Product Dispatch Work Process Line Improvement Using Arena Simulation and Modeling: A Case Study

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Abstract

Simulation and modeling is the process that aids in mimicking the behavior of a real system for the purpose of conducting a study in order to understand operational processes and optimize the outcomes thereof by directly implementing the positive findings from the model in real life situations. The application of simulation and modeling using Arena simulation software has seen successful implementation based on its outcomes in many cases such as manufacturing process lines optimizations and in overall, improvement of supply chains in both manufacturing and service sectors. This study aimed at improvement of dispatch work process line by making use of Arena simulation modeling as tools for identifying areas of improvement of in a coal fly ash processing plant of a manufacturer situated in Sasolburg, South Africa. The manufacturer struggled with daily truck dispatches, Arena simulation modeling software has revealed that key process waste was on amount of time spent on each dispatch work process lines. With the current dispatch process layout, 22 number of trucks are dispatched within an 8 hour shift, time improvement estimations on dispatch work process stages improved the number of trucks dispatched to 30 which was 36% improvement, meanwhile simulation of proposed new dispatch work process layout coupled with work process stages time interval estimate reduction showed an improvement of number of trucks from 22 to 40 which was 45%. It was recommended to the manufacturer to focus on either improving the time requirement within the work process stages using the current layout or opt for completely altering the layout and increase the length of the one out of three available dispatch weighbridge which was 16 meters, thus to 24 meters in order to accommodate all types of trucks, particularly trucks with tankers and pub in order to improve daily number of truck dispatches which is directly linked to sales.

Keywords
Classifier, OEE, Simulation, Bottleneck and Dispatch.

1. Introduction
The South Africa construction industry is one of the sectors that plays a vital role in the country's economy and contributes positively to the economic growth. This is achieved through building and other civil engineering structures with considerable amounts of expenditures. The industry is facing challenges such as public sector capacity, procurement practices and capacity for sustainable empowerment, infrastructure availability and increase in cost of building materials which makes the government spent to be low thus affecting the performance of this industry (Windapo and Cattell 2013).

Productivity improvement through the application of lean manufacturing tools and simulation modeling has been applied in many service and manufacturing facilities and have seen a successful outcomes. Majority of companies chose to adopt lean manufacturing for four primary reasons, viz: reduction of manufacturing resource requirements, increment of level of customer satisfaction, reduction in cycle time of manufacturing and ultimately for the increase in profitability of the industry. Thus manufacturing industries that are traditionally operated tends to face a lot of challenges such as manufacturing cost, lead times of manufacturing that are longer, compromised product quality and negatively affected customer satisfaction (Manikandaprabu and Anbuudayasankar 2019).

1.1 Objectives
The main purpose of this research study was to monitor and improve dispatch work process at the coal fly ash processing plant. The key performance indicator of interest was total number of trucks that can be dispatched under ideal coal fly ash processing plant conditions and tested per certain duration of run, replication ran and total number of replication. The model was based on comparing the current system performance and conduct scenario analysis in order to assess possible options for improvement in order to increase the total number of trucks dispatches. This assisted in further improvement of the customer service as customer forecast.

2. Literature Review
Many enterprises find many ways of improving their businesses in order to attain and maintain their competitive advantages and economic success in different ways. An emphasis on business processes improvement is one of the key ways in which they strive for performance. The implementation of continuous improvement processes assist in identifying key process barriers and problems and workflow can be optimized which ultimately results with efficient business processes (Kirner et al. 2011; Nawale et al.2017).

The concept of lean manufacturing has been established by Taiichi Ohno at Japanese automotive company, Toyota, decase ago where Taiichi Ohno aimed for the improvememt of the operations at Toyota. The principles behind lean manufacturing is the reudtcion of non-value added activities within the enterprise. Bhati and Porwal (2015) further stressed that objective of lean manufacturing in this various industries is for increase in productivity, encouraging continuous improvement in operations, motivation of practices that are innovative for the overall improvement of the operations and also for reduction of waste (Bhati and Porwal 2015). The types of waste include overprocessing, overproduction, inventory, waiting, motion, transportation, rework (Nihlah and Immawan 2018; Alam et al. 2019; Bhati and Porwal 2015).

Nawale et al. (2017) further indicated that other additional goals of lean manufacturing is to improve on product quality by understanding what the customers need and want and design processes to meet and exceed those requirements, another factor is to reduce total costs through minimizing cost whereby the manufacturers need to produce only to customer demand. Overproduction increases a company's inventory costs because of storage needs.
In any production line, simulation can be applied as an important potential and subsidiary working tool (Talapatra et al. 2018). For example, to have a good production planning, various industries make use of simulation modeling in order to plan and control their production (Schuh et al. 2014). It is known that by making use of simulation modeling to forecast the reliability of production, assist the system of manufacturing to take appropriate measures that will enable them to have a reliable schedule of production.

