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Development of Interactive Warehouse Operational Visualization

Mohamad Khairi Hassan[1], Mohd Hazri Mohd Rusli[2]*, Noor Azlina Mohd Salleh[2], Suzilawati M. Kayat[2], Joshua Goh Wen-Hann[3]

[1] *Manufacturing Division, Sugihara Grand Industries Sdn Bhd, 42000 Port Klang, Selangor, MALAYSIA*
[2] *Smart Manufacturing Research Institute (SMRI), College of Engineering, Universiti Teknologi Mara, 40450 Shah Alam, MALAYSIA*
[3] *Business Development, Pyrocell Sdn Bhd, 47120 Puchong, Selangor, MALAYSIA*

*Corresponding Author: hazrirusli@uitm.edu.my
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Abstract

The digitalization era forces organizations to leave the conventional and manual approach of record updating for a rapid and real time data management system. This study analyzes the development of interactive process visualization from operational data, which can provide sufficient information for the user to understand current operational status. Approaches to the study include interviews to understand the current process, determining the visualization item needed and developing an interactive dashboard for visualization by using Google Data Studio @ Looker Studio. The findings revealed that an interactive operational dashboard is able to be initiated from the warehouse operation data which helps the process owner understand the operational status clearly. This study was limited to the receiving, storage and outgoing of warehouse activities that are able to create interactive information centers for the process owner to understand the warehouse operation status in real time and provide sufficient data for rapid decision and action. With a simple, low cost and practical visualization system, it will benefit society, especially the Small Medium Enterprise (SME) in moving toward digitization and digitalization towards the digital transformation of a smart factory in the Fourth Industrial Revolution (4IR).

1. Introduction

A warehouse is defined as an area that is used to store a product temporarily before it is transferred to the destination area. It is used in a manufacturing facility to transport materials received from suppliers for use in production and to store the finished product after it has been processed before it is delivered to the customer. In general terms, activities that are included in the warehouse operation are receiving, storage and delivery of products.

Receiving activities in warehouse operations are determined by accepting material or product from another party or previous process that require transferred items such as the supplier (who), item to deal with (what), timing to receive (when) and quantity (how much). Items that are completely received by the warehouse are required for safe storage and the most important information during this stage is the stock figure. Until there is a demand for taking out the items from storage, charge-out activities are made by the warehouse and again, managing the information of who, what, when and how much is important to be taken care of.

Managing the above information in the daily warehouse operation is important to ensure products are supplied in a timely manner. A warehouse that is normally built in between the supply chain is purposely built to create a buffer flow of processes that is able to absorb any fluctuation in the next process operation. For example, in the automotive supply chain, car components are supplied by vendors according to the timing provided by the car assembler. Each vendor is required to build a warehouse and store the Finished Goods (FG) component, with a requirement to maintain stock for up to three days.

The FG that is delivered to the car assembler is then kept in their receiving warehouse before being supplied to the production line. With this arrangement, any abnormalities occurring within the chain are still able to be absorbed by the buffer stock in the warehouses. Looking at this scenario, it cannot be denied that the existence of a warehouse in the supply chain is truly important, and its operation requires close monitoring with good visualization. Those warehouses that subscribe to the established Warehouse Management System (WMS) normally have better visualization by using Business Intelligence (BI) tools that enable the organization to see and understand the operation status. However, there are still a lot of warehouse operations that use manual methods to control their warehouse activities and have difficulties visualizing their operation status. With the limitations of data in manual paperwork, visualization is done manually with a graph or checksheet that requires dedicated personnel to update the information at a fixed interval.

Even though the visualization for warehouse operations is done manually, it is still able to help the organization get an idea of operational status. However, conducting visualization with a manual approach makes the visualization information unable to be updated in real time since it will be updated by humans. This will cause a delay in understanding the operation status and trend, which will lead to late action reflecting on the condition. In a situation where there is a negative trend in performance, late action may result in a loss to the organization. Besides, manual visualization also requires a dedicated space and area to place the information, as well as the need to be in the area to get the information.

This paper discussed the findings of a case study conducted at one of the factories in Malaysia's automotive supply chain, PRC Sdn Bhd (PRCSB) that supplies automotive components to most of the car assemblers in Malaysia. Daily operations in PRCSB required them to have a dedicated Finished Goods (FG) warehouse that ran activities such as receiving FG from suppliers, keeping the FG and making arrangements for delivery upon request by their customers. The management of the inventory transaction is crucial due to the fact that they manage more than 100 items that they receive from international suppliers and maintain many stocks in their warehouse. A real-time status was not known due to warehouse activities conducted on manual paperwork, making it impossible to make an informed decision quickly enough to prevent any operational losses. A study was conducted focusing on their warehouse operation activity with the objective of initiating a process visualization that would become their monitoring dashboard for a warehouse operation.

