COVID-19 Vaccine Logistics Process Improvement Using Business Process Reengineering

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Abstract

To tackle COVID-19, the vaccine needs to be distributed massively and rapidly. In reality, some problems are found in COVID-19 vaccine distribution, including inefficient order management, time-consuming bureaucracy, and missed flights that lead to the withdrawal of vaccines to the distribution center. Supply chain management plays a significant role in ensuring the distribution efficiency of the COVID-19 vaccine. This paper aims to design the improved outbound distribution of the COVID-19 vaccine in Indonesia to increase logistics performance using Business Process Reengineering. Observation is conducted to gain primary data of this research, and time is obtained from historical data. The process is mapped using Business Process Model and Notation (BPMN) and simulated using iGrafx software. This study results in a radical improvement of the COVID-19 vaccines' outbound distribution, which changes the process time from 74,57 hours to 35,81 hours, with implementation Information Sistem with API Integration, QR Code, and Sign on Glass technology.

Keywords
COVID-19 Vaccine, Supply Chain Management, Business Process Reengineering, Modelling, Simulation.

1. Introduction
One way to overcome COVID-19 virus is by procuring vaccinations. The COVID-19 vaccine was created with the aim of creating group immunity (herd imnunity There are several types of vaccines created, including Sinovac-CoronaVac, Pfizer-BioNTech, Johnson&Johnson, Moderna, AstraZeneca-Oxford, Cansina, Sinopharm BBIBP, and Sputnik V,with injection doses 1 time or 2 times (Biofarma, 2021). Although the COVID-19 vaccination program in Indonesia began in January 2021, until September 2021, only 20.07% of the population in Indonesia was newly vaccinated as much as 2 doses (WHO, 2021).

Indonesia has its own vaccination challenges, one of which is a logistic challenge. Indonesia and its island countries have logistic challenges of vaccination, where with certain temperature restrictions, vaccine products are vulnerable to damage. One of the government's efforts in expanding the scope of COVID-19 vaccination is to implement the Gotong Royong Vaccination (VGR) program, which is a vaccination program outside of the free vaccination program by the government. Gotong Royong Vaccination is the implementation of Vaccination of employees, their families, and other family members whose funds are borne or charged by private companies (*Permenkes No.10*, 2021). Gotong Royong Vaccination Procurement is carried out by one of the State-Owned Enterprises (SOEs) engaged in the pharmaceutical industry.

In the implementation of vaccine outbound distribution activities, the pharmaceutical company outsources by using third-party logistic logistics service providers (3PL), whre the 3PL only acts as a delivery service provider, and the process in cargo preparation, which includes determining the mode of transportation, packaging, and document making is handled by the pharmaceutical company as the sender. The vaccine is stored at pharmaceutical company's National Distribution Center in East Jakarta and then delivered to all regions in Indonesia.

The private company's vaccine product is categorized as Cold Chain Product (CCP), where the delivery must be at a controlled temperature, within a range of two to eight degrees Celsius. One way that delivery can quickly reach the destination is to use air transportation modes. The vaccine is packaged using styrofoam collies to keep temperatures stable within the limit. Delivery can also be done using Reefer Truck or truck with refrigeration. This was done by 3PL to deliver the vaccine to areas in Java Island.

However, based on data from 3PL companies, there are several problems found. Based on ordering data, from August – September 2021 as shown in Figure 1, there is a total of 442 shipment order that have been inputed in pharmaceutical company's system before the order cut off time yet updated on *Google Sheet* after the deadline.

