Increasing Oil/Petroleum Supply Chain Distribution Efficiency through using Autonomous Vehicle

Rizky Yonathan, Sabrina Putri Kinanti, and Zahra
Industrial Engineering Department
University of Indonesia
Depok, West Java 16424, Indonesia
rizky.yonathan@ui.ac.id, sabrina.putri71@ui.ac.id, zahra71@ui.ac.id

Abstract
This paper explains the consideration of the implementation of autonomous vehicles as the main transportation modes pertain to logistic processes in the supply chain area, especially in the oil/petroleum distribution. The major challenge that companies currently facing is inflexible distribution processes. Improvements can be done through lean logistics, for example by changes the old-fashioned transportation or conventional truck towards Autonomous Truck in the future. This alternative needs careful consideration to gain a competitive advantage and increase the efficiency of logistic processes.

Keywords
Supply Chain, Logistic, Discrete Event Simulation, ProModel and Autonomous Vehicle

1. Introduction
1.1 Basic Supply Chain and Logistics
Fundamentally, a supply chain is a total system approach to managing the flow of information, materials, and services from raw material suppliers through factories and warehouses to the end customer (Operations and Supply Chain Management, 2018). The application of this concept is applied to all business processes. The difference lies in the characteristics of primary output that a firm offered (goods/services). Supply chain processes particularly divided into five individual processes, they are planning, sourcing, making, delivering (known as logistics processes), and returning that must be carefully coordinated to maximize the company's profits. Supply Chain Management, in general, comprises into several specialized functional fields, beginning from demand planner—managing all activities pertains inventory management (reorder point, safety stock) and the resource required to produce goods/services, warehouse management—running a warehouse, including replenishment, customer/user order fulfillment, receiving (loading/unloading), logistics and transportation—responses to managing the movement of goods throughout the supply chain. Each function is interrelated and has a critical role to deliver the requirements of demanding customers with low possible costs to support the cash flow essential to the firm's long-term sustainability.

In a supply chain, a company is connected with its upstream suppliers and downstream distributors as materials, information, and capital flow through the supply chain. The delivery process/logistics refers to the science of transport planning, its management, and control. This also includes warehousing and any type of intangible and material operations that take place before the goods/resources are delivered to the intended destination. Logistics is essential to manage various material flows effectively. The objective is to maximize the value of the customer. Nowadays, rapid technological growth is affecting the competitiveness of companies. This phenomenon drives both opportunities and challenges, which require a continuous restructuring of the business strategy and positioning tactics. Businesses are endeavoring to create a competitive advantage. The costs of providing goods or services are critical to high earnings growth, in which earnings growth is a function of the profitability of the company, and profits can be increased through higher sales and/or lower cost. This indicates that those principles are directly applicable to the financial health of the company. The factor used to assess the performance management of the business is made up of efficiency and effectiveness. Efficiency means doing something at the lowest possible cost. In other words, efficiency aims to maximize the output with the minimum input (Henandez, (2012); Balocco, et al., (2011). The input resources might be of financial, material, human, technological or physical components (Holweg & Bicheno, 2002). On the other hand, effectiveness means doing the right things to create the most value for the company. Maximizing those two terms is likely to result in conflicting outcomes between them. Nevertheless, there is an equilibrium point in the trade-off phase. Besides, logistics is used as a strategic tool in a competitive market, as it ensures the search for new sources of increased business performance, expands the areas for non-production assets, and optimizes the interaction of the constituent elements of the enterprise resource potential. The movement of goods from the initial to the endpoint must be strictly controlled to minimize costs. Logistics means an integrated approach to solving challenges by finding and reducing costs. The implementation of the logistics concept aims at reducing the time losses of the production cycle and the timing of orders, stocks of materials and finished products, enhances innovation processes and compliance with contractual obligations while strengthening the integration of all material flows in the production process.

1.2 Supply Chain in Oil Industry

According to Christopher M. Chima, "Supply chain management in the petroleum industry is the configuration, coordination and continuous improvement of sequentially organized operations involved in upstream, midstream and downstream." So, the oil supply chain has three functional segments namely the Upstream, Midstream, and Downstream. The upstream segment of the oil and gas business is also known as the exploration and production (E&P) sector because it encompasses activities related to searching for, recovering and producing crude oil and natural gas. The midstream segment involves infrastructure used in transporting crude oil and petroleum products. The downstream segment is a margin business which is defined as the difference between the price realized for the products produced from the crude oil and the cost of the crude delivered to the refinery.

