DESIGNING OF ELECTRONIC KANBAN AS ONE OF THE WAYS TO REDUCE DELAYS ON A PRODUCTION PROCESS FOR ASSEMBLY LINE OF ELEVATOR AT PT. DIRGANTARA INDONESIA

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Abstract

The Aircraft industry consists of several players those are the sellers as the original equipment manufacturers (OEMs), which include the aircraft and part manufacturers for Boeing, Airbus, etc. PT Dirgantara Indonesia or Indonesian Aerospace is an Indonesian aerospace company that engages in the field of aircraft design and development and manufacture. Currently PT Indonesian Aerospace is conducting an elevator project for an aircraft to meet a demand from customers. An Elevator is a pitch altitude controller of an aircraft, and therefore the angle of attack and the lift of the wing. Based on observations, there are still delays in the process of assembling the elevator. This happened because there are still mismatches between the planning process and actual process due to the lack of information of each worker, especially on an assembly line area, and also there is lateness in parts coming to the assembly line area. So, this research is focused on the parts that caused of delay of the assembling process because there are incomplete work package. To obtain these components and parts that are needed and to control the production system in the right item, right amount, and right time, the appropriate control system that can be used is Kanban. This research proposed to design the Electronic Kanban system to tackle the problem. Electronic Kanban also is known as e-Kanban includes all the features of the traditional Kanban system, using a mixture of technology to replace traditional elements such as Kanban cards in a way to reduce the delay and to achieving production time according to the schedule agreed with the customers.

Keywords: Aircraft, Elevator, Electronic Kanban, Kanban, Delay.

1. Introduction

Aircraft industry consists of several players those are the sellers as the original equipment manufacturers (OEMs), which include the aircraft and part manufacturers for Boeing, Airbus, etc PT Dirgantara Indonesia or Indonesian Aerospace is an Indonesian aerospace company that engages in the field of aircraft design and development and manufacture. Previously, the company was known as *Industri Pesawat Terbang Nusantara*. PT Dirgantara Indonesia produces various types of aircraft to fulfill the needs of specific missions.

Currently PT Dirgantara Indonesia is conducting elevator project for an aircraft to meet a demand from customer. Elevator is a pitch attitude controller of an aircraft, and therefore the angle of attack and the lift of the wing. Main objectives of the elevator are the longitudinal control and longitudinal trim. The elevators are usually hinged into the tail plane or horizontal stabilizer.

The process of assembling elevator components is planned to be assembled within the planned time period. However, on the implementation on the floor production, work on the assembly process of some elevator components are completed in longer time than planned cause one of the problem are some delay. The delay of Elevator assembly known by comparing between actual finish date and plan finish date. Comparison of actual finish date and plan finish date is shown in Table 1.

Table 1 Delay Data of Elevator

Component Name	Plan Start Date	Plan Finish Date	Actual Start Date	Actual Finish Date	Delays
Elevator N117	10-Oct-18	17-Oct-18	10-Oct-18	24-Oct-18	5 Days
Elevator N118	6-Feb-19	13-Feb-19	6-Feb-19	20-Feb-19	5 Days
Elevator N119	23-Apr-19	25-Apr-19	23-Apr-19	1-May-19	4 Days

Based on historical data that shown in Table 1, there are three elevator components that experienced delays during the assembly process. This is because the sub-assembly or constituent parts of the elevator itself are experiencing delays in delivery from the store assembly, it shown in Table 2.

Table 2 Comparison of Elevator Assembly's Delay

Part Description	Plan Start Date	Plan Finish Date	Actual Start Date	Actual Finish Date	Delays
Lever 1	5-Jul-19	12-Jul-19	5-Jul-19	19-Jul-19	5 Days
Lever 2	5-Jul-19	12-Jul-19	5-Jul-19	19-Jul-19	5 Days
Horquilla Equip.	12-Jul-19	15-Jul-19	12-Jul-19	23- Jul -19	6 Days
Lower Fitting	23- Jul -19	26-Jul-19	23- Jul -19	2- Aug -19	5 Days
Servo Tab Bar	24-Jul-19	29-Jul-19	24-Jul-19	2-Aug-19	4 Days
Suporte Exterior	26-Jul-19	31-Jul-19	26-Jul-19	2-Aug-19	2 Days
Trimming Tab	30-Jul-19	5-Aug-19	30-Jul-19	9-Aug-19	4 Days
Counter Weight	1-Aug-19	5-Aug-19	1-Aug-19	8-Aug-19	3 Days
Support Assy 1	5-Aug-19	9-Aug-19	5-Aug-19	15-Aug-19	4 Days
Outboard Bearing	7-Aug-19	12-Aug-19	7-Aug-19	15-Aug-19	3 Days
Support Assy 2	9-Aug-19	14-Aug-19	9-Aug-19	22-Aug-19	6 Days

Based on table above, it shows the delay comparison of elevator assembly in 2019. It can be seen there are some late in completing assembly and mismatch between the plans finish date and actual finish date in some assembly processes. Each sub-assembly have their components and it should be ready for final assembly.

