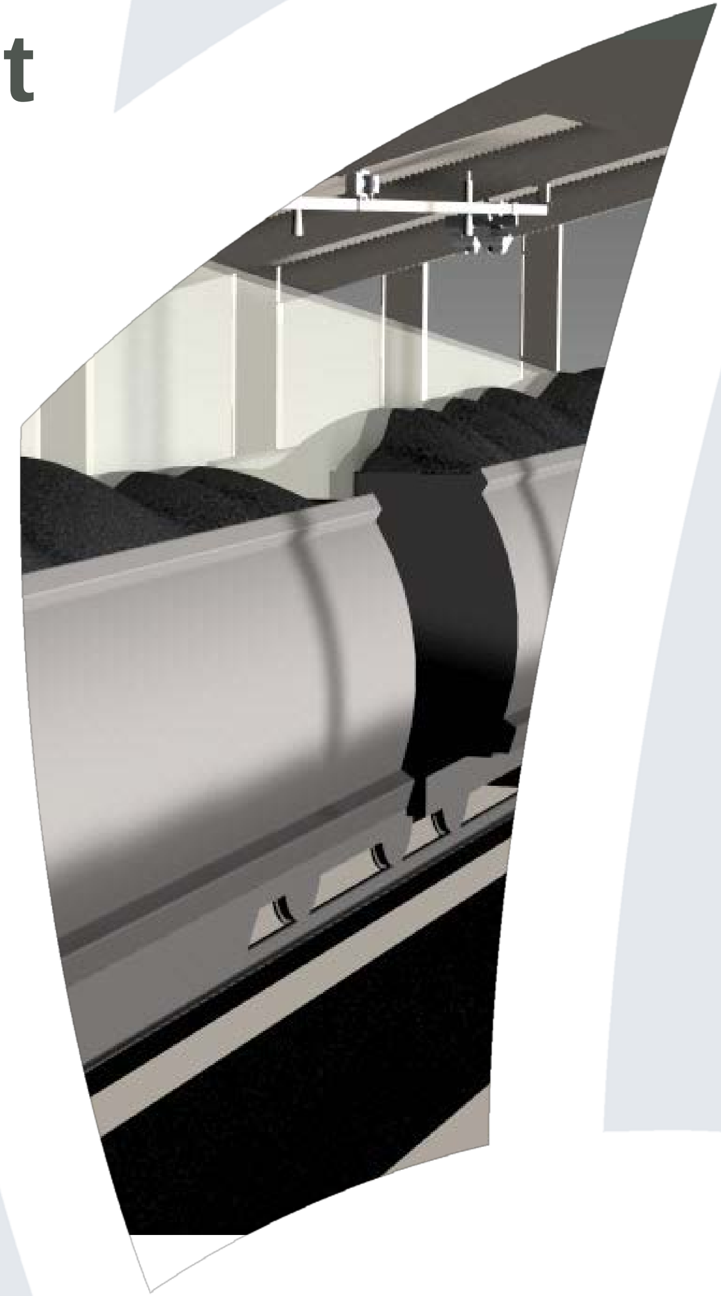
Optimising throughput of rail dump stations, via simulation and control system changes



Rob Angus
BMT WBM Pty Ltd
Brisbane
5 June 2013

BMT WBM

Presentation Overview

- Introduction
- Volumetric vs. DEM Modelling
- Coal Rail Dump Station
- Two Case Studies
- Conclusion

Introduction

BMT is an international multidisciplinary science, engineering and technology consultancy.

BMT WBM is an Australian subsidiary of the BMT Group, with offices in Sydney, Melbourne, Brisbane, Perth, Newcastle, Mackay, Denver, Vancouver.

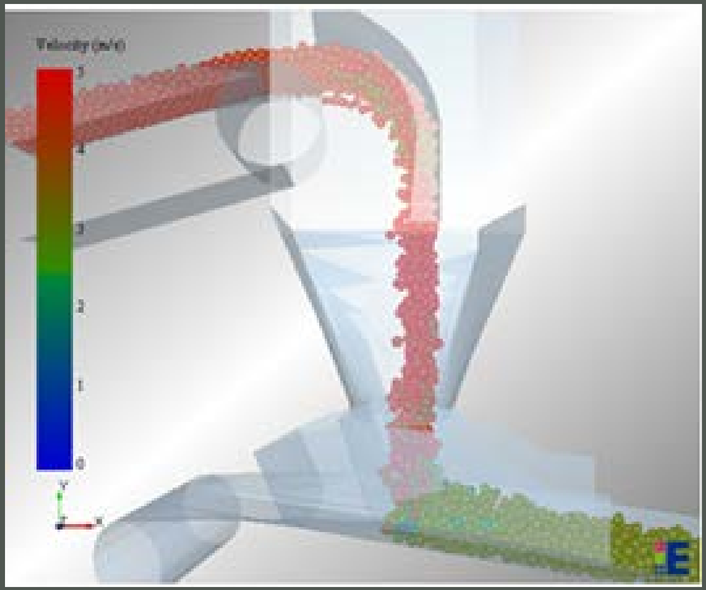
BMT WBM has provided materials handling design, analysis and investigation services for over 40 years.

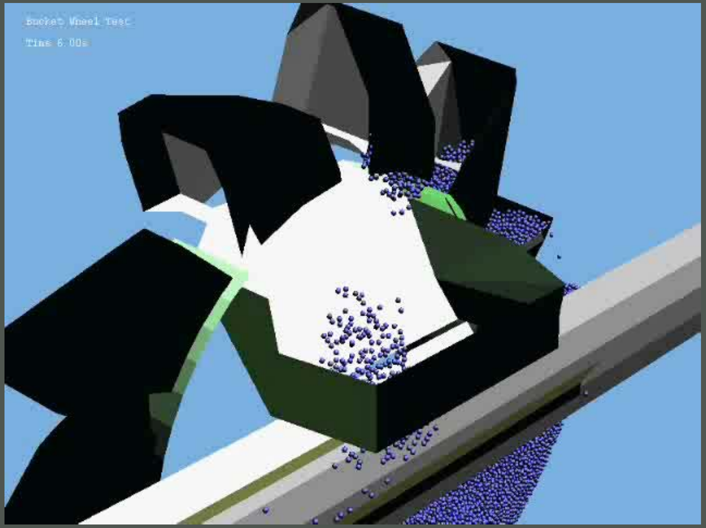
In this presentation we explore computer based dynamic modelling of coal rail dump stations to assess and optimise throughput and minimise operational issues. The modelling technique used allowed the complete dump station system to be modelled including interactions of key features of the system.

