expanding to different perspectives has not been adequately explored. For instance, energy management and emissions management are the important perspective that lean approach can be applied and achieve benefits. What measurements can be used when it is applied to non-manufacturing process to show benefits in terms of energy management and emissions management? This question still need to be considered regarding the lean approach's applicability in practice.

Recently, more and more novel manufacturing modes are introduced by academic researchers. For example, Social Manufacturing mode was introduced by Chinese Academy of Sciences [28] in China and Aalto University in Finland, joint R&D projects are funded and executed [29], and academic papers are published jointly [30-36]. In the near future, we will research the lean approach for removing waste from Social Manufacturing process.

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