# Creation of a Value Stream Map to Improve the Flow of Materials Using Cellular Manufacturing

**Luis F. Romero-Dessens, Anel Arce, Jaime A. Leon-Duarte**

*Abstract*—**Nowadays, many manufacturers are struggling with improving productivity and producing the right products or services according to the demand. In order to survive on this competitive world, companies need to innovate the way they operate and quickly adapt to changes. Lean Manufacturing is an applied methodology that has proved to be resilient at facing such challenges, since it focuses on creating flow of value to the costumer by performing work tasks with a minimum of non-value adding activities; lately, value stream mapping has been the preferred tool to support the lean approach and reduce waste. Another helpful technique to reduce waste is cellular manufacturing, which offers the advantage of being able to maximize the cell independence and reduce the material handling, work-in-process, setup time, and manufacturing lead time and improve productivity, due to the fact that the cell is dedicated to a unique product family. The main objective of this study is to design an efficient value stream mapping to improve the flow of materials and increase the productivity by eliminating non-value added activities at an electronic components manufacturer. The methodology consists of, first, to analyze the wastes located at the production system in the current state map; second, to implement a single minute exchange of die and cellular manufacturing tools aiming to effectively support future state of the action plan. This paper concludes that the designed future value stream map in conjunction with cellular manufacturing and other lean tools is helpful to identify wasteful activities at the production system. The applied tools are an important input for continuous improvement by increasing the productivity at the manufacturer.**

*Index Terms*— **Cellular Layout, Lean Manufacturing, Value stream mapping, Quick-changeover.**

## I. Introduction

In current economic environment, conditions like globalization, rapid market changes and high competition levels have a significant impact on the requirements for any enterprise that want to remain active at the marketplace [1]. Lean manufacturing (LM), originating from the Toyota production system, is the most widely known approach for industrial improvement [2], [3]. In recent, years many tools and techniques have been developed for several fields of industry, aiming to support and enable the creation of a LM system. The focus of this approach is on cost reduction by eliminating non value added activities via focusing on identifying and eliminating waste from each step in the value stream [4]. Since the creation of LM, many of its tools and techniques (e.g., just-in-time, cellular manufacturing, total productive maintenance, kaizen events, single-minute exchange of dies (SMED), production smoothing) have been extensively used [5].

Value Stream Mapping (VSM), defined as ‘‘a tool that helps you to see and understand the flow of materials and information of a product as it makes its way through the value stream” [6], and it is the process of visually mapping the flow of information and material, which is helpful at visualizing the station cycle times, inventory at each stage, manpower and information flow across the supply chain.

VSM involves identifying seven lean wastes (i.e. defects, overproduction, inappropriate processing, unnecessary inventory, unnecessary motion, transport and waiting [7] through the development of a current and, through the application of other lean tools, a future state value stream map [8]. This tool can be an extremely powerful tool, combining material processing steps with information flow as well as other important related data [9].

Cellular manufacturing (CM), defined by Meyers and Stephens [10] as “an application of the group technology philophy with focus on the identification of simmilar parts to the benefir of a particular production”. After grouping parts into various part families, machine cells can be formed to produce those parts well inside the cells [11]. This type of production system can be charactarized as an hybrid system, of cells linking the advantages of both the job-bing (flexibility) and mass (efficient flow and high production rate) production approaches [12], [13]. The significant benefits of CM are a reduced setup time, reduced work-inprocess inventory, reduced throughput time, reduced material handling costs, improved product quality and simplified scheduling, etc. [14], [11].

The cell formation technique applied for this study is related to the LM approach through the creation of a VSM and a SMED. Those tools were selected due to their capability to provide successful results at the industry in regards of flow of materials and productivity improvement [15], [16]. Section 2 of the paper describes the steps taken in order to develop a proper cell design while implementing lean concepts successfully. In Section 3, the case study is given with details of various findings and the corresponding values for some of the key performance indicators at the production system, as well as the formation of the cell and the proposed cell layout based on the takt time. Finally, the results and conclusions of this research are presented.

