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APPLICATION OF VALUE STREAM MAPPING TO "ETP ION DETECT™" COMPANY

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Abstract: Value stream mapping is a tool often applied in organisations working with lean production to visualise and analyse production processes. By creating a value stream map, an organisation can identify its main criticalities and look at both information and material flow mapping to enhance lean manufacturing. Hence, this work aims to develop a value stream mapping for the ETP Ion Detect™ Company to demonstrate the possibilities of seeing sources of waste, shortening the lead-time, and reducing work-in-process inventory with the value stream mapping application.

Keywords: lean production, value stream mapping, current state map, future state map

1 Introduction

ETP Ion Detect™ Company (ETP) is an award-winning and leading manufacturer of product solutions for mass spectrometry (MS). The company's global presence is supported by its technical and distribution networks located throughout the Americas, Europe, Japan, Asia Pacific, India, China, and the Middle East. Its primary R&D and manufacturing divisions, situated in Sydney, Australia, supply approximately 20,000 products a year, which generates an annual turnover of AU$20 million. 90% of ETP's total sales are attributed to seven OEM organisations. ETP Ion Detect™ provides MS instruments with the ability to both ionise and detect the chemical substances used within a myriad of MS technologies, configurations, and separation techniques, such as Quadrupole Mass Analyser (Quadrupole Ion Trap), Time of Flight-Mass Spectrometry (TOF-MS), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

The company assures that each machine possesses the following distinct advantages [3]:

- **Longer Detector Lifetime** – by improving electron-optical efficiency, ETP Ion Detect™'s detectors can last up to ten times longer than current detectors.
- **Gain stability** – extended detector lifetime enables more stable gain operation and less frequent instrument calibration.
- **Improved Dynamic Range** – known to have the highest linear dynamic range available, discrete dynode technology can be adapted to enable a wider dynamic range.

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- **Miniaturisation** – to comply with current market demands, ETP Ion Detect™ has combined new technologies to develop a range of mini and micro ion detection systems for quadrupole and TOF instruments.

However, to remain competitive, ETP Ion Detect™ must be able to sustainably up-scale its plant capacity, without compromising both current and future quality levels despite its technological advancements. Following the 'Lean Thinking' approach, this report re-evaluates the current production process of the company's main production line by constructing a current-state map, future-state map, and implementation plan to advance its current production process and operational performance.

2 Research methodology

The term "lean" was arguably first used in an article by John Krafcik. However, the Lean concept originated with thinking of waste reduction. Lean production is simply "lean" as "it provides a way to do more with less" [6, p. 15], so the "main objective for Lean is to eliminate waste" [1, p. 12]. However, Lean does not simply mean waste reduction. That is because the Toyota system seems to "*add waste rather than eliminate it*" [4]. Lean is not constantly thought of minimising waste but maximisation of value and about getting the right things, to the right place, at the right time, and in the right quantity [2]. The important point is that lean is value-adding. Although researchers have proposed many approaches for lean-based improvements in the value chain, including standard work, 5S, modularisation, and Kanban, Value Stream Mapping (VSM) is among the most important practices of lean, and it is a set of tools that help visualise the production flow and process information. The purpose of this approach is to identify value-added activities and activities that do not add values [5].

The analysis of the Scopus database from 1997 to September 26, 2019, shows that the number of scientific publications using (or analysing) the Value stream mapping tool is constantly increasing, especially in the last five years (Figure 1). This indicates the level of interest and credibility of this scientific method.