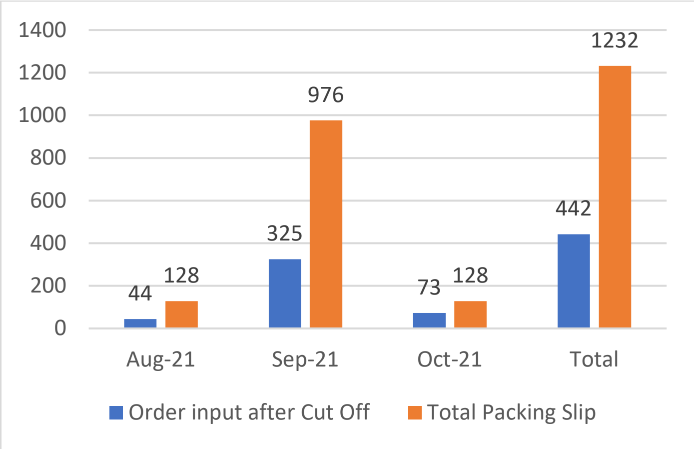

Figure 1. Order Input After Cutoff Time Based on Packing Slip in 2021

Therefore, the shipment is processed the next day and carried out the day after tomorrow. Moreover, from 3PL's data, there are 12% average of overlong outbound from January 2021 to July 2021, which caused by long documents process by the pharmaceutical company's employee. This problem is going to affect the Service Lead Agreement of the 3PL's company, though the problem roots have nothing to do with the 3PL. Also, this is going to affect the delivery time to airport, therefore, there are also 7 cases of late arrival on airport which results in the delivery cargo that has arrived at the airport must be towed back to the National Distribution Center.

1.1 Objectives

From the 3PL company's data, we could see that the process of distribution of vaccines carried out is still less efficient, where many of the COVID-19 vaccine product delivery orders received still use a less efficient order process, bureaucracy that consumes time, with temperature discrepancies and delays to get to the airport. Therefore, the COVID-19 distribution process needs to be reengineered with a design for improvement so that the performance can be improved.

2. Literature Review

2.1. Logistic

The supply chain is made up of producers and suppliers, as well as all other parties involved in meeting client demand (Chopra & Meindl, 2016). As a result, the supply chain is defined as a collection of procedures and organizations (suppliers, customers, factories, distributors, and retailers) that work together to fulfill customer orders (Abdel-Basset et al., 2018a). Logistics, a part of the supply chain, facilitates the movement and coordination of supply and demand in creating time and place utility (Abdel-Basset et al., 2018b) Efficiency, effective planning, implementation, and control that Logistic management has creates the ability to fulfill customers by being able to go ahead and backwards in storage of goods, services, and information relevant to the point of origin (CCSCMP, 2021).

2.2. Third Party Logistics (3PL)

Nowadays, firms can outsource Third Party Logistics Service Providers (LSPs) to perform their logistics operations then brings product and service innovations to market more expeditiously (Lai, 2004). Outsourcing is when a company hires a third party to offer goods or services that it could otherwise provide itself. Third parties are "experts" at efficiently delivering goods or services, whereas the firm may not be able to do so (Lambert & Cooper, 2000). Third-Party Logistics is one type of Logistics Service Provider (LSP) (3PL). 3PL vendors are logistics-specific intermediates who supply organizations with whole or partial logistics services, ranging from transportation to creating, implementing, and maintaining the entire distribution system and other logistical demands over a certain time period (Ying & Dayong, 2005). Third-party logistics, which acts as a mediator between producers (businesses) and customers, is essential in minimizing production costs and maximizing customer satisfaction. 3PL merges transportation and warehousing, then propose these services to managers in order to reduce operating costs (Sheikh & Rana, n.d.).

2.3. Business Process Reengineering (BPR)

A business process is a collection of operations that involve one or more inputs and provide valuable output for consumers (Alameen & Gupta, 2018; Hammer & Champy, 1993; Vergidis et al., 2008). The goal of business processes is really to tackle business challenges (Havey O'reilly® et al., n.d.). Improvement methods are strategies for constructing or handling various company activities (Islam & Daud Ahmed, 2012). Business process reengineering (BPR) can be used to improve business processes and resolve issues. Introduced by Davenport, Short and hammer in 1990, BPR is defined as an endeavor to enhance the foundations and radical redesigning of business processes in order to achieve enhanced efficiency in important components such as cost, quality, service, and speed (Hammer & Champy, 1993). BPR has been used by several companies to reduce costs, cycle times, and increase product quality (Bhaskar, 2018). Moreover, one of the Indonesian dairy industry firms conducts BPR in the research of the manufacturing sector to create improvement strategies for said dependability of finished goods in hopes for improving their business processes (Dachyar & Christy, 2014) and in one of Indonesia's pharmaceutical company where delays and inefficient logistic systems are eliminated (Dachyar et al., 2016). The BPR framework in use is divided into four phases (Lowenthal, 1994), which are change preparation, change planning, change design, and change evaluation.Business process management (BPM) manages the business process ecosystem in order to increase agility and operational efficiency. This is a method for improving a company's operations in a methodical way. The period during which a process is manually and/or automatically characterized is known as business process modeling (workflow). Business Process Modeling is a method of describing a company's process in order to investigate the current processes ("as-is") and make improvements in the future ("to be"). BPM is concerned with optimizing business processes and can be used to reduce or simplify processes that require change. Processes are represented using a variety of techniques, including BPMN, DFD, IDEF, and Value Stream Mapping.