Modelling - DEM

Discrete Element Modelling

- Model individual particles and include particle interaction physics
- Can provide accurate detailed analysis
- Results very dependant on accuracy of material properties
- Computationally very intensive





BMT WBM

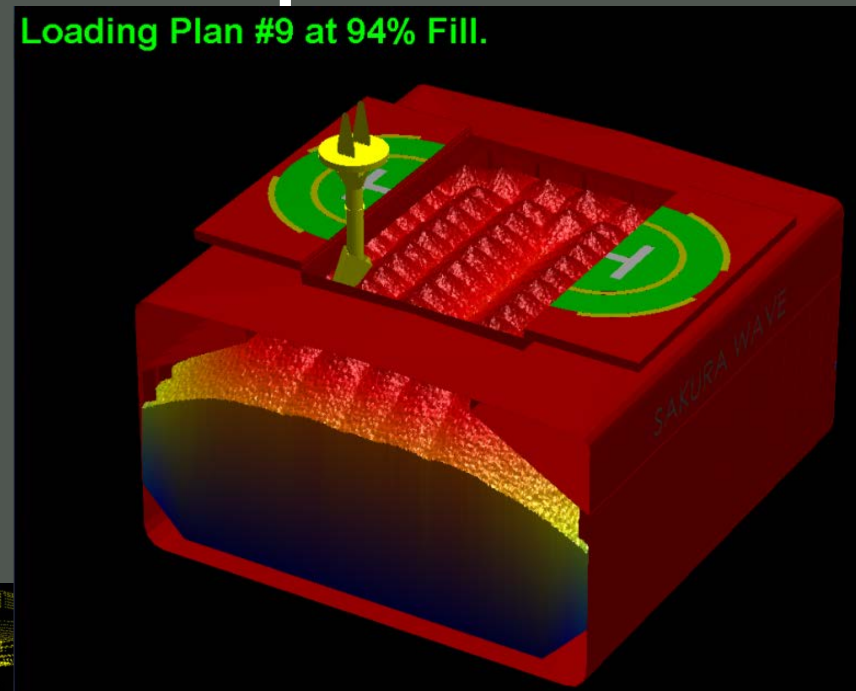
BRW CLIENT CHOICE AWARDS 2013 WINNER

Volumetric Modelling

Developed Volumetric modelling due to limitations of DEM

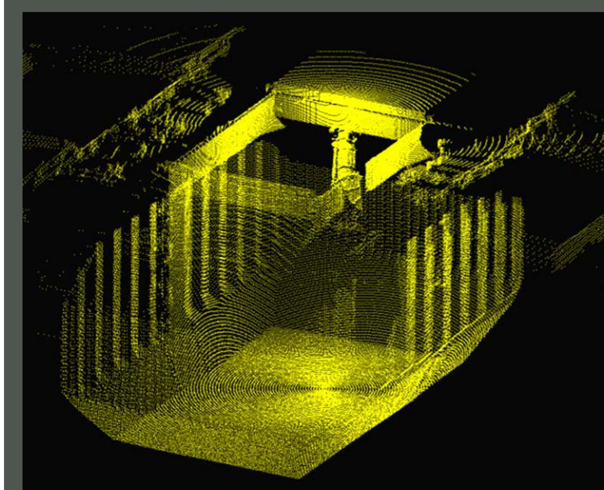
- Simplified modelling approach with ability to model complete system
- Break space into small cells. Apply rules for volumetric flow of material between cells
- Much lower computation effort required. This gives the ability for fast simulation turnaround making it practical to conduct a lot of simulations quickly to gain a good understanding of possible variables
- Simulate interactions of key parameters in the system including controls/logic
- Calibrate against existing system

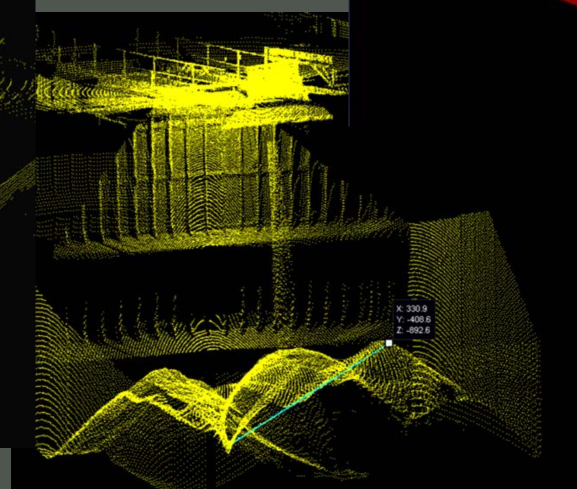
Volumetric Modelling - Example



Loading ship hold

- Volumetric modelling used to assess effectiveness and loading time for different loading sequences to fill ships hold