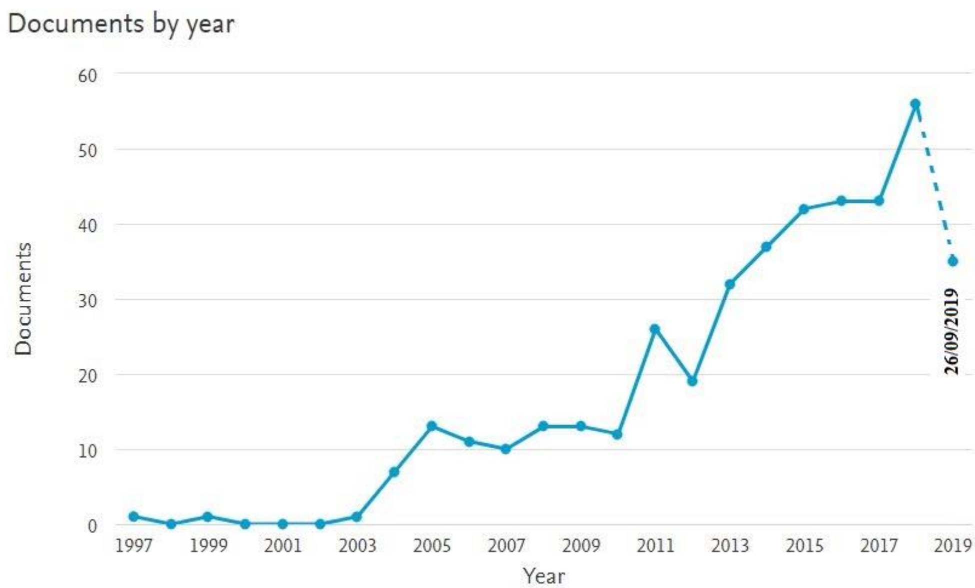

Figure 1. VSM articles published per year in Scopus from 1997 to 26/09/2019

Source: Scopus

For Value stream mapping, three types of activities occur along the stream, namely (1) Steps creating values, (2) Steps creating no values but unavoidable, (3) Steps creating no values and immediately avoidable. In order to make drawing value stream mapping, it is necessary to process the steps as follows (Figure 2):

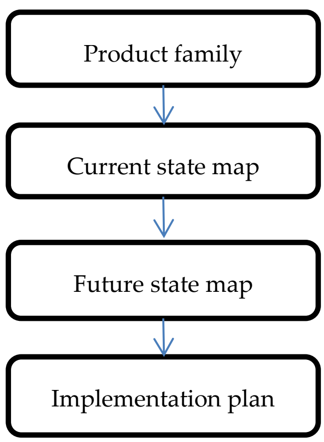

Figure 2. Value stream mapping process

Step 1: Form a team to collect data and map the selected value stream. Gather preliminary information, pick the product family (Group of products that pass through a similar process and utilize common resource).

Step 2: Create a current state map. A *current state map* is a snapshot of all the steps and processes, starting with a supplier and ending with a customer. The process attributes to be collected are cycle time, change-over-time, and the number of workers at each station, and so on.

Step 3: Create a future state map. Improve the current process by eliminating the problems discovered. Production control methods and tools used for this step are the Kanban system, FIFO inventory flow, etc.

Step 4: Develop an action plan (plan to achieve in the future).

3 Discussion

3.1 Product family selection

The ETP Ion Detect™'s major product range is split into four product families (Figure 3). Filtering the company's annual sales by product type indicates the highest saleable products being from the DyneX® product family. Approximately 12,000 units were sold to 10 different customers in 2017, which equates to a total turnover of AU$12 million per annum.

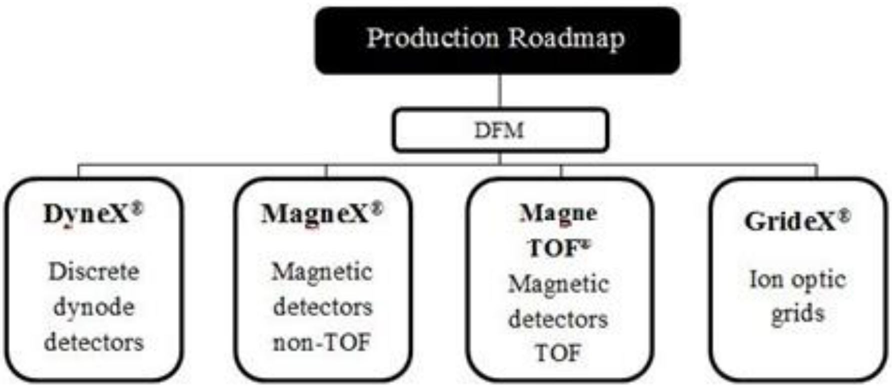

Figure 3. Map of ETP production range (ETP Ion Detect™, 2017)

Although the DyneX® family consists of approximately 50 different models, all are built up of practically the same components and pass through the same manufacturing processes. The basic build-up of a typical DyneX® detector is as follows: 2 x Ceramics (LH & RH), 14–22 x Dynodes (Formed Shims – Coated), 1 x Collector Plate (Formed Shim – Coated), 1 x Input Aperture (Slim/Thin Plate), 1 x Mount (Formed Plate), 1 x Signal Output Pin/Lead, 1 x High Voltage Output Mount (Formed Plate – Coated), and 2 x Spacer Rods.

