Study of Options to increase the throughput of the Hunter Valley Coal Chain

Palitha Welgama[a] **and Rob Oyston**[b]

[a]Rio Tinto Technical Services, GPO Box, A42, Perth, WA 6837.
Palitha.Welgama@riotinto.com
[b]Coal & Allied, P.O. Box 315, Singleton, NSW 2330.

Abstract : The Hunter Valley is one of the largest coal exporting regions in the world. Over 25 coalmines in the region export coal through the Port of Newcastle and a single rail service provider transports coal from the region to the port. In order to meet the projected increase in production and demand, the coal exporters, the rail service provider and the port service provider were looking at various ways to increase the throughput from the Hunter Valley coal chain. This paper reports some details of a successful simulation study of highly complex logistics issues to analyse various options to increase the throughput of the coal chain and to quantify their benefits. The study assisted in getting the coal exporters to agree on the relative merits of these options, enabling the process of their implementation.

Keywords: *Simulation; Modelling; Logistics; Transportation.*

1. Introduction

Hunter Valley (HV) is one of the major coal exporting areas in the world. Over 25 coalmines export coal through the Port of Newcastle. Coal export through the Port of Newcastle reached 70 million tonnes in year 2000, representing over 8000 separate train journeys and over 800 ships.

Port Waratah Coal Services (PWCS) operates two coal-handling terminals, Carrington (CCT) and Kooragang (KCT), to receive, assemble and load coal to ships. The bulk of the coal from HV is sent to the port by rail, and currently, Pacific National (PN) transports all of this coal from mines to the Port. Rail Infrastructure Corporation (RIC) owns and maintains railway lines in HV. Figure 1 represents the coal transport infrastructure. The loops represent rail spur lines at coal loading points while multiple lines represent dual carriageways.

As coal export from the region has been increasing over the last few years, the producers, PWCS, PN and RIC were looking at several options to increase the throughput capacity of the HV coal chain. Some of these options represent capital expansions while others represent changes to operating policies.

This paper reports some details of a successful simulation study conducted to analyse these options to assess their relative merits. The study was undertaken for Coal & Allied (CNA), which is one of the major exporters in the region, representing around 40% of total coal exports from HV. CNA, with PN under an alliance agreement, took a leading role to increase throughput of the HV coal chain.

2. Options to increase the throughput

The options that were under consideration represent both capital expansions and operating system changes.

Capital expansions:

1. Installation of a third-dump station at KCT.
2. Increasing the number of 'consists' available for coal transport. ('Consists' are train units with a certain payload).
3. Various railway infrastructure expansion options.

Operational changes:

1. Use of dedicated stockpile spaces, called Long Horizon (LH) stockpiles, at the Port, together with special means of transport.
2. Use of standard size train consists as against existing mixed size train consists to transport coal to the Port.