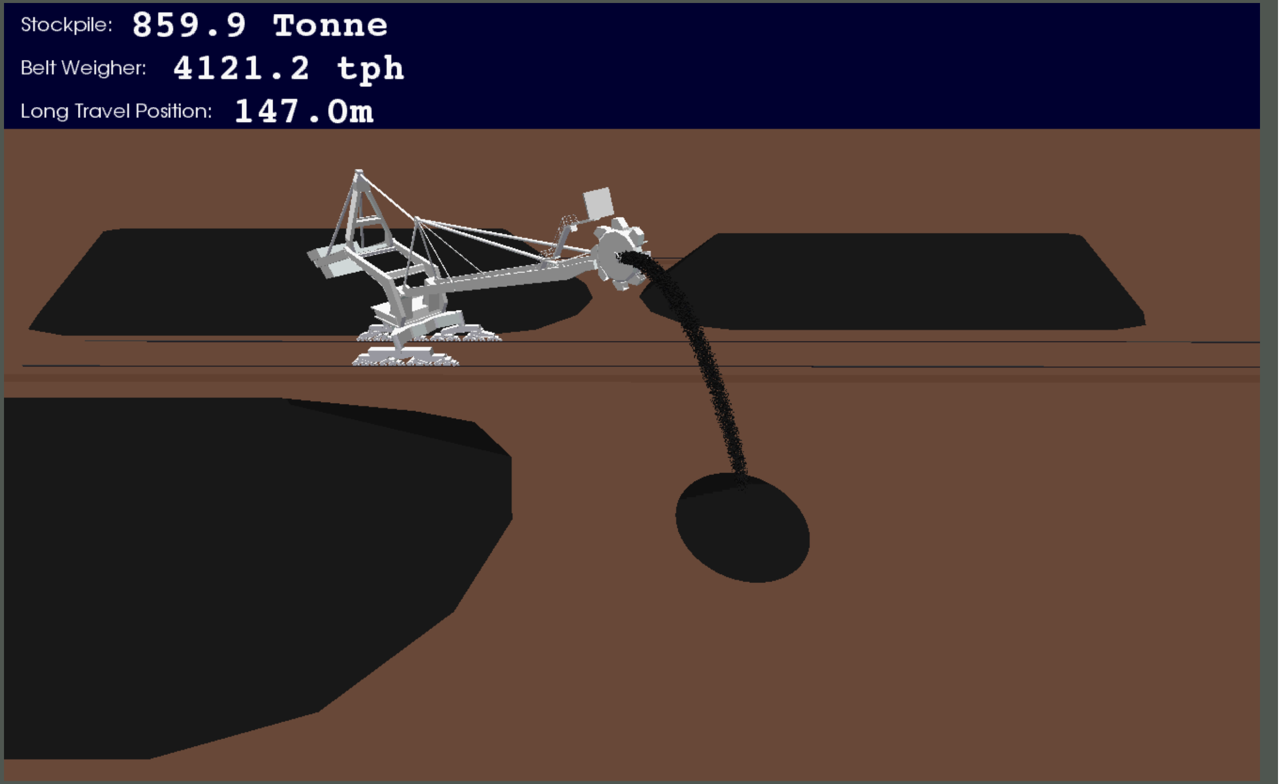




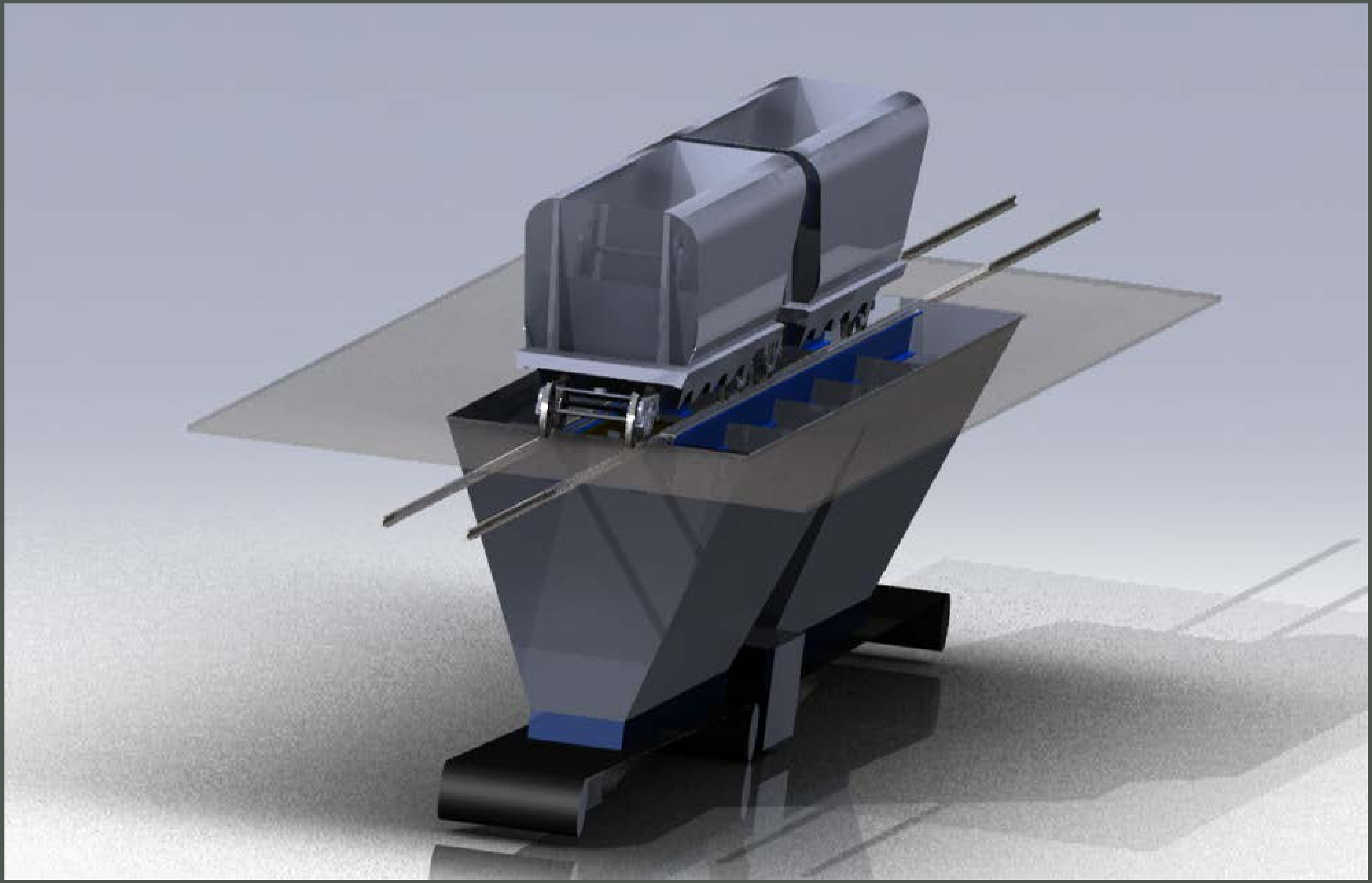
Volumetric Modelling - Example

Stockyard Modelling - Stacker

- Volumetric modelling used to assess resulting stockpile geometry for different stacking schemes

