Implementation Agent: Organiser: Funded by Trade and Industrial Organisation Support Fund, Trade and Industry Department

Methodology Verification Report

Foreword

1. Objective

Digital Lean must be the game changer in Hong Kong small and medium enterprises to driving operation efficiency and reduce waste. Enabling the Industry 4.0 technologies such as real-time data visualization and machine connectivity can expect to reduce enterprises cost and improve quality.

A digital lean analyser for real time monitoring and data collection have been developed by the Council. It has been used into the case study of 20 pilot enterprises to collect the time and quality data per each operational workflow and identify bottlenecks.

The Methodology Verification Report aims to evaluate and demonstrate the claimed performance of the Digital Lean solution during the onsite-assessment of 20 pilot companies in Hong Kong. The solution could be assessed in term of connectivity, accuracy, traceability, user interface, safety and user friendly. The objectives are achieved through:

1. Identifying and reviewing LEAN perspective for Kaizen areas
2. Documenting the overall manual driven process per each industry, then apply LEAN principle to evaluate the operation bottlenecks and improvement

3. Reviewing the input parameters of digital lean tool kits, then demonstrate the defined parameters from each case scenario and show the results.

2. Methodology

To accomplish the objectives of the synthesis, the council's project team conducted a research of Kaizen from academic journals, industry and government reports, advise input from Germany Fraunhofer IPT expert.

Twenty companies from various industries were contacted (4 electronic, 2 metal, 3 Toy, 4 Home Appliance, 3 printing, 1 skincare, 1 textile, 2 logistic) for onsite digital lean assessment. These companies were selected according to their nature of business, existing services available, type of product to be manufactured, etc.

During the onsite assessment, the lead member of the companies and key operation staffs were participated in the interviews. The face to face interviews were taken the lead by the Germany Fraunhofer ITP experts. The interview questions are different from time to time, depending on the company situation and characteristic. However, the questions usually include:

1. What is the current operation flow and resources allocated per each process?
2. Any challenge that they were facing in their current operation
3. Did they apply the digital lean concept, such as implementing real time data collection and virtualization, integrate different systems to improve data transparency?

Moreover, the project team from the Council then use the Hand-Held Digital Lean Analyser to simulate the manual work process. We did it by placing the sensor in each workstation / sub-process and then the operator input the task start time and end time. The Analyser will collect the data from sensor and calculate the waiting time / processing time in the system. Finally, these data could be displayed in Line chart / Bar chart. Figure 1 shows the schematic diagram of Digital Lean Analyser.

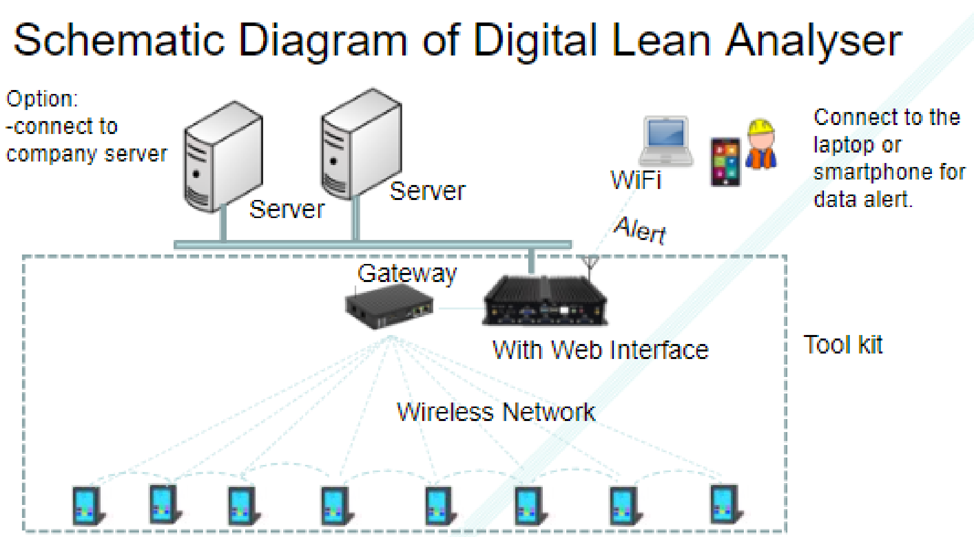

Figure 1. The Schematic Diagram of Digital Lean Analyser.

The digital analyser equipped 3 testing mode, including Normal WIP, Andon, Defect detection:

1. Processing time, waiting time and WIP

- S1 = input sensor of workstation 1, S2 = output sensor of workstation 1, S3 = input sensor of workstation 2, S4 = output sensor of workstation 2
- When operator in workstation 1 get the WIP and pass through S1, processing time is started recording until it passes S2, and at the same time, waiting time start recording.
- When operator in workstation 2 get the WIP and pass through S3, waiting time will stop recording and at the same time, processing time in workstation 2 is started recording.
- Number of WIP between workstations will be estimated by waiting time/take time
- For the data record within workstation, if one of the sensors is not being triggered, the record will be blank. However, if it happens 2-3 times in a row, system will alert corresponding technical person to address the problem.

2. Andon (Figure 2 shows the system logic flowchart under Andon mode)

    - When operators find out problems that will affect the quality of products or unable to proceed their work, then they will push a button of the analyzer to alert mechanics/supervisors for support, where T1 is recorded. At the same time, mechanics/supervisors are alerted by the mobile apps.

- When mechanics/supervisors arrive, they will press another button to start recording T2.
- When mechanics/supervisors finish the fixing, they will press button again to release the work where t3 is recorded.
- Waiting time will be calculated by T2-T1.
- Repairing/fixing time will be calculated by T3-T2.
- System will also count the Andon triggered number of times and will alert the emergency response team once the workstation triggers the Andon system more than a certain number.

3. Defect detection

- When operator inspects a defect of the product, they will select the defect type by pressing button, where finish time is also recorded.
- System will also count the number of defective and will alert the emergency response team once the workstation has discovered successive certain number of defects.

