1-1-2012

underground coal mine delay data analysis system

Ernest Y. Baafi
University of Wollongong, ebaafi@uow.edu.au

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

underground coal mine delay data analysis system

Abstract
Due to the high levels of uncertainty in underground coal mining operations, delays occur regularly which inadvertently reduce the utilisation of mining equipment. In most coal mines delay data is primarily sourced from shift reports, machine monitoring and production systems. The recording process is initiated commonly at the end of a shift to ensure the correct information is recorded for the managerial decision process. An issue that the Australian coal industry faces is the lack of a standardised delay recording process and delay classification system. Tools used within the industry to analyse delay data are mostly mine specific and offer no means of comparing the mine performance to the performance at other mine sites. This paper describes a VBA based delay data analysis tool UCDelay for underground coal mines. UCDelay is an add-in Excel module for classification of delay data into a standardised form.

Keywords
coal, data, analysis, system, mine, underground, delay

Disciplines
Engineering | Science and Technology Studies

Publication Details
Baafi, E. Y. & Porter, I. (2012). underground coal mine delay data analysis system. In R. Singhal, E. Topal, K. Fytas, M. Yellishetty & A. Mehrotra (Eds.), Mine planning and equipment selection (pp. 60-68). Irvine, California, USA: The reading matrix Inc.

Underground Coal Mine Delay Data Analysis System

E BAAFI and **I PORTER**
School of Civil, Mining and Environmental Engineering, University of Wollongong, Wollongong, NSW, Australia

Due to the high levels of uncertainty in underground coal mining operations, delays occur regularly which inadvertently reduce the utilisation of mining equipment. In most coal mines delay data is primarily sourced from shift reports, machine monitoring and production systems. The recording process is initiated commonly at the end of a shift to ensure the correct information is recorded for the managerial decision process. An issue that the Australian coal industry faces is the lack of a standardised delay recording process and delay classification system. Tools used within the industry to analyse delay data are mostly mine specific and offer no means of comparing the mine performance to the performance at other mine sites. This paper describes a VBA based delay data analysis tool *UCDelay* for underground coal mines. *UCDelay* is an add-in Excel module for classification of delay data into a standardised form.

Keywords: Equipment delay analysis, unplanned delays and add-in Excel VBA

1.0 Introduction

A delay is recognised as any event that holds up production or prevents machinery from operating under normal conditions. It occurs regularly in mining processes as the underground environment is unpredictable and operating machinery needs regular maintenance. Figure 1 (Porter et al, 2010) provides a visual representation of the breakdown of the total available time given to any piece of machinery. The calendar time is the total time that the equipment is available. This is normally reduced by non-resourced time, e.g. public holidays where no labour resource is allocated. Once maintenance times and operational delays are deducted from this, the potential operating time for the machine is found. The amount of time left after accounting for maintenance times and operational delays is the operating time. This time is further reduced to production time by other operational procedures when the machine not performing its primary function. The production time is also reduced by inherent unrecorded delays e.g. a continuous miner waiting for a shuttle car. The final time left is the net run time which is the actual amount of time the machine is performing its primary function.

Australian mining companies have compiled different frameworks for the recording and reporting of time and performance measures. Examples of some of the ‘time nomenclatures’ across the industry are provided in Figure 2 (Porter et al, 2010). Mine ‘A’ breaks unplanned delays into two sub categories, electrical delays and mechanical delays under the common category ‘Maintenance’. Mine ‘B’, however, classes unplanned delays into ‘Unscheduled Process’ or ‘Unscheduled Equipment’ delays. Mine ‘C’ combines all the unplanned equipment downtime into a single category named ‘Unscheduled Loss’. There is definitely a lack of consistency within the industry which does not provide an opportunity for mines to benchmark their delays against others.

The Australian coal mining industry has not yet seen the importance of standardising this framework to provide mine sites with a generic ‘time nomenclature’ that provides a base for mines to compare performances. This paper involves the development a VBA based system *UCDelay* (Patten, 2009) which manipulates underground coal mine unplanned delay data into a generic form. *UCDelay* accepts different formats that delay data may be presented and then classifies the mine’s unplanned delays into the following seven categories (Porter et al 2010):

- Mine Process delays which are events that prevent equipment operators from getting to the working face on time. These delays can include industrial disputes or pit top safety meetings.