Maria (1996) defined modelling as a process of producing a model and modell is the representation of the construction and working of a system of interest. The model assist the analyst by predicting the effects of the variations in the system of interest and is compilled closer to approximation of the real system and incorporate most of its silent features(Maria 1996). Figure 1 depicts the schematic of a typical simulation study.

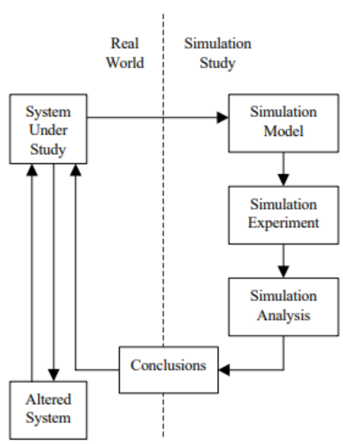

Figure 1. Schematic of a simulation study Source: Maria (1996)

Basically, a simulation study consist of three steps, namely: modelling, analysis and presentation. These three steps can be repeated until the analyst is satisfied with the outcome. Thus modelling is about creating an efficient simulation model, meanwhile analysis entials studies of inputs to and output from the simulation modelling, design of the experiements of interests and optimization thereof(Kin and Chan 2011). Presentation is then about how effectively is the data collected and presentation of the results gathered from simulation and how to communicate to the relevant stakeholders to improve, verify and validate the model and results (Kin an Chan 2011).

Discrete event simulation is a tool that is effective for the analysis of moderate product and process variations and can predict the status of operations and bottleneck at of an eixting manufacturing system, which is important to the critical planning of operations, execution and improvement (Velumani and Tang 2017). Discrete event modelling is used widely to model and optimise systems of manufacturung and assembly lines (Prajapat and Tiwari 2017). Prajapat andTiwari (2017) also stated that discrete event modelling is suited well for modelling manufacturing as it can explicitly model the manufacturing systems' variations by making use of probability distributions. Prajapat and Tiwari (2017) further indicated that discrete event simulation is capable of responding to important operational questions that relates to throughput, allocation of resources, utillization and supply and demand.

Rasib et al. (2021) Arena is a tool that is useful in applications of simulation to imitate the real time data results for measurements of productivity.

Many researchers have used Arena simulation modeling to optimize system performances such as in production lines and supply chain management. For example, Mapfaira et al. (2016) used Arena simulation modeling to and lean tools to improve productivity. Discrete event simulation was used to compare the current manufacturing system performance, and the proposed lean manufacturing system. The findings of their study indicated that the proposed system of manufacturing improved material flow, efficiency of assembly line balance, Utilization of workers, and reduced lead time of manufacturing. Macías-Jiménez et al. (2019) also investigated the ways for productivity improvement of a local security garage door manufacturing company where the company experiences challenges such as long time of throughput, inventory that is high and utillzation of workers that is lower and these challenges resulted with quality of the product that us poor and operating costs that are higher making the company's products uncompetitive. The current manufacturing system's production flow was analysed and simulation modelling was used to model the improved system opportunities. Lean tools was used to improve the system whereby output of production doubled in the new system, utillization of workers has improved significantly and line of production being more balanced.

Furthermore Abdul Rasib et al. (2021) have experienced a successful application of simulation modelling through Arena software where prodiction smoothness improvement in the food processing industry was the case study. The current system of manufacturing in the food industry was analyzed and issues identified with the use of simulation modeling were taken into account possible productivity improvement suggestion made.

Thus most companies apply lean various theories, techniques and tools aimed at operations improvement through maximzation of productivity which results with increased competitive advantage. Proper application of continous improvement concepts, techniques and tools are essential to the real change in the organisations for the betterment of productivity , reduction in cost and obtaining of higher profit margins that are sustainable over time (Torres 2021).

3. Methods

3.1. General approach

A coal fly ash processing manufacturing company was used in the study. The company had challenges with lower number of trucks dispatched daily within 8 hour shift. Visit at the plant was made in order to gather real time data and dispatch process line was selected as the area of focus on the entire processing plant. The data that was used to input in the Arena simulation software were the real data collected through observation using a timer at the dispatch system. The entire process flow was clearly understood and with time interval on each process step noted as real time by studying the follow of a truck from the time it arrives at the plant until it's full dispatched with product. Thus truck was an entity within the modeling exercise. Thus simulation model that represented the entire system was developed and experiments tested on. The model was validated by comparing the total number of trucks out of the simulation software and the total number of trucks dispatched, thus real data obtained from dispatch system, HODIM. Key scenarios were experimented by making alternating the model as follows:

First scenario: Improvement of the time on each process step within the dispatch process
Second scenario: making alterations on the current layout of the plant for the purpose of optimization. Figure 2 summarizes the framework or the methodology that was used in the study.

