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G. Gray
Simulation Modelling Services, Newcastle

E. Baafi
University of Wollongong, ebaafi@uow.edu.au

I. Porter
University of Wollongong, iporter@uow.edu.au

O. Rojas
Simulation Modelling Services, Newcastle

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A SIMULATION MODEL FOR ROADWAY DEVELOPMENT TO SUPPORT LONGWALL MINING

Geoff Gray[1], Ernest Baafi[2], Ian Porter[2] and Osvaldo Rojas[1]

ABSTRACT: The practice of longwall mining is potentially an efficient and cost effective means of extracting coal from underground seams. However, for production targets to be achieved not only must the longwall perform as expected but roadway development must be kept ahead of the longwall advance. The evaluation of development options is a challenging exercise due to the interactions between mining, tramming and clearance operations. In particular, the high levels of variability and uncertainty in operations make it difficult to assess how a particular configuration may perform. A simulation model *RoadSIM* using the ARENA modelling system has been produced to assist in the analysis of the roadway development process. The *RoadSIM* simulator provides means for assessing the operational limitations of roadway development practices at a particular coalmine. The simulation model provides a what if tool to allow a range of equipment, configuration and operating practices to be assessed in terms of achievable advance rates and equipment utilisation. Output from the simulator is in the form of a dynamic visualisation as well as summary reports and detailed logs of operations over time.

INTRODUCTION

The practice of longwall mining is potentially an efficient and cost effective means of extracting coal from underground seams. For longwall production targets to be achieved roadway development must be kept ahead of the longwall advance. In practice there are various inherent characteristics of roadway development practices which fundamentally influence their overall performance rates. One of the recommendations made in a recent report on current practices of Australian Roadway Development by Gibson (2005) was to use a process simulation model to map, manage and monitor the performance of roadway development. In response to this recommendation a project was setup under the Australian Coal Industry Research Program (ACARP) to map and model the roadway development process. As a result of the ACARP project a simulation model of roadway development operations, *RoadSIM*, has been developed.

DYNAMIC SIMULATION

Dynamic system simulation provides a proven technique to study interaction between elements of a complex system. The basic methodology has been available for over 40 years. However advances in computing technology and software development tools have seen increased use of the technique over the last 5-10 years. This type of simulation technology is referred to by a number of different names, these include:

- dynamic simulation,
- discrete event simulation,
- numerical simulation and
- Monte Carlo simulation.

The technique allows for the modelling of a system over time and the interactions between system components to be considered. For example interactions between the miner and shuttle cars, or traffic issues related to shuttle car movements. An important aspect of this technique is its ability to explicitly allow for the randomness/variability in a system. Without allowing for unplanned events and the impact operating cycles any modelling approach is almost certain to over estimate production capacity.

A simulation model allows a model user to identify bottlenecks and establish if local improvements are likely to have a system wide impact. This approach provides the opportunity to optimize an operation

[1] *Simulation Modelling Services, 4 Wolfe Street, Newcastle NSW*
[2] *School of Civil, Mining and Environmental Engineering, University of Wollongong, NSW*

and allocate resources efficiently. The *RoadSIM* system utilises the technique of dynamic simulation. The model has been developed using the ARENA (Kelton, 2007) modelling system.

MODELLING THE ROADWAY DEVELOPMENT PROCESS

The current modelling focuses on the unit operations of two-heading developments from the face to the boot end. The modelling allows, for but does not explicitly model the movement of services etc associated with a sequence move. The aspects of the roadway development process explicitly considered in the modelling include:

- cutting and loading at the development face,
- support,
- shuttle car tramming and
- shuttle car discharging.

To provide useful results any modelling system will need to consider:

- Operations over a complete pillar.
- Allowance for planned and unplanned events that effect production.

In modelling/analysing the underground roadway development process it is essential to consider operations across the entire pillar as the dynamics changes as the miner moves away from the boot end. As the miner advances the tramming distance increases. The increased tramming distance increases the shuttle cycle time and reduces its haulage rate. As a result, the combination of miner, support and car capacities that are most productive at the start of the pillar may not be the best combination towards the end of the pillar. Analysis needs to consider operations across the entire pillar.

RoadSIM modelling system

RoadSIM simulator has inbuilt ability to respond to "what if" variations and provides means for assessing the operational limitations of roadway development practices at a coalmine. Figure 1 shows the basic components of the system. The key attributes of the *RoadSIM* simulation system are:

- The ability to respond to "what if" questions. For example, impact on roadway development rate if the development resources, technologies or practices are altered.
- Reproduction of the randomness of roadway development processes.
- The use of animation to view roadway development operations and bottlenecks.

The *RoadSIM* system has been developed using Microsoft's Excel spreadsheet software and the Arena Simulation system. Excel is used to provide a flexible and familiar data entry and reporting facility while ARENA is used to provide the simulation engine and animation facilities.

Using the system involves defining the configuration to be modelled then testing likely performance by running the model and reviewing the animation and output report. Each model run of the simulator is replicated many times with the same model setup but different unplanned events. Results generated provide likely range for time to develop a pillar length, exposure rates (m/hr) as well as utilisation of time. The model once configured can be used to explore the potential impact on development rates and equipment utilisation of alternate practices and/or equipment.