- Outbye Service delays which are delays that are outside the control of the working panel, for example main belt conveyors, drift winder or mine site power failures.
- Panel Engineering is any delay that is equipment related including planned maintenance or equipment broken down.
- Panel Process delays refer to any event that is controlled by the deputy such as any process part of the mining cycle, which includes crib or brief safety meetings.
- Sequence Moves delays refer to the time taken to move a continuous miner from one heading to another heading or advance the boot end one pillar.
- Unscheduled delays are any delays when no direct labour has been allocated, such as public holidays.
- Unrecorded delays are the loss of production time due to operational necessities such as positioning the miner or waiting on the shuttle car, and are in effect a measure of the efficiency of the cycle after all other delays have been taken into account.

2.0 Design of *UCDelay*

The flowchart of *UCDelay* is shown in Figure 3; its three main design modules are:

1. Categorising Process – This process categorises user specified delays into the above seven generic classes.
2. Combination of delays that are continued on from one another – Combining such delays rather than reading them in as separate delays provides a much more accurate depiction of the actual mining delay.
3. User manipulation and checking of delay categories – The user interaction is vital to the accuracy of the delay summaries.

In most coal mines delay data is primarily sourced from shift reports, machine monitoring and production systems. The delay information is routinely recorded using database software such as Maptek MineSuite. It should be noted that *UCDelay*'s current design only allows for input data in the format that MineSuite creates. Table 1 is a typical output of MineSuite in MS Excel format. The delay reporting process requires the recording of date, time, duration and type of delay. Additional data recorded are sources of delay and whether the delay is scheduled or unscheduled. These key pieces of information are used by *UCDelay* to classify delay data. The key element of *UCDelay* is "word bank" which allows the user to define key words to describe the mine's unplanned delays that correspond to each of the seven generic delay categories.

2.1 Validation of *UCDelay*

To ensure that *UCDelay* produced accurate results, the program was validated against delay data obtained from Mine X and Mine Y. Validation was performed at various stages of the program design, and also at the final completion of the program. The first stage of program validation was performed on the subroutine that sorts the delays into categories. *UCDelay* stores the delay data into the memory and then cross-referenced each delay against the words in the word bank to find which category the delay was grouped under. Validation of this stage used Mine X delay data which had been manually sorted and categorised (Boyd et al, 2009). The delay file that was produced grouped common delays under four different delay headings, 'Event All' (EA), 'Random All' (RA), 'Event Heading' (EH) and 'Random Heading' (RH). In the these classifications 'Event' refers to a particular event, such as stone-dusting that causes a delay in production, 'Random' is a purely random delay, 'Heading' is an event or random delay that only affects the heading in which it occurs and 'All' refers to an event or random delay that affects the development process in all headings. The word bank in *UCDelay* was set-up so that each of the categories was named the same as the four categories used above. *UCDelay* sorted the delay data and placed each corresponding delay under the appropriate delay category (Table 2).This categorising test proved that the sorting logic worked successfully. Others (Anon, 2009) from Mine Y had done a similar grouping to Boyd et al (2009), however the categories used in this case were the same categories that are used by *UCDelay*. Table 3 compares this classification with *UCDelay* using Mine Y delay data.

3.0 Application of *UCDelay*

Baafi et al (2009) used *UCDelay* was used to compare unplanned delay data obtained from three mines; each of the mines uses a different time nomenclature. All three mines had a different length of delay recording period. Data from Mine 1 was taken over three months, Mine 2 was taken over a year and data for Mine 3 was taken over a period of ten months. A summary of two of the mines delay data are provided in Table 4 while Figure 4 shows the distributions of unplanned delays summaries of two roadway development areas. Figure 5 summarises the associated delays for the three mines. Relatively higher delays are associated with panel engineering and panel process for all the three mines. Delays associated with planned panel engineering are typically scheduled maintenance which tends to take an entire shift (Figure 6). Electrical systems for both the continuous miner and shuttle car are the major causes of unplanned panel engineering delays with the three mines. This was followed by breakdown of hydraulic systems (air/water) and conveyors. Although delays associated with the continuous miner are usually few, they may take a minimum of a shit to be rectify. Figure 7 show the distribution of unplanned panel engineering delays in minutes for one of the mines. Most of the delays were under 15 minutes. Figure 8 shows delays associated with unplanned mine process which was in the range of 15-45 minutes. These delays involve injuries and accident investigations. Waiting for resources took up to a full shift. Planned mine process delays took a short time, mostly about 15 minutes involving crib room discussions and undermanager safety discussions. Unplanned delays associated with outbye service for the three mines were relatively few but when they occur may take days to fix causing severe loss of production. These delays are comprised of transport delays mostly belts and diesel machines.