2. Literature Review

2.1 Visualization for Operation

The process of converting substantial data sets and metrics into graphs, charts, and other visualizations is known as data visualization. Real-time patterns, outliers, and fresh insights into the information included in the data are easier to spot and convey as a result of the data's visual representation [1]. Data visualization is the process of representing data graphically so that people can more easily comprehend the significance of particular data and the meaning it conveys. Visualization has carried out its role to improve the agility and convenience of data understanding, provide options for decision-making, quickly understand the connection between data and finally make it easy to spot trends and identify outliers faster [2]. Visualization has proven to help improve the operation. In a case study conducted at a health care product company, the establishment of data visualization through an analytic dashboard has gained benefits to the organization which include faster reporting, analysis or planning for effective decision making, accurate and relevant information as needed, being able to focus on issues and trends, increasing revenues and competitiveness and finally improving operational efficiency [3].

2.2 Digital Operational Dashboard

A dashboard is a tool for visualizing information that keeps track of events or activities quickly by presenting information on one or more pages or displays. A dashboard, as opposed to an infographic, which displays a static graphical depiction, communicates real-time information by fusing intricate data sets together. As the amount of big data increases, more people are using data visualization tools to gain insights on their PCs and mobile devices [1]. Dashboards that visualize real stories in real time will help an organization react and seek better results. A study in Thailand revealed an improvement of 18% in production output productivity after the implementation of a production dashboard at a manufacturing company in Thailand [4].

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2.3 Google Data Studio @ Looker Studio

Google Data Studio @ Looker Studio, a data visualization program created as a user-friendly tool for displaying complex data sets in an appealing and understandable way, was introduced in May 2016 as a component of Google's for-pay Analytics360 suite. Google made the program available to everyone for free in August 2016 and renamed it Looker Studio in October 2022 [5]. The goal of Looker Studio is to assist users in creating dynamic, visually attractive reports and dashboards by integrating external data sources into a user-friendly platform and easing the production and distribution of data-based reports [6]. Looker Studio is used to create useful, simple-to-read, shareable, and completely customizable dashboards and reports from a set of data. With its use as a tool, Looker Studio can display data using highly customizable charts and tables, connect easily with a variety of data sources, as well as for sharing of the information and report collaboration with no limit [5]. Previous studies have shown successful utilization of Looker Studio as a tool to develop an interactive dashboard for operations in various fields of operation. Previous study had used the Looker Studio application to analyze the sales data from one of the companies and provide statistical and graphical results that decision-makers may utilize to solve the company's issues [7]. In the financial sector, analysis on banks' assets, liabilities and net cash flow as well as profitability, was successfully visualized through a dashboard that was fully developed with Looker Studio [8]. A study in the manufacturing sector has resulted in the successful development of a production operational dashboard by using production data in Google Sheets through Looker Studio which has had a good impact on their production efficiency [9].

3. Methodology

The approach of conducting this study is to follow the Kaizen 6 Steps [10] as shown in Fig. 1. The commitment from PRCSB management to the kaizen needs of warehouse visualization has become a kickstart to the entire step of study, following with a review of current conditions, defining targets, developing strategies, doing the kaizen and finally evaluating results.

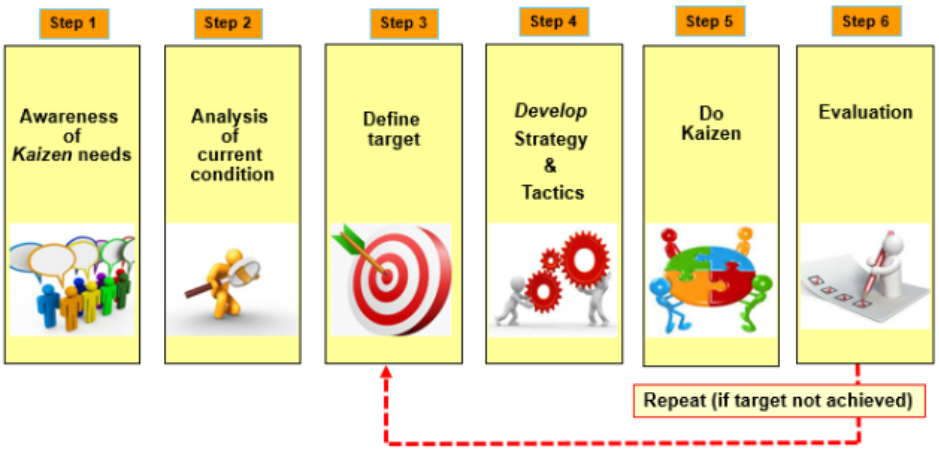

Fig. 1 *The Kaizen 6 steps*

A review is conducted on the existing warehouse activities record and procedure with an interview with the operation personnel in order to understand and analyze the current condition before establishing the target. A strategy is then developed to meet the defined target which can be divided into four stages which are reviewing the current operation record, conforming items to be visualized, creating a database in Google Sheets, and finally developing the visualization using Looker Studio. The steps of conducting this study are described as per the process flow in Fig. 2.

3.1 Reviewing Current Operation Records

Flow and process interactions within the warehouse operation activities are reviewed to get an understanding of what is being done in managing the operation. Records are evaluated and the linkage with other operations is justified. Those manual recording activities are considered to be digitized by initiating Google Sheets format and data is captured.