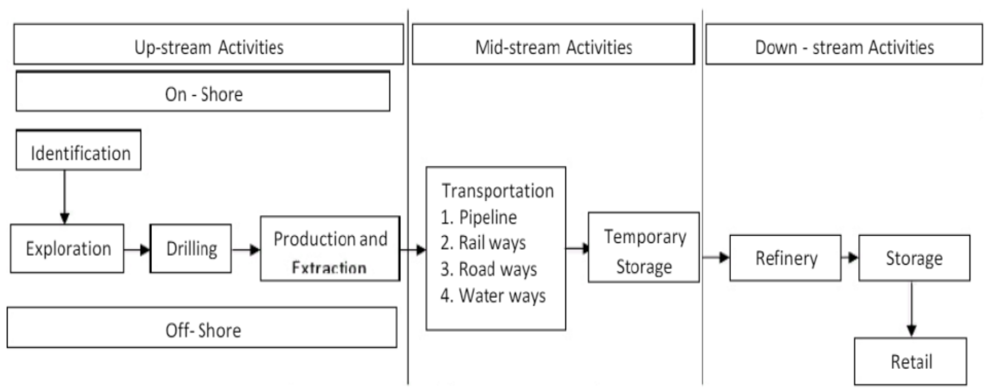

Figure 1. Overview Activities of Oil Industry Supply Chain

1.3 The Next Generation Digital Supply Chain

Industry 4.0 creates a disruption and requires companies to rethink their supply chain design. Several technologies have emerged that are altering traditional ways of working. On top of this, mega trends and customer expectations change the game. The digitization of the supply chain enables companies to address the raising satisfaction of the customers, the challenges on the supply side as well as the remaining expectations in efficiency improvement. Efficiency in the supply chain is boosted by the automation of both physical tasks and planning. Robots handle the material (pallets/boxes as well as single pieces) completely automatically along the warehouse process - from receiving/unloading to putting away to pick, pack, and ship. Autonomous trucks transport the products within the network. To optimize truck utilization and increase transport flexibility, cross-company transport optimization is applied to share capacities between companies. The introduction of Autonomous Vehicle (AV) holds the promise of completely innovating the way in which mobility and transportation logistics are dealt with.

1.4 Electronic Vehicles Regulation in Indonesia

In Indonesia, awareness towards electric vehicles is expressed by issuing president decree no. 55/2019 in August 2019. The document sets out several key points for accelerating the development of electric battery vehicles in Indonesia. It gives all related stakeholders notion of support, It shows concern to protect local industry when it enters the EV age with a steep local content requirement (increasing slowly until 2026), it can also be seen that the government is trying to create local EV and EV component industry by mentioning R&D help for main components of electric vehicles, including batteries, and it also assigns PLN to develop the necessary charging infrastructure. This regulation shows the government support towards electric vehicles development, but there is no further implication on specific type of vehicles are allowed to use, by that, there is no regulation for autonomous vehicles yet.

2. Methodology and Literature Studies

In this paper, the author using pretended data which contains distance between refinery and gas station in North Jakarta, shifting truck (also known as ritase), number of trips for every truck, truck capacity, oil discharge per minute, list and address of every gas stations in North Jakarta, daily consumptions of every gas stations. These secondary data will be inserted as input data in the ProModel Process to generated output (dependent variable) that will be measured to see the comparison between using manual and autonomous vehicle. The relationship between input, process, and output in this research will be explained by System Diagram.

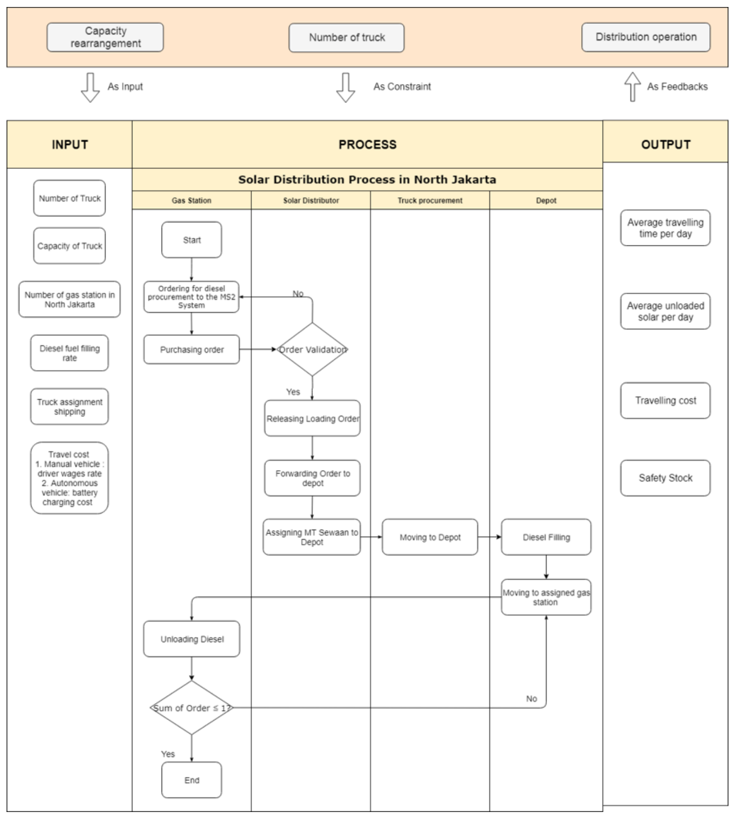

Figure 2. System Diagram for Solar Fuel Distribution in North Jakarta

3. Limitations and Assumptions

This paper only focuses on comparison analysis between before and after the implementation of Autonomous Vehicles in the oil distribution specifically. The author also limits the research area into focus on downstream activities, starting from the warehouse until arrived to the end customer.