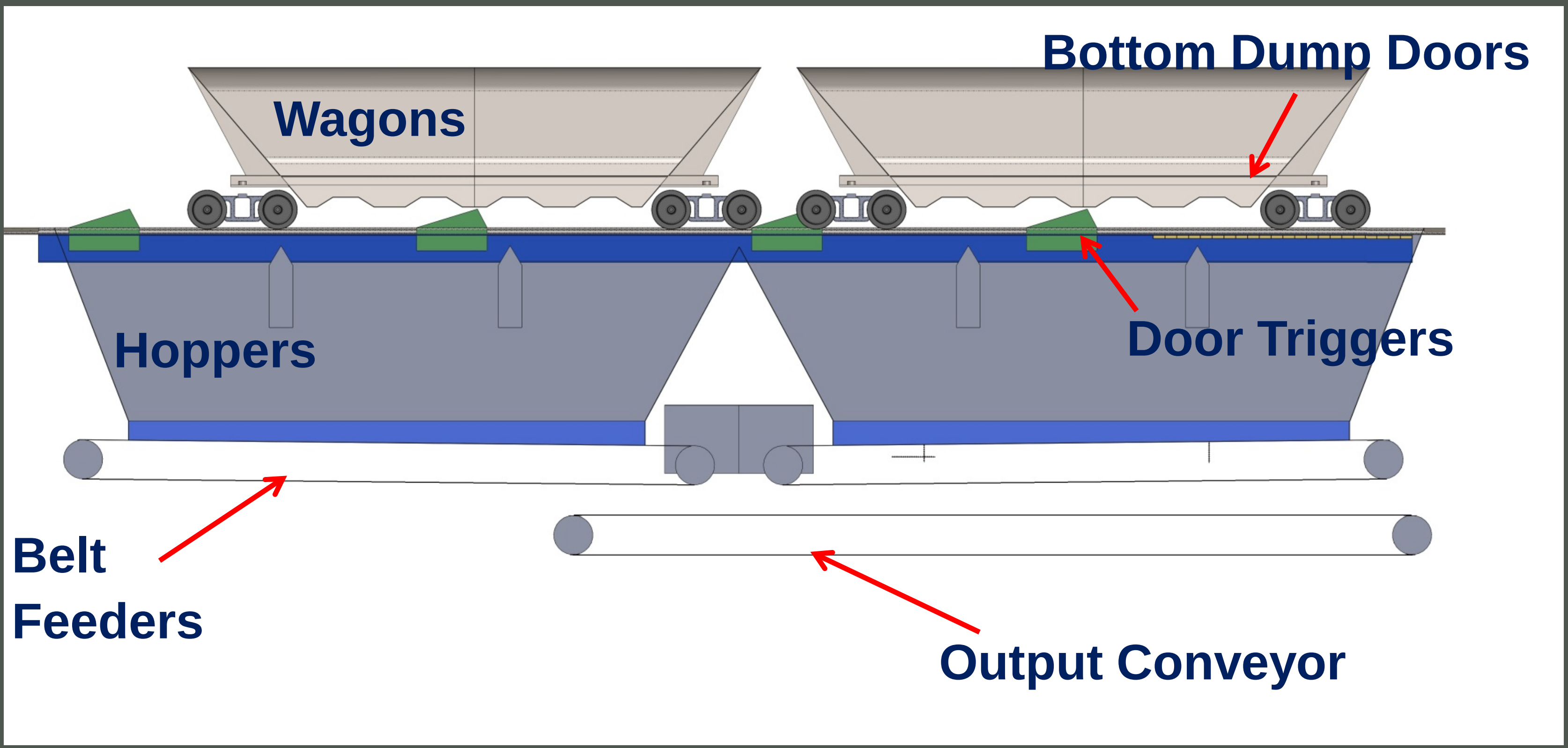


Case Studies – Rail Dump Station



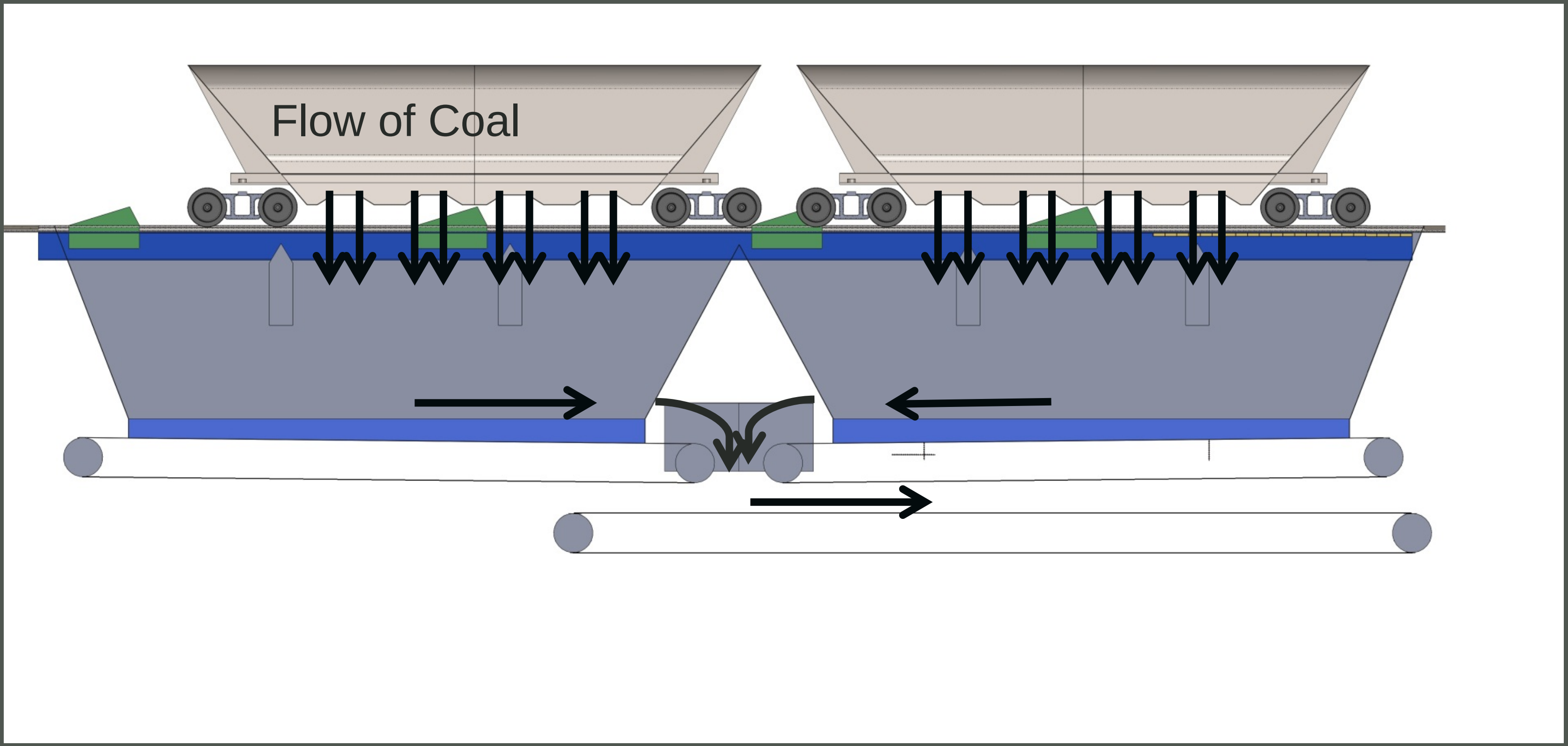
Rail Dump Station Modelling

Typical Rail Dump Station



Rail Dump Station Modelling

Typical Rail Dump Station



Rail Dump Station Modelling

Potential Issues:

- Throughput – Economic advantage in reducing the average train unloading time which results in increased throughput for facility.
- Ploughing – If hoppers overfill there is a potential for coal to build up above the level of the track causing the wagons to ‘plough’ through the coal resulting in the real concern of train derailment. To prevent this, trains can be delayed waiting for hoppers to clear.
- Uneven Coal Discharge from Dump Station – uneven flow of coal out of the dump station has implications for throughput as well as potential issues for downstream stockyard equipment.
- Managing “Sticky Coal” – resulting in coal hang up in the wagons

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Issues:

- Coal frequently building up above level of track – causing "ploughing" issues. Excessive build up of coal leading to concerns regarding derailment.
- Train frequently stopped to minimise risk – resulting in increased unloading times
- Significant variation in flow rate on the output conveyor

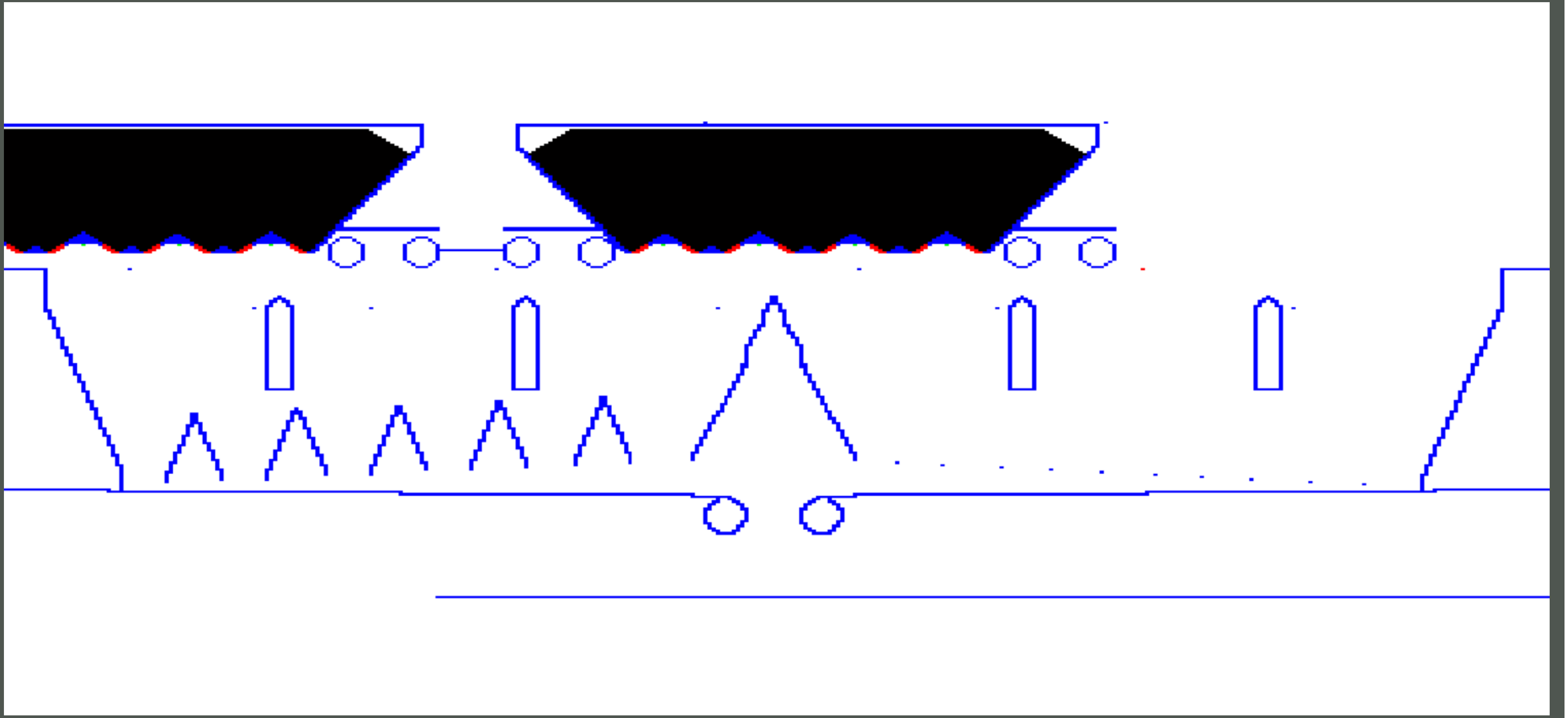
BMT WBM

BRW CLIENT CHOICE AWARDS 2013 WINNER

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Model



Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Model included the following:

- Model whole system of dump station
- Ability to vary wagon speed
- Door opening triggers – location and control logic
- Bin level sensors (and logic used to trigger control)
- Speed and control of hopper belt feeders
- Speed and control of output conveyor
- Interaction of flows, sensors and control system

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Model Calibration:

- Train emptying times
- Observations and measurements on existing dump station

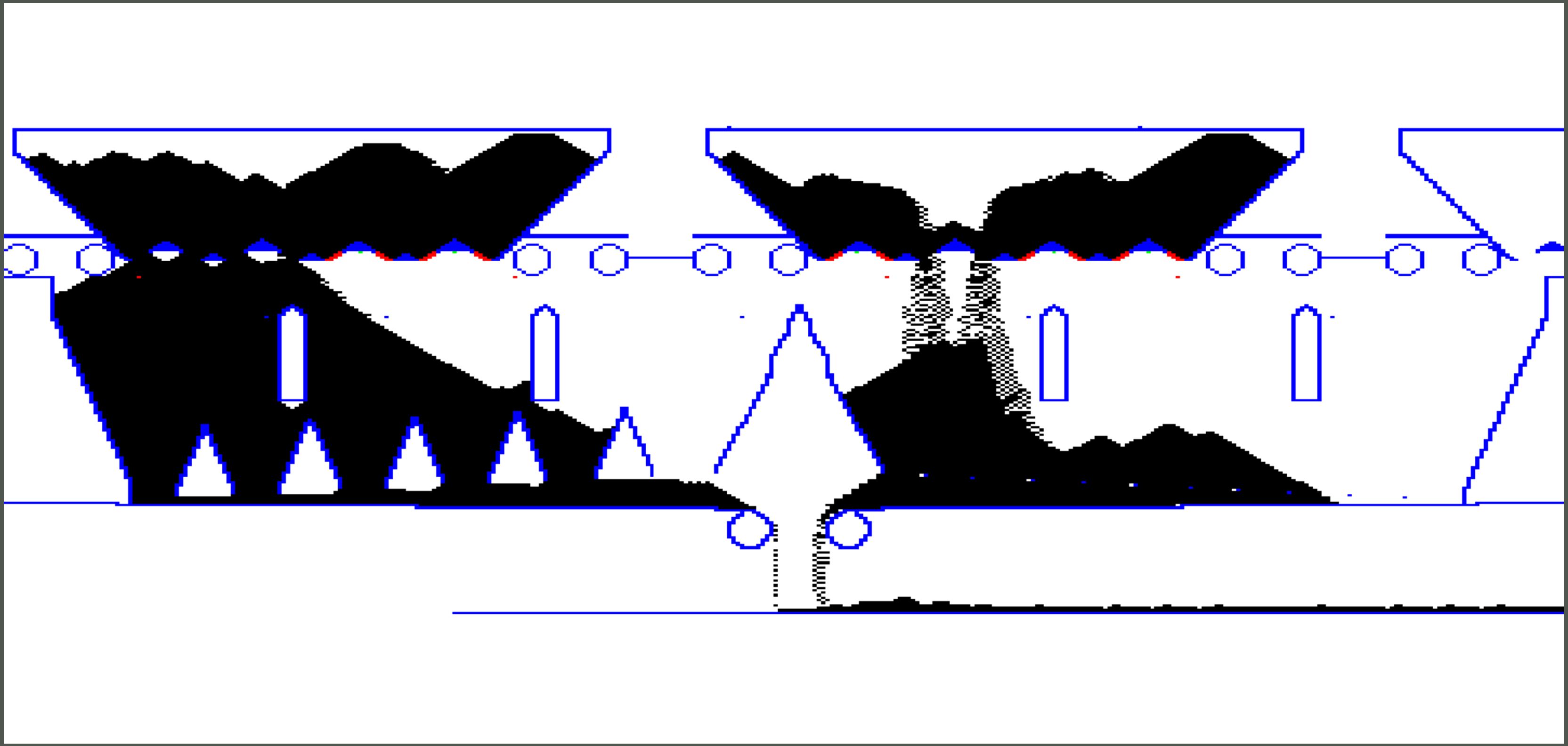
Main Variables for Potential Solutions:

- Trigger sequencing – and control logic
- Hopper conveyor speeds
- Control based on level sensors
- Internal geometry of hoppers

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Results - Model of original setup



BMT WBM

BRW CLIENT CHOICE AWARDS 2013 WINNER

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Results – Model of original setup

- Modelling predicted coal ploughing consistent with observations on site.
- Modelling also predicted uneven flow rates from the output conveyor, consistent with observations on site.

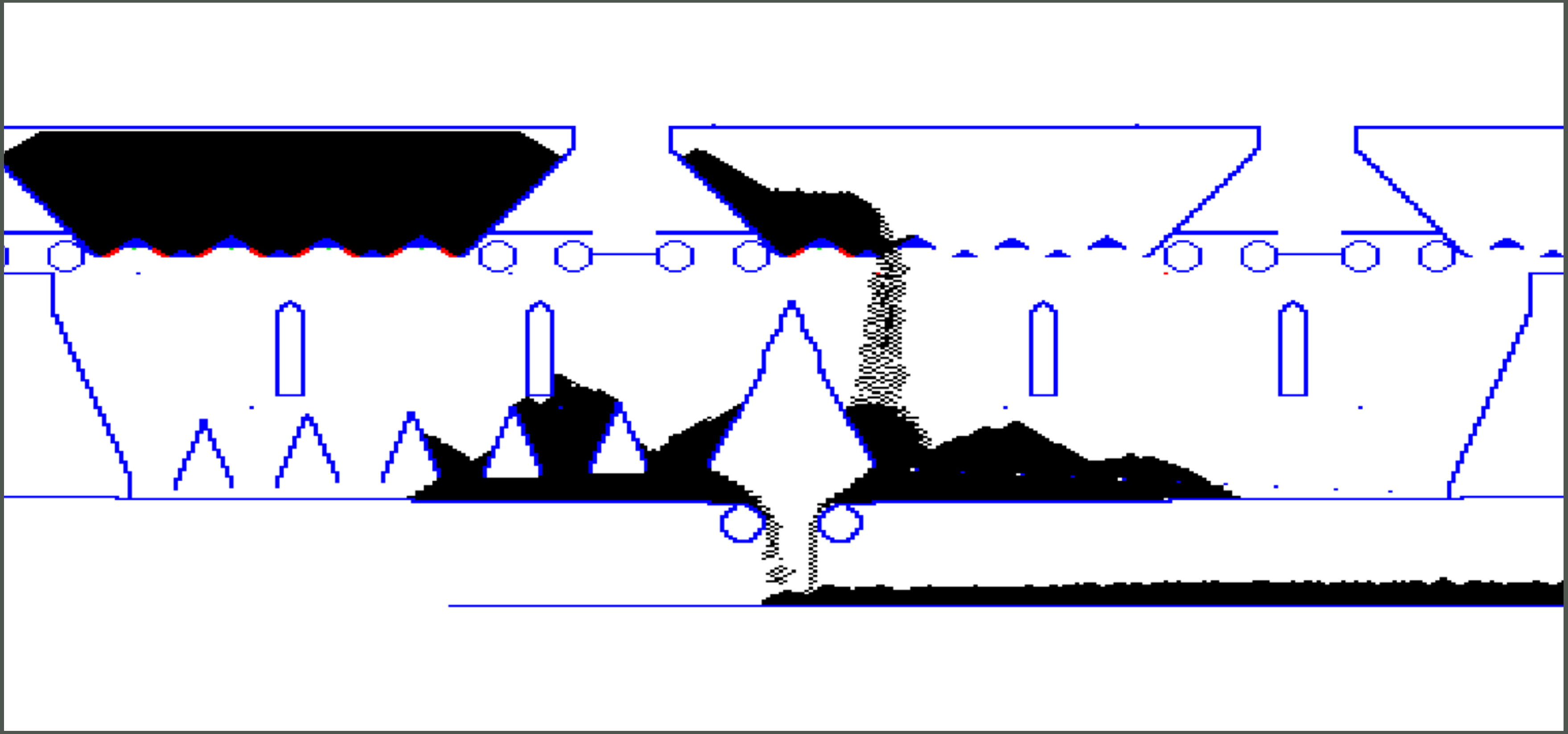
Main Changes Proposed :