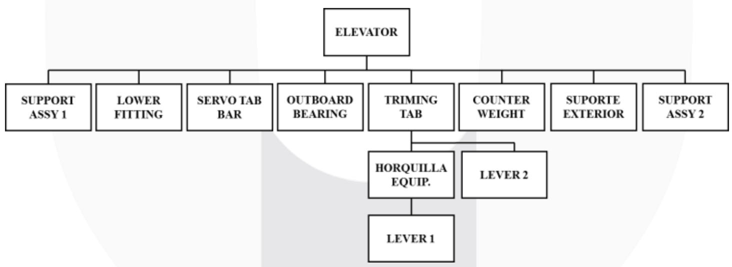


Figure 1 Elevator Assembly

Delays caused by several factors such as there are several components for making up the elevator that are experiencing the delay, it illustrated by a fishbone diagram:

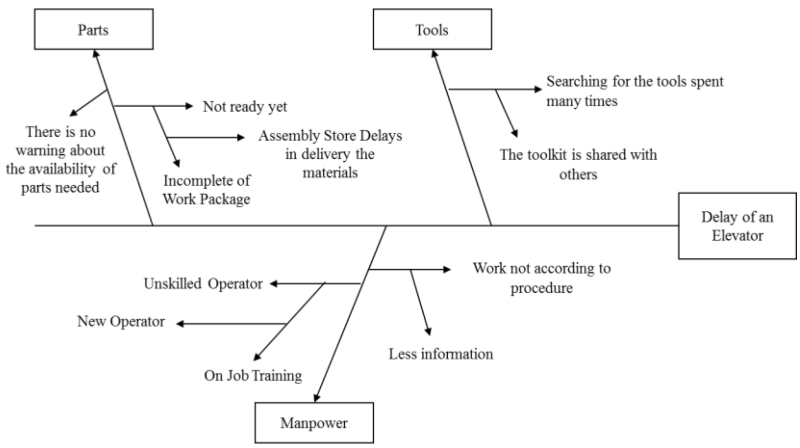
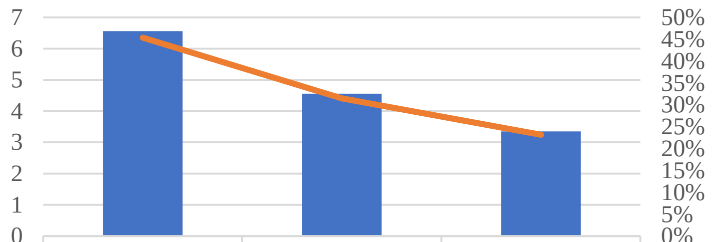


Figure 2 Fishbone Diagram of Delay of an Elevator

It can be concluded that there are three roots of the problem which causes delay in the assembly process of elevator components, i.e. Parts, Tools, and Manpower. Each root have sub factor, first is Parts, the cause of delay in the elevator assembly is that the parts are experiencing delays caused by the parts are not ready yet because there are incomplete of work package that caused by assembly store delays in delivery the material, and there is no warning about the availability of parts needed. Second is Tools, it is because the operator searching for the tools took a long time that caused of the toolkit was shared with others. Last is Manpower, it is caused there is several operator that unskilled, it is because there are new operators who are doing training while working or OJT (On Job Training), also work not according to procedure that caused by less information of each workers. Based on observation, it can be seen that the highest problem that causing of delay is assembly store delays in delivery the materials as shown in Figure:



	Assembly Store delays in delivery the materials	Toolkit is shared with others	New Operator
Frequency	7	5	3
Percentage	45%	31%	23%

Figure 3 Pareto Diagram

There are still mismatches between planning process and actual process due to the lack information of each workers, especially on an assembly line area, and also there are lateness in parts coming to the assembly line area. So that, this research is focus on the parts that caused of delay of assembling process cause there are incomplete work package. To obtain this components and parts that are needed and to control the production system in the right item, right amount and right time, the appropriate control system that can be used is Kanban. Kanban is tag card that communicates product information. [1]

So that, this research is focus on the parts that caused of incompatibility of assembling process. To obtain this components and parts that are needed and to control the production system in the right item, right amount and right time, the appropriate control system that can be used is Kanban. Kanban is tag card that communicates product information.

This research proposed to design the Electronic Kanban system for tackle the problem. Electronic Kanban also known as e-Kanban includes all the features of the traditional Kanban system, using a mixture of technology to replace traditional elements such as Kanban cards. The computer system can also calculate Kanban parameters and update them in the real-time system database. [2]

2. Literature Review

2.1. Just In Time System

Just In Time is no longer a "production system to produce the kind of units needed, at the time needed and in the quantities needed", but rather a more embracing concept. It encompasses not only the production systems but suppliers and customers along with controlling quality and work flow. [1] JIT systems combine both the production-control component and a management philosophy. Four basic principles are required for the success of a JIT system. [1]

1. Elimination of Waste

   Waste is closely related to cost-adding processes. In the context of the manufacturing process, waste is defined as any resource expended over the amount required and valued by the customer. There are several types of the wastes usually called as seven wastes[3]:

   - Transportation

     Waste transportation means that any movement of materials that doesn't have value added to the product, such as moving materials between workstations.
   - Inventory

     It means having unnecessary high levels of raw materials, work-in-process (WIP) and finished products.
   - Motion

Waste motion means that any unnecessary physical motions or walking by workers which take mind of them from actual processing work. This might difficult physical movements, due to poorly designed ergonomics which slow down the workers.

- Waiting
  It is idle time for workers or machines due to bottlenecks or inefficient production flow on the factory floor.
- Over-Production
  Any unnecessary to produce more than the customer demands, or producing it too early before it needed.
- Over-Processing
  It is unintentionally or intentionally doing more processing work than the customer requires in terms of product quality or features such as polishing or applying finishing in some areas of product that will not be seen by the customer.
- Defects
  In addition to physical defects which directly add to the costs of goods sold, this may include errors in paperwork, production according to incorrect specifications, and so on.

