MINIMUM TIME FOR MATERIAL AND INFORMATION FLOWS ANALYSIS (MINIMIFA) - A METHOD TO IDENTIFY CHALLENGES AND IMPROVEMENT OPPORTUNITIES

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Abstract: Material and information flows are often complex at remanufacturing companies. Minimum time for Material and Information Flows Analysis (MiniMifa) is a data collection workshop in which material and information flows' challenges and improvement opportunities are investigated. By carrying the idea of Value Stream Mapping (VSM), MiniMifa turns to an act of cartography of industrial processes. After the workshop, companies have a holistic view of their processes, the current "pains" - challenges, and possible "painkillers" – improvement ideas, including lean-inspired solutions.
This paper demonstrates a pilot MiniMifa at a forklift truck remanufacturer where a potential improvement in e.g. lead time reduction by 93% was discovered.

Keywords: Remanufacturing, Lean, Material and Information Flows, Data collection workshop, Process map

1. INTRODUCTION

By bringing used products back to useful life, remanufacturing puts the product life-cycle into a sustainable loop. Typically, remanufacturing consists of several process steps such as inspection, cleaning, disassembly, reprocess, reassembly and testing (Sundin, 2006). The remanufacturing challenges, caused by process complexity, were first noticed by Steinhilper (1998), followed by Guide (2000) and later Sundin et al. (2008). Simultaneously, the issues of complex information flows were discovered by Guide (2000), Ferrer (2000), Lundmark et al. (2009) and Golinska (2011). The combination of material and information challenges turns the remanufacturing process to a complex material and information flow "*Labyrinth*" (see Fig. 1). At the same time, a complete picture of remanufacturing challenges and improvement opportunities is missing, leading to a situation where improvements in one area cause problems in another. Therefore, MiniMifa satisfies the need for a holistic view of remanufacturing and taking into account the challenges of both material and information flows to develop a common solution for the entire remanufacturing process.

The MiniMifa workshop was designed as a comprehensive method to study remanufacturing challenges and improvement opportunities by following material and information flows. In this case, a phenomenon of interest has determined the data collection method (Law, 2004). The goals of MiniMifa are to:

- gather the remanufacturing companies' employees - MiniMifa participants - together to generate a common picture of the remanufacturing process, focusing on material and information flows;
- create a holistic or "helicopter" view of the remanufacturing process and its interaction with other important product life-cycle actors, such as original equipment manufacturers (OEM), product designers, service/maintenance and customers/buyers;
- define the remanufacturing process challenges and the interdependence of these challenges with the help of a visual process map;
- motivate MiniMifa participants to develop and express their improvement ideas for the identified challenges from their point of view;

- prioritise improvement ideas according to the level of effect on the product quality, process lead time and inventory level improvements as well as ease of implementation; and
- develop an improved remanufacturing process with improvements and lean-inspired solutions for remanufacturers.

Aim of the paper

The aim of this paper is to demonstrate the MiniMifa workshop as a method to identify remanufacturing challenges and improvement opportunities by following a business-critical product's material and information flows. The MiniMifa workshop is also demonstrated through the pilot workshop at forklift truck remanufacturer.

2. MINIMIFA

MiniMifa is a data collection workshop that historically has been applied in a case study including two remanufacturers. MiniMifa investigates **challenges** and **improvement opportunities** of **material** and **information flows** at a studied facility as well as its interaction with influential product life-cycle actors, such as original equipment manufacturers (OEM), product designers, service/maintenance and customers/buyers.

MiniMifa is an interactive workshop that carries a win-win advantage for the participating company and the researcher. MiniMifa, which originated as a data collection method, has been anticipated by the participating companies as *an interactive workshop that builds* "*bridges*" *and open* "*doors*" *to connect departments, functions and partners and discover simple, fast and efficient material and information flows in the remanufacturing* "*Labyrinth*". Therefore, MiniMifa can also solve today's material and information flows complexity - "*Labyrinth*" (see Fig. 1).

MiniMifa is a pleasant and joyful data collection method, although time-consuming. The participants' viewpoints are reached through 2-3 hours of constructive discussions with predefined questions and open dialogues, and often lead to a group consensus on each particular research question. The focus group dialogue is recorded and later transcribed.