3. Methods

The research methodology was taken based on the Business Process Reengineering (BPR) work methodology according to Lownthal, which consists of:

1. Early Stage of Research
   The research began by studying literature from various journals and books to learn more about the theories of Business Process Reengineering (BPR) and to determine and strengthen the research topic, as well as the problem areas taken, namely logistics, distribution, etc. The background of the research then explores the conditions and problems obtained from the object of research, followed by the formulation of the problem and the purpose of the research conducted.
2. Preparation for Reengineering
   The research then continued with the process of preparing for improvement that began by determining the scope of the research. Literature studies from various sources were carried out to find out more about the outbound distribution process in order to get an overview of the company. Then, interviews with stakeholders were conducted so that business processes can be studied further so that they can describe the outbound distribution process in the company as a whole.
3. Reengineering Planning
   From interviews with stakeholders, followed by direct observation to find out the time the process took place, complemented by historical data curated by the company. Then, the outbound distribution process is mapped using a Flow Process Chart so that it can be visualized in its entirety, followed by modeling the current distribution process (As-Is) using a BPMN diagram on Igrafx software and then simulated to obtain the total time of the distribution process.
4. Improvement Design
   At this stage, problems in the company are analyzed and activities that affect process inefficiencies are identified. The solution is then designed, then the new process (To-Be) is modeled in the Igrafx software and simulated
5. Improvement Evaluation
   Finally, in the evaluation phase of changes, the selection of the most optimal solution from the design changes. The most effective and efficient processing time can be seen from the simulation of the To-Be distribution process which is carried out by testing the scenario on the model to find out the changes that occur.

4. Data Collection

Data is collected and processed by observing the distribution process, which is carried out by logistics service providers who transport COVID-19 vaccinations from the pharmaceutical company's national distribution center, as well as by looking at documents and reports produced by the company. Early on in the process, interviews with third-party firms (3PL) stakeholders were conducted to determine how the distribution process was carried out. The pharmaceutical company's national distribution center was then visited for direct observation to better understand the entire distribution process and monitor the time required for each step. Following a knowledge of the distribution process, the current process is modeled using the Igrafx BPMN software and contains time data to recreate the complete process until the overall time of the distribution process is obtained, then using problem analysis to identify potential solutions, the author models the new distribution process in Igrafx BPMN software to determine the overall distribution of improved process time.

Observed time and allowance are obtained from the observations, resulting in normal time. By adding an allowance of the observed activity through the following formula, the standard time is calculated:

$$\text{Standard Time} = \text{Normal Time} \times (1 + \text{Allowance})$$

In Table 1, the whole observed activities, along with the standard time in private company's COVID-19 vaccine outbound distribution process and the actors involved, are listed. The as-is consists of 5 main steps, which are ordering process, planning dispatch process, first mile process, mid mile process, and last mile process. It also consists of two subprocesses, namely loading process and proof of delivery creation process. Normal time and standard time are listed in hh:mm:ss time format.