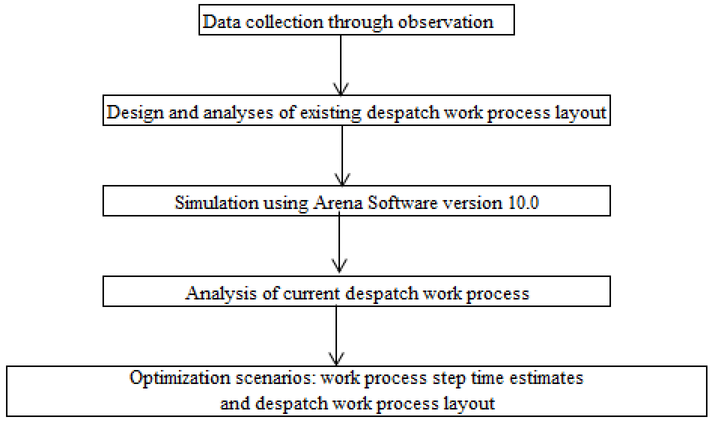

Figure 2. Procedure followed in the study.

4. Data Collection

4.1. Development of the simulation model and analysis

4.1.1. Modeling and simulation statement

Figure 3 shows the overview of the current dispatch system process layout at the coal fly ash processing plant.

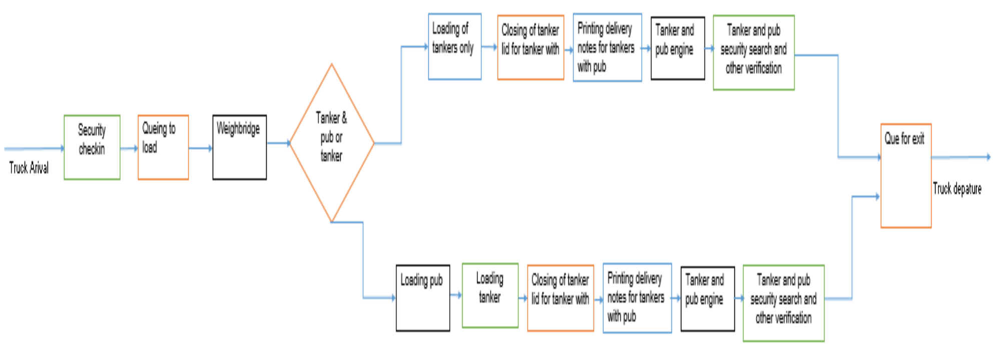

Figure 3. Current dispatch work process flow diagram

At the manufacturer's coal fly ash processing and dispatching plant, on a good product demand day, two types of trucks arrive at plant at an inter-arrival time of 5 minutes with the probability of either truck with tanker or truck with tanker and pub is 50/50%. Figure 4 show the truck with tanker and Figure 5 shows the truck with tanker and pub.

Figure 4. Truck with tanker

Figure 5. Truck with tanker and pub

As soon as the truck arrives at the plant, it checks in at the security office for confirmation of the order number if it appears on HODIM dispatch computer software appearing operated by the security officers, truck gets inspection, driver PPE also gets inspection and driver's journey management plan also gets inspected before the trucks can enter the plant. The process takes between 10 and 15 minutes to complete. The trucks then follow a to a weighbridge, then queuing time takes with a minimum of 23 minutes but not a maximum of 27 minutes. After waiting on que, the truck proceed to a weighbridge where the truck details are captured on HODIM system (truck number plate, order number and drivers name), the processing time takes a minimum of 8 minutes, on average 11 minutes and maximum of 13 minutes. Depending on the type of truck, it decides to be loaded at a specific loading bay. The truck loads 34 tons of coal fly ash products. The loading process for tanker takes between 27 and 31 minutes. Meanwhile on the other side, truck with tanker and pub begins by loading of pub with takes between 10 and 13 minutes. The loading of tanker takes between 25 and 30 minutes.

The loading of tanker then proceeds with the truck driver closing the tanker lid after being fully loaded, which takes between 3 and 5 minutes, printing delivery notes with the aid of dispatch officer which takes about 5 to 8 minutes. The truck then starts up with the start-up process taking 10 minutes, where the truck proceeds to exit the plant. At the exit point, security officer then inspect the truck if it's loaded correctly and further load verifies the product load as per Delivery note and order number. This process takes between 15 to 20 minutes, then the truck queues on their way out of the plant with queuing taking duration between 17 to 21 minutes. The truck with tanker and pub also follows similar path. The challenge that the coal fly ash processing plant faced was longer turnaround time and lower number of trucks dispatches due to long work process queues, congestion of trucks and these affected the daily number of trucks dispatched at the plant.