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## II. Lean Approach to Improve the Flow of Materials

VSM is helpful to eliminate many non-value added activities from the production process such as waiting time, inventories, overproduction, and more. Thus, it is an enabler to achieve the objectives of lean manufacturing and more important, to generate big profits at manufacturers. Many companies implement VSM for the most important product families aiming to see and understand the flows of materials and information as the product make its way to the customer. Some studies report even more than 50% in work-in-process reduction at the workplace [17], [18]; additionally, academic and practitioners of lean have found it to be helpful at reducing the lead time, getting positive results with reduction of up to 92.58% 18], but in many cases the improvement is bigger than 70% [20] - [23]. As shown in figure 2.1, the use of VSM has been growing since its introduction in the lean philosophy, and it is very likely that it will continue to grow until it becomes an important aspect acknowledge by every industry.

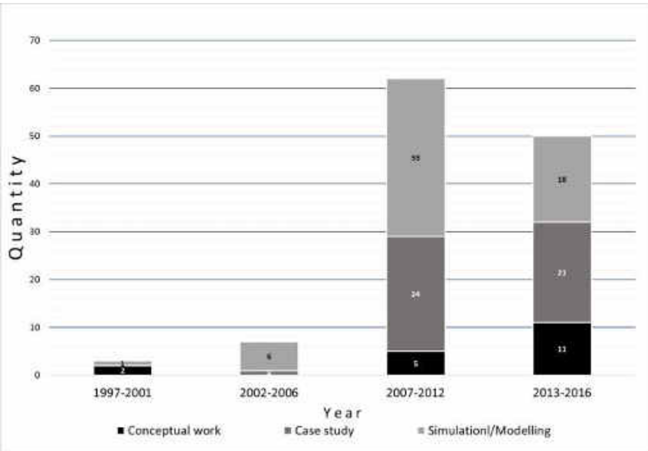



**Figure 2.1 Application of VSM in the literature over time**

Every time when VSM is applied, it works in conjunction with other lean tools, since it helps to see and understand the flows of materials and information, but not to remove it by its own. One of the most powerful tools to remove waste is cell manufacturing, and is brings the benefit of being easily adapted for any industry whether it is a small-scale or a large-scale industry.

It is convenient to implement the methodology of cellular manufacturing when the problem of locating stations and machines at the manufacturing plant arises, this is in order to create a layout design that satisfies every demand. To eliminate these problems, a proper method is required to achieve a rhythm in manufacturing lean line by identifying value adding, non-value adding activities (through the VSM).

Two major forms of waste are work-in-process inventory and unnecessary delays in flow time. Both can be reduced by implementing quick changeover techniques and by applying cellular layout reengineering production processes, and bottleneck removal to reduce unnecessary delays in the production process [24]. This study presents a case study of a global company devoted to the manufacture of electronic components, such as connectors and other devices. Here, a SMED analysis will be started up with detailed process map and time study. It will need the analysis of everything that happens during the changeover to understand the possibilities of activities that can be moved outside the changeover window.

It is important to consider that to make cellular manufacturing efficient, it is necessary the implementation of several concepts of the lean approach. In this paper, we present a case study aiming to design a cellular layout for the implementation of the lean manufacturing or. Summing up, we propose a cellular layout that follows the lean principles to improve the flow of materials, which translates in the increase of productivity. Figure 2.2 shows the proposed methodology described herein.

## III. Case Study

Considering the lean philosophy, we pursued its implementation focusing on potentiating wastage reduction and an increased productivity. This project was carried out at high volume-low mix production system, where the above techniques were put into practice as part of an improvement project.

The research was conducted out in the north of Mexico, the company for this case study will be called XYZ, which is a global company certified in ISO 9000 and has several departments and work stations where it produces electronic components for industries such as defense, healthcare, automotive, among others. We worked at a specific department with a single product family; this means, a set of products sharing similar processes. According to the employees and the manufacturing engineer, the area had productivity issues since about 11 years ago, which translates into a great amount of idle time and ineffective work distribution among operators. Even though they were aware of the importance of providing solutions for this area, it became urgent since the management encourage them to apply urgent improvements due to recent strategic changes at the company.