- Sequencing and control of door triggers - Alter sequencing of door triggers to bias dumping ½ of each wagons load into exit end of each hopper
- Modify feeder speed
- (Checked for variable material properties)

Rail Dump Station Modelling

Case Study 1 – NSW Coal Dump Station

Results - Model with modified sequencing



Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station

Issues:

- Coal frequently building up above level of track – causing "ploughing" issues (similar to Case Study 1)
- Significant variation in flow rate on the output conveyor (similar to Case Study 1)
- Additional complication of "Sticky Coal" varying optimal control

Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station

“Sticky Coal”:

- Results in ‘hang-up” of coal in wagons
- Original remedy was to stop train and use jackhammers on side of wagon to release coal. This significantly increased train unloading times (delays of 1 to 12 hours) and was an OH&S issue
- Dump station had 2 robotic wagon vibrators which provided effective solution to coal hang up – but required additional consideration in developing the most effective control strategy for the dump station

Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station – Wagon Vibrators

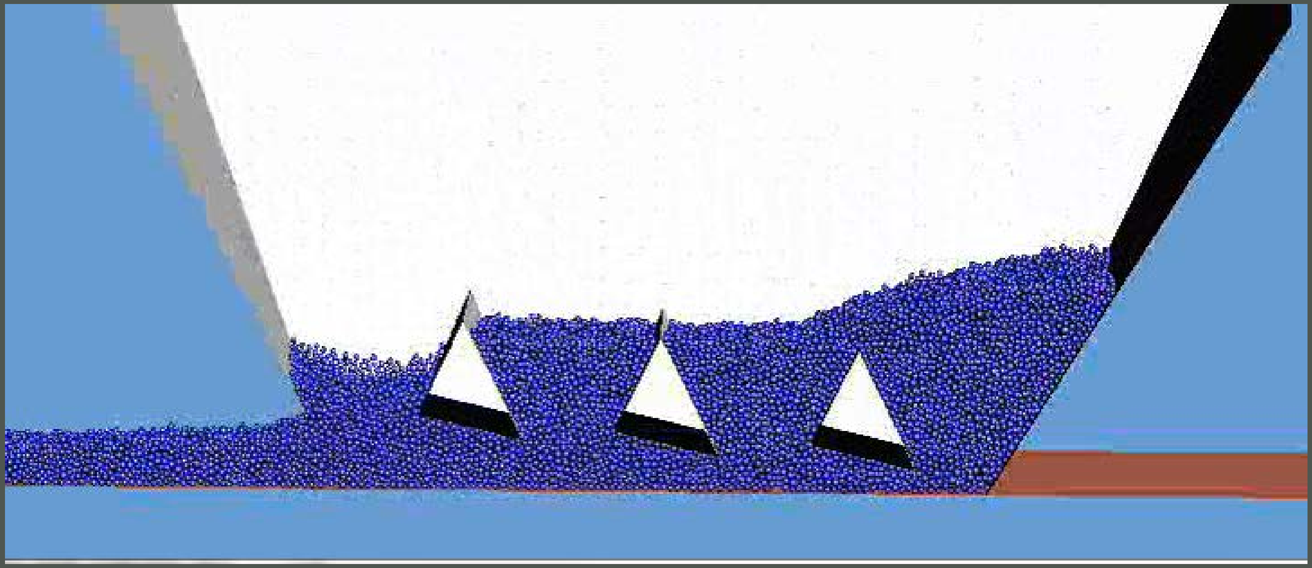
BMT WBM

BRW CLIENT CHOICE AWARDS 2013 WINNER

Rail Dump Station Modelling

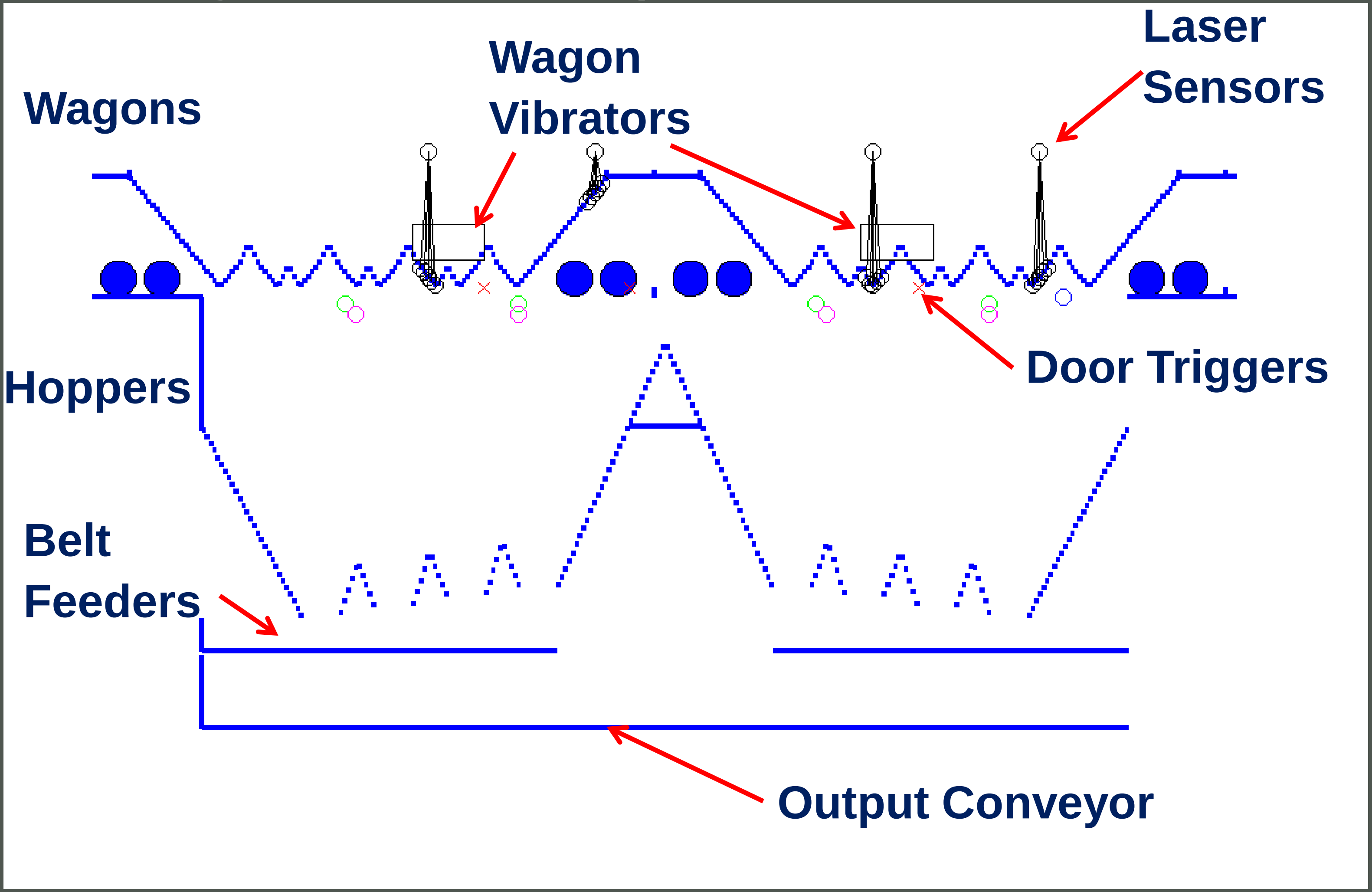
Case Study 2 – Qld Coal Dump Station

- DEM used to assess hopper geometry
- Volumetric Modelling used to assess system and controls



Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station



Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station

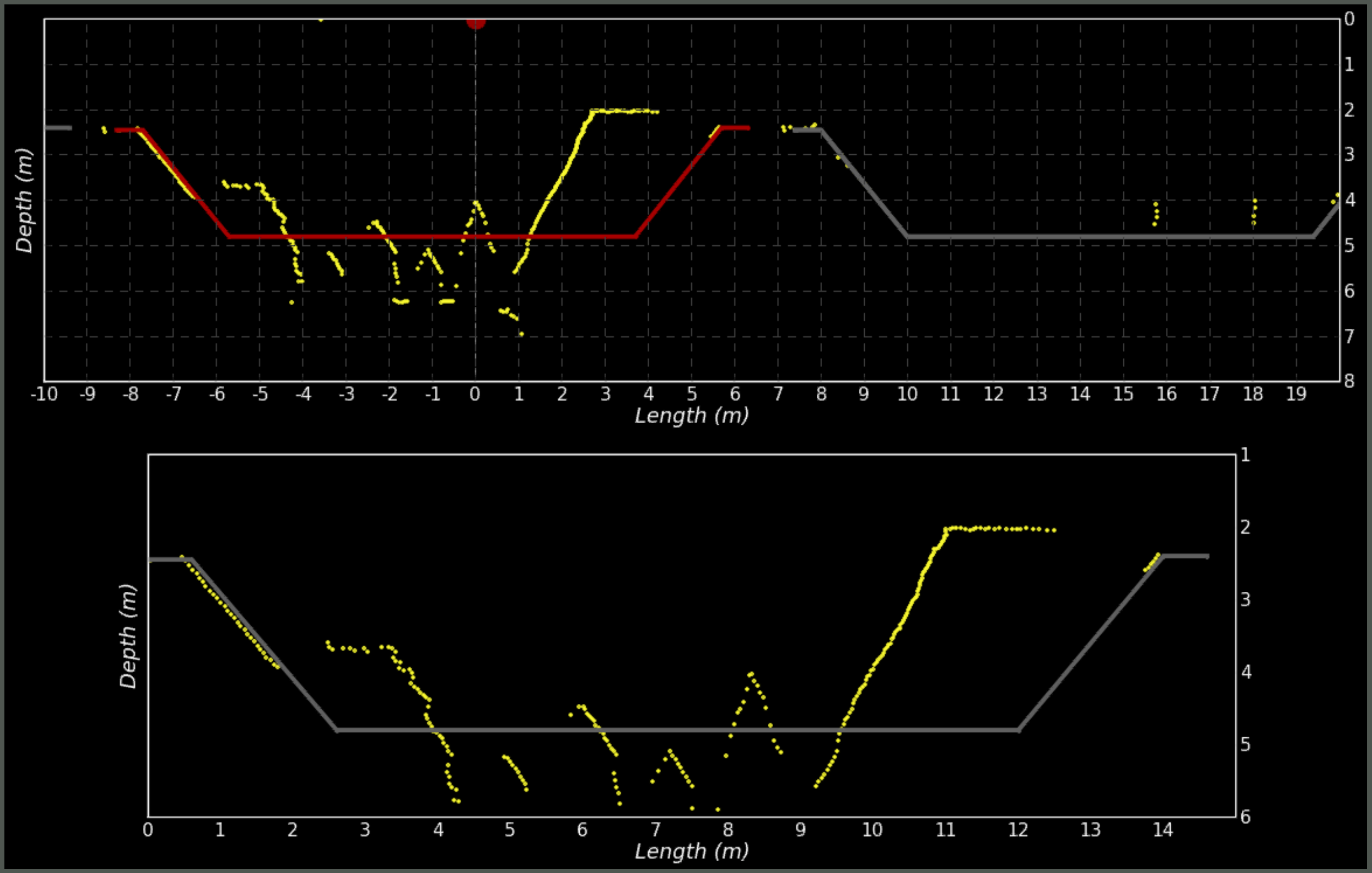
Model included the following:

- Model whole system of dump station
- Ability to vary wagon speed
- Door opening triggers – location and control logic
- Speed and control of hopper belt feeders
- Speed and control of output conveyor
- Laser sensors (to detect coal hang up and trigger Wagon Vibrators)
- Wagon vibrators
- Control logic for engaging wagon vibrators etc.