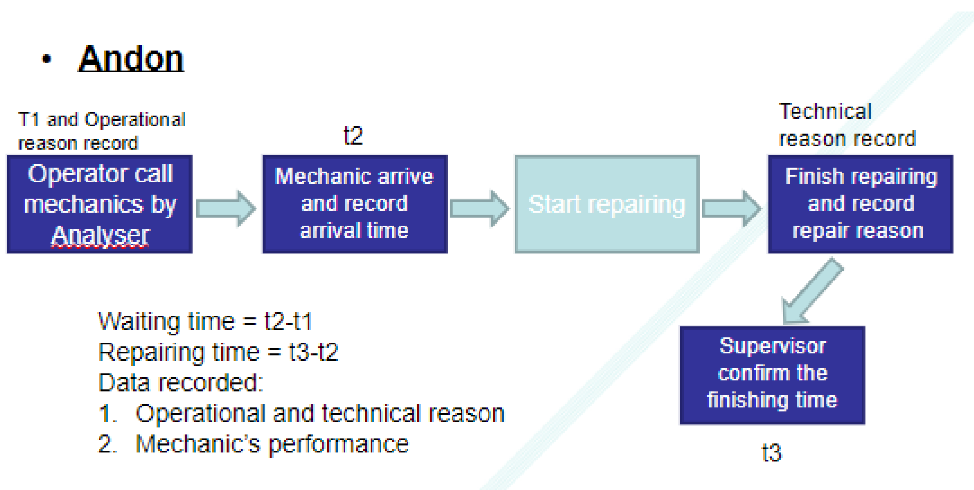

Figure 2. The system logic flowchart under Andon mode.

3. Results

This chapter presents the results of the research review of Kaizen from LEAN perspective in section 3.1 and onsite assessment with representatives of 20 pilot companies in section 3.2.

3.1 Kaizen from LEAN perspective

"Kaizen" is a word from Japanese, which refers on the base idea that small and incremental changes can result in significant improvement over time. Its key concept is continuous improvement, meaning that the enterprises can gradually enhance production efficiency, reduce waste and improve quality by making small improvements.

Another Key concept of Kaizen is the all employees' involvement in the improvement process. Everyone in the enterprise, from top management to front-line workers, shall be encouraged to share their opinion and suggestions for improvement. As a result, the enterprise could collect all the knowledge and creative idea from their employees to identify opportunities for improvement and changes.

Under the Kaizen philosophy, it could be break down into several areas based on LEAN perspective:

- Planned & Predictive Maintenance
- Reengineering Product Process
- Quick Changeover (SMED) Techniques
- Maintenance Optimization
- Bottleneck Removal
- Quality at Source
- Value Stream Mapping
- Waste Elimination
- WIP Reduction Visual Management
- Line Balancing
- Takt Time Analysis
- Poka Yoke Initiative
- Overall Equipment Effectiveness
- Quick Response Management

To better understand the assessment result, these areas are defined as below:

3.1.1 Planned & Predictive Maintenance

Planned maintenance, often known as preventative maintenance, is the practise of periodically arranging maintenance chores so that they are completed far in advance of any potential failure or breakdown. The purpose of regularly planned maintenance is not just to keep operations running without interruption but also to improve their dependability and extend their lifespan.

Predictive maintenance is yet another kind of proactive maintenance that may detect possible problems with equipment before they arise. This allows for maintenance to be performed only when it is absolutely essential. It is necessary to have essential technological enablers for Industry 4.0 such as sensors in order to gather semi-product data from a variety of machines. After this has been accomplished, data analysis tools and machine learning should be used in order to offer insights into the equipment and estimate when it will need to be maintained.

When compared to these two maintenance strategies, the planned maintenance approach is the simpler and more straightforward option because it entails performing routine inspections and repairs on the machinery and does not call for the expertise of a specialist to monitor specialised equipment like sensors and the industry 4.0 advance system.

When doing predictive maintenance, modern technology like as sensors, analytics, and AI algorithms are used to monitor the functioning of the equipment and identify any prospective problems that may arise. This indicates that the business may need substantially greater implementation costs in order to set up the manufacturing line. However, it is able to offer more specific information on the status of the equipment and enable more accurate scheduling of maintenance and repairs. As a consequence of this, it is possible to help prolong the life cycle of equipment, reduce the amount spent on maintenance, and increase productivity by minimising downtime.

In conclusion, scheduled maintenance is straightforward and easy to put into action, but predictive maintenance has the ability to deliver more precise information on equipment, which carries with it the enormous potential to reduce costs associated with maintenance and increase output.

3.1.2 Reengineering Product Process

The practise of reengineering product processes, also known as business process reengineering (BPR), is a typical method that businesses use to rethink and rebuild their existing production processes and workflow in order to enhance their operational effectiveness and product quality. To conduct an examination of the present operation workflow, search for possible bottlenecks that can be improved or addressed, and rebuild the workflow to reach greater levels of productivity, it is customarily necessary to employ the services of a process engineer.

In order to carry out BPR, a process engineer has to first identify and evaluate the existing process. This involves sketching out the process from beginning to conclusion and identifying any points of contention or opportunities for improvement. The technique known as "value stream mapping," which is a tool that helps evaluate which phases in various processes contribute value and which do not, may be used to accomplish this goal. After that, the activity that did not provide value might be removed in order to make the process more efficient and cut costs.

3.1.3 Quick Changeover (SMED) Techniques

The manufacturing sector is the primary user of the Quick Changeover (SMED) approach, which aims to cut down the amount of time spent switching a machine from making one product to another. After the implementation of a rapid changeover, the amount of downtime that occurs between jobs will be reduced, which will result in a decrease in both the production cost and the inventory levels.

Before the operator can conduct a rapid changeover, the actions involved in switching from one product to another must first be broken down into more manageable chunks. It's possible that the tasks will involve cleaning the equipment, switching out the assembly tools, and altering the settings on the machinery. Following that, calculate the amount of time needed for each step, and then decide which steps are taking the longest amount of time.

In addition, the operator is then able to differentiate between internal and external setup operations, which allows them to determine which tasks may be completed while the machine is operating and which tasks must be completed when the machine is halted.

The last thing an operator may do is attempt to analyse the activities and seek for methods to simplify the changeover process by cutting down on the number of steps required and getting rid of activities that aren't essential.

3.1.4 Maintenance Optimization

Maintenance optimisation improves an organization's maintenance processes to increase equipment reliability, reduce downtime, and reduce maintenance costs. To optimise maintenance, an organisation should identify critical assets, develop a customised maintenance strategy, establish performance metrics, implement a computerised maintenance management system (CMMS), train employees, and continuously analyse maintenance data to identify areas for improvement.

Key assets affect productivity and profitability and should be prioritised for maintenance optimisation. Maintenance optimisation starts with identifying important assets. Additionally, each asset requires a customised maintenance plan. Predictive, preventive, or mixed maintenance may be used. Performance metrics are needed to assess maintenance efficiency. Uptime, MTBF, MTTR, and maintenance cost per unit of output are some measurements.