3.2 Current-state map

As displayed in Figure 4, the ETP's manufacturing of DyneX® Detectors begins at the tumbling station, where both supplied ceramics and metal components (formed shims and plates) pass through a finishing (deburring and polishing) process. Once completed, the ceramics move on to circuit screen printing, then become further split into their handed pairs, half of which proceeds to soldering, whilst the remaining returns to stores and awaits picking for final assembly. The metal shims and plates experience a similar journey, some of which require being spot-welded into sub-assemblies, whilst the remaining is also returned to stores until being picked for assembly and/or coating. The shims requiring surface treatment are picked and sent to the coating process (held within a cleanroom), and once completed, progress on to final assembly, along with those uncoated shims, plates, completed ceramics, and standard washers and screws. Once fully assembled and approved, each DyneX® detector is passed on to the shipping department to be staged and shipped to customers daily.

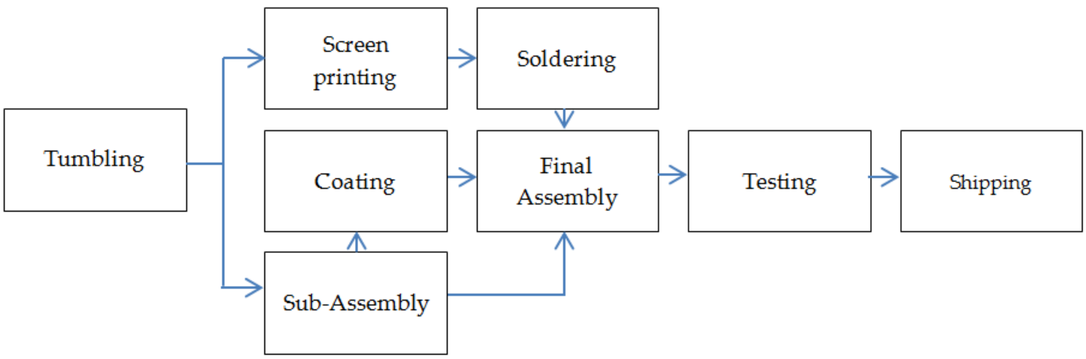

Figure 4. DyneX® Production Process Flow

For simplicity, the VSM in this paper is built upon the processing data of the following key components: Ceramics and metal shims/plates.

The summaries of each process are as follows:

Tumbling		Ceramic printing	
Process time	86,820 s	Operators	2
Cycle time (CT)	87 s	Process time	163,438 s
Change-over time (CO)	1,800 s	Cycle time (CT)	527 s
Observed inventory	1,000 Ceramics 10,000 Shims	Change-over time (CO)	300 s
Uptime (%)	100	Observed inventory	310
Shifts	1	Uptime (%)	90
Available time/Shift	23,760 s	Shifts	2
EPE	3 days	Available time/Shift	23,760 s

		EPE	_
Soldering		**Sub-Assembly (MSA)**	
Operators	2	Operators	2
Process time	100,000 s	Process time	82,037 s
Cycle time (CT)	770 s	Cycle time (CT)	189 s
Change-over time (CO)	900 s	Change-over time (CO)	300 s
Observed inventory	130	Observed inventory	150
Uptime (%)	100	Uptime (%)	90
Shifts	2	Shifts	2
Available time/Shift	23,760 s	Available time/Shift	23,760 s
EPE	_	EPE	_
Coating		**Final Assembly**	
Operators	2	Operators	2
Process time	18,000 s	Lead time	237,600 s
Cycle time (CT)	100 s	Cycle time (CT)	4,752 s
Change-over time (CO)	300 s	Change-over time (CO)	0 s
Observed inventory	180	Observed inventory	50
Uptime (%)	85	Uptime (%)	80%
Shifts	2	Shifts	2
Available time/Shift	23,760 s	Available time/Shift	23,760 s
EPE	1 day	EPE	_

All the information was utilised to generate the current-state value stream map. Thus, the overall manufacturing process can be summarised in Figure 5.