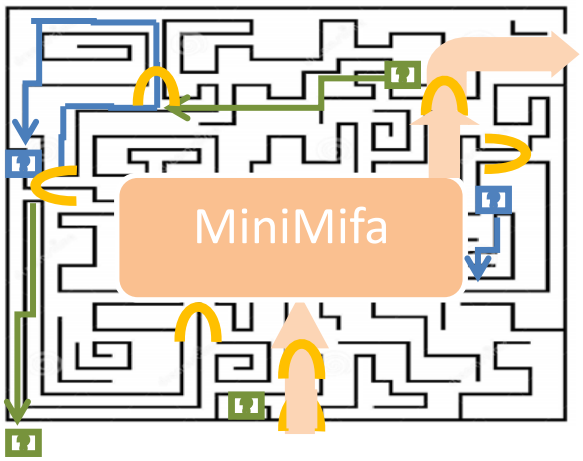


Fig. 1. Material and information flow "*Labyrinth*" (black Labyrinth frame with fixed roots = remanufacturing facility and processes; green arrow = information flow; and blue arrows = material flow; yellow arches = "bridges" to improve connection and/or "doors" – to remove barriers).

2.1. Focus of MiniMifa

The MiniMifa workshop focuses on three groups of remanufacturing challenges, identified through a literature review on remanufacturing challenges and opportunities to be lean (Kurilova-Palisaitiene and Sundin, 2013). Here lean denotes business excellence through continuous improvement. The three examined research topics are: the remanufactured **products' quality**; **process lead time;** and **inventory level**.

2.2. Material and information flows

Two data flows, **material** and **information,** are investigated. It is essential to study material flow parallel to information flow to create a complete picture of remanufacturing operations. Material flow covers the transaction of all kinds of materials, products, components, spare parts, and cores, while information flow incorporates any verbal and non-verbal information exchange, ranging from instructions, specifications and training to e-mail and telephone calls.

One business-critical remanufactured product is selected to study the path it moves on from one involved actor (department/function) to another, and from one process step to the next (like shadowing or following the object and information about the object as described by Czerniawska, 2007). In line with following the material/product flow, the information on that particular product's routes is studied.

2.3. MiniMifa participants

MiniMifa is performed by 5 to 6 of the company's employees involved in daily movements/exchange of material and information around the remanufacturing facility and beyond. A MiniMifa moderator is in charge of coordinating and collecting data during the workshop. The role of moderating was taken by one of the authors. Usually, the participants' competences cover the functions of facility manager, planner, operator or technician, administrator, and sales and logistics managers, depending on the company's operations. It is crucial to select MiniMifa participants who represent the viewpoint of the entire company, from machine operators to the facility's managers. Therefore, people are not a subject of interest, but rather the process they interact with.

2.4. Focus group dialogue

Focus group dialogue, elaborating on predefined questions, is a key part of MiniMifa. MiniMifa participants sit around a table while their discussion is recorded. According to Lydecker (1986), focus groups deal with complex subjects and bring out information that might be missed by a statistical study. Moreover, focus groups successfully gather in-depth information about many topics in a relatively short time. Additionally, the interaction between participants promotes an open discussion on difficult topics and creates an atmosphere for constructive dialogue (Basch, 1987).

The flexibility of focus group dialogues is another advantage, since participants improvise to pursue unexpected but potentially valuable topics of discussion. The reason for high value data from focus group dialogues is an opportunity for on-site data triangulation, which according to Barnett (1989) is one of the biggest benefits of the focus group. However, Morgan (1996) claims that some focus group participants may dominate, and others may not share their views. This concern is appropriate in the MiniMifa workshop performed. Nevertheless, it was noticed that the managers tended to dominate during the improvement idea prioritisation; this is the real-life situation in remanufacturing companies. Therefore, the MiniMifa discussion reflects reality.

The MiniMifa workshop serves as a platform for employees from different departments and functions to share a common understanding about the company's activities, and moreover the challenges that remanufacturing companies face today. Together, MiniMifa's participants, sometimes lacking information about the performance of other departments and having different experience, can together develop improvement solutions for the identified challenges in material and information flows.

3. PROCESS MAP

MiniMifa is not only about talking, but also about drawing. MiniMifa carries the idea of Value Stream Mapping (VSM), broadly used in manufacturing, to identify value and non-value added activities (Rother and Shook, 2003). As in VSM, the main company's operations are schematically plotted in the actual sequence to reflect the production process steps, inventory, and operators, as well as other process-relevant information. With the help of VSM, companies are able to focus on the vital process steps, optimize and simplify the operations, and reduce or eliminate activities that bring no value to customers (Jones and Womack, 2003).