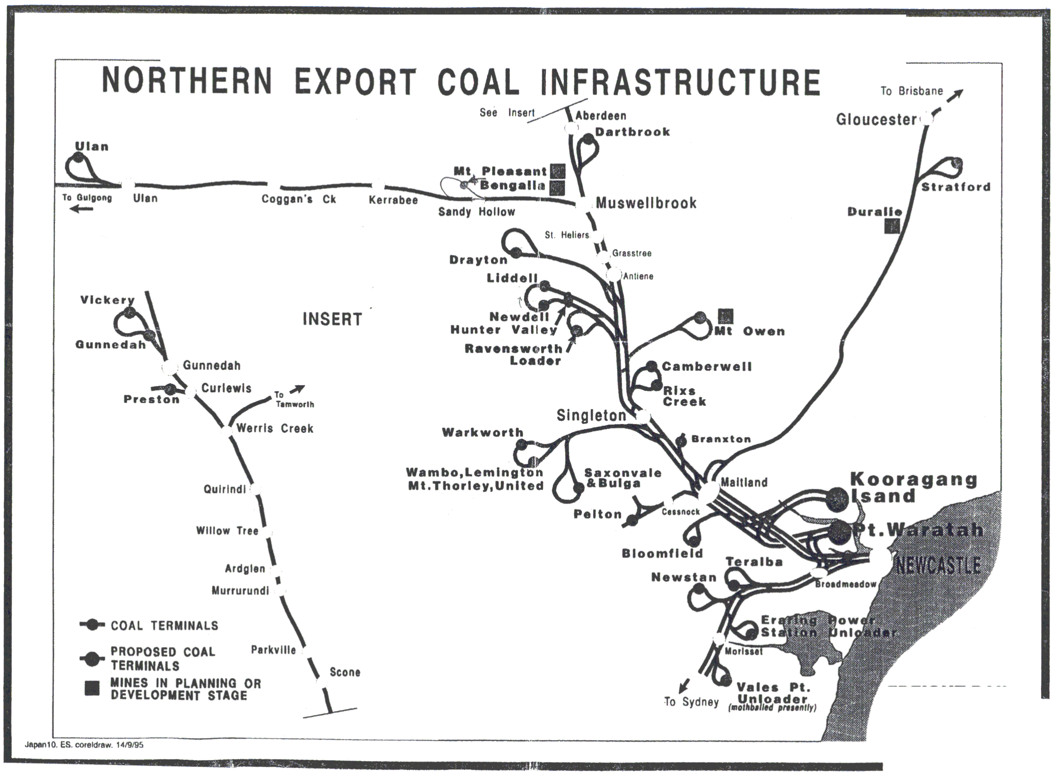

Figure 1: HV Coal Chain Infrastructure (Courtesy of PN)

The major operators in the HV were interested in a gradual increase of the throughput capacity that allows delaying the capital expenditure as much as possible. Therefore the options to change the operating system attracted immediate attention as a short to medium term strategy.

At the time of this study, PWCS was already constructing the third dump station for receiving coal at KCT. At dump stations, rail wagons dump coal, which is then conveyed to the port stockpiles. It was expected that the 3rd dump station would reduce the train turn-around time, thereby increasing the throughput capacity of the HV coal chain. However, there were also doubts at that time whether this would significantly increase throughput due to inefficiencies in other parts of the coal chain. Therefore one of the objectives of this study was to assess the likely improvement possible once the 3rd dump station was commissioned.

CNA, PN and PWCS were of the view that allocating dedicated stockpile spaces at the port, called 'long horizon' (LH) stockpiles, for major users would improve the delivery performance of all HV coal exporters. The existing practice in stockpile allocation used a cargo assembly system, where stockpile space for a particular cargo is allocated around 7 to 10 days prior to the arrival of the corresponding ship. Trains delivering coal to a cargo assembly area, to meet a specific demand, are termed 'conditional' trains. It was envisaged that the introduction of LH stockpiles would allow for the running of 'managed trains' (MT) as well as conditional ones. MT will run at specified intervals (eg. once a day or three times a week), therefore introducing the option of smoothing rail demand peaks, releasing overall system capacity.

It was necessary to study the effect of using MT/LH stockpiles on the delivery performance of the major as well as minor coal exporters in order to assess the benefits and to get their support and commitment to implement this option. A proposed LH stockpile trial at KCT had been postponed until after a study had been made to assess the effect of such a scheme. This investigation fulfilled that requirement.

PN has considered the use of standard train sizes (about 60 wagons) instead of the existing combination of large (about 91 wagons), medium (about 56 wagons) and small trains (about 42 wagons). Standard train sizes were expected to provide additional flexibility, ease of maintenance and improved loading and unloading rates. However, use of large trains in the current fleet was considered to be more efficient to service long distant destinations. The effect of standard train sizes was evaluated in this study.

Increasing the number of consists was not under consideration in the short term by PN due to budgetary constraints. There were some plans to slightly increase the number consists in the medium term.

RIC has planned to carry out some railway network infrastructure expansions over a 5-year period to improve the overall coal delivery performance. These options range from converting some single tracks to dual tracks, to construction of bypass bridges. The effect of these infrastructure expansion options has been previously studied under the existing operating practices. It was necessary to re-investigate the effects of these expansions under the new operating schemes. This study has focussed on the effects of the following infrastructure expansion options on the delivery capacity of the HV coal chain:

- Mount Thorley line duplication
- Whittingham-Branxton headway reduction
- Antene – Muswellbrook line duplication
- Kooragang grade separation
- Queue capacity increase at KCT

3. The simulation model

There was an existing simulation model of the HV coal chain developed for RIC by a third party, Inteplan Pty Ltd, using the assistance of InterDynamics Pty Ltd. We used this model with appropriate modifications and extensions. This model has been constructed with a modular structure, and it consists of three modules:

- A demand planning module: This reads the annual expected sales from each mine, and translates into shipping demands from each mine for the planning period. The shipping demand gives tonnage required and the supply–by date, in terms of the expected time of loading (ETL). This part considers the historical monthly variation of tonnage sent from each terminal, and historical variation of parcel size from each mine-terminal combination.
- A master schedule generation module: This module reads the output of the demand planning module. Considering availabilities of consists, it then prepares a master schedule to deliver coal from each mine to each destination by the required-by date.
- Dynamic network operation module: Once the master schedule has been generated, the dynamic simulation part is invoked to analyse the performance of the schedule under dynamic circumstances. At this stage, the coal trains are sent through the network according to the schedule subjected to delays caused by other trains (passenger, other freight trains) and queuing at terminals/loading points. It is assumed that the other trains are not disturbed by the coal trains.