4.2.1.1 Input data

Observed data and time intervals as described in the current process flow at was then used to model the current system to monitor the number of trucks out of the plant, secondly the optimized time on each process step within the dispatch process was also used as input data to the first improved operating scenario using the current system and finally, the whole dispatch work process layout is altered and with optimized work process stage time arrivals were the key improvement factors as input data in the second improved modeling scenario.

4.2.1.2. Verification and validation

Based on observations and HODIM dispatch computer software, the total number of trucks dispatched at the current dispatch work flow as described in section 4.1.1, are affected by three possible scenarios for coal fly ash processing plant operations product stock availability with these cases described as follows:

First scenario: The total number of trucks dispatched is typically 27 on average at an average loading time of 18 minutes as soon as the truck begins to load at the loading bay or point in an 8 hour shift when the plant production team build product silo stock level of about 2000T. The stock level is potentially built by taking an opportunity when the plant is low on sales demand, particularly during early morning on each shift and on Sundays. Calculations were also made as follows:

Total available time for 34 tons product quantity dispatch in a truck = 8 hours = 480 minutes

$\therefore$ Number of truck dispatches = $\frac{Total\ available\ despatch\ time}{Average\ loading\ time\ per\ truck}$

$= \frac{480\ minutes}{18\ minutes}$

= 26.667 ~ 27 trucks

Thus, the total quantity of coal fly ash dispatched is calculated as follows:

Total quantity of coal fly ash (Tons) = Number of truck dispatches × maximum product quantity allowed per truck

= 27 trucks × 34 tons per truck

= 918 tons in 8 hour shift

Second scenario: When the product silo stock is empty, the trucks are being loaded as production takes place, thus with the production output of 32 tons per hour on classifier under the current challenges of its underperformance, this means that average loading time per truck is 1 hour.

The total available time for 34 tons product quantity dispatch in a truck = 8 hours

$\therefore$ Number of truck dispatches = (Production output per hour × Total time available for 34 tons product dispatches in a truck)/ 34 tons per truck

= (32 tons per hour × 8 hours)/ 34 tons per truck

= 7.529 ~ 8 trucks

Thus, the total quantity of coal fly ash dispatched is calculated as follows:

Total quantity of coal fly ash (Tons) = Number of truck dispatches × maximum product quantity allowed per truck

= 8 × 34 tons

= 272 tons in 8 hour shift

Third scenario: When the product silo stock is empty, the trucks are being loaded as production takes place, thus with the maximum classifier design production output target of 45 tons per hour , this means that average loading time per truck is 1 hour.

The total available time for 34 tons product quantity dispatch in a truck = 8 hours

$\therefore$ Number of truck dispatches = (Production output per hour × Total time available for 34 tons product dispatches in a truck)/ 34 tons per truck

= (45 tons per hour × 8 hours)/ 34 tons per truck

= 10.588 ~ 11 trucks

Thus, the total quantity of coal fly ash dispatched is calculated as follows:

Total quantity of coal fly ash (Tons) = Number of truck dispatches × maximum product quantity allowed per truck

= 11 × 34 tons

= 374 tons in 8 hour shift

NB: In all the three scenarios described no time loss on non-productive time due to dispatch office not available, for example during lunch time. In case of dispatch officer relief requirement during the shift, Shift supervisor carries over to dispatch the trucks thus avoiding the possible time loss or downtime at the dispatch office.

4.1.3. Run parameters

The model was run for a replication length of 480 minutes and one number of replication lengths. The replication length was chosen in order to mimic the 8 hour dispatch shift.

5. Results and Discussion

5.1. Results and findings

5.1.1. Simulation modeling of the current dispatch work process

Observed data and time intervals as described in the current dispatch work process flow was used to model the current system in order to monitor the number of trucks out of the plant and other system performance indicators. The following system components were extracted from the dispatch process system described in the modelling and simulation statement in section 4.1.1 and simulation model was developed by using these system components and built up in Arena simulation software:

- Entity: Tanker truck and a truck with Tanker with pub
- Resources: Security officer, dispatch officer and truck driver
- Process: Assigning of trucks as either truck with tanker and truck with tanker and pub using the decision model at 50/50% probability.
- Attribute: Trucks arriving at exponential distribution of 5 minutes

Figure 6 depicts the current dispatch work process built up in Arena software.