Physical artefacts, such as maps, provide a better interpretation and visualization of the discussed process, which leads to a better group understanding of the underlying issues. MiniMifa has adopted the simplicity of VSM. However, the aim with MiniMifa is not only to define value and non-value added activities, but also to get an overview of the whole remanufacturing process, interconnected to its internal and external suppliers and customers. However, the main interest of MiniMifa is the movements of material (products, parts, and cores) and information (standards, training, and communication).

4. MINIMIFA AT A FORKLIFT TRUCK REMANUFACTURER

MiniMifa is performed in **three steps**:

1 Mapping the process and the actors;
2 Identifying process challenges; and
3 Collecting and prioritising improvement ideas.

4.1. Mapping the process and the actors

The first step is to map the remanufacturing process with all important activities and life-cycle actors. MiniMifa workshop participants develop a remanufacturing process map on a large piece of paper using simple tools, like pencils and post-it notes. One remanufactured truck model is selected to study the path it moves on, from one involved actor (department/function) to another. The material flow is marked with a blue colour, while information flow is green (see Fig. 2). Remanufacturing process steps and process actors are depicted in the map. At a studied company the following actors are identified: external actors (suppliers, sales, customers, logistics, warehouse and other traders) and internal actors (administration, planning, and a company in Baltics and scrap treatment). The following process steps have been identified: gates, workstation and quality control station. When a physical MiniMifa map is created a digital reproduction can be developed (special icons represent different processes or actors) (see Fig. 3).

Fig. 2. Process mapping (create a physical process/system map).

4.2. Identifying process challenges

The second step is to depict all challenges that question the effectiveness of the remanufacturing process. This is the most time-consuming part of MiniMifa, since an extensive discussion arises. In total, more than 20 questions in the area of product **quality**, process lead **time**, **inventory** control and customer **demand** are quantified and discussed among the MiniMifa participants.