As the original master schedule generation module did not follow some of the operating rules of PN, we developed a new master schedule program that more closely follows the rules and timetabling constraints actually used. This was vital, to gain the confidence of PN as well as other coal producers on the outcomes of the simulation study.

The new master schedule program has considered the following:

- Available train paths: Paths provide information on available departure times to be used when scheduling a train to go from a terminal to a load point.
- MT: These can run at any time with a specified frequency (say 4 times a week) between a specified load-point and a terminal.
- Estimated time of loading (ETL) is the main criteria in prioritising shipping demands.
- Higher priority is given to long distance destinations than other destinations when allocating trains.
- "Recovery" times – Recovery time is the time to fill up the loading bin. This provides a constraint on the minimum time between two consecutive trains to the same loading point.
- Assignment of trains to dump stations done on the first-come-first serve basis. (This prepares a dump station schedule while developing train schedule).
- Planned maintenance for consists, dumper and load points.
- Minimum and maximum permissible consist size for each load point.
- Desired safety stock levels for LH stockpiles.

The model inputs are as follows:

1. Forecasted annual demand from each mine.
2. Demand split between terminals.
3. Monthly demand profile at terminals.

4. Consist data: type/size, number of consists and payload, refuelling frequency and duration.
5. Terminal data: unloading rate, pre/post-unload times, queue capacity, post-unload dwell time.
6. Loader data: Loader locations, loading rate, pre/post load time.
7. Cycle time data: Rail network and section related data such as up/down travel time, headway, and dual/single track.
8. Train paths: Starting times, frequency, and stations on the path.
9. MT: Mine, terminal, frequency, consist size, safety stock of LH stockpile.
10. Scheduled Maintenance frequency and duration for consists, loaders and dump terminals.
11. Background traffic: origin, destination, departure/arrival time and frequency.

The model generated the following outputs:
1. Demand stem: origin, destination, tonnage and required-by time.
2. Master schedule: Origin, terminal, dump station, consist identification, payload tonnes, demand tonnes.
3. Delivery data: tonnage delivered, late deliveries (number of trains and tonnage).
4. Utilisations: consists and loaders.

The model was calibrated and validated using year 2000 data before running experiments with various operating scenarios. For the validation purposes, the following model outputs were compared against the actual values:

- Annualised export tonnage.
- Delivery performance, in terms of late arrivals for each mine and overall late arrivals.
- Average daily tonnage delivered.
- Average number of train trips per day.
- Consist utilisation.

The key criteria used to evaluate the simulation scenarios are the delivery performance and the annualised throughput.

4. Results

Main outcomes of the simulation are as follows:

1. Effect of 3rd dump station at KCT:

The simulation results showed that, while this improves the overall delivery performance by about 5-10% for projected throughput requirement in 2002-2003, it alone is not sufficient to achieve the required delivery tonnage and performance levels.

2. MT/LH stockpile scheme

Several alternative MT/LH stockpile schemes were investigated using the simulation to identify options that provide the best overall improvement in delivery performance / tonnage. We also looked at the effect of each option on smaller mines. Figure 2 shows example results involving three scenarios. The base_W3d scenario represents the base case where 3rd dump station is assumed to be operational with railing assumed to be done for cargo assembly only (existing method). MT Scen1 – 3 assume different LH stockpile schemes and corresponding MT to transport coal to these LH stockpiles. This simulation identified the most effective MT/LH stockpile schemes.

3. Effect of standard size consists

The simulation analysis confirmed that the use of standard size consists (60 wagons) outperforms the existing fleet in the short term as shown in Figure 3. In Figure 3, 'Base' represents the existing fleet of mixed sizes, 'Stand1' represents the standard size fleet, 'Mixed2' represents a mixed size fleet with increased number of consists, and 'Stand2' represents increased number of consists with standard sizes. In the medium term, the relative difference between the two consist sizes is not large enough as increased number of consists in both options have improved the delivery performance dramatically. The simulation showed that in the long run, when the throughput requirement is over 90 million tonnes per annum, a mixed size fleet will outperform the standard size fleet, as the use of increased number of consists in the standard size fleet will congest the rail network by then.