Set up a computerised maintenance management system (CMMS) to improve maintenance operations. CMMSs simplify equipment monitoring, planning, and tracking. Real-time data on equipment performance and maintenance needs may help firms optimise their maintenance efforts.

Training workers ensures they understand the new maintenance methods and their roles in the company. This may help ensure efficient maintenance operations. Finally, maintenance data must be routinely analysed to identify areas for improvement. Recognising frequent equipment failures, analysing maintenance costs, or getting comments from maintenance professionals may help.

Improved equipment reliability, reduced downtime, and lower maintenance costs boost production, profitability, and customer satisfaction. This is crucial in professions and industries where machinery and other equipment are crucial to organisation.

3.1.5 Bottleneck Removal

The process of finding and removing bottlenecks that hinder or limit the flow of data, commodities, or services in a system is referred to as bottleneck elimination. These bottlenecks may lead to inefficiencies, delays, and other problems that harm system performance.

The first step in reducing a bottleneck is locating it, which may be accomplished by data analysis, observation, and interaction with stakeholders. Once the bottleneck has been identified, a variety of methods, such as lowering workload, simplifying procedures, enhancing communication, and investing in new technology, may be applied.

Redistributing workloads or boosting the capacity of an overburdened location may help to reduce workload. Process streamlining may assist to eliminate inefficiencies and enhance workflow. Improving communication channels may remove bottlenecks caused by poor communication, and investing in new technology can remove bottlenecks caused by obsolete or insufficient technology.

Removing a bottleneck requires a methodical approach as well as a willingness to make system adjustments. Bottlenecks may be avoided and system performance enhanced by addressing the fundamental cause of the issue and applying effective remedies.

3.1.6 Quality at Source

"Quality at source" prioritises finding and addressing product or service quality concerns at their source. It prioritises prevention above inspection and correction.

The quality-at-source attitude holds that everyone who makes or delivers a product or service is responsible for its quality and for fixing any problems. This method includes empowering people to identify and address quality issues, designing products and processes with quality in mind, and using data and analysis to make informed decisions.

Increasing manufacturing quality may boost customer satisfaction and save operational costs. By emphasising engagement and development, companies may boost profits.

Businesses must embrace continuous improvement, data-driven decision-making, and employee empowerment to implement quality at the source. They must monitor and analyse their processes to find and fix quality concerns.

Quality at the source is a proactive quality management strategy that may help firms reduce waste, improve productivity, and satisfy customers. When prevention is prioritised above correction, organisations may create a quality culture that promotes success and profitability.

3.1.7 Value Stream Mapping

As part of the lean approach, value stream mapping is a way to visualise and analyse the flow of materials, actions, and information that go into making a product or service. The main goal of value stream mapping is to find places in the value stream where there is waste, inefficiency, or room for change.

To make a value stream map, a thorough plan is made that shows the whole value chain, from the raw ingredients to the customer receiving the finished product or service. The flowchart shows how long each step takes, what resources are needed, and how much value is added at each step.

Value stream planning can help find wasteful areas like too much goods, too much output, too much waiting time, too much motion, and mistakes. Then, plans can be made to get rid of these areas of waste, such as using "just-in-time" product management, shortening setup times, and getting better at keeping track of quality.

Value stream planning is a very effective way to improve speed, cut down on waste, and make customers happier. By looking at the whole value stream, organisations can find ways to improve and make changes that can save a lot of money and make the business more profitable.

Value stream mapping is often used with other lean methods, like Kaizen and 5S, to improve efficiency and get rid of waste even more. By keeping an eye on and studying the value stream all the time, organisations can keep up a mind-set of growth and have long-term success.

3.1.8 Waste Elimination

Eliminating waste is an ongoing process that requires constant tracking and research to find areas where waste is happening and places where things could be better. By getting rid of trash, businesses can cut costs, boost efficiency, and make customers happier.

There are many different kinds of waste that can happen in a system. Some examples are overproduction, having too much goods, waiting, moving around when it's not necessary, mistakes, over processing, and wasted talent. These mistakes can lead to delays, bottlenecks, and other flaws that can hurt the system's performance.

Before you can get rid of waste, you need to know where it is happening. This can be done by looking at facts, watching how the system works, and talking to people who are part of the process. Once the garbage has been found, plans can be made to get rid of it.

Value stream mapping is another way to get rid of waste. This is done by drawing and examining the flow of materials, information, and activities that go into making a product or service. This method helps to find waste and failure and come up with plans to get rid of them.

Overall, getting rid of waste is an important part of process growth and lean production. By keeping an eye on and changing processes all the time, organisations can get rid of waste, boost efficiency, and make customers happier.

3.1.9 WIP Reduction Visual Management

WIP Reduction (Work in Progress) Visual Management is a lean method that uses visual cues to control the flow of work and limit the amount of work-in-progress in a system. The goal is to keep from making too much, cut down on wait times, and make things run more smoothly generally.

Visual management means making a visual picture of the work, like a Kanban board, that shows the state of each job at any given time. This helps teams understand how work moves through the system and find places where work is wasted or not done as well as it could be.

Teams can find problems that cause delays and work to get rid of them when they use visual management. This can help cut down on the amount of work that is being done at any given time, which can make things run more smoothly and cut down on wait times.

Using pull systems like kanban is a good way to reduce the number of things you have to keep track of visually. Pull systems only make things when they are needed, instead of making them ahead of time. This method can help cut down on extra stock and make wait times more reliable.

In conclusion, WIP reduction visual management is a strong way to make a system more efficient and cut down on waste. Organisations can reduce wait times, improve customer happiness, and make more money by using visual cues to control the flow of work and limit the amount of work in progress (WIP).

3.1.10 Line Balancing

Lean line balancing distributes work equitably across workstations to improve output. Queue balancing reduces idle time and bottlenecks to increase productivity and decrease wait times.

Line balancing involves analysing the manufacturing process to determine what jobs are required to manufacture each product. This distributes the labour. Based on time and capacity, computers are assigned certain tasks. Each machine should have the same workload.

Queue balancing may reduce idle time and waiting time, improving efficiency. It can also reduce supply needs and estimate wait times.

Longest task time (LTT) may balance a queue. This strategy entails placing the longest task on a large desk. The next longest assignment is handed to the next workstation with space, and so on until all tasks are assigned.

The priority diagram technique (PDM) also evens lines. This requires creating a model that demonstrates how activities fit together and in what sequence. This methodology may identify bottlenecks and ensure each computer is working equally.

Line balancing improves production efficiency and reduces waste. Companies may enhance production, reduce waste, and please consumers by dividing work amongst computers.