The following is several assumptions used by the author in doing this research:

- The solar fuel assumed to be quantified as lot size (Each lot represents 8 kilo litre, up to 32 kilo litre)
- Ideal traffic applied for each process from Depot to each gas station.

4. Model Building

In this section, the author using ProModel software which able to simulate a model of real system of the case oil/petroleum distribution. Essentially, ProModel provides several basic elements, in example *locations, entities, arrival, processing,* and many more. The following section is an explanation of each element used by the author in building the model.

4.1 Locations

In this context, the author using location—where entity is being processed that describes the distribution flow, beginning from the get in/out in the warehouse, filling shed, and the gas stations in the North Jakarta.

4.2 Entities
The entities are an object which can enter and exit the system. The author using solar and truck as the entity. Although the solar fuel is liquid, it is assumed to move in 'one lot quantity'. Each lot size represents eight kilo litre of solar. The maximum lot size is four.

4.3 Arrivals
Based on the aforementioned scoping used, arrival is the distribution time (interarrival time) for each trip in the parking area of the warehouse.

4.4 Path Network
Each truck moving on path network from Depot to gas station in North Jakarta. Fastest and nearest route will be chosen automatically by ProModel. Path network designed by modeler using time travel as input which is estimated by multiplying distance to between gas station and average velocity of the truck.

4.5 Processes
Process will explain about how truck and solar moving from solar fuel filling point to each gas station. Process involves some logics as distribution logic for truck based on each capacity (16 up to 40 kilo litre), truck's waiting time in every solar filling points, solar being loaded to truck logic, routing process for truck from exit main gate to each gas stations, incremental of traveling time variable, unloading solar to each gas stations, exiting truck and solar.

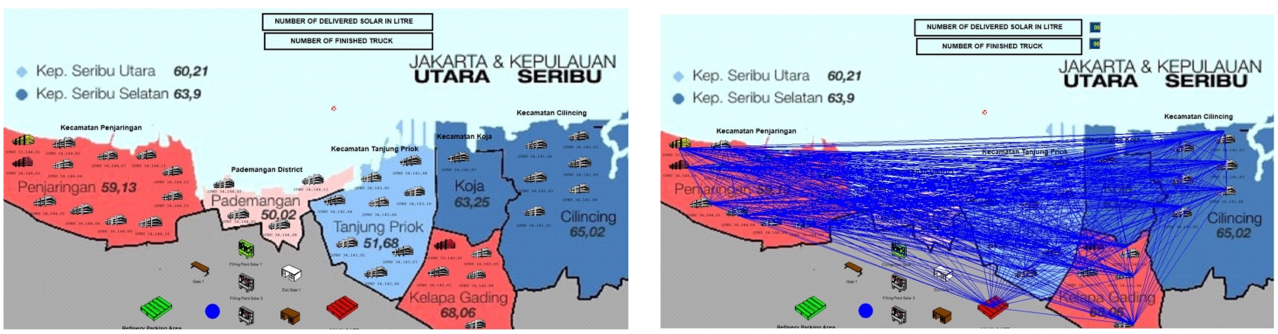

Figure 3. Model Interface

4. Finding and Discussions

4.1 Autonomous Vehicles vs Manual Vehicles
The model shows some differences from the existing conditions (old-fashioned truck) and the future (using Autonomous Vehicles). The statistic result from simulation point out that the truck needs 414 minutes to reach each gas stations in a day. From traveling time variable, total travelling distance for a day can be calculated by multiplying time variable and average speed of truck. Therefore, travelling cost can be calculated by multiplying distance and cost of fuel (for manual vehicle) and battery charging cost (for autonomous vehicle).

Furthermore, the author compares the total cost for one unit. Based on the existing market price, manual vehicle can be bought at $21,978.02 and it is assumed to have a lifetime of seven years. Therefore, the fixed cost for manual vehicle is $25,117.74. Otherwise, autonomous vehicle currently have about $151,000 in fixed expenses (financing and depreciation cost, lifetime up to fifteen years), $110.53 in variable expenses (one time charging cost up to 100%) and are driven about 12,000 annual miles, which averages about 50 cent per mile which about 20 cent per mile is operating miles (AAA 2017; Litman 2009).