3.2 Conforming Items To Be Visualized

An interview with the process owner is conducted in order to understand the item and control parameters that are important as data for the operation's monitoring. Obtaining this information is based on the outcome of

operations. The item that needs to be controlled, the category of the item that is being dealt with, the person involved with the activities and the timing of the receiving and delivery are the focus areas for a question to be asked. This data is then finalized as information that needs to be visualized in the dashboard.

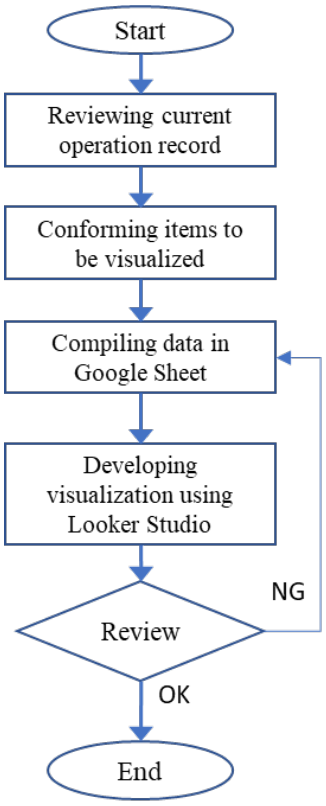

Fig. 2 *Flow of conducting a study*

3.3 Compiling Data in A Google Sheet

The Looker Studio that will be used as an online tool for developing a dashboard visualization is retrieving data from the Google Sheet. Therefore, a Google Sheet format needs to be initiated for records that are currently captured manually. Those records that are captured in another format also need to be transferred into Google Sheets format.

3.4 Developing Visualization Using Looker Studio

Based on the item finalized in 3.2, visualization is developed by using built-in functions in Looker Studio. Depending on the data suitability, several functions are applied to create visualization in dashboard mode such as tables, score cards, graphs (bar, pie, line) and controls (drop-down list, filter, slider).

Establishment of the dashboard has become an outcome for Step 5 of the Kaizen 6 Steps. The process owner is required to review the content and functionality of the visualization dashboard to make sure that the visually appealing data can assist in monitoring operations and achieving the goal. As per the final step, getting back to Step 3 is required if there is an improvement needed in matching the establishment objective.

4. Results and Discussion

By following the Kaizen 6 Steps, a dashboard is created that meets the objective of providing interactive information for PRCSB warehouse operations. The results that were obtained during the dashboard establishment are described as Fig. 3.

4.1 Reviewing Current Operational Record

From interviews and actual process observation, process interrelationships within the warehouse operation activities are clarified and can be illustrated in Table 1.

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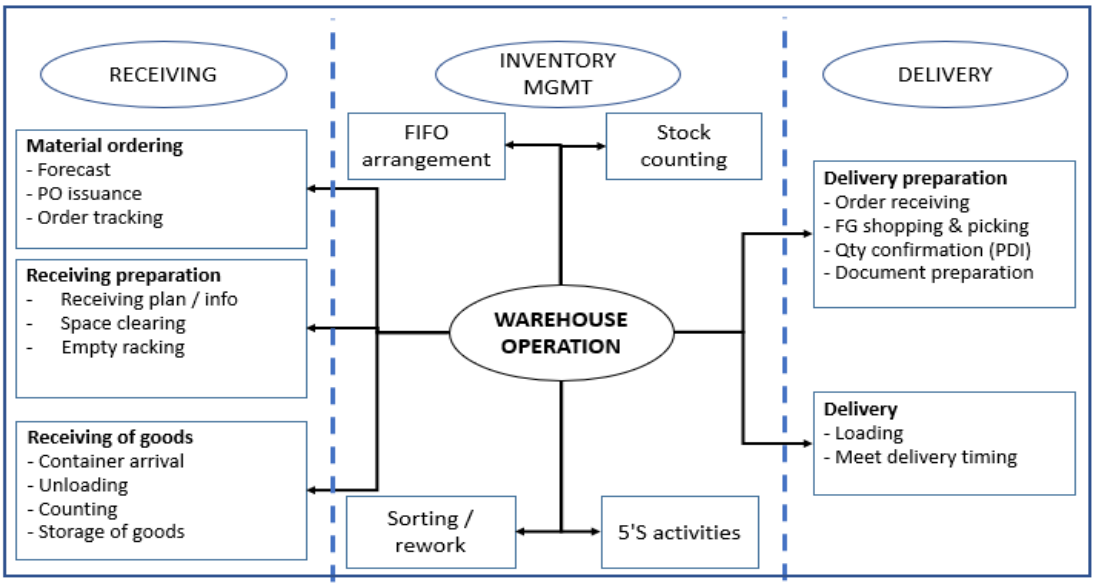

Fig. 3 *Process interaction of PRCSB warehouse operation*

Table 1 *Process activities and capturing record matrix*

Activities	Description	Record
Material ordering	Raise an order to supplier	Stock card, Purchase Order (PO)
Receiving preparation	Planning and preparation to receive Goods from supplier	Summary list of delivery
Receiving of Goods	Receive of ordered item from supplier, update stock	Packing list, stock card