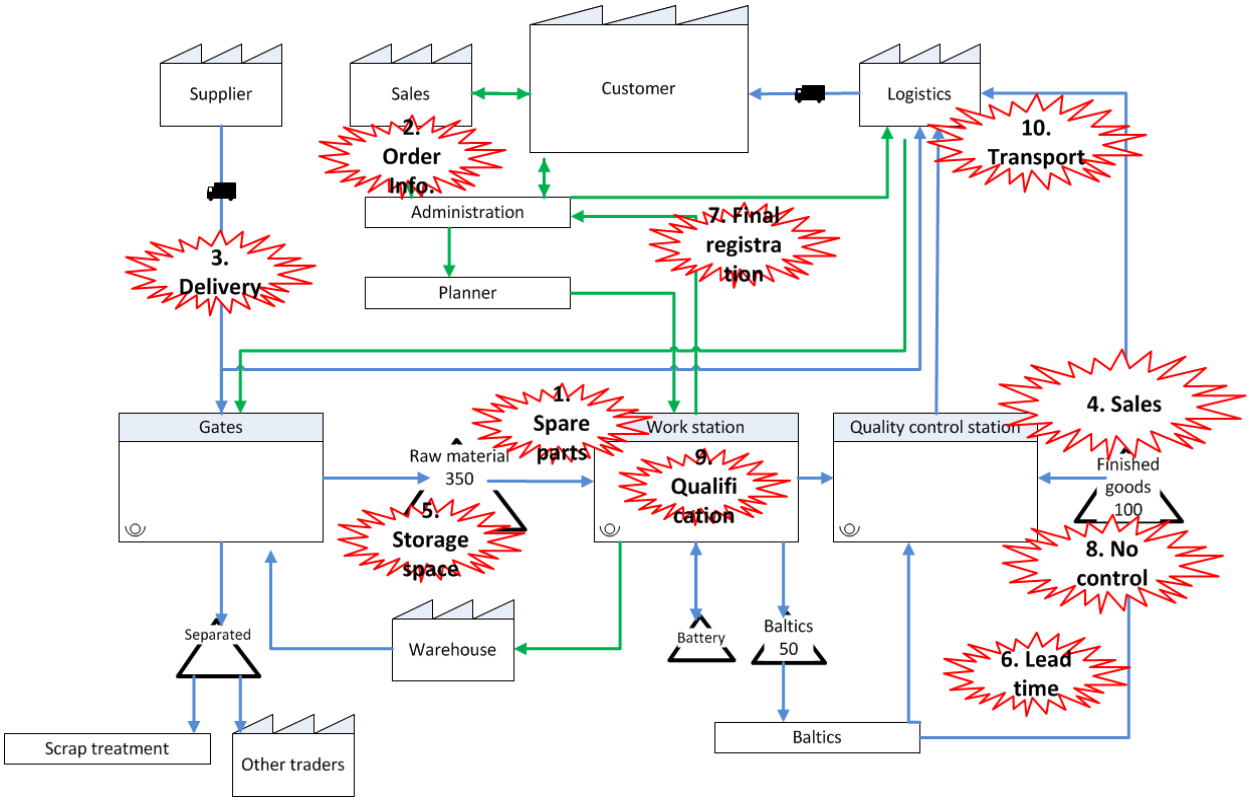


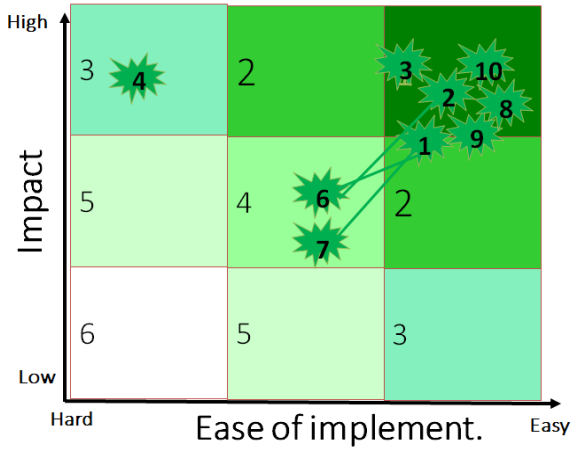
Fig. 3. Challenges (marked process/system challenges = red stars).

MiniMifa participants write down the challenges of material and information exchange on the post-it notes, mark them with a red colour and place directly on the developed process map (see Fig. 3). Thus challenges form the previously invisible dependency between remanufacturing processes challenges stressing the process functionality and the power of the responsible actors.

4.3. Collecting and prioritising improvement ideas

The third step is to develop solutions for the identified challenges. Each participant has a chance to present her/his improvement ideas, which are written on the post-it notes and placed directly on the map with the corresponding challenges. Afterward solutions are compared against each other and prioritized considering their impact on product quality, process lead time and inventory level, as well as the difficulty in implementing those solutions (see Fig. 4). Typically the ease of implementation is a subject to the following factors: availability of resources, time and capital investments, company's policy and culture, experience and/or knowledge as well as the willingness to change the working environment.

The improvement ideas are prioritized in the plot area, which consists of nine squares with amplitude varying between 1 (green), denoting high impact of improvements and easy implementation, and 6 (white), standing for a low level of improvement and difficult implementation (see Fig. 4). The ease of implementation and the impact on material and information flow improvements are two criteria that determine which improvement ideas will be implemented, postponed or disregarded in the short and long term.



1 Early order of spare parts
2 Technical training and new ordering system for sales and administration
3 Owning delivery (control over delivery)
4 Proactive approach, better contact with sales
5 *Removed* after introducing a simple control function to limit inventory
6 Depends on challenges nr. 1, 2, and 4
7 Depends on challenge nr. 1
8 Reordering system, second-hand webpage
9 Training for technicians/operators
10 Advanced ordering of special trucks

Fig. 4. Collected and prioritised improvement ideas (green stars).

5. DEVELOPMENT OF LEAN-INSPIRED SOLUTIONS

The remanufacturing process information and material flow is analysed in order to show the current situation, communication, information exchange, material exchange and logistics links. The challenges of the current process are documented and well-defined. A future map is developed based on recommendation of the solution square and MiniMifa discussions. The process lead time can be calculated and value-added added (port, administration, planning and logistics, work station, quality control) and non-value added activities (raw material inventory, waiting time for information from sales, waiting time for spare parts, finished goods inventory) can be presented (see Fig. 5). The lead time was a key focus in the studied company.

At the forklift truck remanufacturer the opportunity to apply lean-inspired solutions to improve remanufactured operations was investigated. Lean, originating from Toyota Production Systems (TPS), has become a source for inspiration for improvement ideas in diverse industries, service organisations, and various companies and in healthcare. A redesigned and simplified material and information flows have been developed for the forklift truck remanufacturer (see Fig. 6) (see Womack and Jones, 1996).

To tie information and material flows together into a well-functioning operational system a Kanban reordering system was suggested during MiniMifa workshop. A Kanban system in remanufacturing tends to stabilize the remanufacturing process by optimizing the process steps, improving the cooperation with customers and suppliers (Kurilova-Palisaitiene and Sundin, 2014). Therefore, a successful Kanban system application to a remanufacturer studied can boost the effect of lean "painkillers" to remanufacturing "pains".

