Optimising bulk coal delivery in South Africa

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South Africa produces an average of 224 million tonnes of marketable coal annually, which makes it the fifth-largest coal-producing country in the world. As most of the coal used in South Africa is transported by road, a need arose to optimise coal delivery to coal stockyards.

The Department of Industrial and Systems Engineering at the University of Pretoria, in collaboration with Business Enterprises at University of Pretoria (BE at UP) and WorleyParsons South Africa, completed a series of comprehensive studies of bulk resource transport optimisation at the end of 2013. This included a coal stockyard study, a coal delivery traffic impact study and a construction traffic impact study.

Coal stockyard study

The aim of the coal stockyard study was to determine the delivery requirements of a coal stockyard based on demand requirements and variability. The study also aimed to determine the number of stockyard resources required to process the deliveries.

Key stockyard operations were simulated in a model. that considered delivery variability, planned downtimes (scheduled maintenance) and unplanned downtimes (machine failures).

The simulation model was used to verify that the stockyard's design could sustain the required capacity without any potential system failures. The simulation also highlighted all potential bottlenecks. Solutions to alleviate these bottlenecks were identified.

Conservative assumptions for the development of different scenarios were made, each with different demand requirements. For each scenario, key performance indicators, such as queue length, turnaround time and average resource utilisation, were calculated.

The number of resources required for the different scenarios were then determined.

Coal trucks or conveyor belts can deliver coal to the stockpile. The results in Figure 2 show summarised vehicle statistics and resource requirements for this scenario.

This study aimed to verify that the stockyard's design can comfortably hold the required amount of coal. A number of different scenarios were simulated, which determined that the stockyard's demand increased over time. This meant that more trucks had to deliver coal more frequently, which could result in a slower turnaround time for trucks. It could also cause bottlenecks.

Coal delivery traffic impact study

The second project, a coal delivery traffic impact study, also commenced in August 2013. The aim of this project was to determine the feasibility of trucks for transporting coal from a colliery to a stockyard. The study considered existing and proposed new roads on and around the stockyard. Along with meeting the demand, safe and efficient coal delivery is important.

The aim of the study was to determine whether the existing road infrastructure surrounding the stockyard could support the required number of truckloads to be processed by the stockyard. It also identified risks that could constrain coal delivery via the road network.

Coal trucks entered the simulation model at key intersections surrounding the stockyard and exited the simulation model at various points of the stockyard. Only intersections that were affected by coal trucks were modelled in the simulation.

The main objective was to determine if, and under which conditions, the road network can