Table 1 Private company's COVID-19 Vaccine Outbound Distribution Activity and Time Details

Step	**Activity Detail**	Actor	Allowance	Normal time	Standard time
	Ordering Process				
1	Accept delivery requests by pharmaceutical company system	Admin pharmaceutical company	13%	00:00:20	00:00:23
2	Waiting for pharmaceutical company admin to update order on *Google Sheet*	Planner 3PL	11%	03:14:28	03:38:30
3	Update order on *Google Sheet*	Admin pharmaceutical company	13%	00:08:23	00:09:38
4	Receive orders	Planner 3PL	13%	00:01:05	00:01:15
5	Recapitulate orders	Planner 3PL	13%	00:44:32	00:51:12
6	Looking for flight schedules	Planner 3PL	13%	00:44:32	00:51:12
7	Send recap order to PIC pharmaceutical company on *Whatsapp*	PIC pharmaceutical company	13%	00:00:50	00:00:58
8	Awaiting confirmation of PIC pharmaceutical company	Planner 3PL	11%	05:57:17	06:41:27
9	Receive confirmation of order changes on *Google Sheet*	Planner 3PL	13%	00:00:50	00:00:58
10	Confirm the number of submissions on *Whatsapp*	PIC pharmaceutical company	13%	00:00:50	00:00:58
11	Enter an order to TMS as *Job Order*	Planner 3PL	13%	00:13:50	00:15:54
	Planing Dispatch Process				
12	Input order to a flight vendor on *Google Sheet*	Planner 3PL	13%	00:06:21	00:07:17
13	Inform flight vendors on *Whatsapp*	Planner 3PL	13%	00:00:50	00:00:58
14	Find cargo space on flight	Flight vendor	13%	00:55:36	01:03:54
15	Vendor informs planner on *Whatsapp*	Flight vendor	13%	00:00:50	00:00:58
16	Planners looking for alternative flight schedules	Planner 3PL	13%	00:12:10	00:13:59
17	Provide information to PIC pharmaceutical company that the shipment is confirmed	Planner 3PL	13%	00:00:50	00:00:58
18	Schedule pick up with flight vendors	Planner 3PL	13%	00:05:21	00:06:10
19	Sending fleet data (driver personal info, fleet data)	Flight vendor	13%	03:10:13	03:38:39
20	Provide fleet data information to pharmaceutical company	Planner 3PL	13%	00:00:50	00:00:58
21	Waiting for scheduled departure	Planner 3PL	11%	05:08:00	05:46:04
	First Mile Process				
22	Fleet queuing to enter the *National Distribution Center* (NDC)	Flight vendor	21%	00:07:50	00:09:55
23	Waiting for cargo to be loaded into the fleet	Flight vendor	21%	00:36:23	00:46:03
24	Loading process		22%	00:27:11	00:34:50

24a	Check the suitability of the number of items with *packing slip*	Checker 3PL	31%	00:10:03	00:14:27
24b	Transporting cargo to the fleet	Checker 3PL	42%	00:36:42	01:03:17
24c	Make discrepancies report	Checker 3PL	13%	00:05:06	00:05:52
25	Create *Proof of Delivery* document		13%	00:39:10	00:45:01
25a	Give the manifest to the pharmaceutical company document admin	Checker 3PL	18%	00:02:42	00:03:18
25b	Create a *Delivery order Document*	Checker 3PL	13%	00:04:17	00:04:55
25c	Create *Handover document* (bast)	Checker 3PL	13%	00:04:17	00:04:55
25d	Waiting for *Delivery order Document* (exit letter)	Flight vendor	11%	00:32:55	00:37:00
25e	Receive *Delivery order Document* as *Proof of Delivery*	Admin pharmaceutical company	11%	00:00:50	00:00:56
25f	Give *Proof of Delivery* document to the driver	Flight vendor	18%	00:02:42	00:03:18
26	Queuing out	Flight vendor	21%	00:07:15	00:09:10
27	Travel to the airport	Flight vendor	21%	04:14:03	05:21:35
	Mid Mile Process				
28	Waiting for flight time	Airlines	10%	06:53:05	07:38:59
29	Flight to the destination airport	Airlines	21%	02:35:49	03:17:14
30	Fleet picks up to the airport	*Vendor last mile*	21%	01:59:43	02:31:32
31	Carrying out the *clearance* process	Airlines	42%	02:10:52	03:45:38
	Last Mile Process				
32	Travel to the destination	*Vendor last mile*	21%	01:59:43	02:31:32
33	Checking the suitability of the number of goods with documents	*Vendor last mile*	31%	01:40:47	02:25:01
34	Unloading process	*Vendor last mile*	42%	01:40:47	02:53:46
35	Create discrepancies order	PIC pharmaceutical company destination	13%	00:10:09	00:11:40
36	Sign a *Proof of Delivery* document	PIC pharmaceutical company destination	13%	00:04:17	00:04:55
37	Photograph all *Proof of Delivery* documents	*Vendor last mile*	13%	00:10:43	00:12:19
38	Waiting for information on delivered goods confirmation	Planner 3PL	11%	02:05:20	02:20:49
39	Sending photos *of Proof of Delivery* documents on *Whatsapp*	*Vendor last mile*	13%	00:00:50	00:00:58