2. Employee involvement in decision making
   In a JIT system, this is achieved through teamwork and employee empowerment. Each employee is given more responsibility for the production process. A typical example is responsibility for quality. Its extreme expression is that every employee can stop the whole production line if quality is not satisfactory. This is known as Jidoka in the Japanese terminology.
3. Supplier participation
   Supplier participation indicates a different working relationship with the suppliers. Instead of being looked upon as adversaries, suppliers are regarded as partners. The tendency is to reduce the number of suppliers and establish long-term associations with them.
4. Total quality control

2.2. Kanban

In Japanese, Kanban means card or visible record. It is a communication signal from a consumer (such as a downstream process) to a producer (such as an upstream process). As such, it is a manual information system to control production, material transportation, and inventory. Kanban system work best when demand is level, and waste is minimized. [4]

There are two kinds of kanban are mainly used, those are withdrawal kanban and a production-ordering kanban. A withdrawal kanban determines the kind and quantity of product which subsequent process should withdraw from the preceding process. [5]

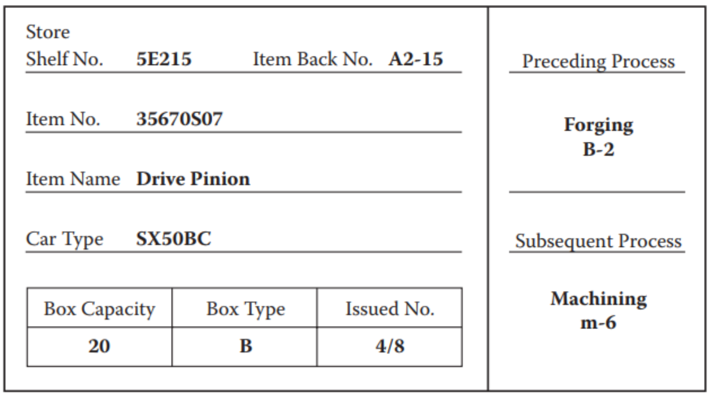


Figure 4 Withdrawal Kanban [5]

A production-ordering kanban determines the kind and quantity of product which the preceding process must be produced.

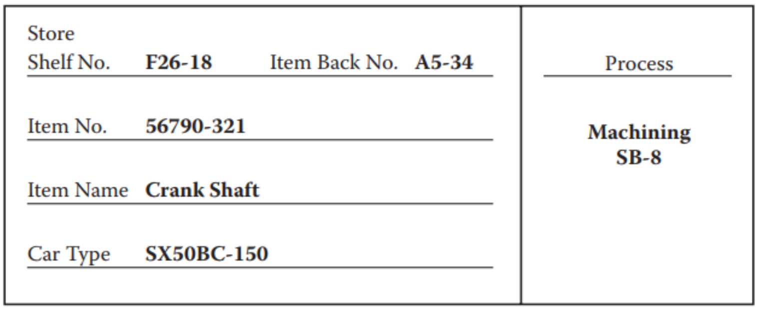


Figure 5 Production-ordering Kanban [5]

2.3. Electronic Kanban System

The electronic Kanban system is a signaling system that uses a mixture of technology in order to trigger the movement of materials within a manufacturing or production facility. E-Kanban acts as a “command panel”, which allows real time visibility of demand signals and gives an overview of the status of each workstation in the systems. [2]

The e-Kanban system also can help to implement a pull production system in a manufacturing environment where the traditional Kanban system would face difficulties. Therefore, it can bring visibility and improve the production and management of materials into an arrangement where operations are dispersed, it can eventually work in an environment where a Kanban based card would not function properly if implemented with care.

3. Conceptual Model

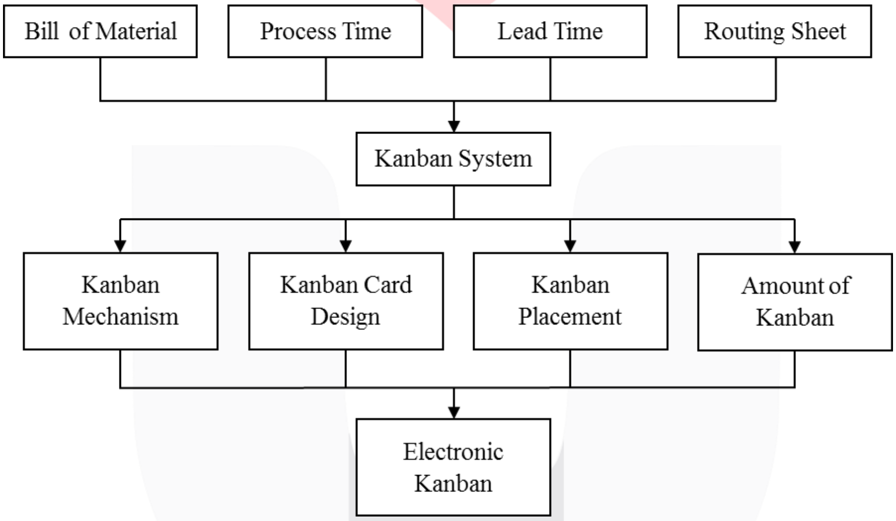


Figure 6 Conceptual Model

Conceptual model is a concept of thinking that helps researcher formulate problem solving framework and assist in formulating solutions or proposals of discussed issues. This study aims to design a system that can control the availability of materials to be assembled on assembly lines of Elevator at PT Dirgantara Indonesia. This research is done by using tools in the form of Electronics Kanban which are expected to create a timely production flow. The model to solve the problems of this research can be seen in Figure 6.