4.2 Conforming Item To Be Visualized

Based on input from the process owner, items that are important and require monitoring can be divided into three areas which are the stock overview, receiving information and delivery information. The Stock Overview page gives information on the actual stock status in real time, storage space occupied, space consumption by items, stock by category and stock by supplier. This information is able to be filtered by supplier, type, product and item name by using the control list. The Receiving Information page tells about the incoming activities that include receiving ratio by supplier, ratio received item by the Unit of Measurement (UOM), received quantity by item, recent receiving item by date and receiving supplier by month. All this information about receiving data can be filtered by month and supplier. Information that relates to the delivery area is compiled on the third page where three of their major customers are required to be monitored. It will show the delivery ratio by customer and the delivery by item which can be filtered by month.

4.3 Compiling Data in Google Sheet

A specific format in Google Sheets has been established to provide a database for the Looker Studio. All the required data is compiled in one Google Sheet file which includes the master list, receiving data, delivery data and integrated data. The master list sheet is created to provide a centralized database of item information which includes item name, item number, source of supplier, product grouping, UOM and physical item size. Receiving data and delivery data are compiled in separate sheets with the information of received and delivered items which include the transaction date, items, quantity, supplier or customer, product grouping and UOM as shown in Fig. 4 and Fig. 5.

These two data are then compiled in another sheet named Integrated Sheet, where the total quantity received and delivered is formulated to calculate the balance of stock by item. Besides receiving and delivery data, the opening stock figure has also been captured in this integrated sheet, and the following formulation is used for the stock balance:

$$\text{Balance} = (\text{Opening Stock} + \text{Total Received}) - \text{Total Delivered} \quad (1)$$

NO	MONTH	DATE	SUPPLIER	ITEM NAME	ITEM NO	QTY	UOM
531	Nov	28-Nov-22	SS	D93L-VPT139BL01 (M011 STD MAIN)	S082513	1407.9	METER
532	Nov	28-Nov-22	SS	381A,FABRIC TRITON BLACK(TR089BL01)	S086058	1520.3	METER
533	Nov	28-Nov-22	SS	D93L-TR131BL01 (M038a X-OVER BOL)	S082516	1141.3	METER
534	Nov	28-Nov-22	SS	D93L-TR510BL02 (STD BOL)	S082514	2686.1	METER
535	Nov	28-Nov-22	SS	FAB JAYCEE 1.3T (H2E6)	S086101	504.4	METER
536	Nov	28-Nov-22	SS	TR701 BL01 L2/30H NB 10G	S086072	397.9	METER
537	Nov	28-Nov-22	SS	D27A, TE027 BL01 LA3T/D20/PE40D + EMB	S082525	3461.5	METER
538	Nov	28-Nov-22	SS	D27A, TE027 BL01 LA3T/D40/PE40D + EMB	S082526	535.2	METER
539	Nov	28-Nov-22	SS	640A,FW086 BLO1-1.3T (ETERNO BLACK)	S086069	372.8	METER
540	Nov	28-Nov-22	SS	965B FAB COAST B 3T (TE020 BL02 L3MM/20)	S086091	789.27	METER
541	Nov	28-Nov-22	SS	230B/231B FAB TRITON 3T BLACK (TR089 BL01 L3MM-UFL20)	S086075	239.84	METER
542	Nov	28-Nov-22	SS	TR089 BL 01 LA3/30 OLE	S086073	489.49	METER
543	Nov	28-Nov-22	SS	230B/231B,FAB TRITON 1.3T BLACK (TR089 BL01 L1.3MM-UFL20)	S086074	2144.83	METER
544	Nov	28-Nov-22	SS	D93L-TR131BL01 (M040a X-OVER MAIN)	S082515	698.2	METER
545	Nov	28-Nov-22	SS	TR103 BL01-KGP2 (P32R/L02D)	S086085	105.4	METER
546	Dec	5-Dec-22	SS	D93L-VPT139BL01 (M011 STD MAIN)	S082513	151.9	METER
547	Dec	5-Dec-22	SS	D93L-TR131BL01 (M038a X-OVER BOL)	S082516	1014	METER
548	Dec	5-Dec-22	SS	D93L-TR510BL02 (STD BOL)	S082514	4039.3	METER
549	Dec	5-Dec-22	SS	D51A, TR136BL01 W=1.4M	S082522	3001.3	METER
550	Dec	5-Dec-22	SS	D27A, TE027 BL01 LA3T/D20/PE40D + EMB	S082525	2146.2	METER
551	Dec	5-Dec-22	SS	D93L-TR131BL01 (M040a X-OVER MAIN)	S082515	1226.3	METER