Furthermore, from the MiniMifa workshop it was determined that there was an opportunity to shorten the lead time by 25% directly after workshop without major resource, time and capital investments (see square 1 Fig. 4). Finally, MiniMifa discovered that if the selected prioritised improvement ideas were implemented together with lean-inspired solutions including Kanban (see Fig. 4 and Fig. 6), the projected non-value added activities can be diminished and eliminated, which would lead to the 93% savings in lead time. This corresponds to a reduction of the unpredictable lead time from between 1 and 29 weeks to a more predictable and stable 1 and 2 weeks. These findings support the former research findings in the area of lean remanufacturing (see Kanikula and Koch (2008), Sundin (2006), Seitz and Peattie (2004), Östlin and Ekholm (2007), Dowlatshahi (2005)).

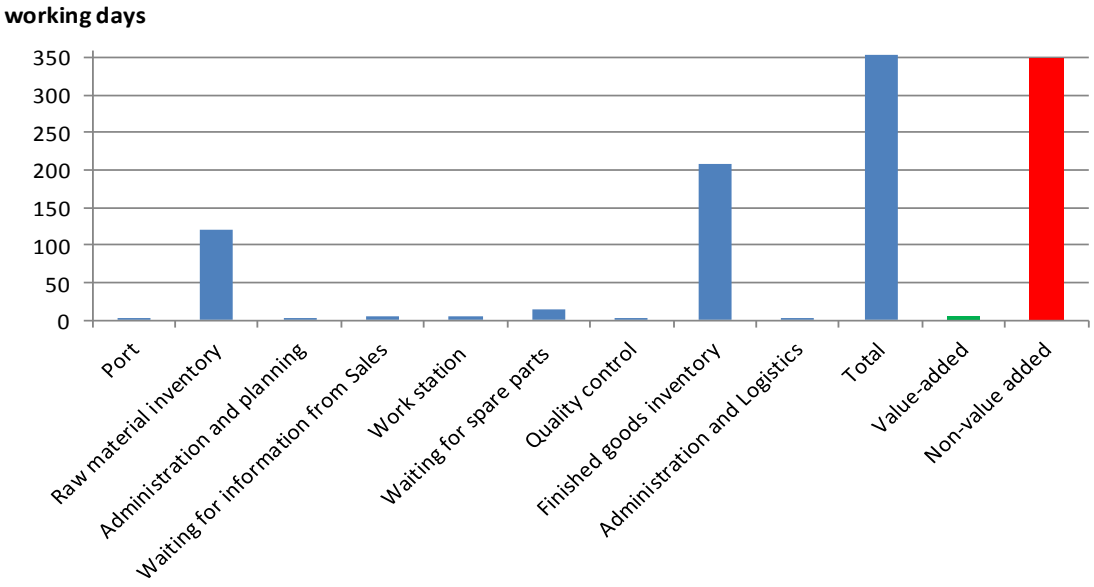


Fig. 5. Breakdown of current lead time (1 to 29 weeks) at the studied remanufacturer and value- and non-value added activities.