- Door to Door/Total Lead Time = 72.3 days (3.6 months).
- Value-added Time/Total Processing Time = 6,092 seconds (101.5 minutes; 1.7 hours).
- The current state displays higher than required levels of inventory between processes and thus demonstrates many of the eight kinds of Muda (Overproduction, Waiting, Transportation, and Inventory Excess).

Typical VSM symbols are shown in Figure 6. Software packages such as Microsoft Visio, eVSM, and Edraw Max could be used to draw value stream maps.

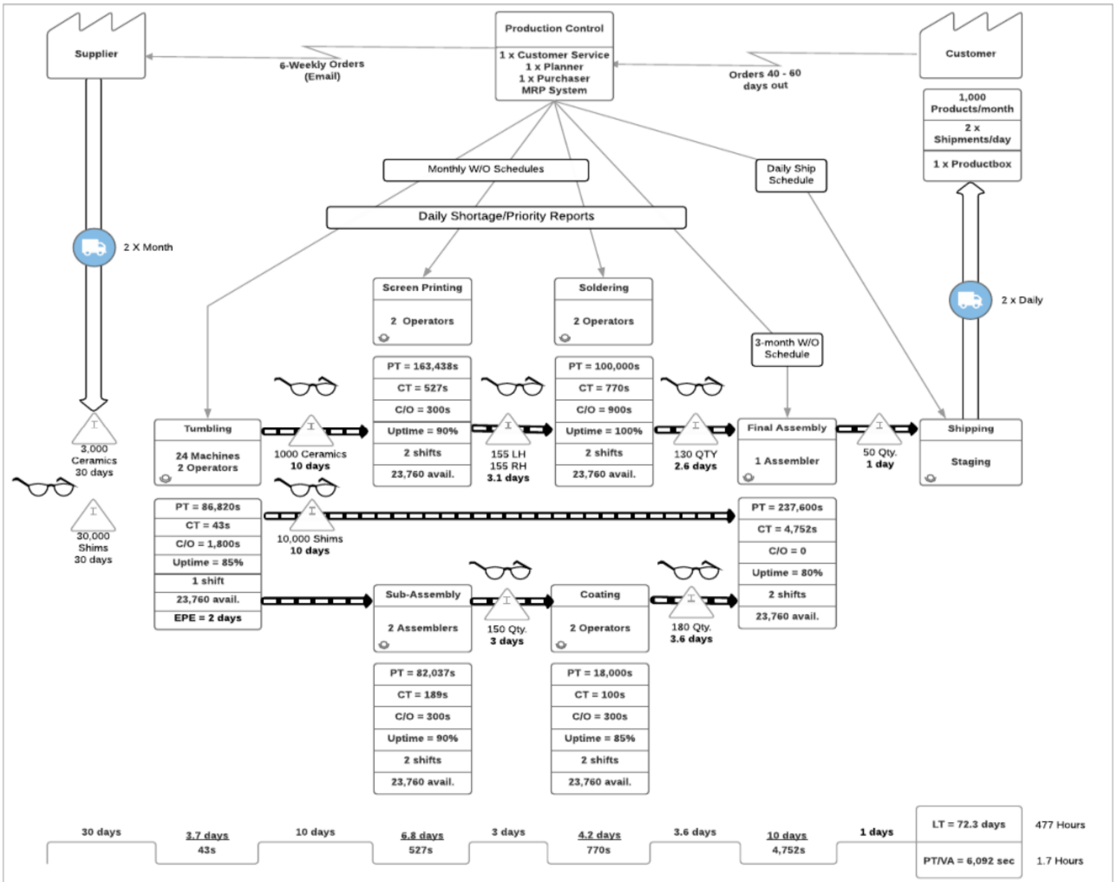

Figure 5. DyneX® Current-State Value Stream Map

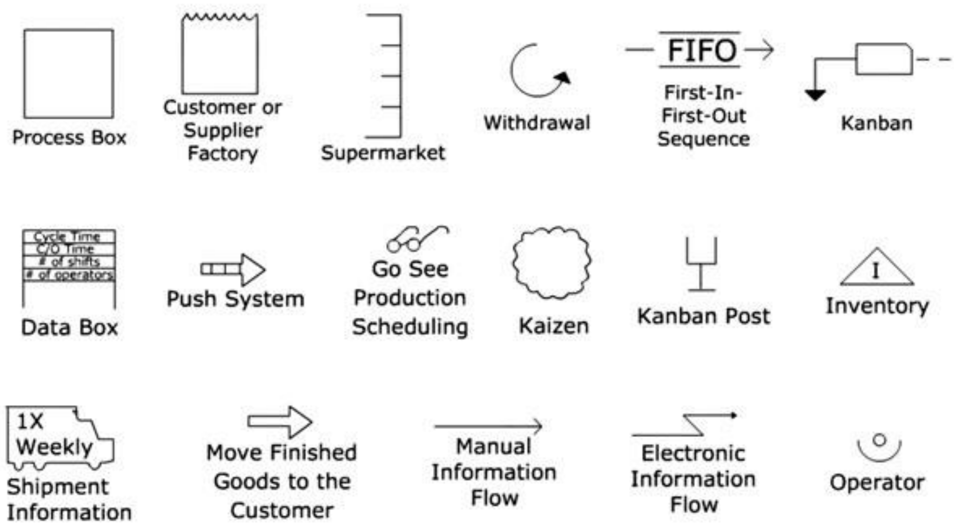

Figure 6. Typical VSM symbols [5]

3.3 Future-state map

The operator balance chart (Figure 7) summarises the current-state cycle times for each of the ETP's production processes. The lowest cycle time (43 seconds) is experienced at tumbling, which changes over to serve many product lines. Thus, it serves best under batch operation controlled by downstream processes through a supermarket-based pull system. Similarly, the coating system also serves many product lines and also benefits from serving through the control