Figure 6 shows the conceptual model of this research. Before collecting the data and do the further research, it is important to know the whole activity of the assembling process of the Elevator. The first step is collecting data of collecting data of Bill of material, it is a list of parts and assemblies needed to manufacture a product, sometimes also the process needed to manufacture the assembly unit. Process Time is to know the time between the initiation and completion of a production process. Lead time is the lead time taken of the assembly process. Routing Sheet to know the sequence of an elevator assembling in a way to know where the Kanban will be placed.

After the problem identified, the output for this final projects is an Electronic Kanban to reduce the delay and avoid line stop in assembling of elevator, so it will achieved the purpose of timely assembly process.

4. Result and Analysis

4.1 Workstation of Elevator Assembly

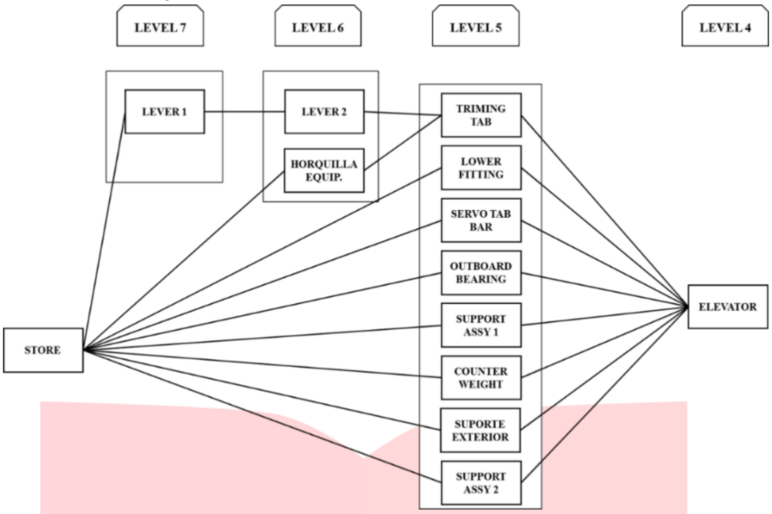


Figure 7 Assembling Process Chart of Elevator

It shown an assembling process chart of Elevator. Which starts from the Sub Assembly Store, then to level 7, level 6, level 5 and level 4. There are three levels for the making up of an elevator, namely level 7, level 6, and level 5 consisting of eleven sub-assemblies to arrange an Elevator. Then the level 4 is the elevator itself. The assembly process starts from the lowest level, which is level 7. Parts needed at Level 7 will be sent from the Sub-assembly store. After level 7 is completed, then the part will be sent to level 6 workstation which is workstation 2. If the sub assembly has been processed at level 6, the parts from level 6 then will be sent to level 5 workstation which is workstation 3. At level 5, not all parts will be worked on from the previous level, there are seven sub-assemblies that are sent directly from the sub assembly store, so that not all of them need to wait from the previous level to arrange an elevator. If all the constituent parts of the elevator have been completed in the assembly, then the elevator is ready for assembly at workstation level 4 which is Elevator Assy. And the workstations layout are illustrate in Figure 8 below.