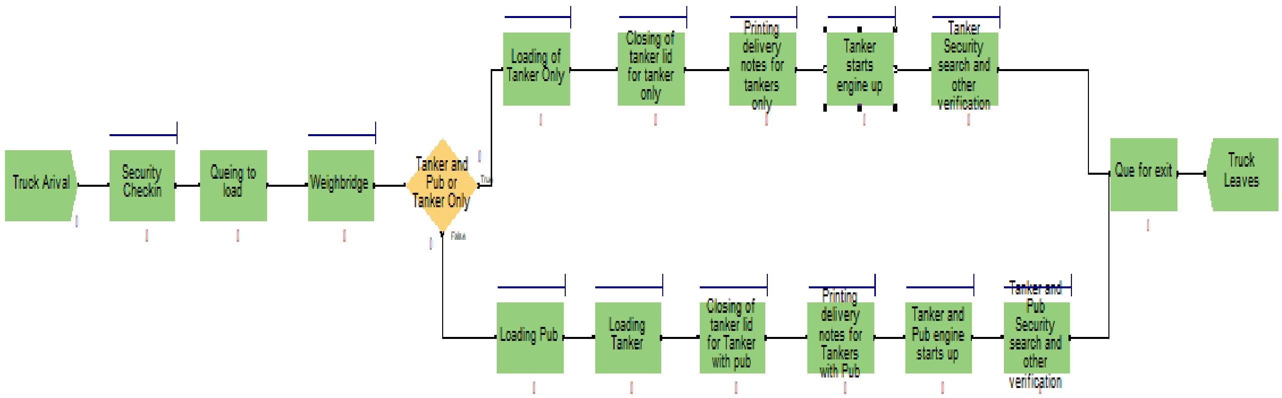

Figure 6. Simulation modeling of current dispatch work process mapping

5.1.1.1. Simulation results and analysis

Simulation results and analysis are presented in Table 1.

Table 1. Simulation runs for current dispatch process.

System key performance indicate from Arena Software	Unit of measure	Value
Total number of trucks exiting the system		22
Total number of trucks entered the system		88
Average waiting time on queue for loading of tankers only	Minutes	53.340
Average waiting time on queue for loading of pubs only	Minutes	0.497
Average waiting time on queue for loading of tankers (That had pub)	Minutes	14.406
Average waiting time on que at weighbridge	Minutes	0.355
Average waiting time at the security check-in	Minutes	147.28
Average number of Tankers only on queue for loading		2.141
Average number of Pubs on queue for loading		0.015
Average number on queue for loading of tankers (That had pub)		0.407
Average number of trucks waiting for security check-in		25.479
Average number of trucks waiting on que at weighbridge		0.026
Instantaneous utilization of resource, entry security officer		1.000
Instantaneous utilization of resource, dispatch officer at weighbridge		0.777
Instantaneous utilization of resource, dispatch officer for delivery note printing		0.196
Instantaneous utilization of resource, dispatch officer loading Tanker		0.875
Instantaneous utilization of resource, dispatch officer tanker loading for tanker with Pub		0.702
Instantaneous utilization Security Officer Exit for Tanker		0.461
Instantaneous utilization of resources, Security Officer Exit for Tanker and Pub		0.394
System efficiency	%	25.00

The system efficiency expressed as a percentage was calculated as followed:

$$\text{System efficiency (\%)} = \frac{\text{Total number of trucks exiting the system}}{\text{Total number of trucks entered the system}} \times 100$$

System efficiency = $\frac{22}{88} \times 100$
System efficiency = 25.00%

5.1.1.2. Optimized time on each process step within the dispatch process system

5.1.1.2.1. Modeling and simulation statement

Based on the qualitative data through interviews, it was evident on average that, time is lost at the entry point where the drivers spent a long time sorting out order number issues, also not having correct paperwork such as Journey management plan and truck not road worthy, thus making them take longer to enter the plant. On the que to weighbridge, sometimes the trucks battle with engine start up after waiting for long and this consume time thus adding to the longer waiting time, the capturing of the truck details on the HODIM software takes longer than it usually should not due to network challenges at the plant, similarly to the printing of delivery not software due to the network and software needing to be upgraded. The truck start up for it to leave the plant also consume time and upon truck exit, the exit officers most of the time realize that the truck after loading does not seal the product on the discharge side of the truck's pump, also the truck leave the factory with coal fly ash spillages on top of the tanker and this causes delays as they have to return back to clean the truck with compressed water running through a hosepipe as the truck cannot leave the factory being dirty, at the coal fly ash is a finer and "dusty" material and can cause environmental pollution as truck is driven.