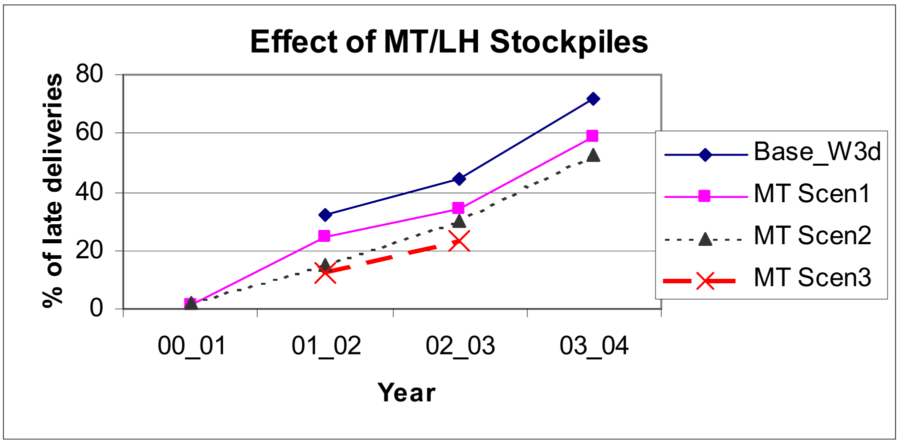

Figure 2 – Effect of MT/LH Stockpiles on the Delivery Performance

4. Network Infrastructure expansions

This simulation study analysed the effect of various railway network infrastructure expansion options under the use of standard size consists and mixed size consists. The results identified the expansion options that offer significant improvements in the overall delivery performance.

5. A feasible pathway towards increasing throughput identified.

The series of simulations carried out enabled identification of a feasible pathway, in terms of using MT/LH stockpiles, standard size trains, increased number of consists and various network infrastructure options, to achieve up to 100 million tonnes per annum of throughput from the HV coal chain at a reasonable level of delivery performance.

5. Benefits of the study

This study:

- Assisted the CNA/PN alliance to persuade other users on the benefits of MT/LH stockpile scheme for all HV coal exporters.
- Provided CNA and PN with quantitative estimates of the benefits of the standard train sizes.
- Enabled CNA and RIC to assess the impact of proposed infrastructure expansions under different consist options on the overall delivery performance and capacity.
- Identified a feasible path for increasing the coal export capacity from the HV region from 67mt at present to 100mt in 5 years.

Standard sized trains have now been implemented, resulting in increased delivery capacity and better on time delivery performance than in previous years. A trial of LH stockpile scheme and managed trains had been completed. Other infrastructure expansion options have been planned for implementation in 2003-5.

6. Difficulties faced during this study:

The problem considered in this study is a very complex logistics system involving many players representing rail, port, infrastructure and mines. There were many difficulties to overcome while doing this study.

- Decision on the type/nature of the model: At the beginning of the study a crucial choice had to be made between the alternatives: use of a modified version of an already developed simulation model (HVDSI) of the coal chain for RIC, or developing a separate model for this purpose. As the HVDSI model had most of the features required for the study, and due to many players potentially affected by the outcomes of the study, it was decided, correctly, to use appropriately modified version of the HVDSI model. It was a considerable challenge to adapt a detailed model for one application to another.

- Time restrictions: Time and budget constraints are problems with any simulation project. The HVDSI model, due to the complexity of the problem handled, was taking a considerable time to run. With many scenarios to run, it was decided to make simulation runs with minimum random variations.
- Difficulties in validation: Validating a simulation model always is a challenging task, and time consuming (Balci (1990) and Law and Kelton (2000)). However, validation is important to build the confidence on the model. As several players were involved in this work, the model had to be calibrated and validated at a considerable expense of time.

7. Conclusion

Highly complex logistics issues at the Hunter Valley coal chain were addressed using simulation modelling and analysis to analyse various options to improve the throughput and the delivery performance. The simulation results assisted decision-making for the key players and also for those whose support was essential for successful implementation. Several difficulties had to be overcome during the study, and it will be interesting to hear about what alternative models that might have been useful to handle various issues addressed here.

8. Acknowledgements

We greatly appreciate and acknowledge the support provided by Rail Infrastructure Corporation and Inteplan Pty Ltd by providing us with the HVDSI model to use with this study. We also greatly acknowledge the cooperation provided by PN, and many other producers in the Hunter Valley. Finally, Rio Tinto Technical Services and Coal & Allied are acknowledged for their support for presenting this work.

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