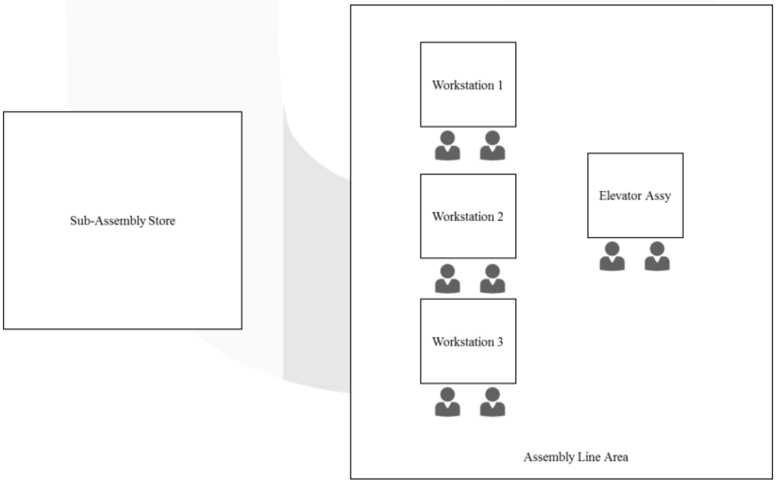


Figure 8 Workstation of Elevator Assembly

4.2 Mechanism System of Kanban

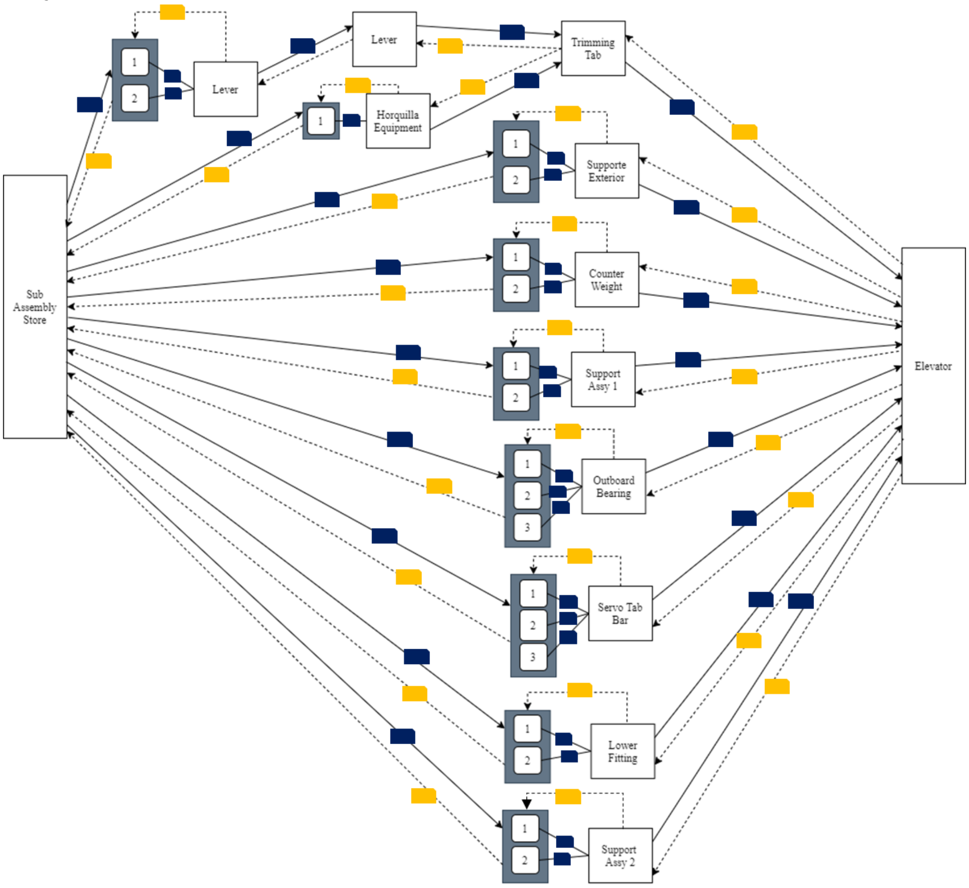


Figure 9 Mechanism System of Kanban

After we know the workstation of making an elevator assembly, next is design of Kanban system mechanism that shown in Figure 9. The information flow from assembly line area that must be assemble according to fulfill the demand marked with the yellow cards. Each workstation send the Kanban card in order to control the process of Elevator assembly from the part package that has been sent by the sub assembly store until it is processed into components and become a final product marked with the blue card.

4.3 E-Kanban Flow Mechanism

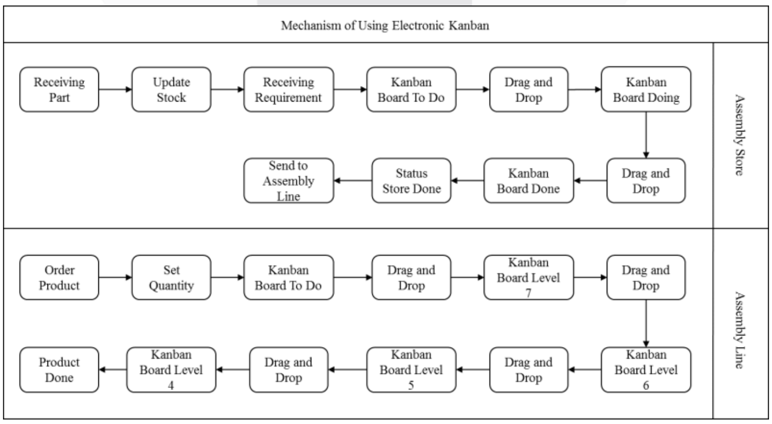


Figure 10 Electronic Kanban Flow Mechanism

Based on Figure 10 above, it shows the flow mechanism of using an Electronic Kanban in a system. For each area, Assembly store and Assembly line should be organize the e-Kanban in a way drag and drop, create a list of any activities that will to do, what activities that is being done in a doing list, it all can be recorded and displayed on a

system. Then, if the item has been processed and the status on that area is already 'done', the item will be sent to the next area.
For sub assembly stores, starting with receiving parts from fabrication. After receiving the parts, the operator will update the stock in the store, then if sub-assembly store receive an order from the assembly line area, the sub-assembly store will receive a request for material parts needed and the notification will appear on the Kanban Board To Do. If all material requests are available, the sub-assembly store operator will drag and drop the Kanban to the Doing status. If all material requests have been fulfilled, then the material will be send to the Assembly Line area.
While for the assembly line operator, starting from ordering products to the assembly store. Product orders are included with the quantity needed to making up an elevator. After the order is finished, this will appear on the Kanban board To Do. If the material demand has been met, the operator will drag and drop from level to level to the top level, which is level 4. Level 4 itself is the arrangement of elevator. When the assembly process is complete, the elevator has been completed.

4.4 Kanban Card Calculation

After determining the position of the Kanban card, next is to make the calculation of Kanban Card. The Kanban card needed to help to monitor the production process from the sub-Assy to Assembly line area.
There are two types of Kanban which is Production-ordering Kanban and Withdrawal Kanban. In this research, using the Withdrawal Kanban. But to calculate the number of Kanban card, there are several step must be done. The calculation results are shown in Table. Here are the following steps for calculating Kanban cards:

1. Determine the Number of Parts During the Lead Time
   According to Monden (2012), the number of parts needed in the subsequent process during the lead time will be determined by the following equation:
   Necessary number of parts during the Lead time of Kanban = Quantity of parts needed X Lead Time.
   Whereas, operating hours per day is 8 hours, convert to minutes so it is equal with 480 minutes per day.
   Therefore, Necessary number of parts during the Lead time of Kanban = 1 X (2.62 / 480) = 0.005 units.
2. Determine the Safety Inventory
   Safety Inventory = Necessary number of parts during the Lead time of Kanban X 0.1.
   Therefore, Safety Inventory = 0.005 X 0.1 = 0.00005 units.
3. Determine the Total Number of Kanban card

$$\text{Total Number of Kanban} = \frac{\text{Necessary no of parts} + \text{Safety Inventory}}{\text{Capacity Box}}$$

$$\text{Total Number of Kanban} = \frac{0.005 + 0.00005}{1}$$

$$\text{Total Number of Kanban} = 0.00551 \cong 1 \text{ kanban sheets}$$

Table 3 Kanban Card Calculation

ID Part Number	Lead Time (H)	Qty. of parts	Necessary No. of Part During Kanban Leadtime	Cap. Box	Safety Inventory	No. of Kanban Card	Kanban Card
212-32004-5A01	2.62	1	0.005	1	0.00005	0.006	1
212-32118.1A01	3.941	1	0.008	1	0.00008	0.008	1
212-32101-03.1	3.49	1	0.007	1	0.00007	0.007	1
212-32100-04.1	2.54	2	0.011	1	0.00011	0.011	1
212-32229.1A03	4.256	1	0.009	1	0.00009	0.009	1
212-32229-03.1	1.66	1	0.003	1	0.00003	0.003	1
212-32229-01.1	3.82	1	0.008	1	0.00008	0.008	1
212-32224-0003A01	2.909	1	0.006	1	0.00006	0.006	1

212-46240-03.1	2.48	2	0.010	1	0.00010	0.010	1
212-46240-04.1	1.79	2	0.007	1	0.00007	0.008	1
212-46240-0203	3.39	1	0.007	1	0.00007	0.007	1
212-32113.1	2.176	1	0.005	1	0.00005	0.005	1
212-32113-02.1	2.53	1	0.005	1	0.00005	0.005	1
212-14105-02.1	1.24	1	0.003	1	0.00003	0.003	1
212-32102-07.2	2.92	1	0.006	1	0.00006	0.006	1
212-32101.3A01	4.629	1	0.010	1	0.00010	0.010	1
212-32118-02.1	8.22	1	0.017	1	0.00017	0.017	1
212-32100-04.1	2.50	2	0.010	1	0.00010	0.011	1
212-32119.1	6.158	1	0.013	1	0.00013	0.013	1
212-32119-03.1	2.16	1	0.004	1	0.00004	0.005	1
212-32119-02.1	2.36	1	0.005	1	0.00005	0.005	1
212-32217.1	2.612	1	0.005	1	0.00005	0.005	1
212-32217-02.1	1.02	1	0.002	1	0.00002	0.002	1
212-14105-02.1	1.19	1	0.002	1	0.00002	0.003	1
212-32203.5A01	5.681	1	0.012	1	0.00012	0.012	1
212-32220.3A01	1.896	1	0.004	1	0.00004	0.004	1
212-32221-02.4	4.51	1	0.009	1	0.00009	0.009	1
212-32221-02.3	2.82	1	0.006	1	0.00006	0.006	1
212-32221.5	4.795	1	0.010	1	0.00010	0.010	1
212-32203-47.1E01	3.600	1	0.008	1	0.00008	0.008	1
212-32203-47.1	3.386	1	0.007	1	0.00007	0.007	1

4.5 E-Kanban Placement Design

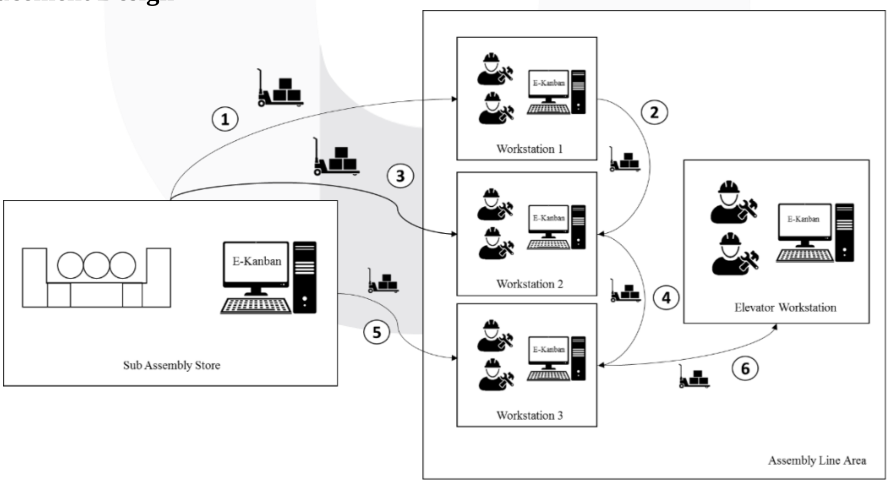


Figure 11 e-Kanban Placement Design

From the Figure 11, the e-Kanban placement are in the assembly store area and sub-assembly line. The store will send the material needed and has been ordered by the operator's sub-assembly line, to workstations 1 2 and 3. Workstation 4 will receive material from workstation 3.

4.6 Kanban Card Design

Kanban card will be made as the information system design that will be displayed as the visual form to be used to help the Kanban system that have been made. The showed information in the card are: Product ID, Card Number, Component Number, Name of Component, and Quantity.

The designed Kanban card will be as the template that will be inputted automatically as the information for application of electronic Kanban.

Component number will be used on sub assembly store and assembly line. At the sub assembly store, the component number is used to view detailed item information. Whereas, the component number is used to input material at the assembly line so it can be display the working status on the monitor screen of electronic Kanban. It can be seen in Figure 12 and Figure 13.