Having stated these time consuming activities, there is a room for reduction in the time which can be on estimation. Below is the time estimation which was optimized at each process step:

- Security check-in: process time optimization estimate was now between 9 and 13 minutes
- Queuing to load: process time optimization estimate was now between 24 and 24 minutes
- Truck details capturing on HODIM software: process time optimization estimate was triangularly distributed at 8, 11 and 13 minutes.
- Loading of Truck with tanker (for the truck with pub): process time optimization estimate was now between 18 and 20 minutes.
- Printing of delivery note: process time was optimized to an estimate between 3 to 6 minutes.
- Exit point security exit: process time optimization estimate was now between 12 minutes and 18 minutes
- Truck plant exit process: process time optimization estimate was now between 12 and 18 minutes

Other process steps time not being optimized and resource allocations remained the same as in the current system process described in section 4.1.1. Thus this information was used as input data to perform modelling and simulation on the optimized time estimate between process stages. Also, the system components were extracted from the dispatch process system described in the modelling and simulation statement, section 4.1.1 and simulation model was developed by using these system components and built up in Arena simulation software as this work flow process remained the same in this optimization scenario. Figure 7 depicts the simulation model build up in the Arena simulation software.

5.1.1.3. Simulation results and analysis

Simulation run for current dispatch process at improved time at process stages in Table 2.

Table 2. Simulation run for current dispatch process at improved time at process stages

System key performance indicate from Arena Software	Unit of measure	Value
Total number of trucks exiting the system		30.000
Total number of trucks entered the system		101.000
Average waiting time on queue for loading of tankers only	Minutes	14.002
Average waiting time on queue for loading of pubs only	Minutes	0.953
Average waiting time on queue for loading of tankers (That had pub)	Minutes	38.130
Average waiting time on que at weighbridge	Minutes	0.971
Average waiting time at the security check-in	Minutes	116.65
Average number of Tankers only on queue for loading		0.468
Average number of Pubs on queue for loading		0.046

Average number on queue for loading of tankers (That had pub)		1.789
Average number of trucks waiting for security check-in		26.083
Average number of trucks waiting on que at weighbridge		0.085
Instantaneous utilization of resource, entry security officer		1.000
Instantaneous utilization of resource, dispatch officer at weighbridge		0.871
Instantaneous utilization of resource, dispatch officer for delivery note printing		0.107
Instantaneous utilization of resource, dispatch officer loading Tanker		0.626
Instantaneous utilization of resource, dispatch officer tanker loading for tanker with Pub		0.863
Instantaneous utilization Security Officer Exit for Tanker		0.382
Instantaneous utilization of resources, Security Officer Exit for Tanker and Pub		0.643
System efficiency	%	30.000

The system efficiency expressed as a percentage was calculated as followed:

System efficiency (%) = $\frac{\text{Total number of trucks exiting the system}}{\text{Total number of trucks entered the system}} \times 100$

System efficiency = $\frac{30}{101} \times 100$

System efficiency = 29.703% ~ 30%

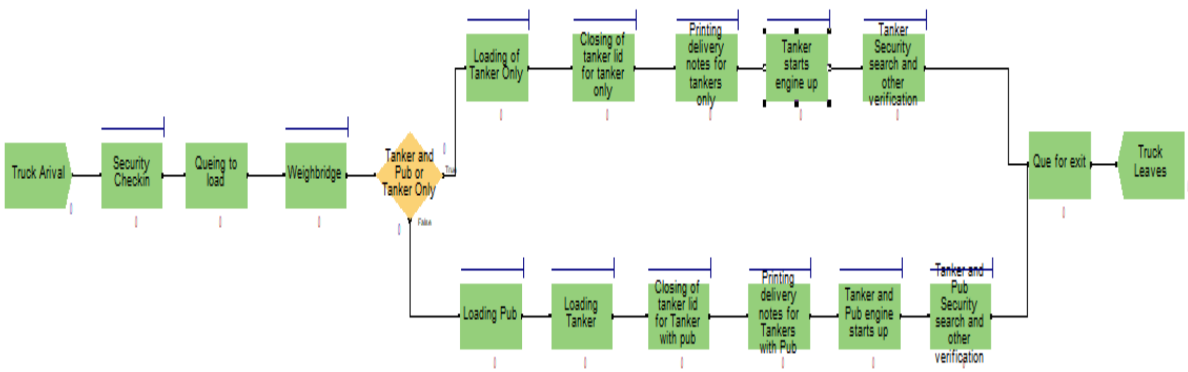

Figure 7. Work process mapping using Arena software for first dispatch work process optimization scenario (optimized process step time intervals).

5.1.1.3. Optimized dispatch work process layout and time at each process stage

5.1.1.3.1. Modeling and simulation statement

This optimization scenario entailed elimination of some of the process steps from the current dispatch work process flow or layout as described in section 4.1.1 and further, improved time estimations for optimization purposes were also considered as time waste activities were defined in section 5.1.12.1. The manufacturer also had only one loading bay for trucks that has tanker and pub only, this type of a loading bay is 24 meters long than the conventional loading bay for loading trucks with tankers only and is 16 meters long. The trucks with tankers only can load on the 24 meters loading bay but, the trucks with tankers and pub cannot load on the 16 meters loading bay as they are long thus cannot accommodated. Figure 8 shows loading bay and Figure 9 shows a truck on a bay preparing to load product.