of a supermarket arrangement. Both printing and soldering workstations' cycle times are not far apart from one another and close to the takt time (soldering slightly over by 120 seconds). Both serve the ceramic production line, ensuring that a continuous flow between each process is highly possible. This also saves the need for all processed parts to travel to and from stores, as well as the unnecessary build-up of parts between the two isolated processes (Transportation and overproducing Muda). Dividing the total printing and soldering work content by the takt time (1,297 seconds divided by 950 seconds) indicates a requirement for two operators to run both processes in a continuous flow at takt. The remaining two operators can be reassigned to other value-added activities.

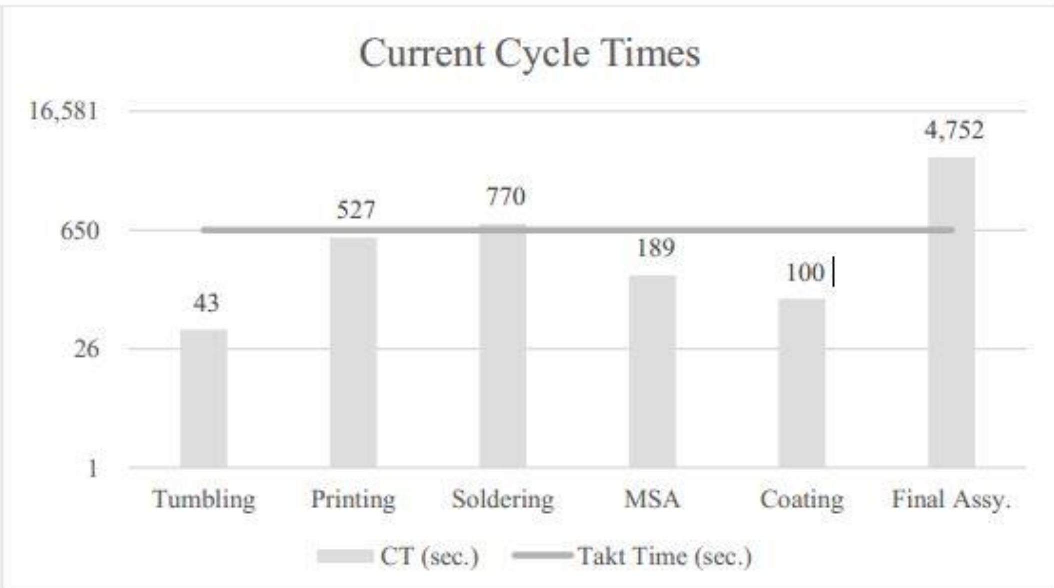

Figure 7. Current ETP production process cycle time

The information and material flow highlighted within ETP's future-state VSM (Figure 8) can only be achieved if the following improvements are made:

- Reduced change-over-time and batch sizes at the tumbling process, which allows quicker response rates to downstream usage.