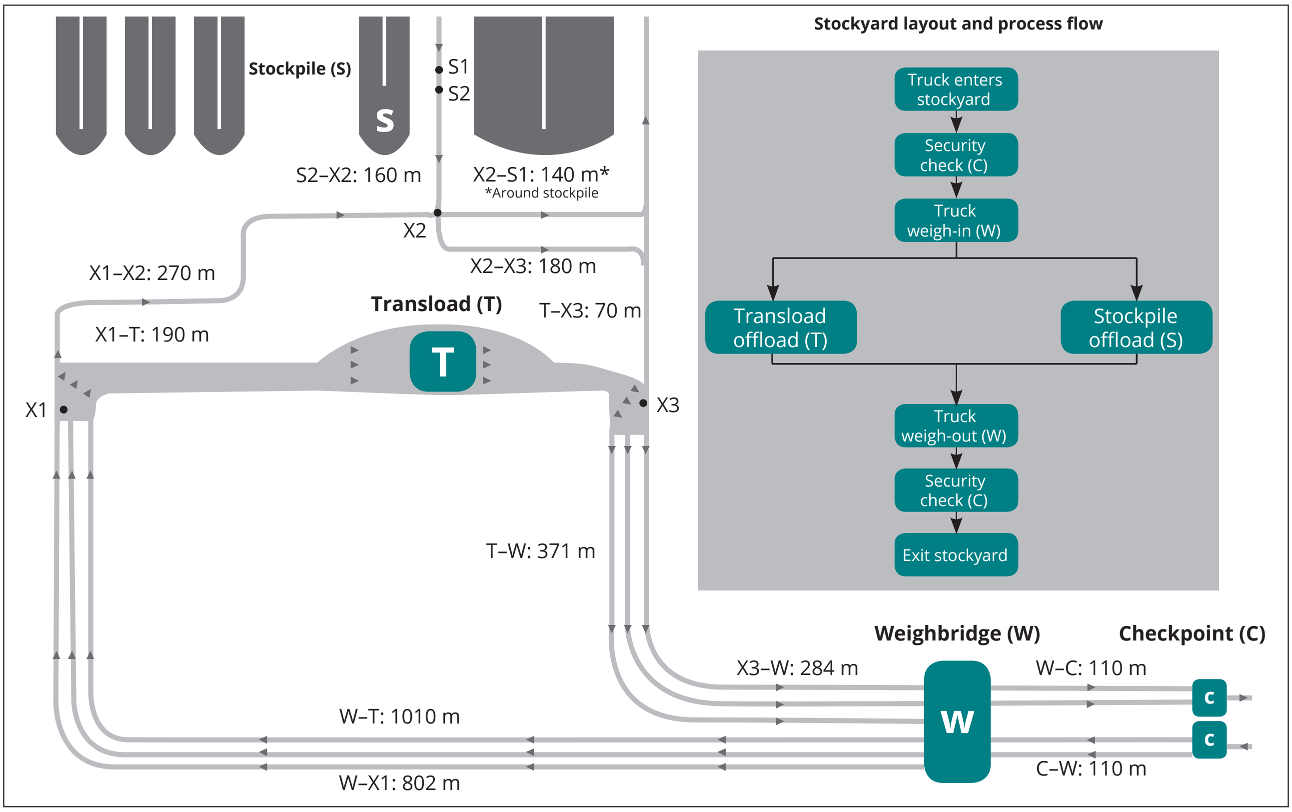


Figure 1: The coal stockyard layout and process flow.

supply the stockyard's maximum demand. Traffic density, truck arrival and departure profiles were considered to confirm the suitability of the road layout.

Different scenarios were tested. Construction vehicles and coal trucks were modelled to follow specific roads and to enter the coal stockyard at dedicated entry points.

The coal delivery traffic impact study succeeded in mapping the traffic patterns of trucks entering and leaving the stockyard.

These results could then be used in a further study that aimed to alleviate traffic congestion in and around the stockyard.

Construction traffic impact study

After examining the rate at which the coal stockyard needed replenishment and the peak traffic patterns around it, the team embarked on a third study, which aimed to identify and evaluate peak traffic alleviation options.

This study was conducted during October and November 2013. The high volume of construction vehicles entering and exiting the stockyard caused congestion.

The team developed a simulation model of the main intersections surrounding the stockyard. Current general traffic volumes, construction traffic volumes and projected construction volumes were used to determine the time it took for construction vehicles to enter and exit the stockyard.

Different alleviation options were identified, such as placing pointsmen at congested intersections, upgrading the road infrastructure to allow for increased traffic volumes, and changing construction shift times. The different options were simulated and each option was evaluated according to the time it takes for construction vehicles to enter and exit the stockyard.

Figure 2 shows traffic flow at the main entrance of the construction site during afternoon peak traffic.

The control scenario captured the current state of traffic flow, and the scenarios on page 66 illustrate how implementing different alleviation options would affect traffic flow. Based on the results of the different scenarios, recommendations were made as to which alleviation options, if any, would alleviate congestion at the main entrance of the construction site.

The simulation model showed that the deployment of pointsmen is the most effective traffic alleviation option, eliminating the exit queue and allowing vehicles to exit the site. This reduces the time it takes to clear the intersection to one minute.

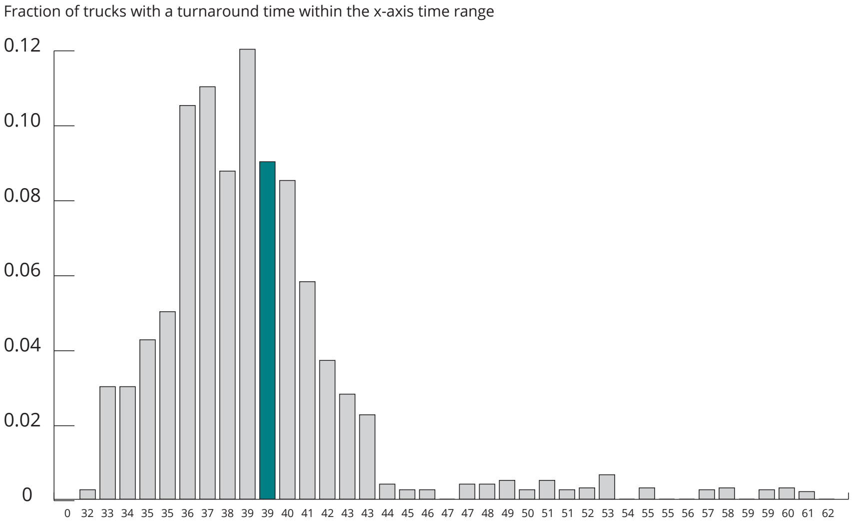
Conclusion

The three different studies investigated a coal stockyard's logistical needs in terms of coal delivery. Aspects such as stockyard delivery requirements, the viability of trucks as a mode of coal transport and the congestion these trucks cause were investigated.