5. Results and Discussion

5.1 Current Model

Following an in-depth interview and observation, the author constructed a modeling of the entire current outbound distribution business process, from the order placed to the order being acquired by the trade and distributor in the designated location, as shown in Figure 2. There are five processes in the outbound distribution of COVID-19 Vaccine, namely ordering process, planning dispatch process, first mile process, mid mile process, and last mile process.

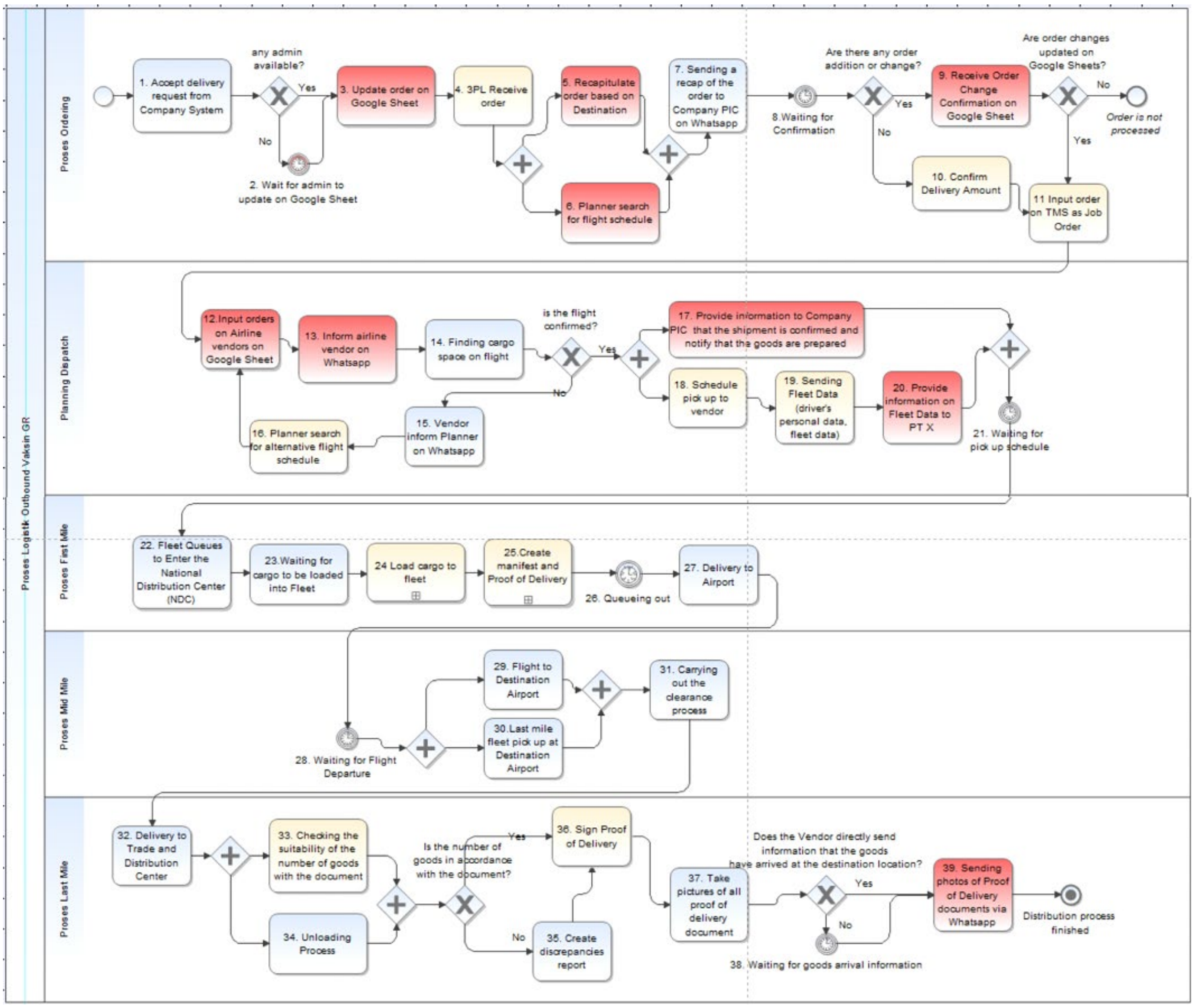

Figure 2 Private Company COVID-19 Vaccine Outbound Distribution

Based on the current outbound distribution process modeling, a simulation of the model is done, producing the overall total time for delivering the vaccine to the region distributor as well as the time for each procedure. The outbound distribution process now takes 75.57 hours, including a 25.20-hour wait period, and the detailed time of process is presented in Table 2.

Table 2. Simulation Result from As-Is Model of COVID-19 Vaccine Outbound Distribution

Detailed Transaction Stastics (Hours)			
Process	Avg Cycle	Avg Work	Avg Wait
Ordering	24,27	11,67	12,59
Planning Dispatch	7,16	7,16	0
First mile	6,45	6,45	0
Mid mile	14,70	14,70	0
Last mile	20,68	8,07	12,61
Loading Subprocess	0,58	0,58	0
Document creation Subprocess	0,74	0,74	0
Total Transaction Stastics (Jam)			
VGR Outbound Distribution	74,57	49,36	25,20

In Figure 2, there are some processes marked by red squares and yellow squares. The activity marked with red squares indicate the eliminated process in to-be model, and the yellow squares indicate processes that are combined or implemented by technology. The present distribution process is then examined to find the source of the problem, which is caused by a long processing time. According to the current distribution process model, there are three key processes with difficulties that create long distribution process times, which are as follows:

1. In ordering process, the order update process is delayed due to waiting for an admin who is not immediately available, order confirmation is also delayed due to waiting for unavailable PIC, and the order needs to have repeated confirmation is done because the order update process is not real-time so pharmaceutical company's PIC adds orders unilaterally from their system
2. In first mile process, document preparation by the pharmaceutical company takes a long time to finish,
3. In last mile process, The delivery status is not updated in real-time. Therefore, the 3PL company must wait for information whether the shipment has been received. Also, the process of sending information is complicated, where proof of delivery documents, which is a combination of several documents, must be photographed one by one.

5.2 Proposed Improvements

Based on an examination of the problems in the COVID-19 outbound distribution process that result in significant wait times, improvement needs to be done by redesigning the process. Using goal-problem-solution analysis, the solutions are designed by implementing BPR Best practice, which are elimination of process and integration of technology. The proposed technologies are:

1. System Integration Using API Integration
   API stands for application programming interface, and it is a technology that facilitates software development and innovation by allowing apps to share data and functions in a simple and safe manner. APIs allow businesses to exchange application data and functionality with third-party developers, commercial partners, and internal departments. It enables services and products to talk with one another and utilise one another's data and capabilities via specified interfaces (IBM, 2021). System integration strategies using API Integration are used on several processes from the entire business proces. In the ordering process, the API can connect the pharmaceutical SOE's system with the 3PL company's TMS so that no more workers are needed to input the order to Google Sheet. In addition, the API can automatically withdraw flight schedules from external party sites such as filghtradar24.com, so that planner no longer needs to search for flights through Google on a one-on-one basis.
2. Improved function of Transportation Management System (TMS) application using information system
   Currently, the use of Transportation Management System owned by 3PL is only limited to filling out the database only. Therefore, this application can be increased in potential by making TMS as an end-to-end application, where the process of confirmation, recapitulation of orders, flight search and booking to flight vendors, and real-time track and trace shipment is carried out. Thus, the repeated confirmation process can be eliminated, and information will be accessible in real time. Improvement of information systems can be done by designing information systems using entity relational diagrams (ERD) and relational tables, as well as use case diagrams and data flow diagrams (Azzahra & Dachyar, 2021). From the information system framework, data flow can be accessed in a more structured manner to improve the functionality of 3PL's Transportation Management System (TMS).
3. Use of QR Code technology
   QR Code (Quick Response) technology is a two-dimensional matrix code (2D) that is included in the machine-readable code. Compared to barcodes, which are one-dimensional (1D) matrix codes, QR codes can store more data in smaller spaces and their use can be more reliable (Lotlikal et al., 2013). The use of QR Codes can be implemented as a combined identifier code of an Exit Letter (SKB) document, which can also serve as a delivery number. With the implementation of this activity, the process of checking the suitability of goods with documents can be accelerated with the addition of real-time tracking features of the status of goods delivery. In addition, the collection of Delivery Order Documents that will be carried in delivery as Proof of Delivery can be made digital so that there is no longer a need to print many physical documents to be carried in delivery.
4. Implementation of sign on glass technology to sign Proof of Delivery documents
   Sign on glass technology, is another name for digital document signing activities. Today, digital signature technology is already applied to purchases on the Internet, distance education, web entertainment, and digital finance (Chang et al., 2007). The use of sign on glass will be implemented in the process of receiving goods at distributor purposes. With the implementation of this technology, the process of signing proof of delivery documents consisting of a combination of several documents does not need to be signed each to reduce the process time. In addition, the receiving status of goods will be automatically updated to be accepted, so that the cargo tracking process becomes easier, without having to photograph all documents and send them to Whatsapp.

The simulation model of the proposed improvement is shown on Figure 3. The green squares indicate additional new process implementation. In total, there are 11 activities eliminated from the process and 5 activities are combined or implemented by technology.