Firstly, the current VSM was created by one single person at the company, according to the accepted methodology for the utilization of this tool. Thereafter, a team of the area conformed by people from different hierarchy positions at the selected department among operators, engineers, and an

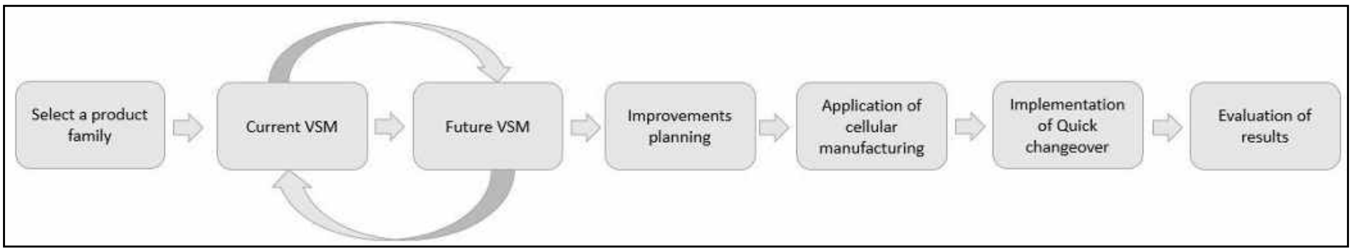



**Figure 2.2. Proposed methodology**

external researcher met to analyze the diagram with its respective flows drawn and the conditions of the product family. They aimed to remark the possible improvements by techniques such as brainstorming and simulations of the proposed solutions, emphasizing on layout redesign and quick-changeover techniques. The current VSM can be observed at appendix A.

Then, the team carried out a physical simulation of the cell proposed, times of the proposed solutions were estimated and the members gave their individual opinions of the solutions proposed, reaching an agreement about the necessary changes to implement. The operators offered ideas in regards of ergonomic situations where the productivity was affected, their approach had an impact on the redesign of the semi-automatic equipment utilized at the production line; the production engineer, as well as the process engineer coincide on these arguments and determine the redesign of the equipment. This was important to be taken into account when performing the quick-changeover.

After the solutions where shared and discussed by the team members, they selected the better ones and outlined a plan to carry such improvements out. In order to continue, they proceeded to illustrate the changes on the VSM belonging to the future state, which is observed at the appendix B. This diagram was created on the basis of boosting the productivity, reducing over-production and several waiting times between stations, which demonstrates to improve the overall performance of the productive system.

Figure 3.1 shows the rout of the pieces while they are being manufactured, traveling from the line production to the quality inspection area, then back to be packaged at the production line and finally, it was transported to the place where the storer person come for the finished products and take them to the shipping area at the warehouse. Here can be appreciated one of the reasons why cellular manufacturing was used, in order to reduce traveling time and be customizable to different production orders from a lean perspective. The proposed cell for the product family under study is shown on figure 3.2, where stations 1 to 4 are devoted as follows: 1) crowns and housings are located, 2) pneumatic press, 3) the product is labelled and 4) packaging station; additional stations 5 and 6 are situated in case than more presses are needed, this was decided by the engineers, considering that a little more of space would allow to manufacture eleven additional part numbers, rather than only two.

For the implementation of the changeover, a spaghetti chart was developed, containing the transportation of the mechanic in charge, illustrating the rout followed every time, when a changeover was needed at the area. This can be observed at appendix C. The times were recorded by means of a chronometer, join the mechanic while performing the activities of the changeover, including the travel exchange of dies times, as well as all the steps between the moment when the production stops and the moment when a new good piece is manufactured.