3.1.11 Takt Time Analysis

Takt time analysis is a concept of lean manufacturing that includes figuring out how fast production needs to go to meet customer needs. The word "takt" means the rate of product production needed to meet customer demand. It comes from the German word for "beat" or "pulse."

In takt time analysis, the available production time is divided by the customer demand to figure out the needed production rate. For example, if a company has 960 minutes of work time per day and needs to make 240 units, the takt time would be 4 minutes per unit.

Aligning production with the takt time is a good way to find and get rid of waste in the production process, such as needless breaks, waiting times, and overproduction. This way of doing things improves speed, cuts costs, and makes sure that customer needs are met.

3.1.12 Poka Yoke Initiative

The poka yoke technique is a quality control method that comes from Japan. Its goal is to stop mistakes from happening during manufacturing or other processes. Its name means "mistake-proofing" or "error-proofing."

To use poka yoke, methods and tools are made to make it hard for people to make mistakes. This can be done by giving operators visual or physical cues, labelling and organising parts and tools correctly, or putting in automatic sensors or alarms that identify mistakes or problems and tell operators about them.

The goal of poka yoke is to make sure mistakes don't happen or to find them quickly so that they can be fixed before they cause problems or loss. By reducing the need for rework, checks, and customer complaints, this method aims to improve quality, boost speed, and cut costs.

Poka yoke is often used with other quality control methods, like Statistical Process Control (SPC), Total Quality Management (TQM), and Six Sigma, to achieve continuous growth and boost customer satisfaction.

3.1.13 Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) evaluates industrial methods and equipment. It assesses how frequently the device creates excellent items at its maximum pace.

Access, performance efficiency, and product quality impact overall equipment effectiveness (OEE). Tools' availability determines their production time. Performance efficiency compares equipment output to its intended output. Quality measures how many products fulfil requirements.

OEE measures equipment performance by multiplying availability, performance efficiency, and product quality. High OEE scores indicate superior equipment performance and product quality. Low scores indicate the opposite.

OEE may reduce downtime and increase tool performance in production. OEE increases production, reduces waste, and boosts profits.

3.1.14 Quick Response Management

Quick Response Management (QRM) reduces wait times and simplifies customer service. Customers sought greater customization and quicker product life cycles.

QRM reorganises factories into smaller, more flexible cells that can respond rapidly to consumer demand changes. This method reduces wait times by eliminating unnecessary tasks and encouraging cross-departmental collaboration.

QRM emphasises letting people utilise their talents and expertise to solve issues and improve procedures. This strategy may excite employees and encourage ongoing improvement and higher performance.

Medical, aerospace, and high-tech industries employ QRM for flexibility and personalization. QRM may make firms more flexible and responsive, resulting in happier consumers, cheaper costs, and greater competition.

3.2 Onsite assessment of Digital Lean Solution

The onsite assessment result of Digital Lean Solution to 20 pilot companies in Hong Kong, described below:

3.2.1 Electronic Industry

The Council (we) has visited 4 companies in electronic sector for digital lean onsite assessment. They are electronic manufacture to produce electronic components such as semiconductors and robotic for industrial, telecom and consumer application.

We visited a printed circuit board (PCB) production site of an electronic company in Kwai Chung with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from shop floor, we identified the following production activities for PCB as below:

I. Design PCB using computer-aided design (CAD) software
II. Printing on the specific film for PCB
III. Surface Planarizering process
IV. Surface cleaning and etching

V. Post-Etch Punching
VI. Random Pattern Projector (RPP) Laser Process
VII. ENEPIG Process
VIII. Soldermask Development Process
IX. Bare-board inspection by operators
X. Shipment

To control the scope of digital lean assessment, we choose the production process from Surface Planarizering to bard board inspection.

The Digital Lean examination described as below:

I. The remote units and input sensors were placed near each machinery per process

II. Run the test script of digital lean tool kits to verify the function of tool kits

III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.

IV. Repeat the second step until the entire production cycle was done.

We follow the examination procedure above and the result are described below:

I. The operator brought the specific film to the Surface Planarizerting machine
II. The operator scanned the sensor 1 (S1) to record the start time of Surface Planarizerting process
III. Waiting the machine to raise the planarization capability for the board thickness up to 200mil or above; and Equip with rotary scrubbers to improve copper surface uniformity
IV. Surface Planarizerting process completed, the operator scanned the sensor 1 (S1) to record the end time of Surface Planarizerting process
V. The operator put the PCB to MaxVIA Plasma System for Desmear and landing pad cleaning, and etching
VI. The operator scanned the sensor 2 (S2) to record the start time of Surface cleaning and functionalization
VII. Waiting MaxVIA Plasma System to complete surface cleaning and functionalization
VIII. The operator took out the PCB from the MaxVIA Plasma System
IX. The operator scanned the sensor 2 (S2) to record the end time of Surface cleaning and etching
X. The operator put the PCB to Post Etch Punching machine
XI. The operator scanned the sensor 3 (S3) to record the start time of Etching
XII. Waiting the Post Etch Punching machine to complete etching, which to drill hole into the substrate where the components will be placed. The machine Improve punching positional accuracy to +/-0.5mil from current +/-1.0mil, Improve overall layer-to-layer registration to +/-1.5mil from current +/-3mil
XIII. The operator took out the PCB from Post Etch Punching machine
XIV. The operator scanned the sensor 3 (S3) to record the end time of Etching

XV. The operator put the PCB to Random Pattern Projector (RPP) Laser

XVI. The operator scanned the sensor 4 (S4) to record the start time of Random Pattern Projector (RPP) process

XVII. Waiting the Random Pattern Projector (RPP) Laser to complete the process, which provides more even surface plating thickness to support semi-additive process.

XVIII. The operator took out the PCB from the laser

XIX. The operator scanned the sensor 4 (S4) to record the end time of Random Pattern Projector (RPP) process

XX. The operator passed it to the machine for ENEPIG process

XXI. The operator scanned the sensor 5 (S5) to record the start time of ENEPIG process

XXII. Waiting the machine to complete the ENEPIG process, which is capable for to provide good wire bondable surface with the aid of palladium layer, via electroless nickel and palladium deposition

XXIII. The operator took out the PCB from the machine of ENEPIG process

XXIV. The operator scanned the sensor 5 (S5) to record the end time of ENEPIG process

XXV. The operator put the PCB into the machine for soldermask development process

XXVI. The operator scanned the sensor 6 (S6) to record the start time of soldermask development process

XXVII. Waiting the machine to complete soldermask development process, which is to create a protective layer to the surface of the board to prevent solder bridges and other issue. It can raise the soldermask develop capabaility up to aspect ratio 20:1

XXVIII. The operator took out the PCB from the machine for soldermask development

XXIX. The operator scanned the sensor 6 (S6) to record the end time of soldermask development process

XXX. The operator took the PCB to bare-board inspection station

XXXI. The operator scanned the sensor 7 (S7) to record the start time of bare-board inspection

XXXII. Waiting the operator to finish the bare-board inspection, which is to ensure the PCB meets the required specification and quality standard through Visual inspection. If bard-board yield result is below planned figure, pre-alert to customer for potential slip-up will be made.