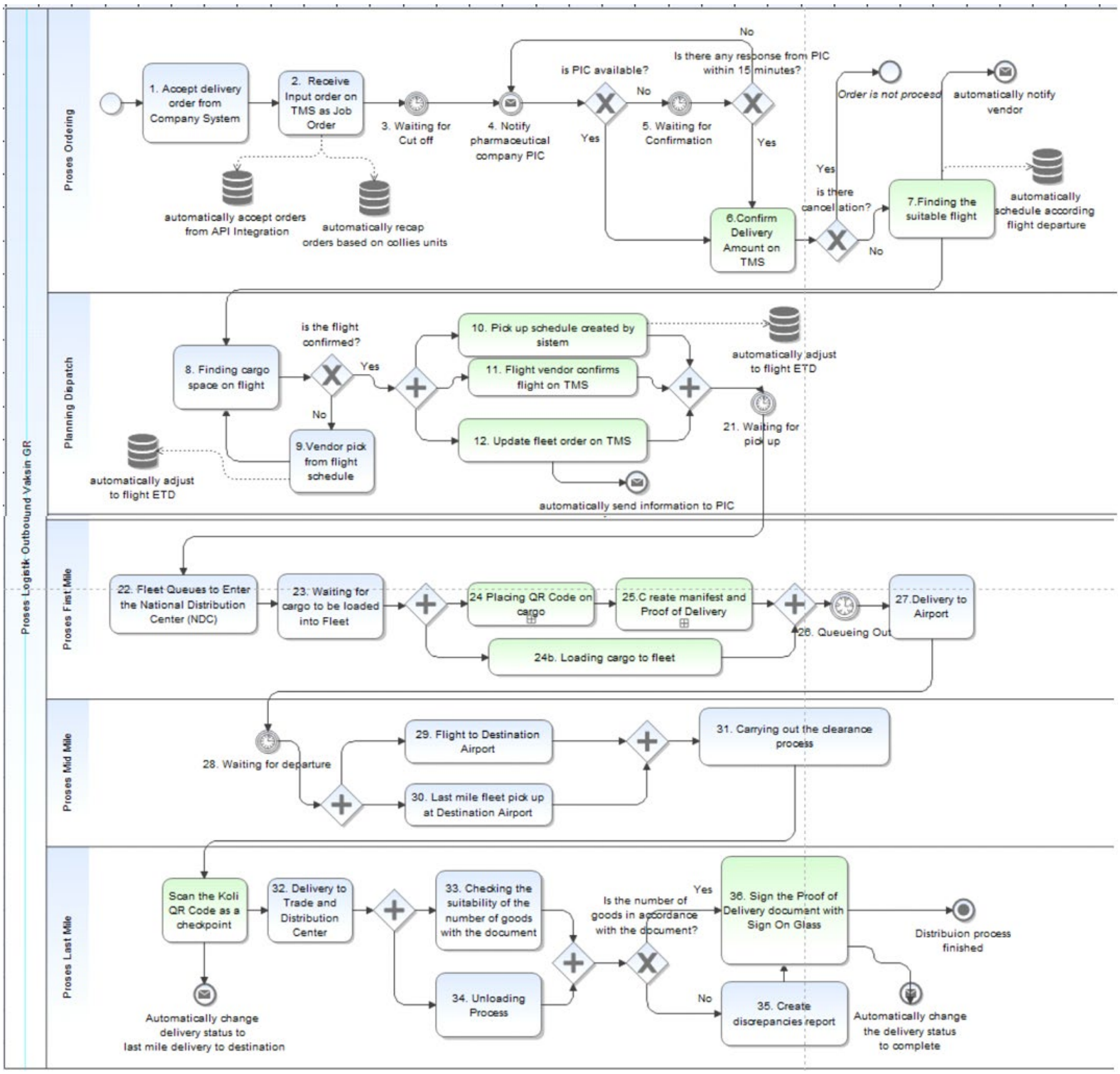

Figure 3 Proposed To-Be Model of Vaccine Distribution

These technologies then combined with the implementation of new standard operating procedur (SOP) on ordering process. Based on (Husada Tarigan et al., 2019), procedure changes have a positive impact when applied in conjunction with business process reengineering (BPR). Two scenarios are proposed, which are implementation of two cut off time with one delivery per day, and two cut off time with two deliveries per day. The simulations results are shown in Table 3.

Table 3. Proposed To-Be Model Simulations Result Compared to As-Is Model

	As - Is			Scenario 1			Scenario 2		
Proses	Avg Cycle	Avg Work	Avg Wait	Avg Cycle	Avg Work	Avg Wait	Avg Cycle	Avg Work	Avg Wait
Whole Process	74,57	49,36	25,20	39,81	39,81	0,00	35,81	35,81	0,00
Transaction Statistics (Hours)									
Proses	Avg Cycle	Avg Work	Avg Wait	Avg Cycle	Avg Work	Avg Wait	Avg Cycle	Avg Work	Avg Wait
Ordering	24,27	11,67	12,59	8,02	8,02	0,00	4,02	4,02	0,00
Planning Dispatch	7,16	7,16	0	6,90	6,90	0,00	6,99	6,99	0.00
First mile	6,45	6,45	0	4,67	4,67	0,00	4,67	4,67	0,00
Mid mile	14,70	14,70	0	14,70	14,70	0,00	14,70	14,70	0,00
Last mile	20,68	8,07	12,61	5,44	5,44	0,00	5,44	5,44	0,00

The implementation of this scenario results in a decrease in waiting time on ordering process. Scenario 1 is a model that results in a longer cycle time, this is because the waiting time for the cut off becomes longer, considering that the delivery is only done once in one day. Scenario 2 produces the fastest time with a total cycle time difference of 4 hours, as a result of the process of waiting for the cut off being trimmed. The two-delivery scenario provides less lag waiting time, but in the operational process, there is certainly a tradeoff that must be considered, namely the company must provide additional labor resources because of the need for the enactment of two shifts in one day.

6. Conclusion

Based on the research conducted, several conclusions about the following research were obtained:

1. The private company's COVID-19 vaccine distribution process is currently modeled with the Business Process Reengineering method with the help of Igrafx software resulting in an average processing time of 74.57 hours.
2. Two types of scenarios are using a combination of 4 technologies, namely system integration using APIs, improving the function of Transportation Management System applications using information systems, checking cargo using QR Codes and implementing sign on glass technology resulted in a reduction of business processes by 11 activities.
3. Improvement of business processes with a scenario of 2 cut off time, 1 delivery in 1 day, resulting in an average process time of 39.81 Hours.
4. Improvement of business processes with a scenario of 2 cut off time, 2 deliveries in 1 day, resulting in an average process time of 35.81 hours.

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