4.0 Concluding remarks.

A VBA program *UCDelay* has been developed as an add-in for Microsoft Excel to provide mine sites with a generic ‘time nomenclature’ that provides a base for Australian coal mines to compare performances. It is capable of combining any delays that overlap over adjacent shifts. Analysis of delay data from three mines suggests that higher delays are associated with panel engineering and panel process. Delays associated with planned panel engineering are typically scheduled maintenance which tends to take an entire shift.

5.0 References

Anon (2009), Personal Communication.

Baafi, E. Y., Gray G., Porter, I. and Rojas O. (2009), The Modelling of Roadway Development to Support Longwall Mining, ACARP Project C17019 Final Report, 156pp.

Boyd, M.J., Baafi, E. Y. and Porter, I., (2009), Categorising Underground Roadway Development Delays, Unpublished Internal Report, University of Wollongong, 5pp.

Patten, B. J. (2009), “Development of Underground Coal Mine Delay Data Analysis System”, Unpublished BE(Mining) Thesis, University of Wollongong, 146p.

Porter, I., Baafi, E. Y. and Boyd, M. J., (2010), Underground Roadway Development Delays, Published in the Proceedings of Third International Symposium Mineral Resources and Mine Development, pp 321-331.

Table 1 Example *UCDelay* data file

	A	B	C	D	E	F
1	**Shift Date**	**Shift**	**Start Time**	**Duration**	**Major Delay**	**Minor Delay**
2	1/06/2007 0:00	Day	7:00:00	220	Planned Maint.	Electrical
3	1/06/2007 0:00	Night	2:53:00	10	Outbye Services	Coal Clearance
4	1/06/2007 0:00	Night	4:27:00	15	Outbye Services	Coal Clearance
5	1/06/2007 0:00	Day	10:40:00	220	Planned Maint.	Mechanical
6	1/06/2007 0:00	Night	23:00:00	40	Continuous Miner	Roof Bolter
7	1/06/2007 0:00	Day	14:20:00	220	Planned Maint.	Operational
8	2/06/2007 0:00	Night	0:00:00	360	Standby	Week End
9	2/06/2007 0:00	Day	11:20:00	10	Mining Delays	Floor Conditions
10	2/06/2007 0:00	Day	15:51:00	40	Labour Availability	Crib
11	2/06/2007 0:00	Day	8:50:00	20	Mining Conditions	Roof Conditions
12	2/06/2007 0:00	Day	11:00:00	20	Mining Conditions	Roof Conditions
13	2/06/2007 0:00	Day	8:30:00	15	Mining Cycle	Set up Unit

Table 2 *UCDelay* compared to Boyd et al (2009) classification

	Event Duration (Mins)					
RoadSIM Category	**Avg**	**Min**	**Max**	**Total**	**UCDelay**	**M. Boyd**
Event All (EA)	124	5	630	132308	1067	1067
Event Heading (EH)	30	10	180	2351	77	77
Random All (RH)	45	5	630	27099	603	603
Random Heading (RH)	58	5	510	19695	341	341
			Total=	181453	2088	2088

Table 3 *UCDelay* compared to Anon's (2009) classification

	Event Duration (Mins)					
RoadSIM Category	**Min**	**Max**	**Total**	**UCDelay**	**ACARP**	**Difference**
Mine Process (Planned)	5	5280	29116	136	136	0
Mine Process (Unplanned)	10	175	970	16	16	0
Outbye Service (Unplanned)	3	4020	69312	2239	2237	2
Panel Engineering (Planned)	20	720	58643	312	312	0
Panel Engineering (Unplanned)	5	2880	70165	1185	1185	0
Panel Process (Planned)	5	720	49116	5366	5366	0
Panel Process (Unplanned)	5	720	58403	2756	2758	-2
Sequence Move (Planned)	30	3060	87502	191	191	0
Unscheduled Delay (Planned)	30	3870	344865	610	610	0
		Total	768092	12811	12811	0

Table 4 – Summary of delays of one of a coal mine (Baafi et al, 2009)