Rail Dump Station Modelling

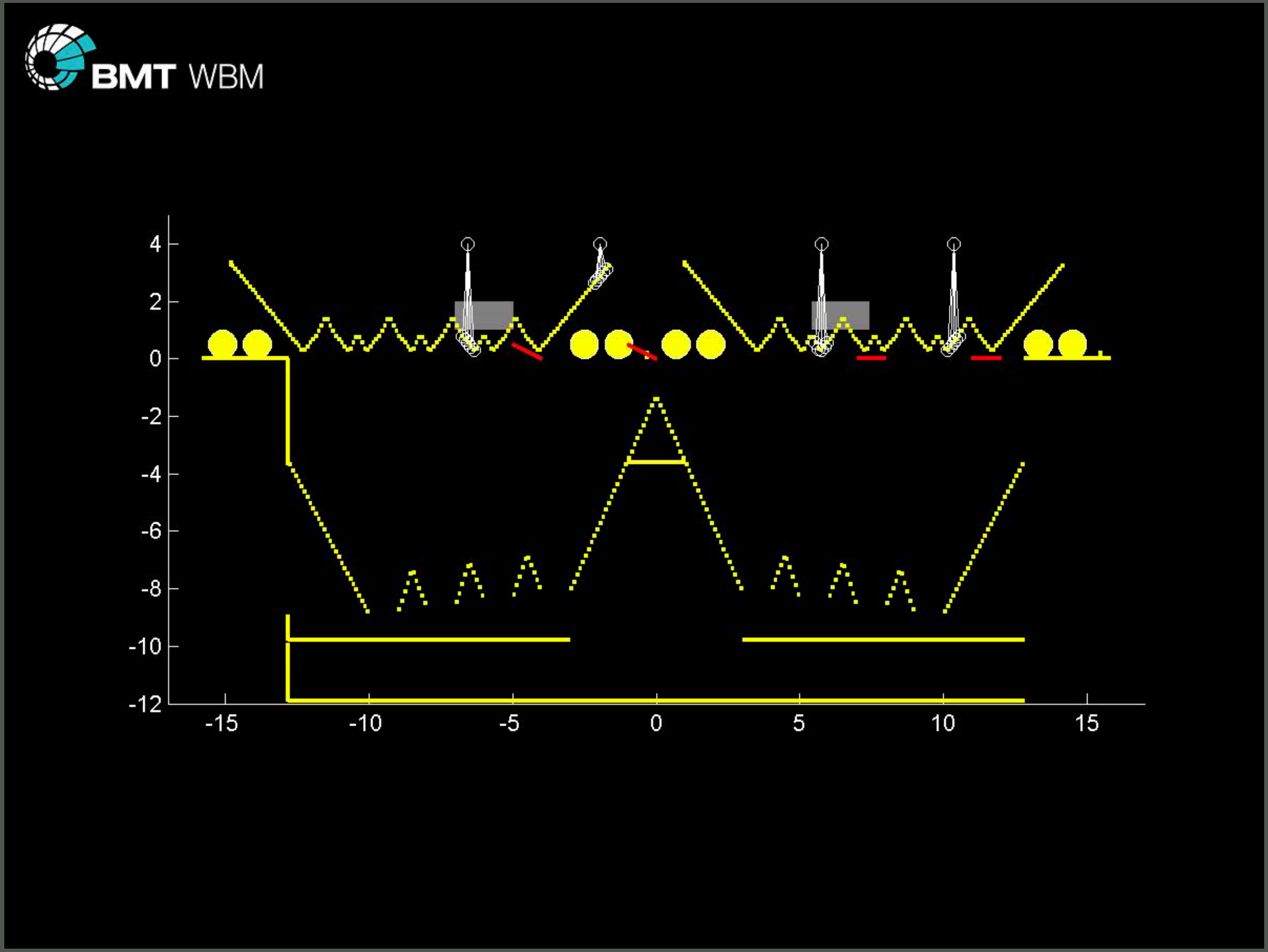
Case Study 1 – Qld Coal Dump Station

Additional Calibration Data from WV Instruments – Laser Scan



Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station – Model of Original Setup



Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station

Results – Model of original setup

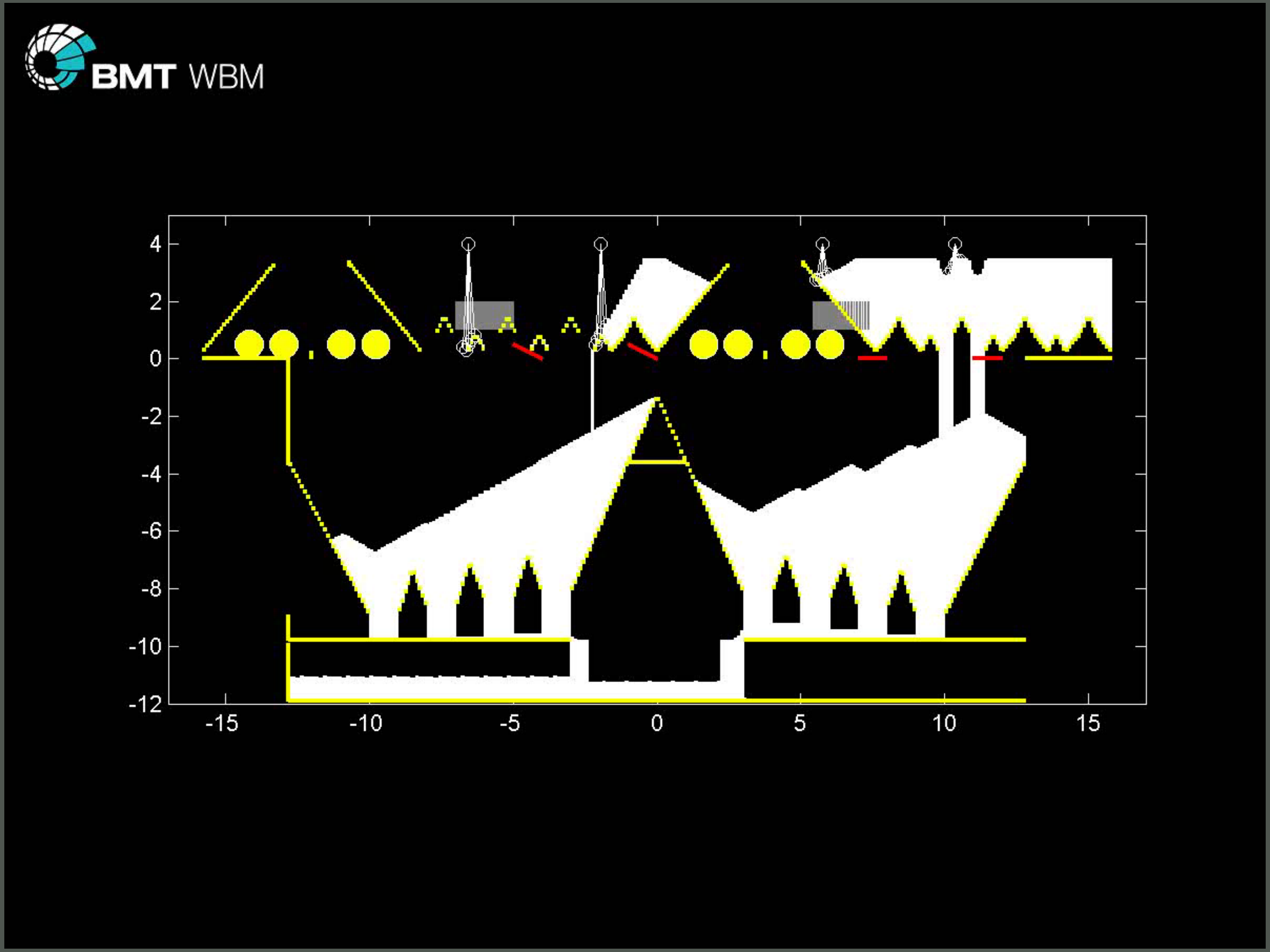
- Original setup showed good results when there was no coal hang-up
- Too much carry over into second hopper when have trains with “sticky coal” (random timing)

Main Changes Proposed :

- Improved upstream hopper geometry (from DEM modelling)
- Change trigger sequencing combined with changes to feed conveyor control (max speed on upstream feed conveyor and control downstream feed conveyor). Aim to bias loading into upstream hopper and use downstream to handle when have hang-up.

Rail Dump Station Modelling

Case Study 2 – Qld Coal Dump Station – Modified Control



BMT WBM

BRW CLIENT CHOICE AWARDS 2013 WINNER

Conclusions

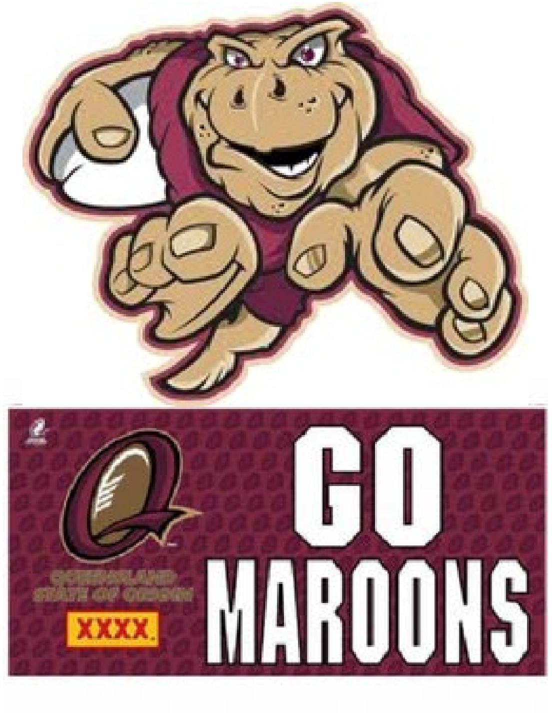
Volumetric Modelling

- Simplified modelling approach with ability to model complete system
- Much lower computation effort required allowing fast simulation and many iterations
- Ability to simulate interactions of key parameters in the system including controls/logic

Where Next?

- Complete stockyard modelling
- Embedding models in control systems

Thank you / Questions



Rob Angus

BMT WBM Pty Ltd

(07) 3831 6744

email: Rob.Angus@bmtwbm.com.au

web: www.bmtwbm.com.au

BMT WBM

BRW CLIENT CHOICE AWARDS 2013 WINNER