XXXIII. The operator completed the bare-board inspection

XXXIV. The operator scanned the sensor 7 (S7) to record the start time of bare-board inspection

No	Process	Start time	End time	Processing Time	WIP	idle time
1	Surface Planarizering process	10:32:13	11:45:34	1 hour 13 min 21 s	7	0
2	Surface cleaning and etching	11:45:34	12:10:02	24 min 28s	7	00:01:16
3	Post-Etch Punching	12:10:02	12:27:50	17 min 48s	7	0
4	Random Pattern Projector (RPP) Laser Process	12:30:21	13:04:32	34 min 11s	14	0
5	ENEPIG Process	13:05:12	14:58:09	1 h 52 min 57s	7	0:55:17

6	Soldermask Development Process	15:03:09	15:25:19	22 min	7	0
7	Bare-board inspection	15:30:01	17:30:15	2h 0 min 14s	14	0

Figure 3. Data collected from digital lean analyser in PCB manufacturing process.

Figure 3 demonstrate the data we collected from digital lean analyser in PCB manufacturing process. To summarize, excluding bare-board inspection process, all are machine-centric and their processing time are quite depending on the machinery performance and characteristic of its process. For example, the ENEPIG Process usually take longer processing time than the others.

However, we discover that the bare-board inspection process has the longest processing time than the others. The possible reason will be they did the process by human visual instead of other inspection methods, such as X-ray or automated optical inspection. To remove this bottleneck, a more efficiency inspection method is suggested to implement in order to reduce the processing time and idle time of next activity, which is dispatch.

3.2.2 Metal Industry

The Council (we) has visited 2 companies in metal sector for digital lean onsite assessment. They are metal manufacturer to do extraction, fabrication and produce metal products.

We visited a PC case production line in Shenzhen with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from shop floor, we identified the following production activities for plastic figure as below:

I. Design the PC case with CAD software
II. Material preparation
III. Cutting
IV. Bending
V. Welding
VI. Assembly
VII. Packaging and shipment

To control the scope of digital lean assessment, we choose the production process from Cutting to Assembly process.

The Digital Lean examination described as below:

I. The remote unit and input sensors were placed near each work process station.

II. Run the test script of digital lean tool kits to verify the function of tool kits

III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.

IV. Repeat the second step until the entire production cycle was done

We follow the examination procedure above and the result are described below:

I. The operator scanned the sensor 1 (S1) to record the start time of cutting process
II. The operator put the metal sheet into the laser machine for cutting
III. When completed, the operator takes out the cut metal from the machine
IV. The operator scanned the sensor 1 (S1) to record the end time of cutting process
V. The operator scanned the sensor 2 (S2) to record the start time of Bending process
VI. The operator uses a press brake to bent the metal into desired shape
VII. The operator scanned the sensor 2 (S2) to record the end time of Bending process
VIII. The operator scanned the sensor 3 (S3) to record the start time of Welding process
IX. The operator welds these metal sheets together by TIG welding method

X. The operator scanned the sensor 3 (S3) to record the end time of Welding process
XI. The operator scanned the sensor 4 (S4) to record the start time of Assembly process
XII. The operator cleans the surface of the PC cases and attaching various components such as power supply and motherboard
XIII. The operator scanned the sensor 4 (S4) to record the end time of Assembly process

No.	Process	Start Time	End Time	Processing Time	WIP	Idle Time
1	Cutting	09:02:14	09:37:22	35 min 8 s	2	0
2	Bending	09:45:08	10:28:19	43 min 11s	1	00:02:02
3	Welding	10:30:27	11:15:23	44 min 56 s	1	0
4	Assembly	11:18:04	14:28:55	3h 10 min 51s	1	05:02:00

Figure 4. Data collected from digital lean analyser in PC case manufacturing process.

3.2.3 Toy Industry

The Council (we) has visited 3 companies in Toy sector for digital lean onsite assessment. They are toy manufacturer to produce various of products including figures, board game, puzzles, etc.

We visited a plastic figure production line in Dongguan with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from shop floor, we identified the following production activities for plastic figure as below:

I. Receiving design CAD file of plastic figure
II. Prototyping in traditional sculpting techniques
III. Preparing tools (metal mold)
IV. Molding
V. Painting
VI. Inspection
VII. Packaging and shipment

To control the scope of digital lean assessment, we choose the production process from molding to packaging process.

The Digital Lean examination described as below:

I. The remote unit and input sensors were placed near each work process station.

II. Run the test script of digital lean tool kits to verify the function of tool kits

III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.

IV. Repeat the second step until the entire production cycle was done

We follow the examination procedure above and the result are described below:

I. The operator scanned the sensor 1 (S1) to record the start time of molding process.
II. The operator equipped the metal mold into the Molding machine
III. The operator press "start" to operate the molding machine, which produces the plastic figure by injection molding
IV. The operator collected the plastic figures at the end of molding machine production line
V. The operator scanned the sensor 1 (S1) to record the end time of molding process.
VI. The operator passes a batch of plastic figure to painting station
VII. The operator scanned the sensor 2 (S2) to record the start time of painting process.
VIII. The operator paints the plastic figure one by one with the aid of machine
IX. When finish a batch, the operator scanned the sensor 2 (S2) to record the end time of painting process.
X. The operator passes a batch of painted plastic figure to the inspection workstation
XI. The operator scanned the sensor 3 (S3) to record the start time of inspection process.

XII. The operator checks the quality of each plastic figure to see if any of them are painted incorrectly
XIII. When finish inspection of a batch, the operator scanned the sensor 3 (S3) to record the end time of inspection process.
XIV. The operator scanned the sensor 4 (S4) to record the start time of packaging process.
XV. The operator put the checked plastic figures into carton and seal it by tape
XVI. When completed, the operator scanned the sensor 4 (S4) to record the end of packaging process.