	Event Duration (Mins)		
Delay Category	**Min**	**Max**	**Total**
Mine Process (Planned)	5	5280	29116
Mine Process (Unplanned)	10	175	970
Outbye Service (Unplanned)	3	4020	69312
Panel Engineering (Planned)	20	720	58643
Panel Engineering (Unplanned)	5	2880	70165
Panel Process (Planned)	5	720	49116
Panel Process (Unplanned)	5	720	58403
Sequence Move (Planned)	30	3060	87502
Unscheduled Delay (Planned)	30	3870	344865
		Total	768092

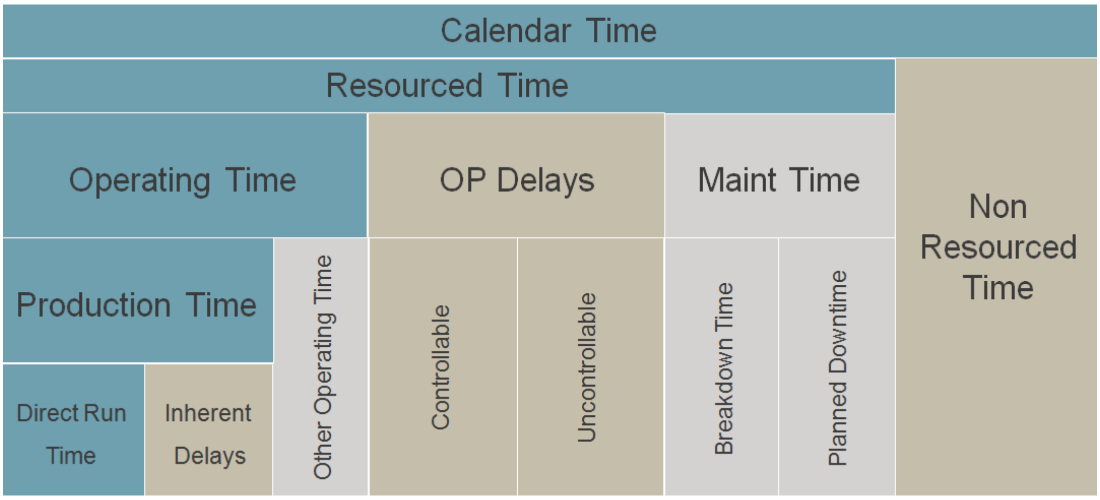
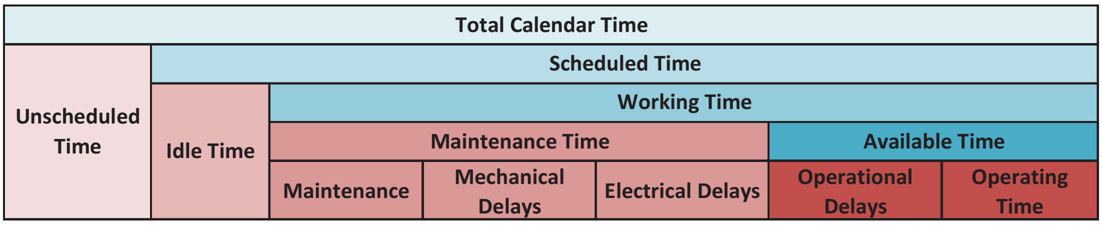
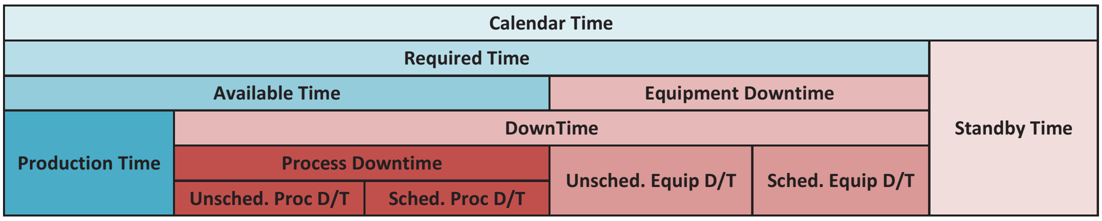