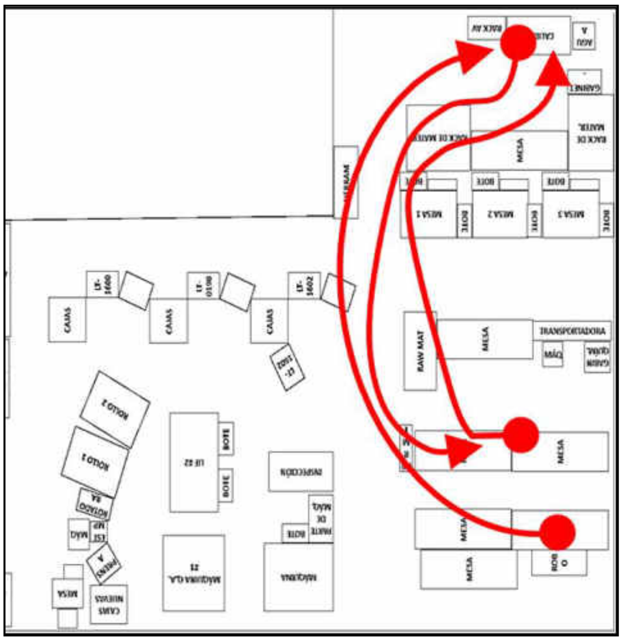


**Figure 3.1. Spaghetti chart for the selected product family**

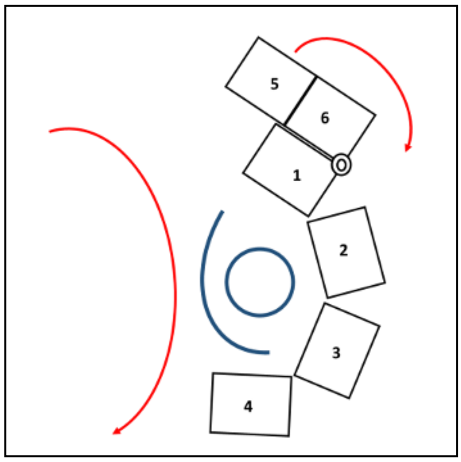



**Figure 3.2. Proposed cell for the product family**

The implementation of the quick changeover consisted of, first, identifying each of the activities performed in the space of time between the last piece of the previous order is done at the concerned equipment, which in this case is a pneumatic press at station 2, and the moment when the first good piece is produced in the new equipment. All the information in this regards was recorded and ordered in the table 3.1; it can be observed, that the activities were classified into internal or external.

## IV. RESULTS AND CONCLUSIONS

The application of the selected lean tools allowed the team to obtain better results on the desired aspects of the production (e.g. key performance indicators); this is shown in table 4.1. Additionally, there were another type of improvements such as ergonomic benefits, as the impact on mental workload was positive, and operators appreciated the fact of being involved as an important part of the team and the decision-making process. Each of the engineers agreed to the convenience of implementing the proposed layout redesign

**Table 3.1. Internal and external activities of current (left) and proposed (right) changeover**

**Current Changeover**

| No. | Description | Time | Classification |
|---|---|---|---|
| 1 | Select the order to be produced | 0:03:30 | preparation |
| 2 | Bring components | 0:05:08 | Transportation |
| 3 | Bring tools to perform Changeover | 0:05:10 | Transportation |
| 4 | Change the press | 0:00:50 | Set up |
| 5 | Produce one piece | 0:02:55 | Set up |
| 6 | Produce the first five pieces | 0:05:57 | Set up |
| 7 | Measure the pieces | 0:02:12 | Set up |
| 8 | Get the necessaty formats | 0:02:58 | preparation |
| 9 | Record the measures of the pieces | 0:03:10 | Set up |
| | | 0:31:50 | |

**Future Quick Changeover**

| No. | Descipción | Tiempo | Clasificación | Actions |
|---|---|---|---|---|
| 1 | Select the order to be produced | 0:00:00 | preparation | Show the sequence of production orders visually. (in-process kanban, signal kanban). Convert them into external operations. |
| 2 | Bring components | 0:00:00 | Transportation | An external assigned operator will bring the components as an external operation |
| 3 | Bring tools to perform Changeover | 0:00:00 | Transportation | cart with specific partitions containing the tooling |
| 4 | Change the press | 0:00:30 | Set up | Layout redesign |
| 5 | Produce one piece | 0:00:28 | Set up | |
| 6 | Produce the first five pieces | 0:02:23 | Set up | |
| 7 | Measure the pieces | 0:00:00 | Set up | Re-assign the responsibility of signing up and store the formats, Convert it into external operations. |
| 8 | Get the necessaty formats | 0:00:00 | preparation | Re-assign the responsibility of signing up and store the formats, Convert it into external operations. |
| 9 | Record the measures of the pieces | 0:00:00 | Set up | Re-assign the responsibility of signing up and store the formats, Convert it into external operations. |
| | | 0:03:21 | | |