Fig. 4 *Receiving item record sheet*

DATE	CUSTOMER	TRIP	ITEM NAME	QTY	SHIP NUMBER	ROLL / BOX NUMBER 1	QTY 1	ROLL / BOX NUMBER 2	QTY 2	ROLL / BOX NUMBER 3	QTY 3	ROLL / BOX NUMBER 4	QTY 4	ROLL / BOX NUMBER 5	QTY 5
2-Sep-2022	PECCA	23155	FOAM 5T FINE	60	Aic#13	51	56								
2-Sep-2022	PECCA	23296	TE027BL01 LA3T/D20	500	Ss#08	224	39.2	220	29.1	217	44.3	263	47	221	29.8
2-Sep-2022	PECCA	23296	TE027BL01 LA3T/D20	100	Ss#08	218	48.4	235	48.1						
2-Sep-2022	PECCA	23358	PVC TIARA 3T BLACK	30	Pt#07	2	30								
2-Sep-2022	PECCA	23358	PVC TIARA 1.3T WARM GRAY	60	Pt#07	30	25	35	25						
2-Sep-2022	PECCA	23358	884A, PNP CARPET	120	Pt#6a	4	120								
2-Sep-2022	PECCA	23358	FOAM 8T FINE	120	Aic#23	43	60								
2-Sep-2022	PECCA	23358	QUEEN CORD	240	Pt#07	11	49	16	49	23	50	28	49	25	50
2-Sep-2022	PECCA	23996	FOAM 8T FINE	80	no stock										
2-Sep-2022	PECCA	23996	FAB ETERNO 3T BLACK	50	Ss#09	188	47.32								
2-Sep-2022	PECCA	23996	PVC TIARA 3T WARM GRAY	30	Pt#07	32	27								
2-Sep-2022	PECCA	24476	FAB TRITON 0T	60	Ss#08	186	51.2								
2-Sep-2022	APM	P20008469	D93L-TR131BL01 (M040a X-OVER MAIN)	240	Ss#7	259	41.9	262	49.2	274	41.9	271	48.8	272	33.8
2-Sep-2022	APM	P20008853	D93L-TR131BL01 (M038a X-OVER BOL)	400	Ss#7A	222	53	225	52	229	52.7	232	52.7	220	52.6
2-Sep-2022	APM	P20008853	D93L-TR131BL01 (M038a X-OVER BOL)	80	Ss#7A	235	52.8	226	52.8						
2-Sep-2022	APM	P20008975	D27A, FXN1-T34075 KEEN (MAIN) W=1.64M	80	PSI#2A	11	50	18	45						
2-Sep-2022	APM	P20008975	D27A, FXN1-T22075 KEEN (MAIN) W=1.64M	80	PSI#2	19	50	28	50.5						
2-Sep-2022	APM	P20008469	D51A, TR136BL01 (4% WAX), W=1.55M	400	Ss#8A	125	47.2	124	41.8	121	50	154	47	153	47
6-Sep-2022	PECCA	23078	TE027BL01 LA3T/D40	50	SS#06	329	43.4								
6-Sep-2022	PECCA	23155	FAB ETERNO 1.3T BLACK	100	Ss#5s	126	48.6	130	46.65						
6-Sep-2022	PECCA	23296	TE027BL01 LA3T/D20	400	Ss#08	229	48.8	212	29.8	211	41	241	39.3	239	38.5
6-Sep-2022	PECCA	23311	D27A, FAB GRITTY 0T	24	Pt#06	703	40								
6-Sep-2022	PECCA	23358	PVC TIARA 1.3T BLACK	30	Pt#08	14	30								
6-Sep-2022	PECCA	23358	PVC TIARA 3T BLACK	30	Pt#07	7	25								

Fig. 5 *Delivery item record sheet*

Fig. 6 shows the integrated sheet which became the main reference data for the Looker Studio.