Figure 8. Loading bay

Figure 9. Truck on bay to load product

Figure 10 shows the proposed layout of the dispatch work process

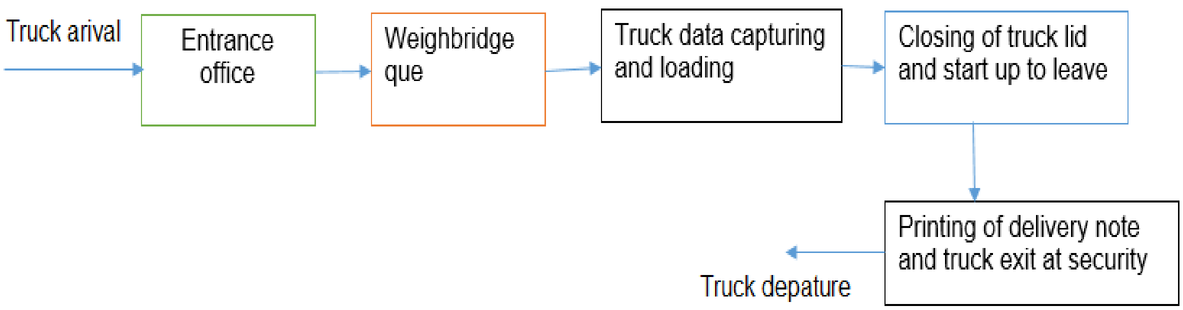

Figure 10. Proposed new layout of the dispatch work process flow

Based on Figure 9, it was proposed to the manufacturer to invest in increasing the length of the 16 meters weighbridge to 24 meters so it also caters for all truck types. This can assist in reducing some of the standing time that the trucks with tankers and pub are facing. Furthermore, Figure 9 denotes that the printing of delivery note is the proposed to be done at the security officer where the truck leaves the plant. This meant that the security officers needs to be given training in order to be able to print and fully use the functionalities of HODIM dispatch system in order to avoid delays or congestion the plant.

5.1.1.3.2. Input data

Below were the proposed dispatch work process steps in the new layout and optimized time estimation on each process step:

- Truck arrival time remained the same at 5 minutes
- Truck entry: truck entry was 5 minutes and security officer assist with the truck check in
- Weighbridge queuing time: process time optimization estimate was 13 minutes
- Truck details capturing on HODIM software and product loading: process time optimization estimate was between 10 and 12 minutes and made use of a dispatch officer
- Truck driver closes lid of the truck and start up to exit process: process time optimization estimate was now between 8 minutes.
- Truck prints the delivery note with the help of security officer and exit the plant: process time optimization estimate was now between 3 and 5 minutes.

Figure 11 shows the new proposed layout and as it was built in the Arena simulation software at optimized time intervals at each stage.

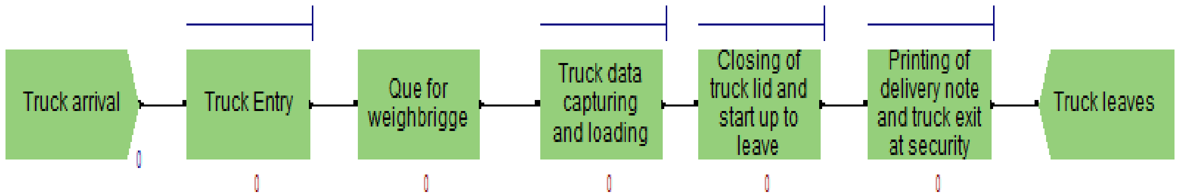

Figure 11. Work process mapping using Arena software for dispatch work process optimization scenario on improved layout and process stages time intervals

5.1.1.3.3. Simulation results and analysis
Simulation run at proposed layout and optimized time estimates on each process stage in Table 3.

Table 3. Simulation run at proposed layout and optimized time estimates on each process stage

System key performance indicate from Arena Software	Unit of measure	Value
Total number of trucks exiting the system		40.000
Total number of trucks entered the system		89.000
Average waiting time on queue truck data capturing and loading	Minutes	124.57
Average waiting time on queue for loading of tankers (That had pub)	Minutes	38.130
Average waiting time on que at weighbridge	Minutes	0.971
Average loading time at the security check-in	Minutes	116.65
Average number of Tankers only on queue for loading		0.468
Average number of trucks waiting on que for entry		9.264
Average number of trucks on que for data capturing and loading		19.861
Average number of trucks on que for entry		1.774
Instantaneous utilization of resource, entry security officer		1.000
Instantaneous utilization of resource, dispatch officer		0.963
Instantaneous utilization of resource, Security Officer for entry		0.862
Instantaneous utilization of resources, Security Officer for exit		0.349
System efficiency	%	45.000