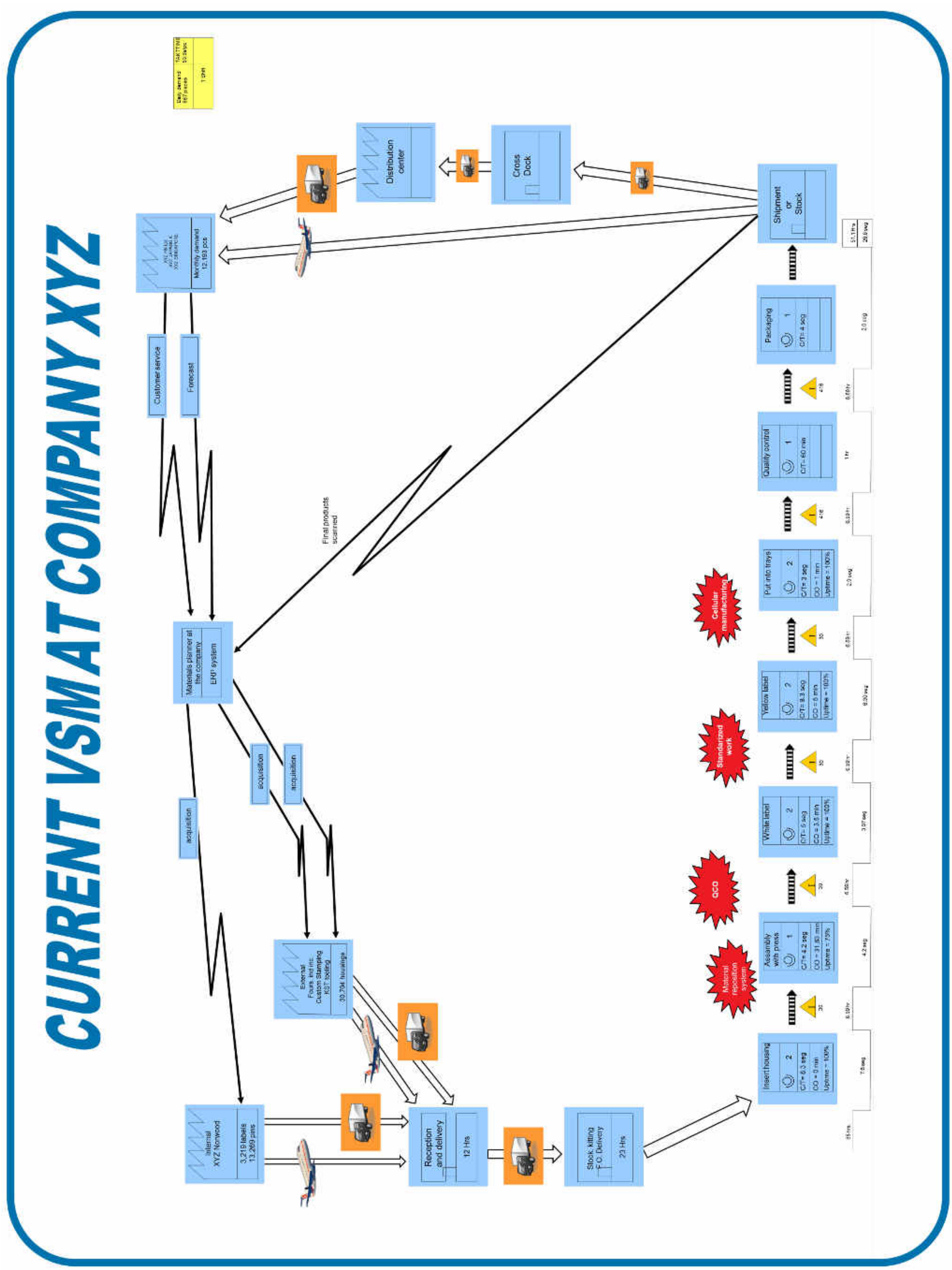
and the quick changeover process. Furthermore, the numeric analysis demonstrated that the productivity and waiting time levels would be highly improved with the application of the proposal here presented. The management level verified and accepted our proposal; to date, the changes had started to perform, the cell is under construction and a Kanban system has started to operate.