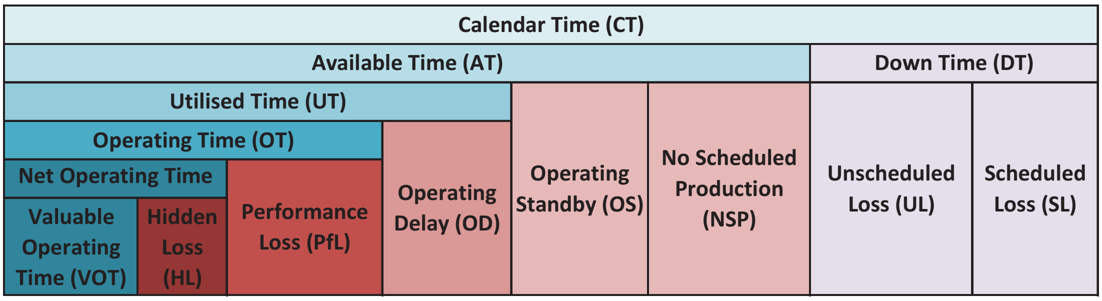
Figure 1 Breakdown of calendar time for typical mining equipment (Porter et al, 2009)



(a) –Mine 'A' time nomenclature



(b) –Mine 'B' time nomenclature



Mine 'C' time nomenclature

Figure 2 Examples of delay time nomenclatures (Porter et al, 2009)