No.	Process	Start Time	End Time	Processing Time	WIP	Idle Time
1	Molding	10:45:02	11:25:03	40 min 1 s	80	00:05:15
2	Painting	11:28:15	12:32:43	1 h 4 min 28s	40	0
3	Inspection	12:38:43	15:08:31	2 h 29 min 48s	60	01:30:00
4	Packaging and shipment	15:15:17	16:30:22	1 h 15 min 5s	100	00:00:57

Figure 5. Data collected from digital lean analyser in plastic figure manufacturing process.

Figure 5 demonstrates the data we collected from digital lean analyser in plastic figure production process. To summarize, it has been noticed that the digital and lean management practises of pilot enterprises that use manual assembly lines have great room for improvement. The lack of system data to support warehouse operations and on-site management, reliance on manual data recording and material delivery, low transparency of manufacturing data, manual operation for manufacturing arrangement and order, inadequate collection of manufacturing data, and failure to reflect production progress in actual production operation and planning and scheduling are some of the key issues that have been identified.

QR codes and bar codes are part of the methods that companies use to track and trace materials and moulds. The management team can easily control where the goods are or what state they are in. Information about the handler, as well as the rate of consumption, position, and the state of orders, will be recorded, making it easy to keep track of operations and plan and schedule. Other than the data from the tools, there are no records of the data from the human work. The vast majority of them use Excel to handle job orders and keep track of data.

3.2.4 Home Appliance Industry

The Council (we) has visited 4 companies in home appliance sector for digital lean onsite assessment. They are home appliance component manufacturers to produce lighting devices, kitchen appliances, electric sockets and personal care appliances.

We visited a light bulb production line in Dongguan with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from shop floor, we identified the following production activities for light bulb as below:

I. COB module Fabrication Process
II. Plastic Shell Fabrication Process
III. Soldering & Assembly Process
IV. Quality Checking Process
V. Packing Process

To control the scope of digital lean assessment, we choose the production process from solder & assembly to packing process.

The Digital Lean examination described as below:

I. The remote unit and input sensors were placed near each work process station.
II. Run the test script of digital lean tool kits to verify the function of tool kits
III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.
IV. Repeat the second step until the entire production cycle was done

We follow the examination procedure above and the result are described below:

I. The operator scanned the sensor 1 (S1) to record the start time of copper wire insertion process.
II. The operator places the mass light board onto fixture and inserted 2 copper wires to each light board.

III. The operator scanned the sensor 1 (S1) to record the end time of the wire insertion process.
IV. The operator scanned the sensor 2 (S2) to record the start time of lamp body installation process.
V. The operator separate mass light board into twelve individual light boards and install it into the aluminium lamp body, followed by inserting a lamp cap into lamp body.
VI. The operator scanned the sensor 2 (S2) to record the end time of the lamp body installation process.
VII. The operator scanned the sensor 3 (S3) to record the start time of riveting process.
VIII. The operator inserted the lamp cap side into the rivet machine to fix the lamp cap onto the lamp body while cutting the excess length of wire.
IX. The rivet machine connected the light bulb with electricity for checking the quality of the installation.
X. The operator scanned the sensor 3 (S3) to record the end time of the riveting process.
XI. The lamp bodies were transferred to bulb cover assembly line.
XII. The operator scanned the sensor 4 (S4) to record the start time of bulb assembly process.
XIII. The operator loaded the plastic moulded bulb cover and lamp bodies onto machine one-by-one.
XIV. The machine performed glue dispensing, bulb cover installation and laser marking onto the lamp body.
XV. The machine unloaded the light bulb to a tray.
XVI. The operator scanned the sensor 4 (S4) to record the end time of bulb assembly process.
XVII. The light bulb was transferred to testing line.

XVIII. The operator scanned the sensor 5 (S5) to record the start time of testing process.

XIX. The operator placed the light bulb onto the testing machine and wait the light bulb to come out from the machine.

XX. The operator checked the quality of the light bulb including the brightness, colour variance, wattage, COB temperature and the finishing.

XXI. The operator scanned the sensor 5 (S5) to record the end time of testing process.

XXII. The light bulb was transferred to packing station.

XXIII. The operator scanned the sensor 6 (S6) to record the start time of packing process.

XXIV. The operator packed the light bulb into coloured box and hence carton box.

XXV. The operator scanned the sensor 7 (S7) to record the end time of the packing process.

No.	Process	Start Time	End Time	Processing Time	WIP	Idle Time
1	Wire insertion process	14:21:22	14:23:16	1m 54s	12	N/A
2	Lamp body installation	14:23:16	14:26:56	3m 40s	12	N/A
3	Riveting Process	14:26:56	14:28:04	1m 8s	12	2m 32s
4	Bulb assembly process	14:30:21	14:33:12	2m 51s	12	1m 0s
5	Bulb Testing Process	14:52:09	15:01:29	9m 20s	60	18m 57s
6	Packing Process	15:10:13	15:15:08	2m 55s	60	8m 44s

Figure 6. Data collected from digital lean analyser in light bulb production process

Figure 6 demonstrates the data we collected from digital lean analyser in light bulb production process. It is observed that there are some idle times starting from the riveting process to packing process. The possible reason will be the workpiece batch change from 12 per process to 60 per process for less manual transport from line to line. To fix this issue, it is suggested to re-arrange the workstation location or transporting method to eliminate the unnecessary waiting time.

3.2.5 Printing industry

The Council (we) has visited 3 companies in printing sector for digital lean onsite assessment. They are printing companies involving production of printed materials, including magazines, books, game cards, brochures and posters. We visited the one of their printing production site in Kwai Chung with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from the shop floor, we identified the following key manufacturing activities for printing books:

I. Receiving digital copy of book for printing from client
II. Plate-making

III. Printing
IV. Trimming
V. Binding the page
VI. Quality control
VII. Packaging and shipping

To control the scope of digital lean assessment, we choose the processes from process 2 to 5 to identify any potential bottlenecks.

We evaluated the printing process with the digital lean analyser. The digital lean examination describes as below:

I. The remote units and input sensors were placed near each machinery per process

II. Run the test script of digital lean tool kits to verify the function of tool kits

III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.