NO	SUPPLIER	PART NAME 1	PART NO	PRODUCT GROUP	UOM	APM	PECCA	TBU	TOTAL OUT	TOTAL RECEIVED	OPENING STOCK	BALANCE
1	SS	766A,UFL20-10T(GRAY)W/T 83DTEX	B020023	FOAM	METER	0	0	0	0	0	0.00	0.00
2	SS	231B UFL20(CREAM)3T+TRICOT 40D(PINK)	B020028	FOAM ROLL	ROLLS	0	0	42.23	42.23	0	1,526.56	1,484.33
3	SS	231B UFL20(CREAM)5T+TRICOT 40D(PINK)	B020043	FOAM ROLL	ROLLS	0	1340.15	0	1340.15	0	504.00	-836.15
4	SZ	640A,FOAM 8T+TRICOT FINE 75	B020055	FOAM	METER	0	0	0	0	0	393.37	393.37
5	SZ	640A,FOAM 5T+TRICOT FINE 75	B020056	FOAM	METER	0	0	0	0	0	3,689.66	3,689.66
6	SZ	640A,FOAM 3T+TRICOT FINE 75	B020057	PVC	METER	0	0	0	0	0	521.10	521.10
7	SZ	650A,RIGID FOAM(DENSITY 34KG)	B020058	RIGID FOAM	BOXES	0	0	0	0	0	420.00	420.00
8	SZ	660A,RIGID FOAM(DENSITY:25KG)	B020060	RIGID FOAM	BOXES	0	0	0	0	0	400.00	400.00
9	SZ	640A,RIGID FOAM(DENSITY:25KG)-SIZE(MM):6.5T x 1355 x 1725	B020061	RIGID FOAM	BOXES	0	0	0	0	0	1,520.00	1,520.00
10	SZ	660A, CHIP URETHANE FOAM (12T X 54 X 80 MM) 200KG	B020065	CHIP URETHENE	BOXES	0	0	0	0	0	900.00	900.00
11	AIC	231B RIGID FOAM DENSITY 34KG	B020076	RIGID FOAM	BOXES	0	0	0	0	0	2,160.00	2,160.00
12	AIC	230B RIGID FOAM DENSITY 34KG	B020077	RIGID FOAM	BOXES	0	0	0	0	0	1,280.00	1,280.00
13	PSI	HONDA TLAA/TLAY RIGID FOAM 34KG/M3	B020078	RIGID FOAM	BOXES	0	0	0	0	0	1,150.00	1,150.00
14	PSI	SEAL A 83200-T02A-T010-26 [EE-1010]	B020079	CHIP URETHENE	PCS	0	0	0	0	0	0.00	0.00
15	PSI	PAD A 83200-T02A-T010-27 [CBF 60KG + AS-5000]	B020080	CHIP URETHENE	PCS	0	0	0	0	0	0.00	0.00
16	PSI	PU FOAM 34KG/M3 T:6.3MM	B020081		BOXES	0	0	0	0	0	1,440.00	1,440.00
17	SS	104D, CARPET 250G/M2, 1.5M (W) X 50M (L) C2L8BK	K021001	CARPET ROLL	ROLLS	0	0	0	0	0	4,349.00	4,349.00
18	SS	104D, CARPET 380G/M2, 1.5M (W) X 30M (L) C2L8BK	K021002	CARPET ROLL	ROLLS	0	0	0	0	0	1,569.00	1,569.00
19	SS	104D, PE WOVEN SHEET WHITE (HS24), W=870MM	K021003		METER	748.2	0	3989.21	4737.41	0	0.00	-4,737.41
20	SS	104D, PE WOVEN SHEET WHITE (HS24), W:1000MM	K021004	FABRIC ROLL	METER	0	0	0	0	0	0.00	0.00
21	SS	IMV(338B),PVC TIARA 1 (BLK)+T:3MM (D30 PU FILM)	P050002	PVC	METER	0	0	0	0	0	119.00	119.00
22	SS	IMV(338B),PVC TIARA 1 (BLK)+T:10MM (D30 PU FILM)	P050003	PVC	METER	0	0	0	0	0	0.00	0.00
23	SS	IMV(338B),PVC TIARA 1 (BLK)+T:1.3MM (D20 HT75)	P050004	PVC	METER	0	0	0	0	0	238.91	238.91
24	SS	IMV(338B),PVC TIARA 1 (BLK)+T:3MM (D20 HT75)	P050005	PVC	METER	0	0	0	0	0	51.00	51.00

Fig. 6 *Integrated sheet that combines the information for the stock balance*

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4.4 Developing Visualization Using Looker Studio

The development of the dashboard started with the Stock Overview page where the integrated sheet containing data on stock balance is linked as reference data. Following the item that was decided in 4.2, visualization is created by using a scorecard, gauge, bar chart and pie chart as per Fig. 7.