- Removing change-over-time (300 s) and improving uptime (90%) at the sub-assembly process.
- Removing change-over-time (300 s) and improving uptime (85%) at the coating process.
- Removing change-over-time (1,200 s) and improving uptime (90%) at the combined screen printing and soldering process. To allow continuous flow through to final assembly.
- Improving uptime (80%) at the final assembly process. Also, allowing continuous flow and mixed production through to FG and the shipping department.
- Further kaizen bursts at all processes to remove such wastes as waiting (queue) times, overproduction, downtime, transportation, and defective parts to reduce the total process lead times down to align with the cycle times. Thus, creating a more efficient process individually, as well as to the overall production process.
- Additional improvements could be made to the tumbling process. Researching alternative finishing methods such as electropolishing which could provide immense reductions in processing times (up to 80%). As could utilising suppliers to provide already, finished items to begin with.

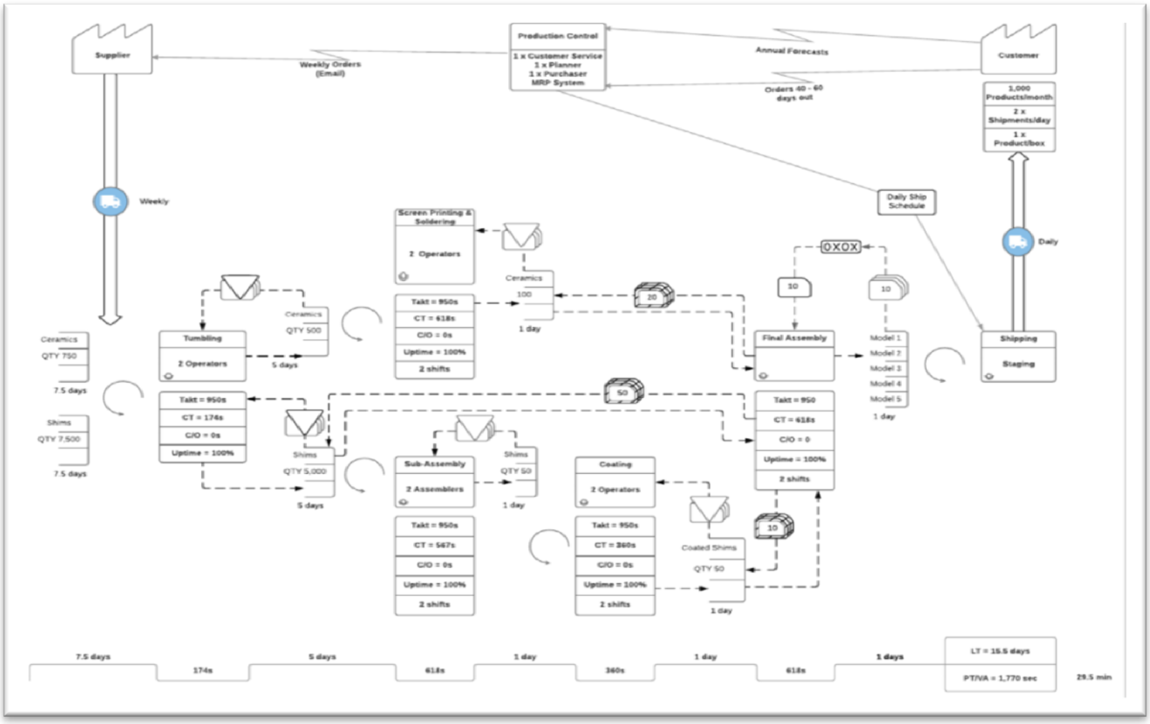

Figure 8. DyneX® Current-State Value Stream Map

3.4 Implementation plan

Before deploying future VSM for enabling reconfiguration of the manufacturing process, a meeting should be conducted. The analysis of the responses will indicate the feasibility of deploying VSM. After the final meeting was conducted and once the future state mapping has been discovered and agreed upon by all the stakeholders, an action plan is written so that all people can understand and are at ease in doing the changes. The plan that contents the value stream objectives will be implemented, and improvement team members have responsibility for committing to operational process and program improvement as an intrinsic part of their work.