Table 1. Financial Projection for Oil Distribution based on the simulation result.

Cost	Manual Vehicle	Autonomous Vehicle
Fixed Cost		
Financing	$21,978.02	$150,000

Depreciation	$3,139.72	$1,000
Subtotal	$25,117.74	$151,000
Variable Cost		
Fuel or Charge Cost	$37.00	$110.53
Driver Wages	$93,657.00	-
Subtotal	$93,694.00	$110.53
Total Cost	**$118,811.30**	**$151,110.53**

4.2 Battery Policy

Assuming that the company is buying a Tesla Semi Truck. The truck will have a maximum distance of 800 kilometers per 100% battery condition. This autonomous car consumes 1.15 kWh per kilometer. Nowadays, there is already existing supercharger that has 150 kW power. Below is the time for the battery to be fully charged 100%.

$$Charge\ Time = \frac{Battery\ Capacity}{Charge\ Power\ x\ 0.9}$$

$$= \frac{kWh\ per\ km\ x\ Total\ km}{Charger\ Power\ x\ 0.9}$$

$$= \frac{1.15\ x\ 800}{150\ x\ 0.9}$$

= 6hours 49minutes

It is not desired that the truck will have to stop because of the battery insufficiency. So, the calculation of the battery safety stock is necessary to be done. The calculation is using safety stock formula. Where, maximum daily usage is the percentage of the battery used and average lead time is the duration of the trip. Maximum daily usage number is coming from the comparison calculation between 800 kilometers (100% battery condition) and the maximum number of distances in one day that is 480 kilometers (assuming the car is driving at 20 km/h speed). Maximum lead time is written in days, where the maximum lead time is one full day and average lead time is from the simulation result that shows the duration of 414 minutes.

Safety Stock (Battery Percentage) = [Maximum daily usage *x* Maximum lead time] –
[Average daily usage *x* Average lead time]

Safety Stock (Battery Percentage) = [60 *x* 1] – [17 *x* 0.29]
= 55.07%

The safety stock shows the ideal time on when the truck should be recharged. From the calculation, the most optimal is to charge it when the battery shows the number of 55.07% that will happen on the third day after the last full charging time.

5. Conclusion and Suggestion

5.1 Conclusion

Autonomous Vehicles could be a breakthrough in the supply chain area which supports the logistics function. However, decision-making must be carefully considered. Simulation Modelling used to predict the future implementation of the alternative to gain insight and reducing time, cost, risk.

As mentioned before, the case is about a solar fuel distribution in a small area of Jakarta. So, the route will be short, and therefore, the capability of the truck is not maximized. That leads to the inefficiency of autonomous vehicle implementation for this case. Here are some reasons why this thing can happen:

1. **The truck is more suitable for a long trip**. Designed for 800 km per one fully charged, this autonomous car able to almost cross the whole Java Island (a Long trip for around 16 hours)
2. **The speed limit of the truck is low in a crowded city.** The drivers need to drive at a low limit speed because of its traffic
3. **The wage of drivers is low. One of the compositions for the variable cost is driver wage.** The low rate of wages can lead to the low expense the company's need to spend.

5.2 Suggestion

From this report, there are some aspects can be developed from this simulation case for the next study material, consists of:

1. The measurement of the environmental aspects (low carbon)
2. The number of trucks optimization
3. The long route modeling
4. Risk mitigation analysis

References

Jacobs, F.Robert, Chase, Richard B. *Operations and Supply Chain Management*, 15th Edition, The McGraw-Hill Education Series (2018)

Holweg, Matthias, John Bicheno. "Supply chain simulation: a tool for education, enhancement and endeavor." *Production Economics 78* (2002)

Lepekhin, Aleksander, et al. "Supply-chain management in the oil industry." *E3S Web of Conferences 110* (2019)

Meldert, Bram V., Boeck, Liesje De. "Introducing autonomous vehicles in logistics: a review from a broad perspective." *Ku Leuven Faculty of Economics and Business*

Biographies

Rizky Yonathan is a penultimate undergraduate student majoring in Industrial Engineering at University of Indonesia. His research interests include supply chain management, logistics, simulation and modelling, system thinking. Rizky is also a Laboratory Assistant of Systems Engineering, Modelling, and Simulation (SEMS) at Industrial Engineering Department. He has gained the third winner place in an internal competition Kanban Games.

Sabrina Putri Kinanti is an undergraduate student at Industrial Engineering, University of Indonesia, currently looking for opportunity to research about simulation, supply chain, and system thinking. She has achieved the third winner place in a business case competition which brought up disruption era to financial technology as their topic.

Zahra is a penultimate undergraduate student at University of Indonesia majoring in Industrial Engineering. She has been awarded the third winner position in a marketing competition. Zahra holds keen interest in management and sustainable development.