Typically *RoadSIM* would be used to consider the impact on development rates of aspects of operations such as:

- pillar and cut through dimensions,
- number of shuttle cars in use,
- cycle times for cutting and loading at the development face,
- cycle times for bolting,
- shuttle car tramming speeds,
- cycle time for discharge of a shuttle car,

- delays effecting f out bye services, and
- delays effecting face operations.

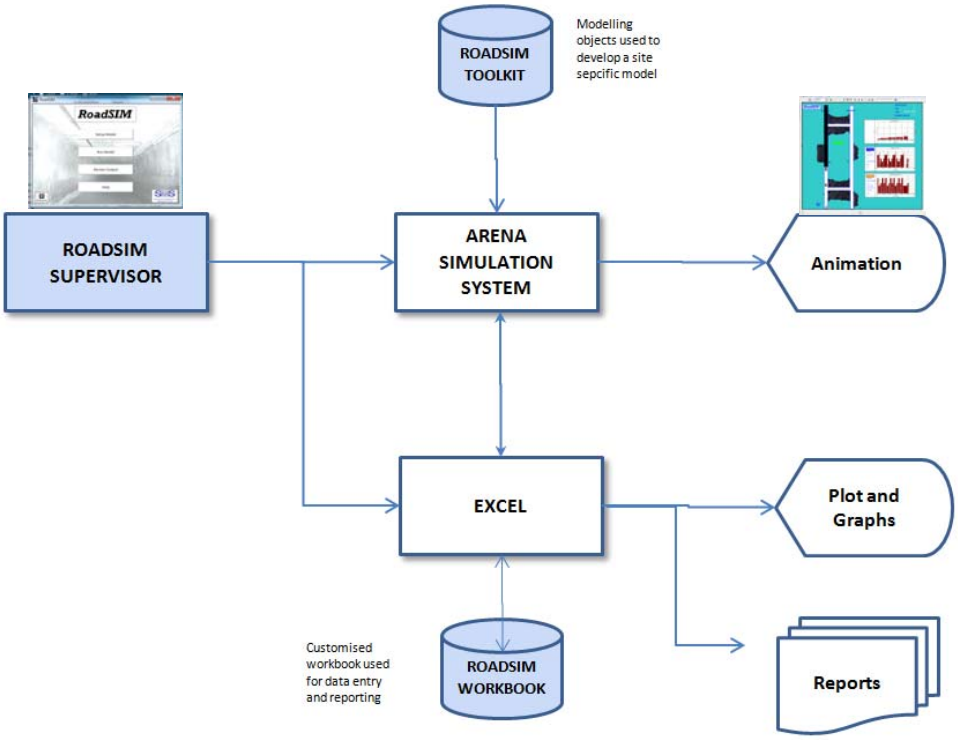

Figure 1 - Basic Elements of *RoadSIM System*

RoadSIM setup

An example of the Excel workbook used to set up the simulation model is shown in Figure 2. Data is entered using customised Excel spreadsheets enhanced with a menu and navigation system. Data required to setup the model includes:

- roadway dimensions,
- the performances of continuous miner, bolter and the shuttle car, and
- planned delays and unplanned (randomly imposed) delays.

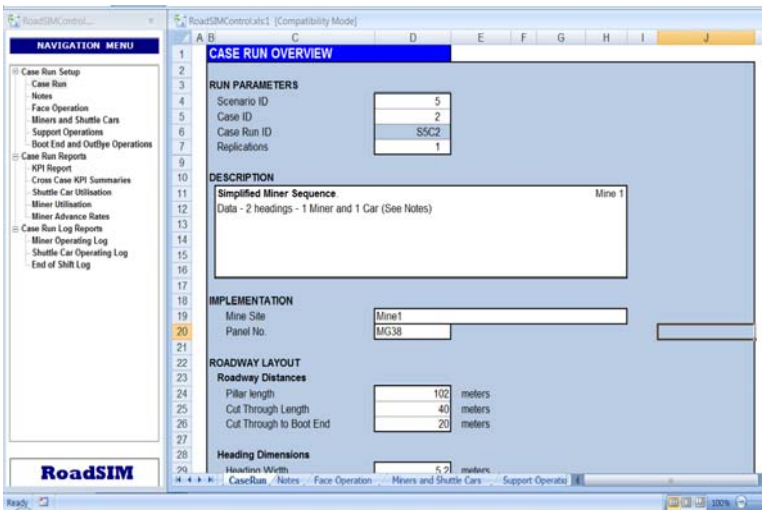

Figure 2 - *RoadSIM* run overview

Once the model is configured the model is run so that the animation (Figure 3) can be reviewed to both ensure the operations are as intended and to provide an understanding of the dynamics of the system. To complete the analysis each model run is replicated many times with the same model setup, but different unplanned events. When analysis is complete the model results are loaded back into Excel for review.