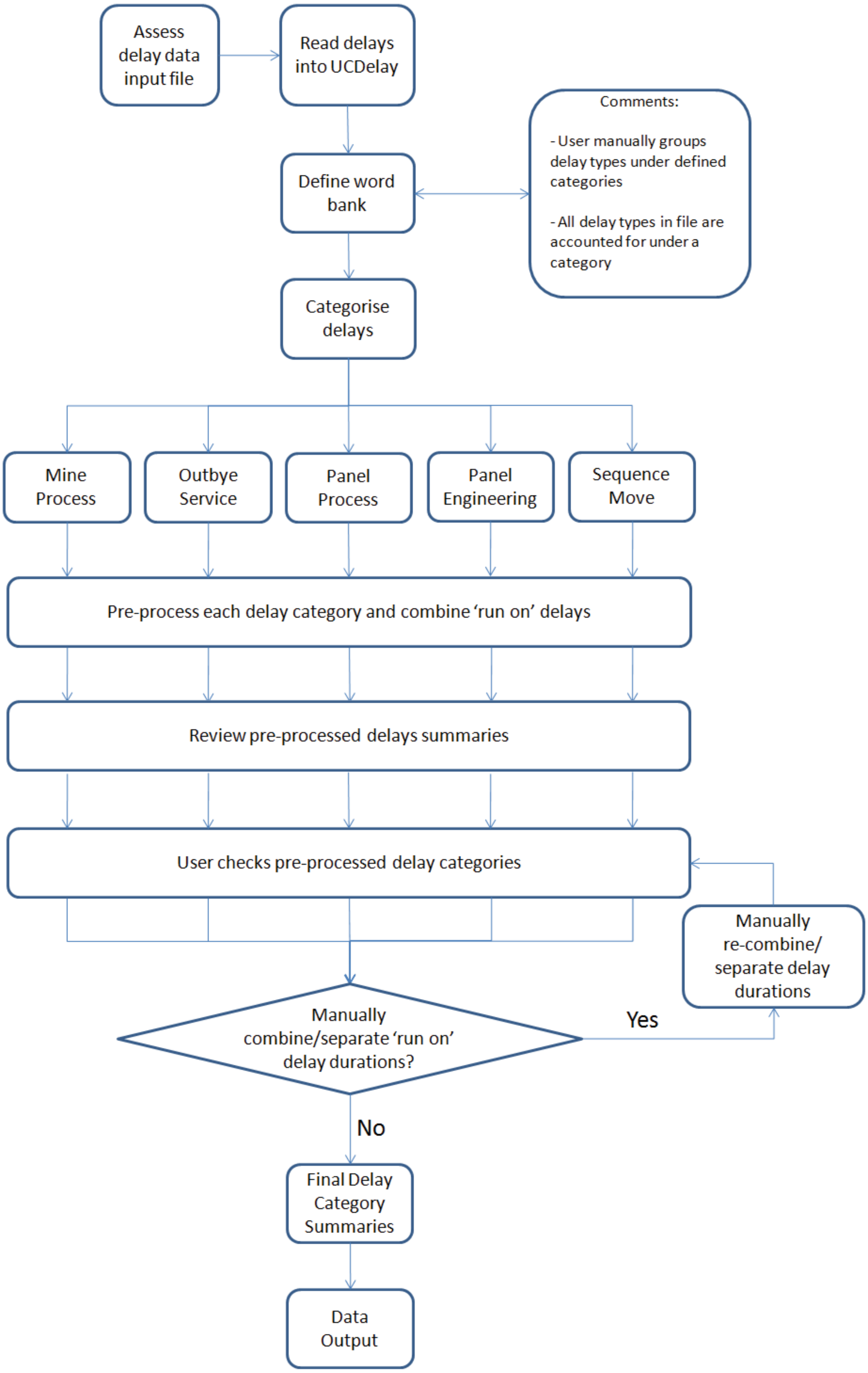


Figure 3 *UCDelay* program flowchart

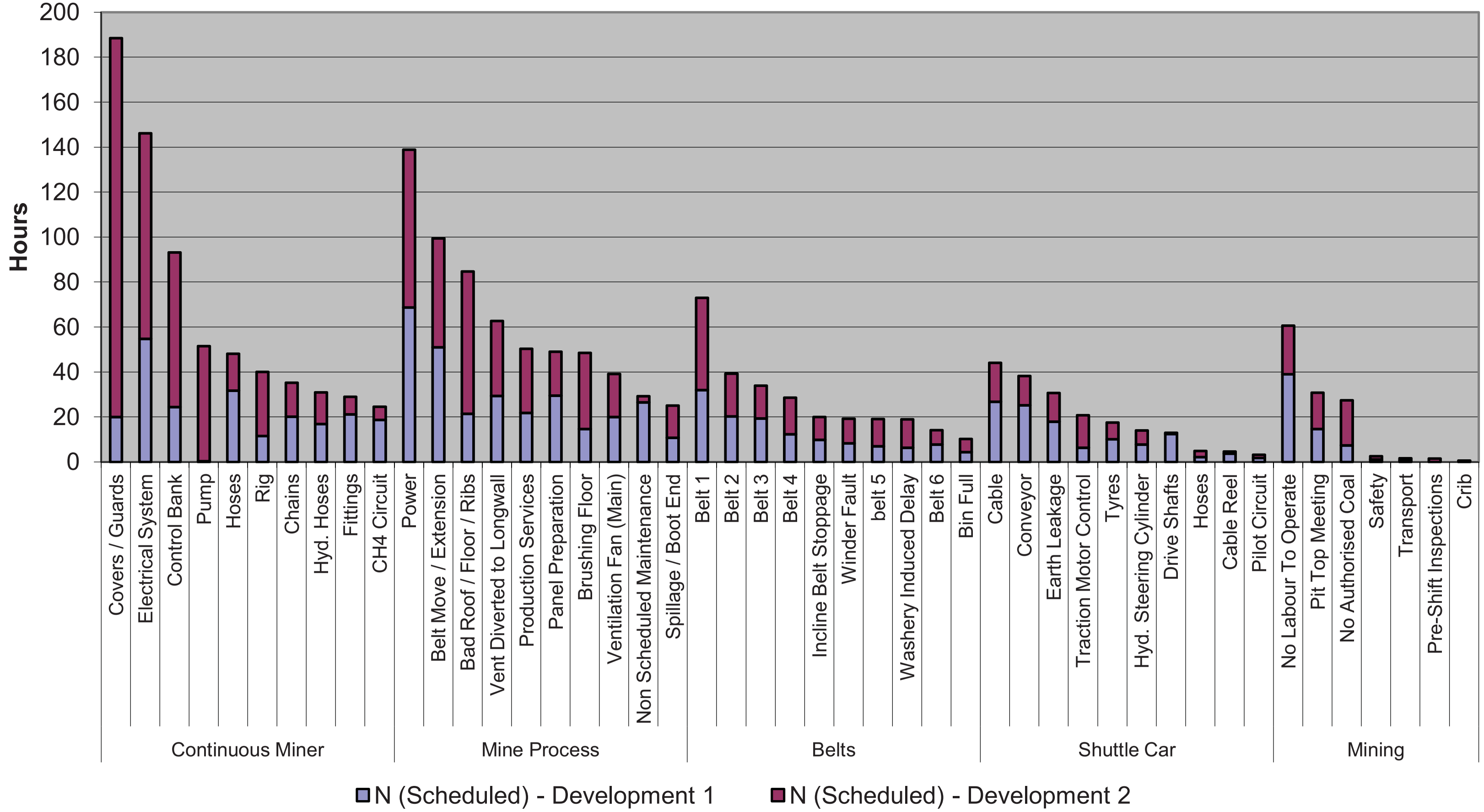


Figure 4 Delay types of a typical development panel

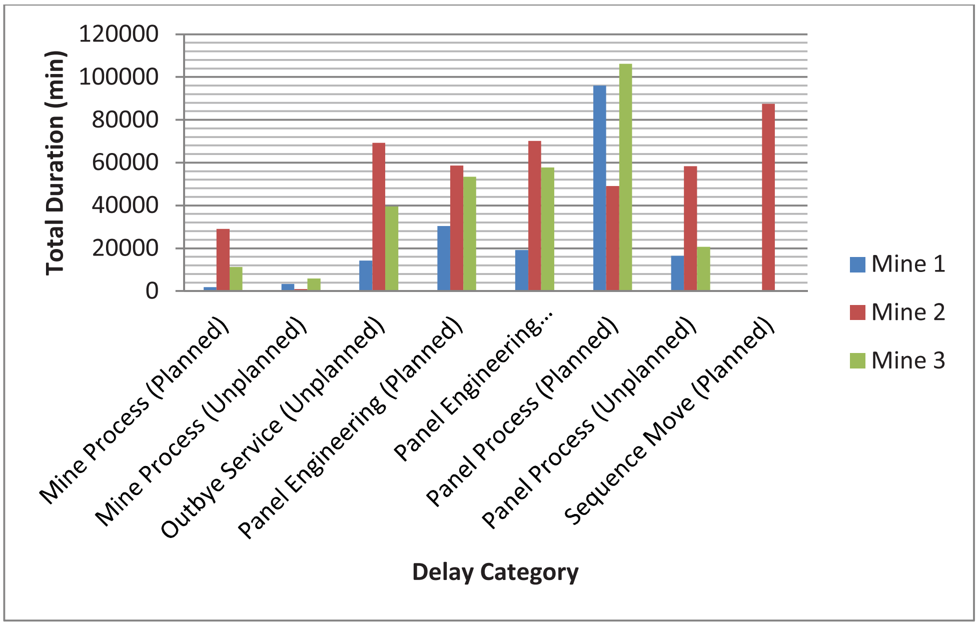