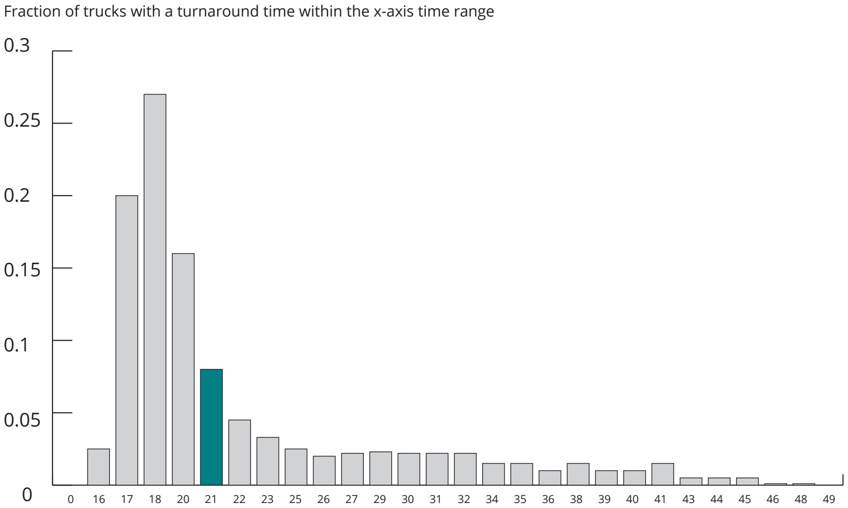
VEHICLE STATISTICS

	Transload offloads	Stockyard offloads
Turnaround time (TAT) (minutes)* *Calculated through simulation model	Min: 15 Average: 30 Max: 69	Min: 33 Average: 49 Max: 87

Stockyard entry vehicle queue length	Number of trucks on stockyard
Average: 1 truck (22 m)	Average: 2
Max: 24 trucks (528 m)	Max: 5



Scenario 3a (direct stockpile and transload offloading) – June 2016: Stockyard vehicle TAT (minutes) distribution



Scenario 3a (direct stockpile and transload offloading) – June 2016: Transload vehicle TAT (minutes) distribution

RESOURCE REQUIREMENTS

Weighbridges (W)	In	Out
Number of units required:	2	2
Average utilisation:	68%	
% of time at full usage:	78%	

Checkpoints (C)	In	Out
Number of units required:	2	2
Average utilisation:	47%	19%
% of time at full usage:	47%	10%

Coal trucks or conveyor belts can deliver coal to the stockpile.

→ *Figure 2: The simulation results for a scenario with different replenishment requirements than the control scenario.*

The simulation of various scenarios in a coal stockyard could aid the optimisation of bulk resource transport.

From these three studies, it is clear that the simulation of various scenarios in a coal stockyard could aid the optimisation of bulk resource transport.

→ *Figure 3: The control scenario at the main entrance during afternoon traffic. Vehicles are shown in yellow and blue. A queue, peaking at 17:15, formed as vehicles exited the construction site. It took the vehicles 10 minutes to exit the site.*

→ *Figure 4: Staggered working shifts for workers were implemented in the simulation model to balance vehicle departures at the construction site. A queue still forms at the construction site exit at 17:15. It took the vehicles six minutes to exit the site.*

→ *Figure 5: In this scenario, road upgrades were implemented to alleviate congestion. The exit queue still peaked at 17:15, and it took the vehicles six minutes to exit the site.*

→ *Figure 6: In this scenario, pointsmen were deployed to alleviate congestion.*

Figure 3

Figure 4

Figure 5

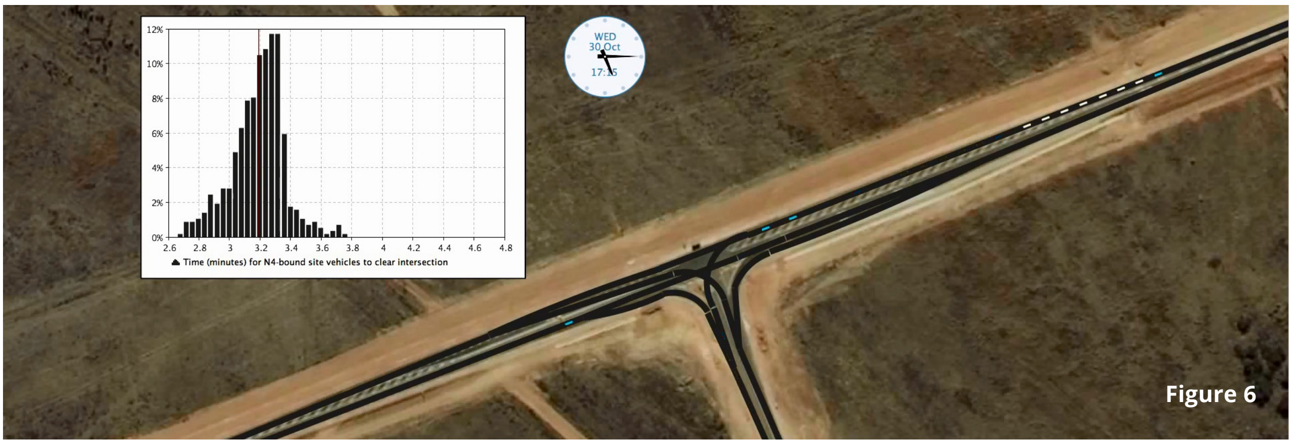


Figure 6