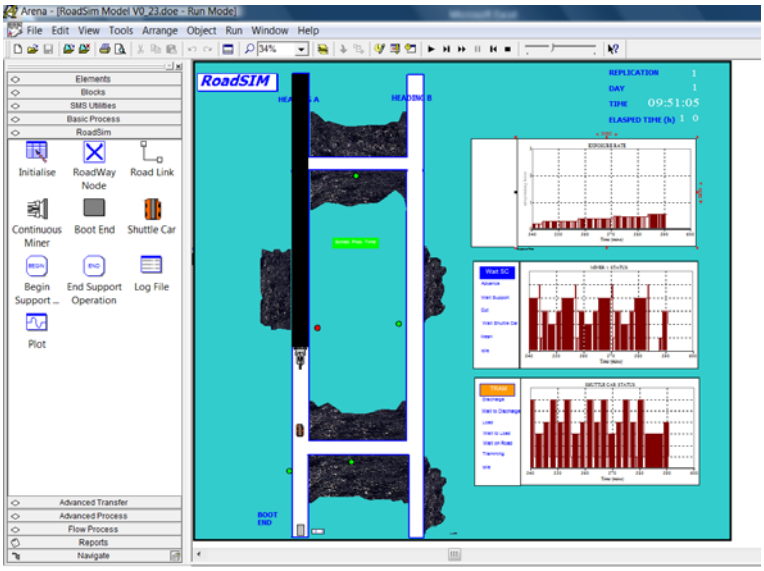

Figure 3 - *RoadSIM* animated display

RoadSIM output

Model output provides summary information on performance indicators such as:

- First coal to first coal time between pillars.
- Face exposure rates in meters per operating hours.
- Miner utilisation.
- Shuttle car utilisation.

As well as high level summaries (Figure 4) more detailed information is available on likely advance rates across the length of the pillar (Figure 5).

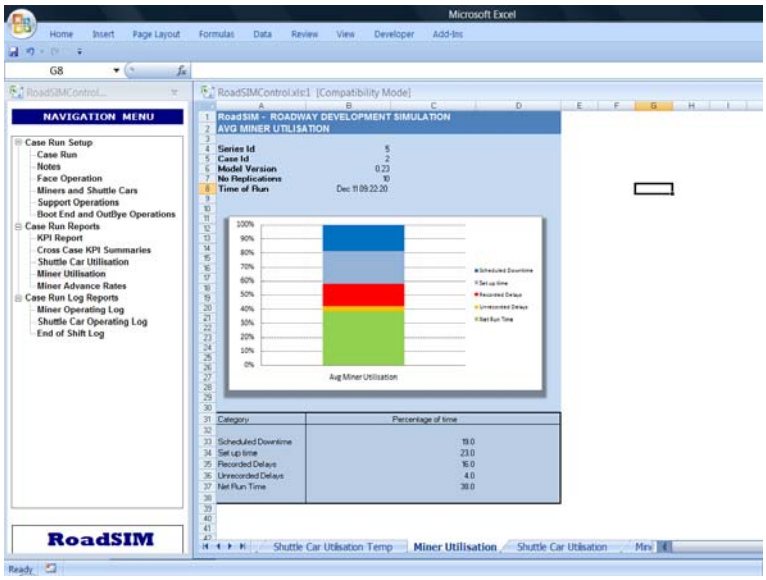

Figure 4 - *RoadSIM* Summary Statistics

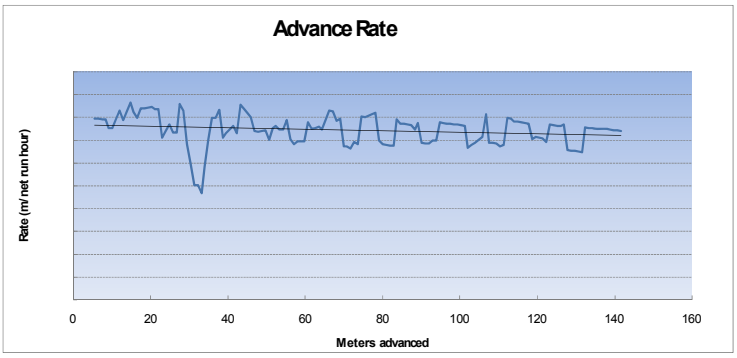

Figure 5 - *RoadSIM* Sample Output

By comparing the performance statistics generated the model can be used to determine if options being considered provide a improvement in development rates, or simply move a bottleneck to another point in the process.

CONCLUDING REMARKS

A discrete simulation model has been developed using ARENA for the Australian coal mining industry to model and manage the performance of roadway development as required to support longwall mining operations. The modelling system allows various options to be explored to determine how a required development rate can be best achieved to support longwall advance rates. The current version of the *RoadSIM* template provides a model for up to two continuous miner with single or multiple shuttle car operations operating in two headings. Future development work will include alternative headings and face equipment configurations as well as continuous haulage systems.

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REFERENCES

Gibson, G (2005), *Australian Roadway Development – Current Practices*, ACARP Project C15005, 134pp

Kelton W D (2007), *Simulation with ARENA* McGraw-Hill, ISBN 978-0-07-352341-5, 630pp