<table>
<tr><th colspan="3">ELEVATOR</th></tr>
<tr><td>Card Number</td><td>0001</td><td>Preceding Process</td></tr>
<tr><td>Product ID</td><td>1234567890</td><td rowspan="3">Installation</td></tr>
<tr><td>Component Number</td><td>212-32004-5A01</td></tr>
<tr><td>Component Name</td><td>Sub Assembly</td></tr>
<tr><td>Part Quantity</td><td>10</td><td>Subsequent Process</td></tr>
<tr><td colspan="2"><table><tr><td>Box Capacity</td><td>Box Type</td></tr><tr><td>1</td><td>A</td></tr></table></td><td>Adjustment</td></tr>
</table>

Figure 12 Withdrawal Kanban Card Design

<table>
<tr><th colspan="3">ELEVATOR</th></tr>
<tr><td>Card Number</td><td>0001</td><td>Process</td></tr>
<tr><td>Product ID</td><td>1234567890</td><td rowspan="4">Machining</td></tr>
<tr><td>Component Number</td><td>212-32004-5A01</td></tr>
<tr><td>Component Name</td><td>Sub Assembly</td></tr>
<tr><td>Part Quantity</td><td>10</td></tr>
</table>

Figure 13 Production Kanban Card Design

4.7 E-Kanban System on Elevator Assembly Analysis

The flow of e-Kanban system of a Kanban Board that have been designed is on Sub-Assembly Store and Assembly Line. The e-Kanban System at Sub-Assembly area helps to control the component needed by the assembly line and to control the flow of sorting part process. Each component needed will be sent to the assembly line area. After the component has been sent, the sub-assembly store must update the stock available in the store and send the information to assembly line also to fabrication to request more component available.

The e-Kanban system at assembly line area used to control the flow of assembly process of each components. The Kanban card will be flow in each sub assembly and main assembly workstation where the elevator is assembled. The working system of Kanban Electronics is explained in the following:

1. The first step is ordering materials needed by assembly line operator, the due date for make a lever is 9th April 2020.

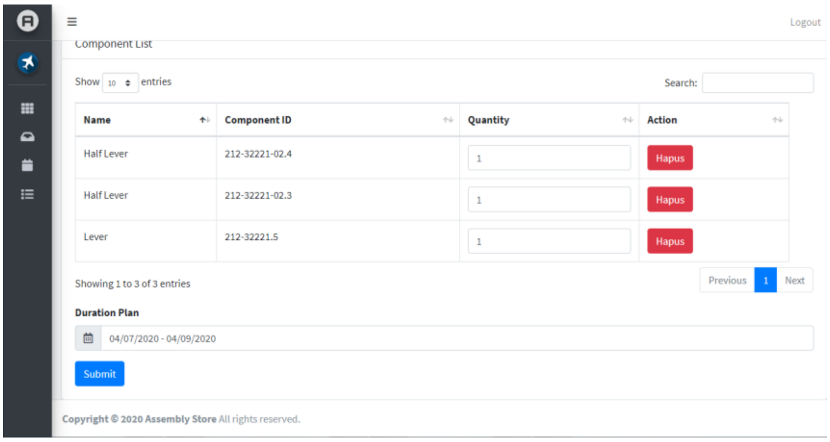


Figure 14 Ordering Material Needed

2. Sub-Assembly Store will get notification on the Kanban board, what requirements from assembly line area.

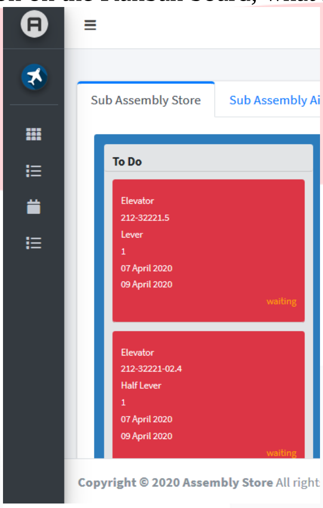


Figure 15 Sub-Assembly Store Kanban Board

3. The operator of assembly line area have received the materials from the store. Because materials that have been ordered are for level 7, so it will be displayed on level 7 status on the Kanban board.

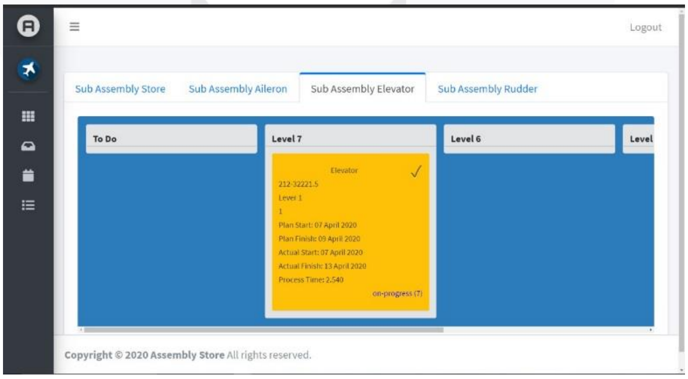


Figure 16 Level 7 of Elevator Assembling

4. All the assembling process are done, all the level will drag and drop to the level 4 which means it is elevator assembling process or last process of assembly.