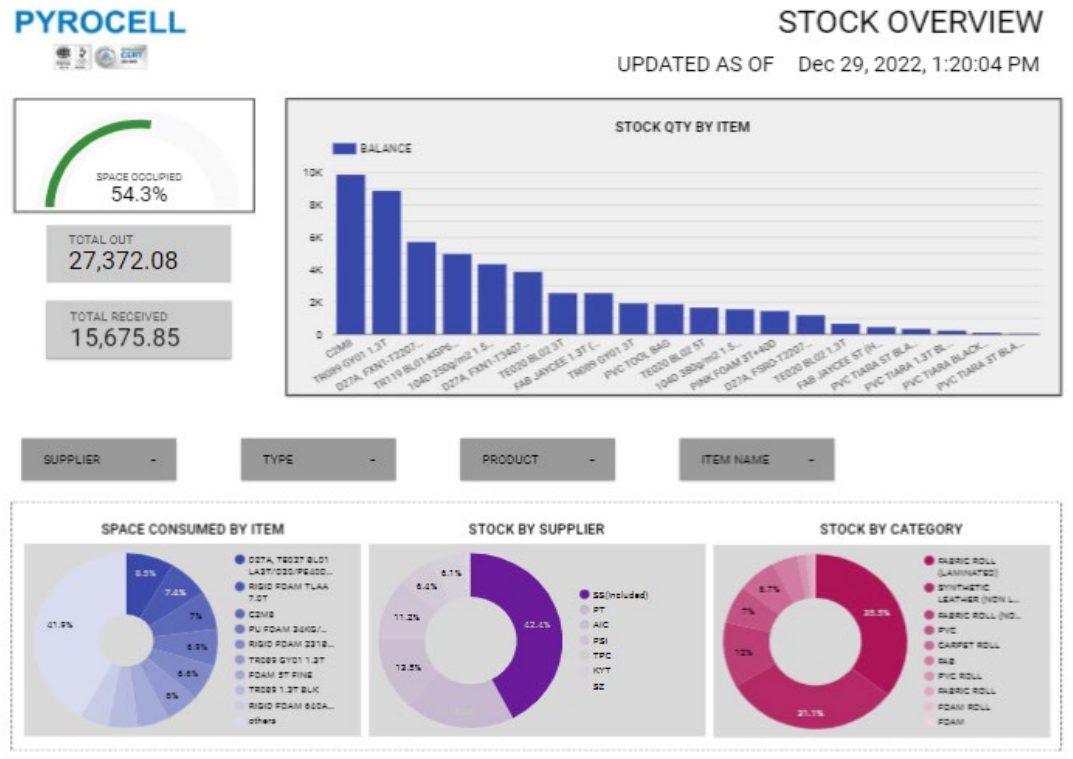

Fig. 7 *Stock overview page*

Space occupancy is shown by using a gauge to get a percentage reading which visually shows how much space is being filled up by the products. The bar chart represents the stock balance item while the space consumption by item, stock by supplier and stock by category are shown in percentage ratio by the pie chart. With the control function of the drop-down list, the dashboard will interact with the user by showing the item that was selected by the user. For example, if the user only wants to see and select a certain supplier, the graph and the scorecard box will turn to the specific input selected.

The space utilization ratio, which is shown as a percentage, gives an indication of how full the warehouse is with goods, giving the user an image of overall stock. Occupied ratio below 60% will indicate stock is low, with probably many items in low stock, while over 95% indicates overstock condition and not supposed to have a receiving of items. The user has to maintain gauge level at 60% to 95%, as this is optimum stock control at all times. Stock balance by item is shown in a graph presenting the real-time stock balance of each item so the user will be able to know the balance quantity by item. The graph will reflect and show desired items based on the selection of menu buttons for supplier, type, product and item name which puts a focus on what the user wants to see. The pie chart that shows information on space consumed by item, stock by supplier and stock by category is providing input to users on which item, category and supplier are currently occupying the warehouse.

The status of received parts was summarized on another page of the dashboard, which was named Receiving Overview. The information related to the items that were received from the supplier is compiled in a scorecard box, pie chart and bar chart. Scorecards show the total received quantity in a separate UOM with rolls, meters, boxes, and pieces. The ratio of quantity received by supplier and by UOM was compiled in a pie chart, while the quantity received by supplier, item and month were shown in the bar chart. By using the function of drop-down selection, all this information will change and only show on selection either by month or supplier. The dashboard interface for this receiving overview page is as per Fig. 8.

From the bar chart, users will be able to trace the receiving activity of the item which can be filtered by month and supplier. This provides information for users to understand previous ordering and receiving trends which can be used for future ordering input. Besides, it also helps the user to do fast traceability upon the requirement to trace affected receiving batches in the event of an abnormal occurrence.

The delivery activities were reported on the third page of this dashboard as shown in Fig. 9. Their three major customers were selected to be visualized with detailed information of the ratio delivered by item that

showed the pie chart while the bar chart showed the delivered quantity by month. All the information can be filtered by month with the drop-down list button. From the pie chart and bar chart of each customer, users will be able to understand the order and delivery trend by month which will become a good input for future forecasting and material ordering. The dashboard has been designed to visualize the information of PRCSB warehouse operation activities continuously within a one-year cycle without requiring any updates at intervals. By having a selection for a desired month to be seen, the user is able to interact with the dashboard to know related information within the selected month. This dashboard provides useful information that is required by the user especially when making a decision.