IV. Repeat the second step until the entire production cycle was done.

We follow the examination procedure above and the result are described below:

I. The operator passed the client printing order with the book design file to plate-making department

II. The operator scanned the sensor 1 (S1) to record the start time of plate-making process
III. The operator put the plate into the machine and transfer the book design to it
IV. When completed, the operator scanned the sensor 1 (S1) to record the end time of plate-making process
V. The operator scanned the sensor 2 (S2) to record the start time of printing process
VI. The operator brought the plate to the printing machine with raw materials (papers and ink)
VII. The operator set up the parameter into the machine and press “start” to print the book
VIII. When completed, the operator took out the plate from the machine and pass the printed paper to assembly department
IX. The operator scanned the sensor 2 (S2) to record the end time of printing process
X. The operator scanned the sensor 2 (S2) to record the start time of trimming
XI. The operator went to cutting station to trim the edge of the paper
XII. When completed, the operator passes the trimmed paper to binding station
XIII. The operator scanned the sensor 2 (S2) to record the start time of binding
XIV. The operator starts to bind the paper into a book by manual
XV. When completed, the operator scanned the sensor 2 (S2) to record the end time of binding

No	Process	Start time	End time	Processing Time	WIP	idle time

1	Plate-making	09:14:21	09:23:44	9 min 23 s	5	NA
2	Printing	09:25:14	10:48:29	1 h 23 min 15 s	1	9 min 23 s
3	Trimming	10:50:05	11:19:36	29 min 31 s	3	1 h 23 min 15 s
4	Binding the page	11:21:09	14:23:50	3 h 2 min 41 s	2	29 min 31 s

Figure 7. Data collected from digital lean analyser in book printing process

Figure 7 demonstrates the data we collected from digital lean analyser in book printing production process. In the printing sector, there are a variety of manual procedures, such as paper cutting, binding, digital printing, labelling, machine parameter setting, material transportation, and packing. Some paper product has been seen sitting about doing nothing as it waits to be processed. During the process of material transportation, both time and people are often squandered. Some businesses have access to advanced printing equipment, but they lack a framework for integrating their data.

3.2.6 Skincare Industry

The Council (we) has visited 1 company in skincare sector for digital lean onsite assessment. This company is a skincare manufacturer to produce skincare products such as skin cream, toner and facial masks.

We visited a skin cream production line in Cheung Sha Wan with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from shop floor, we identified the following production activities for cleanser as below

I. Skin Cream Mixing
II. Bottling and Labelling
III. Skin Cream Filling
IV. Packing
V. Logistic

To control the scope of digital lean assessment, we choose the production process from skin cream mixing to packing.

The Digital Lean examination described as below:

V. The remote unit and input sensors were placed near each work process station.
VI. Run the test script of digital lean tool kits to verify the function of tool kits
VII. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.
VIII. Repeat the second step until the entire production cycle was done

We follow the examination procedure above and the result are described below:

I. The operator brought the ingredient to a tank and pre-heat the tank.
II. The operator poured the stearic acid into the heating tank.
III. The operator scanned the sensor 1 (S1) to record the start time of oil-soluble phase formulating process.
IV. Wait the stearic acid to be fully liquefied. Adding the blend of lanolin and isopropyl myristate as a softening agent and keep heating and mixing until the mixture is completed.
V. The operator scanned the sensor 1 (S1) to record the end time of the oil-soluble phase formulating process.
VI. The operator scanned the sensor 2 (S2) to record the start time of water-soluble phase formulating process.
VII. The operator poured the glycerin into a mixing tank and keep heating and stirring inside the tank.
VIII. The operator then poured purified water and added floral fragrance into the tank and continue to heat the mixture and keep it just below the boiling point
IX. The operator scanned the sensor 2 (S2) to record the end time of water-soluble phase formulating process.
X. The operator pumped oil phase into the bottom of the water phase mixing tank.
XI. The operator scanned the sensor 3 (S3) to record the start time and blending process of oil phase and water phase.
XII. The operator lowered the temperature of the tank after oil phase is filled into the mixing tank.
XIII. Wait the blending process of the oil phase and water phase until the mixture become creamy and bright white skin cream.

XIV. The operator scanned the sensor 3 (S3) to record the end time of blending process.

XV. The operator pumped the skin cream from the mixing tank to supply tank.

XVI. The operator scanned the sensor 4 (S4) to record the start time of plastic jars labelling process.

XVII. The operator took out the plastic jars from cartons and put them onto a conveyor belt of the labelling machine.

XVIII. The plastic jars were labelled along the machine one by one.

XIX. The operator collected the labelled jars from the labelling machine and packed them into a carton.

XX. The operator scanned the sensor 4 (S4) to record the end time of collection of labelled plastic jars.

XXI. The operator scanned the sensor 5 (S5) to record the start time of unboxing the jars onto a turntable.

XXII. The operator unpicked out all labelled jars from carton to turntable.

XXIII. The jars moved from turntable to filling line by conveyor belt. The skin cream was depositing into jars through the nozzles.

XXIV. The jars then moved to capping machine to receive a lid for each jar.

XXV. The capped jars were then moved to cap label machine for applying an adhesive label onto the cap.

XXVI. The jars are printed with production date by laser printer.

XXVII. The operator scanned the sensor 6 (S6) to record the start time of collection of one carton of skin cream jar.

XXVIII. The operator collected jars from the line and pack them into a carton until it is full.

XXIX. The operator sealed the carton with plastic tapes and scanned the sensor 6 (S6) to record the end time of packing one carton of skin cream jars.

No.	Process	Start Time	End Time	Processing Time	WIP	Idle Time
1	Oil-Phase Process	11:21:58	11:57:03	35 m 5s	200	8 m 52s
2	Water-Phase Process	11:21:58	12:04:55	43 m 57s	200	N/A
3	Skin Cream Blending Process	12:04:55	12:39:21	34 m 26s	200	N/A
4	Jar Loading to Labelling Line	12:39:21	13:07:01	27 m 40s	100	15 m 56s
5	Jar Loading to Filling Line	13:37:28	14:30:47	53 m 19s	100	30 m 27s
6	Jar Packing Process	14:30:47	15:04:08	34 m 21s	100	15 m 52s

Figure 8. Data collected from digital lean analyser in skin cream production process

Figure 8 demonstrates the data we collected from digital lean analyser in skin cream production process. It is observed that most of the processes are highly depending on the machinery performance while operators in each station were only responsible for load / unload material to/from the machines. To better utilize the workforce, it is suggested to re-arrange the responsible process of the operators to reduce idle time of the manpower.

3.2.7 Textile Industry

The Council (we) has visited 1 companies in textile sector for digital lean onsite assessment. It is a textile manufacturer to produce Jean with various printing pattern. We visited the one of their production site in Kwai Chung with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from the shop floor, we identified the following key manufacturing activities for Jean:

I. Pattern making & material selection
II. Fabric cutting & Product collection
III. Chemical Mixing
IV. Washing
V. Packaging and Distribution

We evaluated the jean manufacturing process with the digital lean analyser. The digital lean examination describes as below:

I. The remote units and input sensors were placed near each machinery per process

II. Run the test script of digital lean tool kits to verify the function of tool kits

III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.

