# Modeling the mine-to-port supply chain

## Integrated simulation modeling yields reliable results, even with complex scenarios

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Over the last decade demand on the world's ports has significantly increased, especially for both coal and iron ore export terminals. In an attempt to maximize exports, many port operations have transitioned to a just-in-time delivery operation.

Historically, coal and iron ore terminals have been designed with a considerable buffer between product reception and shipment. That is, product was delivered to ports significantly before ships arrived. This buffering function was intended to disconnect the operation of the delivery system (often rail) from the shiploading operation. However, such an operation requires a significant amount of storage space, typically 5 to 10 percent of annual export volume.

Today, many terminals are constrained in land use and can no longer expand their storage space to match increasing demands. Moving away from a buffered operation to a just-in-time delivery system allows increased exports for a given amount of storage space. Such an operation can also result in a more cost-effective use of the terminal. However, the close integration required between the rail system and the marine terminal creates significant challenges for the operators, and complications in capacity and bottleneck analysis.

## Analysis of complex systems

For expediency, and to keep costs acceptable, analysis has traditionally been performed on the terminal and the rail systems independently, which is appropriate for systems where the terminal and the rail system are buffered by a large stockpile.

In a just-in-time system, the rail network and the terminal are much more tightly connected, and performing separate analyses carries significant pitfalls. The overall capacity of a tightly linked supply chain with minimal buffer is not necessarily equal to the capacity of the weakest part of the chain. Delays in one area will propagate through the chain. Trains can be delayed, product remains undelivered, ships will queue for lack of product, demurrage will increase and target shipments will be missed. Track maintenance will have impacts on shiploading; ships arriving late will cause the stockyard to fill up. These issues create a need to account for variability throughout the entire system.

Not only is there a danger that system delays will not be accounted for, but with separate models for the terminal and rail portions of the system there is the danger that the model for each sub-system might use unrealistic assumptions about the behavior of the other sub-system, leading to an over-estimate of the performance of the entire system. An integrated mine-to-port simulation model minimizes these dangers.

Recent advances in modeling technology, along with the ever-increasing computing power available, have made such models feasible. Ausenco Sandwell recently demonstrated this by expanding a simulation model of the Dalrymple Bay Coal Terminal (DBCT) to include the rest of the Goonyella Coal Chain†.

## The Goonyella coal chain

DBCT, located in the state of Queensland, Australia, is a component of the larger Goonyella Coal Chain that consists of 18 mines, two marine terminals, a shared fleet of train consists, and over 800km of rail. The system, shown in Figure 1, exported


Figure 1. Modeled Goonyella rail system.

more than 80 million tonnes of coal with over 70 types of coal products each year for the last four years, servicing about 1,000 ships per year.

DBCT is a common-user terminal that operates on a just-in-time basis, with a relatively low amount of static storage – approximately 2.5 percent of its annual export volume. Product delivery to the terminal is driven by the expected ship arrival date. Stockpile space is allocated to each parcel of the ship to maximize the shiploading rate and to avoid reclaimer conflicts. Trains are scheduled daily. All of this occurs on a just-in-time basis to minimize the time that product is in the terminal.

## Simulating the Goonyella coal chain

In the past, Ausenco Sandwell created a model of the Dalrymple Bay Coal Terminal for DBCT Management and focused only on the marine terminal, relying on reasonable assumptions about the interaction of the terminal and the Queensland rail network. The Goonyella Coal Chain model was created from the existing model of DBCT, to which all the details of the rail network and mines were added.

The model also included a simplified version of the Hay Point Services Coal Terminal, located next to DBCT, which shares the use of the rail network and train consists with DBCT. Figure 2 shows an overview of the port section of the model. The entire system was modeled to a high level of detail, with approximately 700 permanent entities such as rail signal blocks (258), stockpiles (132), conveyors (39), trains (32), etc.

The completed Goonyella Coal Chain Simulation Model was used to test different stockpile management systems, including remnant management and zonal management. These stockpiling systems had an impact on the shiploading and on the train operations, which shows the value of an entire coal chain model. Yard conflicts due to stockyard management and train operations created delays in shiploading. Similarly, constraining trains to unload into certain sections of the yard created delays in trains. These are two areas that would not have been accurately captured in separate models.

## Cost-effective planning with confidence

Ausenco Sandwell now incorporates the associated rail system in the majority of port simulation models they create. These models are used to analyze the capacity of the entire system, incorporating any interactions between the rail network and the marine terminal. Integrated models allow planners to avoid using 'rules of thumb' and instead quantify the impacts of storage space, number of products, equipment utilization, and congestion on the overall system capacity. In turn, this can allow users to avoid the expensive and unnecessary capital expenditures required to satisfy these out-of-date rules of thumb. The use of an integrated simulation model of the entire supply chain allows for a high level of confidence in the results, even with the complicated logistics of a just-in-time operation.

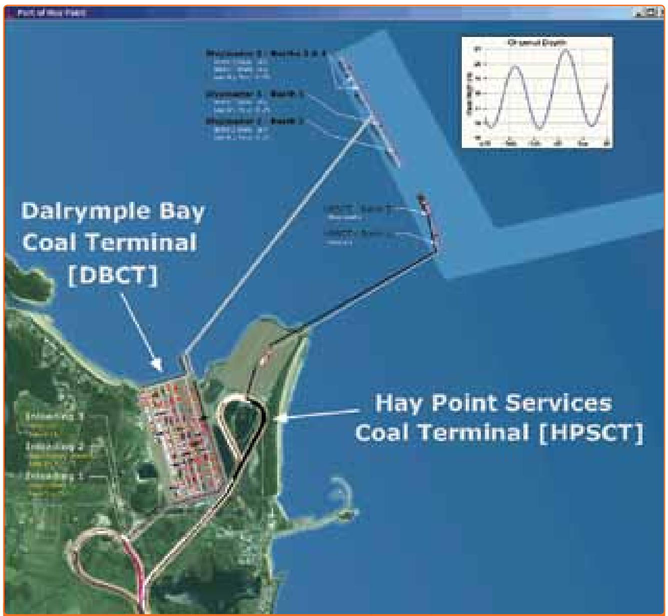


Figure 2. Modeled port of Hay Point.

†*Ausenco Sandwell would like to thank DBCT Management for permission to use their project as an example in this article.*

## ABOUT THE AUTHORS AND COMPANY

**Alan Sagan** is a consultant with Ausenco Sandwell, specializing in the optimization of bulk handling systems. He has simulated all of the major iron ore and coal export terminals throughout the Australian states of Western Australia and Queensland, having advised many of the leading Australian resource companies. He has a Bachelor of Applied Science in Engineering Physics from the University of British Columbia.

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