The system efficiency expressed as a percentage was calculated as followed:

$$\text{System efficiency (\%)} = \frac{\text{Total number of trucks exiting the system}}{\text{Total number of trucks entered the system}} \times 100$$

$$\text{System efficiency} = \frac{40}{89} \times 100$$

$$\text{System efficiency} = 44.944\% \sim 45\%$$

5.2. Discussion

The outcome of the simulation and modeling of the current dispatch work process flow as described in section 4.1.1 clearly indicated that the system was inefficient based on the number trucks (include tankers and tankers with pub) of 88 that accessed the plant versus 22 number of trucks that got dispatched in a replication length of 480 minutes (8 hours operational shift). The achieved system efficiency was 25%.

This inefficiency was attributed to longer waiting time on que of 53.340 minutes for loading of tankers only and 14.557 minutes for average waiting time loading of truck with tanker and pub, calculated as the sum of average loading time on que for pub which was 0.497 minutes and average loading time of tanker which was 14.06 minutes. Within this system also, the major time loss was at the security entrance where 147.28 minutes were spent by trucks waiting at the entrance. This holds a fact as many times, the truck stands at the security entrance having challenges with order number not appearing on the system, also drivers not having the correct PPE and truck sometimes was not road worthy and the average number waiting to enter the plant is 25.479 approximately 25 trucks. These cascaded to the dispatch of 22 trucks than the full potential of product demand, which was a lost opportunity due to time. Simulation and modeling on the optimized dispatch work process time intervals across each stage yielded a system efficiency of 30%, which was an increase in 5%. The total number of trucks waiting at the security entrance was reduced to 116.65 minutes. The optimized system also further indicated a reduction in the average waiting time of que from 53.430 minutes to 14.002 minutes for loading of trucks with tankers only, meanwhile the trucks that had tankers and pub, took longer in the improved time intervals , where the waiting time increased from a total of 14.903 minutes to 39.083. The total number of trucks dispatch in the time interval improved system increased from 22 trucks as from the initial system to 30, thus an increase with 8 trucks which was an additional sale in an 8 hours ran. The instantaneous utilization of the resources indicated how busy the resources were within the simulation period, the results showed that the security officer and dispatch officer remained fairly busy across the two scenarios being modeled. However, with high number of trucks waiting on que to access the plant, it was noted that the dispatch officer was busy than they should have been busier. The 22 total number of trucks dispatched in both the current dispatch work process and 30 total number of trucks dispatched in the improved time interval on each stage process, showed a direct similarity with the 8 and 27 total number of trucks that can be dispatched as calculated in section 4.1.1 for the overall verification and validation of modeling results for when the plant is underperforming and when it is improved with stock availability as is the similar expression in this simulation scenarios. These indicated a clear reliability of the simulation and modeling data obtained.

In the case of improved dispatch work process layout and time intervals on process stages, the number of trucks dispatched increased from 30 to 40, also the system efficiency increased from 30% to 45%. It was also important to note that the improved dispatch work process layout and time intervals on process stages admitted a total of 89 trucks where 40 of the trucks were dispatched in an the 480 minutes replication length ran. These indicated good system efficiency increased and the resources remained fairly utilized. This optimized system holds to be true to be implemented by the manufacturer based on the fact that there is time loss due to availability of only one loading bay that can accommodate trucks with tankers and pub, thus resulting with reduction with total of trucks. This improved layout catered for all truck types.

5.3 Proposed Improvements

The following recommendations were made to the manufacturer in order to improve the total number of trucks dispatched per day:

- Improve the time intervals within the dispatch work process stages
- Ensure that the order numbers given to transporters are pre-checked that they are valid in order to avoid delays on product dispatches
- Invest in work process layout coupled with increasing the length of the available weighbridge in order to accommodate all types of trucks, particularly trucks with tankers and pubs.

6. Conclusion

Based on the outcome of the simulation and modeling, it was evident that there was a time wastage on various process stages within the dispatch work process lines which needed to be optimized. The improvement in the time on each process line directly improved the total number of trucks that can be dispatched per day in an 8 hour shift, with number of trucks improving from 22 to 30, that was, 36% improvement, meanwhile in the case proposed new dispatch work process layout added with improved time within work process stages, improved the number of trucks dispatched in an 8 hour shift, thus from 22 to 40 which was 45% improvement. These signified that the implementation of the process stages time intervals improvement and improvement of dispatch work process layout combined process stages time intervals improved the daily sales of the manufacturer as the number of trucks per day is directly proposal to sales. Simulation and modeling is the based tool for continuous improvement of work process within the management of operations.

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