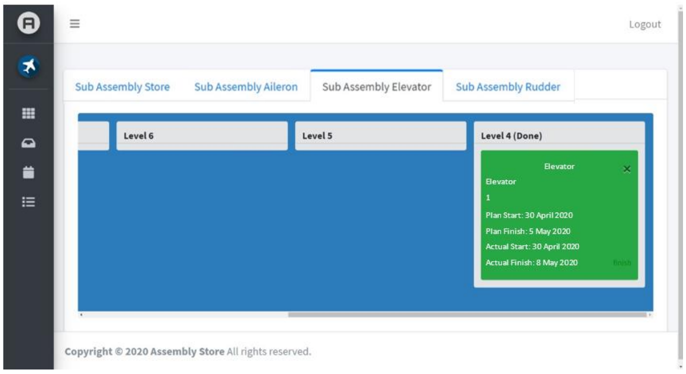
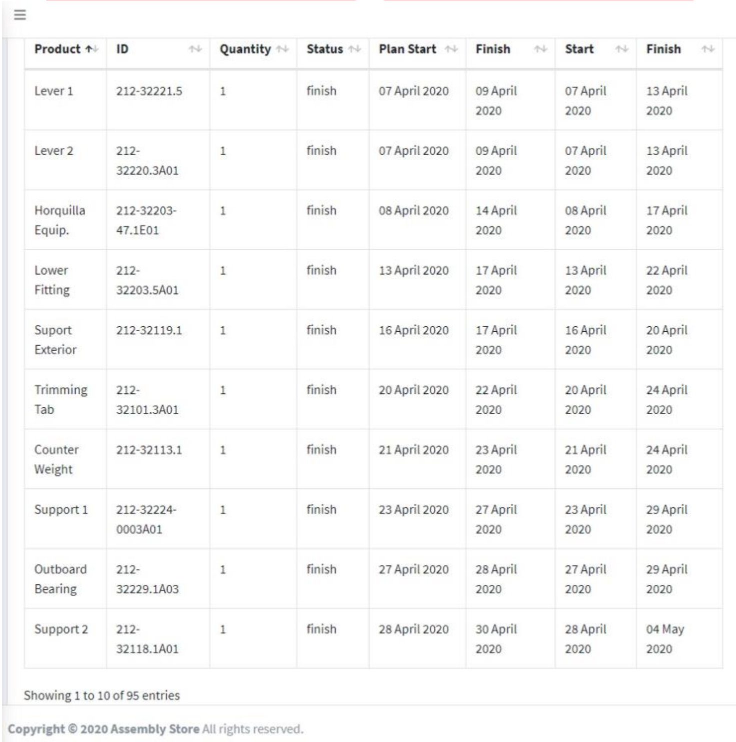


Figure 17 Process Assembly of Elevator

5. Next, all assembly process has been done. All activities will be shown in the report tab such as shown in Figure 18.



Product	ID	Quantity	Status	Plan Start	Finish	Start	Finish
Lever 1	212-32221.5	1	finish	07 April 2020	09 April 2020	07 April 2020	13 April 2020
Lever 2	212-32220.3A01	1	finish	07 April 2020	09 April 2020	07 April 2020	13 April 2020
Horquilla Equip.	212-32203-47.1E01	1	finish	08 April 2020	14 April 2020	08 April 2020	17 April 2020
Lower Fitting	212-32203.5A01	1	finish	13 April 2020	17 April 2020	13 April 2020	22 April 2020
Suport Exterior	212-32119.1	1	finish	16 April 2020	17 April 2020	16 April 2020	20 April 2020
Trimming Tab	212-32101.3A01	1	finish	20 April 2020	22 April 2020	20 April 2020	24 April 2020
Counter Weight	212-32113.1	1	finish	21 April 2020	23 April 2020	21 April 2020	24 April 2020
Support 1	212-32224-0003A01	1	finish	23 April 2020	27 April 2020	23 April 2020	29 April 2020
Outboard Bearing	212-32229.1A03	1	finish	27 April 2020	28 April 2020	27 April 2020	29 April 2020
Support 2	212-32118.1A01	1	finish	28 April 2020	30 April 2020	28 April 2020	04 May 2020

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Figure 18 Report Status of Elevator Assembly Process

4.8 The impact of e-Kanban System on Elevator Assembly

Table 4 Delay Data Comparison between Existing and Suggested

Material Description	Delays Existing	Delays after using e-Kanban
Lever 1	5 Days	1 Day
Lever 2	5 Days	1 Day
Horquilla Equip.	6 Days	3 Days
Lower Fitting	5 Days	3 Days
Servo Tab Bar	4 Days	1 Day
Suporte Exterior	2 Days	1 Day
Trimming Tab	4 Days	2 Days
Counter Weight	3 Days	1 Day
Support Assy 1	4 Days	2 Days

Outboard Bearing	3 Days	1 Day
Support Assy 2	6 Days	1 Day
Elevator	4 Days	2 Days

5. Conclusion

Based on the background that described in the first chapter, the result of this research is electronic Kanban system. It is able to control the flow of production, so that the parts and components needed are appropriate in the right time and the right amount. Through the electronic Kanban system, there is no more lack information and lack of material needed. The incomplete of work package can be fulfilled just in time and the job-stop are slightly reduced, because this e-Kanban system expects to reduce the delay up to 45%. This result is obtained through comparison the delay data existing and delay data after using e-Kanban. Although it is still possible that it is still delay because this research was only carried out in the assembly store and sub-assembly line areas, not to fabrication. However, by implementing this e-Kanban system it is reducing delays because the assembly line will run smoothly in according to the time requested.

The design of an electronic Kanban system also has a good impact that will increase accuracy and ease when compared with manual systems. It is based on the display of Kanban board itself that easy to use and easy to understand with drag and drop feature. However, the facilities needed to implement this system are monitor and personal computer.

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