As a take-away, there were comments in regards of the importance of conforming a team which involves all the hierarchy levels at the company, from operators to management; the more involved the people are, the better and quicker the proposal seemed to be. We recommend that this be object of further research. The VSM as well as the quick changeover allowed to remove obvious and hidden sources of waste, such as raw material and work-in-process inventory, waiting times, transportation, over-production, at the time that productivity was increased.

| | Current | Proposed | Improvement |
|---|---|---|---|
| Space (sq/ft) | 240 | 80 | 67% |
| Productivity (pcs/hr/op) | 43 | 148 | 244% |
| Work in Process (pcs) | 952 | 1 | 99.9% |

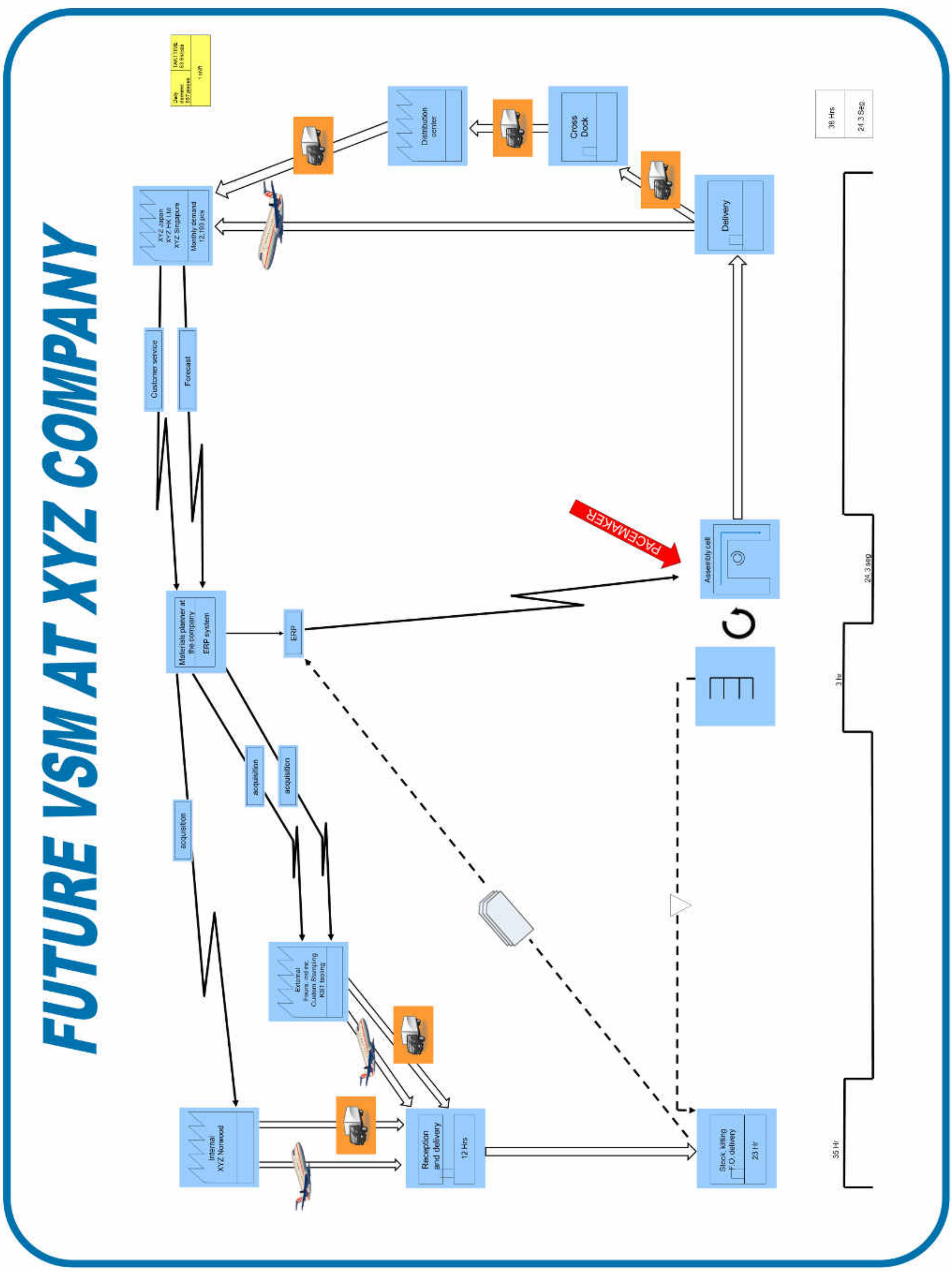
**Table 4.1. Improvements at the production system**