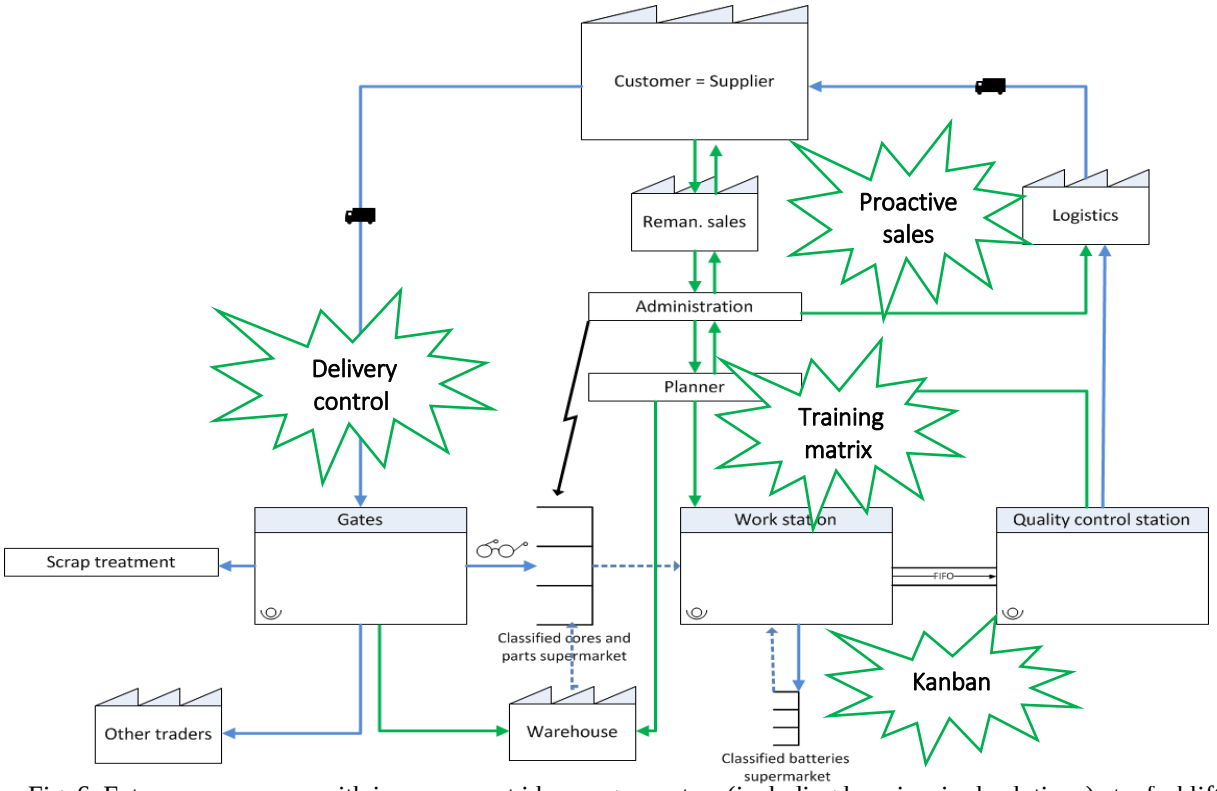


Fig. 6. Future process map with improvement ideas = green stars (including lean-inspired solutions) at a forklift truck remanufacturer.

7. DISCUSSION

MiniMifa showed that employees working in their area of responsibility have great knowledge about how to deal with the local challenges, but that they can barely recognize the challenges of the employees from other departments. To avoid this drawback, MiniMifa gathers employees in one common session and motivates them to develop a consensus about the appropriate improvement strategy for the whole company. MiniMifa closes the gap between participants and provides more accurate results. However, the biggest advantage of this method is reduced complexity when a variety of research questions are covered during one MiniMifa workshop.

Each MiniMifa step is clearly defined and explained to the participants, and the execution is recorded by audiotape and visual process map. The analysis of the findings is strictly based on the MiniMifa discussions and MiniMifa process map. MiniMifa, with its multiple data collection methods (focus group dialogues and questions) provides an opportunity to verify data to strengthen the research findings and conclusions. The Based on feedback from workshop participants, MiniMifa can be further developed and applied to a great number of industries, services, and both private and public companies. The role of the MiniMifa leader – moderator can be taken by other researchers and practitioners.

8. CONCLUSIONS

MiniMifa is the act of cartography of industrial processes. It studies the remanufacturing challenges and improvement opportunities by following one business- critical product's material and information flows along remanufacturing operations and even beyond factory limits. MiniMifa participants are employees who develop the visual process map, filling it with challenges and improvement ideas developed through 2 to 3 hours of dialogue. Three research questions are in focus: remanufactured product quality, process lead time and inventory level. After MiniMifa, companies have a holistic view of the processes, the current challenges, or "pain", and possible "painkillers", or improvement ideas. Moreover, MiniMifa provides researchers a basis to develop possible lean-inspired solutions to remanufacturing and contribute to improvements in the whole product life-cycle.

This paper presented MiniMifa, a data collection workshop, and an example of a pilot MiniMifa at a forklift truck remanufacturer in three steps: mapping the process and actors, identifying process challenges, and developing and prioritising improvement ideas. The map, with plotted material and information challenges and improvement ideas, followed by a lean-inspired solution application on a developed future remanufacturing process map, is demonstrated. MiniMifa showed a studied company's potential to shorten its process lead time by 25% directly after the workshop. Finally, it was discovered that if all prioritized improvement ideas and lean-inspired solutions are implemented the projected lead time savings could reach 93%, corresponding to lead time reduction from 29 to 2 weeks maximum.

9. FUTURE RESEARCH

The next step after MiniMifa could be to test the lean-inspired solution and analyse the effect of the developed initiatives on the company's performance. The findings of this research will contribute to the future development of lean principles and philosophies designed exclusively for remanufacturing.

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