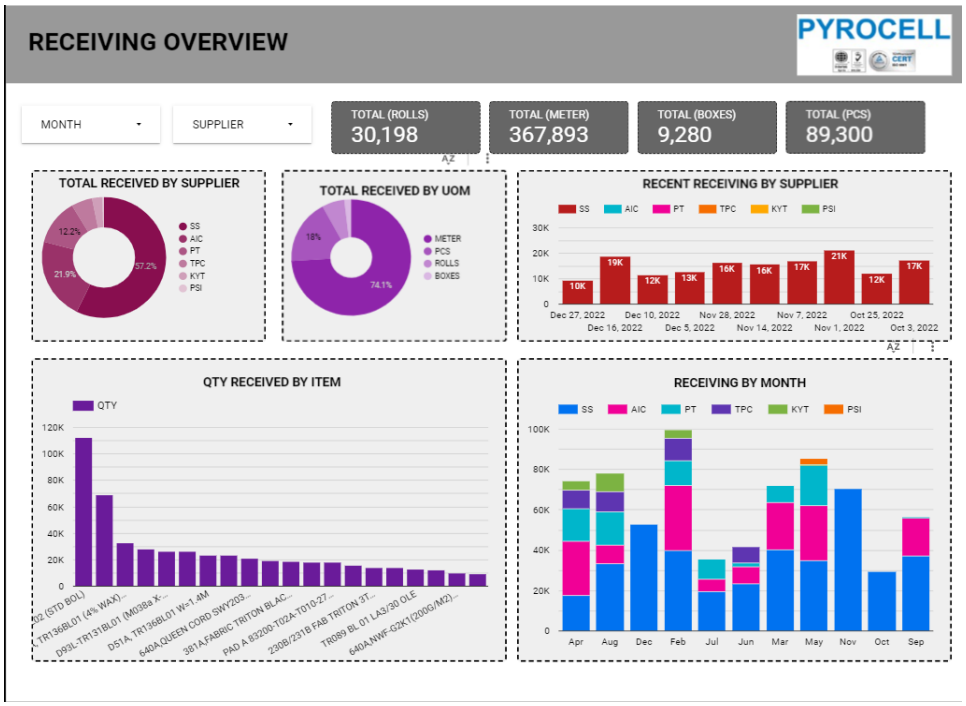

Fig. 8 *Receiving overview page*

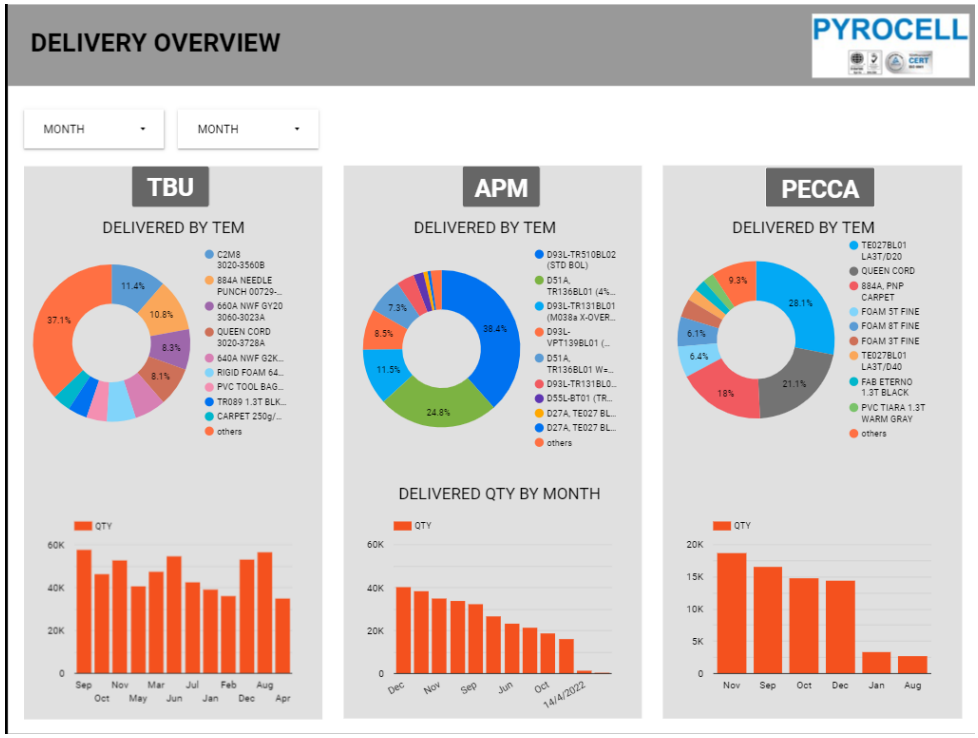

Fig. 9 *Delivery overview page*

4.5 Users Feedback on The Dashboard

Using a Google Form, a survey has been launched to gather user feedback on the dashboard's effectiveness and suitability for their regular operational activities in the warehouse. In total, eight respondents from three functional areas which are management, operational staff directly involved in warehouse operation, and supporting groups that indirectly interact with warehousing activity provided feedback on the survey. The survey's main goal was to learn how users felt about the dashboard's functionality and how it helped them complete their daily tasks. The survey resulted in 100% of respondents agreeing that the dashboard helps improve warehouse efficiency, with 62.5% giving it a full rating while another 37.5% gave it a 4 out of 5 rating. In terms of the dashboard contribution to daily task accomplishment, all respondents also agreed it really contributed, with 50% giving it a full rating of 5, while others rated it as 4. This survey concluded that the establishment of the interactive dashboard has contributed to smoothing the operational activities in the PRCSB warehouse.

5. Conclusion

A simple, easily customized, informative and interactive operation dashboard has been successfully developed by using open-source software by Google, which is Google Sheet and Looker Studio. It was developed based on input from the user on what they would like to see from daily warehouse operation activities for PRCSB. The information that is shown in the dashboard is selectable based on which item users want to explore more and use this as an information center. Previous manual recording has been eliminated and replaced with a database using Google Sheets. The operation information and status provided in the dashboard help users get accurate and fast information for making the right decision that helps improve the organization's performance.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Mohamad Khairi Hassan, Mohd Hazri Mohd Rusli;* ***data collection:*** *Joshua Goh Wen-Hann;* ***analysis and interpretation of results:*** *Noor Azlina Mohd Salleh, Mohamad Khairi Hassan;* ***draft manuscript preparation:*** *Suzilawati M. Kayat. All authors reviewed the results and approved the final version of the manuscript.*

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