IV. Repeat the second step until the entire production cycle was done.

We follow the examination procedure above and the result are described below:

I. The operator scanned the sensor 1 (S1) to record the start time of Pattern making & material selection process
II. The operator created a blueprint of the jeans with computer-aids design software (CAD)
III. The operator prepared the denim fabric and simulate the result of printing pattern on it.
IV. The operator scanned the sensor 1 (S1) to record the end time of Pattern making & material selection process
VI. The operator scanned the sensor 2 (S2) to record the start time of Fabric cutting & product collection process
V. The operator put the denim fabric into the laser machine
VI. The operator input the design specification and pattern layout
VII. The operator press “start” to operate the laser machine
VIII. During the time, the operator monitored the laser machine operation
IX. When the machine operation completed, the operator collected the laser-processed jeans
X. The operator scanned the sensor 2 (S2) to record the end time of Fabric cutting & product collection process
VII. The operator scanned the sensor 3 (S3) to record the start time of Chemical Mixing process

XI. The operator mixed the washing power, environmental non-hazardous chemical and water with the aids of machine
XII. When nano-bubbles for micronization were generated, the operator put the mixed chemical into the washing machine
XIII. The operator scanned the sensor 3 (S3) to record the end time of Chemical Mixing process
XIV. The operator went to the washing machine and scanned the sensor 4 (S4) to record the start time of washing process
XV. The operator put the jeans into the washing machine and started it
XVI. The operator controlled the flow of nano-bubbles, and the machine rotate, stops and do mirconization automatically
XVII. After the process completed, the operator picked out the jeans from the washing machine, then scanned the sensor 4 (S4) to record the end time of washing process
XVIII. The operator moved the jeans to dispatch area, then scanned the sensor 5 (S5) to record the start time of Packaging and Distribution process
XIX. The operator folded the jeans and pack them in the box by manual
XX. When finished, the operator scanned the sensor 5 (S5) to record the end time of Packaging and Distribution process

No.	Process	Start time	End time	Processing Time	WIP	idle time
1	Pattern making & material selection	14:57:14	15:18:20	21 min 6 s	1	NA

2	Fabric cutting & Product collection	15:19:18	15:29:54	10 min 36 s	1	0
3	Chemical Mixing	15:30:31	16:18:23	47 min 52 s	1	0
4	Washing	16:19:40	17:23:50	1h 4 min 10s	1	00:01:00
5	Packaging and Distribution	17:24:00	17:44:26	20 min 26 s	1	0

Figure 9. Data collected from digital lean analyser in Jean manufacturing process

Figure 9 demonstrates the data we collected from digital lean analyser in jean manufacturing process. To summarize, In the textile sector, there are many different types of manual procedures, such as picking, folding, and packaging. The efficiency of a manual operation is contingent on the organisation of the production line as well as the productivity of the workers. The production of the company and the amount of time it takes to complete a task will be influenced by the factors outlined above.

3.2.8 Logistic Industry

The Council (we) has visited 2 companies in logistics sector for digital lean onsite assessment. They are third-party logistic companies which provides warehousing and transportation service to consolidate the orders from e-commence or shipment and distribute the goods to the end-customers.

As we understand that the picking and dispatch process in warehouse may involve different manual driven process, which is suitable to apply the digital lean concept to identify the bottleneck from the warehouse inbound to outbound workflow. We visited the one of their warehouse in Kwai Chung with the digital lean analyser for digital lean assessment.

After the onsite meeting with the top management and operation staffs from the warehouse, we identified the following key warehouse activities for inbound and outbound:

Inbound:

I. PO receiving
II. Quality checking
III. Bring the goods to workstation for Putaway
IV. Putaway completed

Outbound:

I. Receiving outbound orders
II. Picking goods
III. Packaging
IV. labelling
V. Dispatch

To control the scope of digital lean assessment, we choose the outbound processes from receiving outbound orders to Labelling to identify any potential bottlenecks.

The Digital Lean examination described as below:

I. The remote units and input sensors were placed in pick & pack station and Labelling station
II. Run the test script of digital lean tool kits to verify the function of tool kits
III. When the operator started and end each process, he had to scan the sensor to record the start time and end time of each process.
IV. Repeat the second step until the entire outbound process was done.

We follow the examination procedure above and the result are described below:

I. The operator received outbound order from Warehouse management system (WMS), the orders will be grouped into pick task for picking.
II. The pick task and its information sent to RF hand-held device. The operator then clicks the start button in the device to start the pick task

III. The operator scanned the sensor 1 (S1) to record the start time of picking and packaging process
IV. The operator brought the trolley with the bucket on it
V. The operator followed the guidance in the device to locate the inventory location of goods
VI. When the operator reached the inventory location, he used the PDA to scan the QR-code in that location first, then start to pick the specific goods from there.
VII. The operator recorded the actual picked quantity in the PDA and repeat step 4-5 until all goods were picked.
VIII. The operator then chose suitable size package box to pack different size of goods
IX. The operator manual packed the goods into the carton box with tape
X. When the packaging done, the operator scanned the sensor 1 (S1) to record the end time of pick and pack
XI. The operator scanned the sensor 2 (S2) to record the start time of labelling
XII. The operator input the pick order data in the workstation computer and print out the label with bar code
XIII. The operator manual stuck the label on the box
XIV. The packed box sent to dispatch area for goods transportation
XV. The operator scanned the sensor 2 (S2) to record the end time of labelling

No.	Process	Start time	End time	Processing Time	WIP	idle time
1	Picking	14:30:36	14:35:02	5 min 26s	NA	0

2	Packaging	14:30:36	14:35:02	5 min 26s	NA	0
3	Labelling	14:35:03	14:36:58	1 min 55s	NA	1 min 55s

Figure 10. Data collected from digital lean analyser in warehouse outbound process

Figure 10 demonstrates the data we collected from digital lean analyser in warehouse outbound process. To summarize, picking and packaging were done by manual. As the total number of orders being process during the time we performed the assessment could not be retrieved from PDA, we could not accurately record the WIP and idling time per these two process. Further improvement of the examination will be to have track and trace system to get the amount of order being process when the time before these orders start being picked.

Moreover, we observe that there is a line unbalancing between pick & pack and labelling as their processing time are not matched to meet the production rate to the takt time (Pick & Pack: 5 min 26s vs Labelling: 1 min 55s). To address this issue, the council suggests the company to implement more efficiency picking method, i.e. goods-to-person with autonomous mobile robot (AMR) to replace current person-to-goods picking method. As a result, the picking efficiency will be improved to match the processing time in labelling process.

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