Loop 1. Pacemaker loop

Objectives

- Develop a continuous flow throughout the final assembly and on to FG.
- Establish a pull system through Kanban batch with coating, tumbling and ceramic printing and soldering department supermarkets (eliminate schedules).
- Kaizen Blitz to reduce total cycle time to 4,510 seconds or less.
- Improve assembler uptime to 100%.

- Develop a pull system with the FG supermarket system (eliminate schedules).
- Generate material handler routes between supermarkets and the process cell.

Goals

- Only 1 day of FG inventory in a supermarket.
- No inventory between workstations: 4

Loop 2. Upstream processes loop

Objectives

- Establish a pull system between ceramic printing and soldering with tumbling supermarket (eliminate schedules).
- Reduce ceramic printing and soldering batch sizes to 100 items (1 day).
- Establish a pull system between coating and sub-assembly supermarket (eliminate schedules).
- Reduce coating batch sizes to 50 items (1 day).
- Establish a pull system between sub-assembly and tumbling supermarket (eliminate schedules).
- Reduce sub-assembly batch sizes to 50 items (1 day).
- Reduce process changeover to a minimum.

Goals

- Only 1 day of inventory produced by each process.
- Limit batch sizes to above-mentioned quantities, between changeovers.

Loop 3. Supplier loop

Objectives

- Develop a pull system with a ceramic supermarket.
- Develop a pull system with a shim supermarket.
- Introduce weekly deliveries of both materials.
- Kaizen blitz to remove all unnecessary wastes to reduce process lead time.
- Improve machine uptime to 100%.

Goals

- Only 7.5 days of inventory in goods inwards a supermarket.
- Only 5 days of inventory in goods outwards a supermarket.

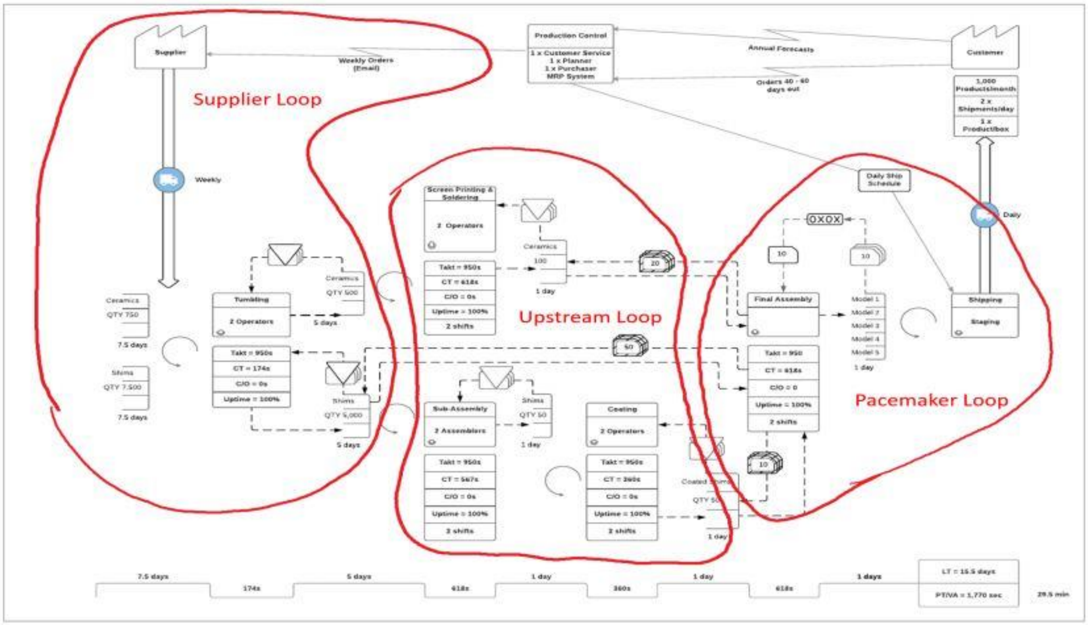

Figure 9. Future stage value stream loops

4 Conclusion

This paper is a case study explaining the successful implementation of lean manufacturing tools and techniques in the development and implementation in the case industry plant. It can be said that most companies do not realise the production costs of non-value-added activities. This leads to deviations in the calculation and selection of improved solutions. The results are the basis to expand or apply research for other lines at the company as well as other companies.

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