Appendix A



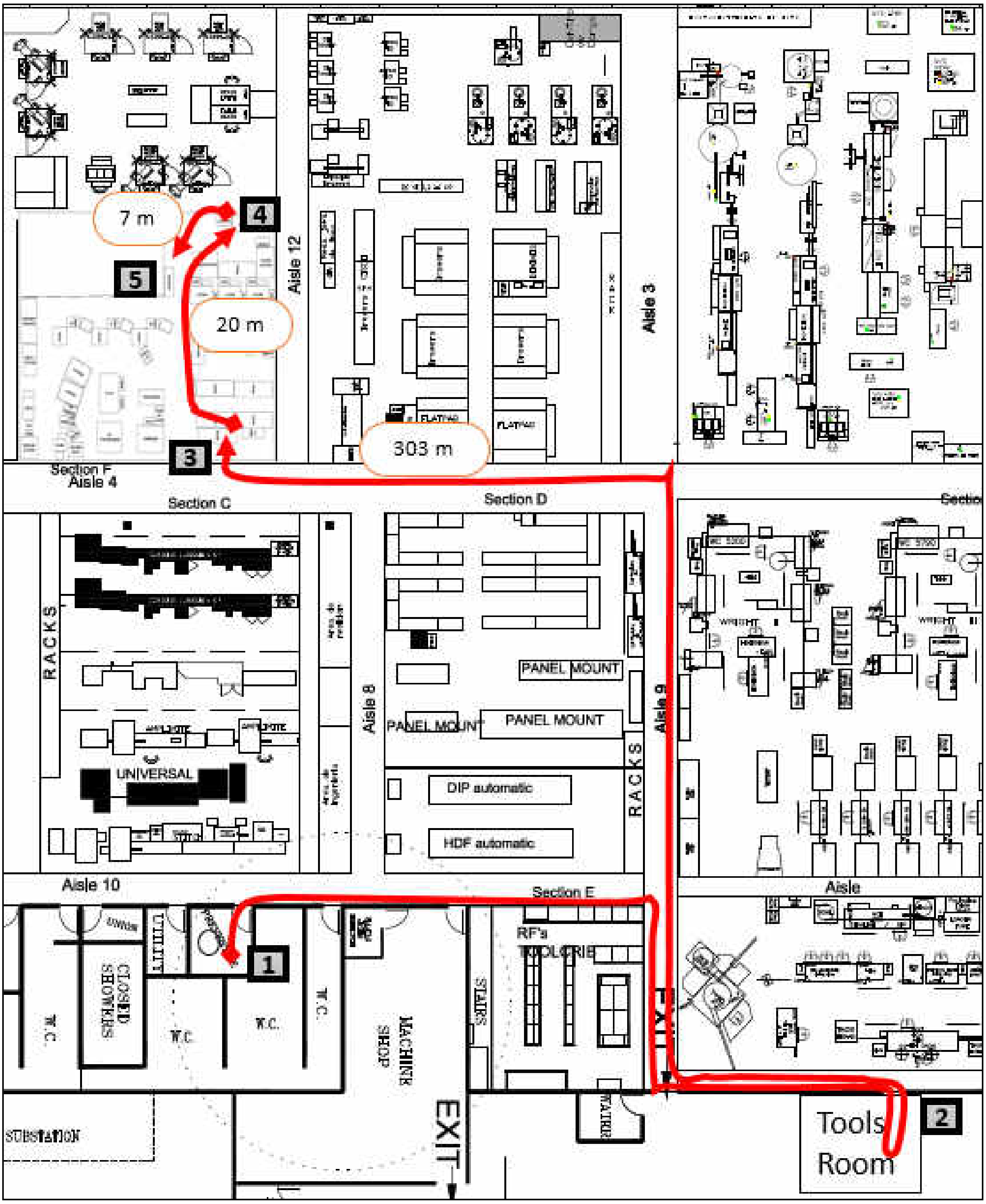

**Current VSM developed for the selected product family at company XYZ**

Appendix B




**Future VSM developed for the selected product family at company XYZ**

Appendix C




**Spaghetti chart for the current changeover of the selected product family at company XYZ**

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