Figure 5 Summary of overall delays for Mines 1, 2 and 3

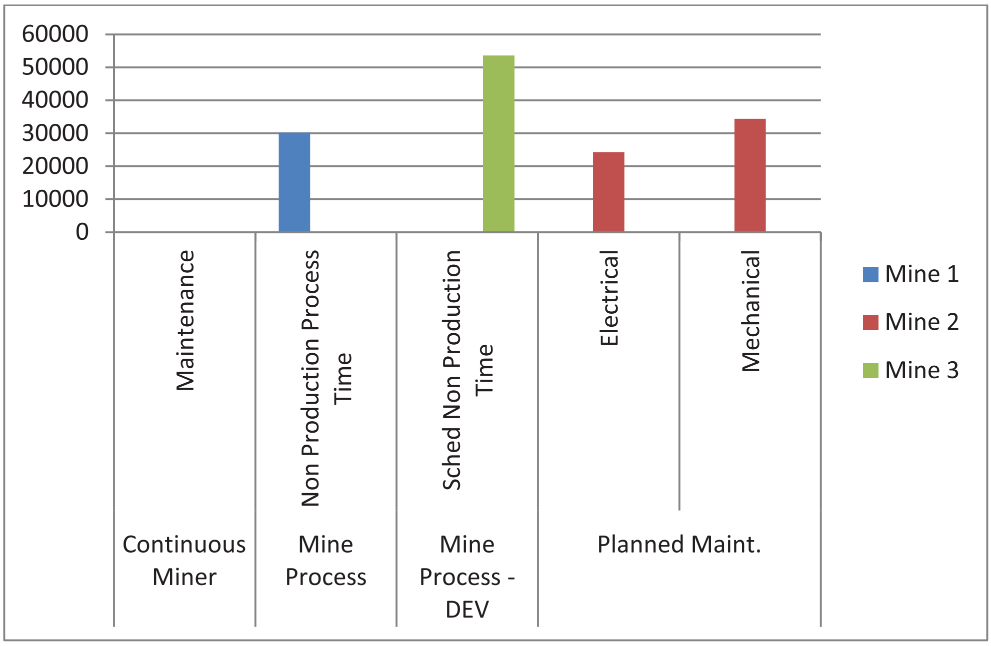


Figure 6 Summary of Mines 1, 2 and 3 Panel Engineering (Planned) delay times (min)

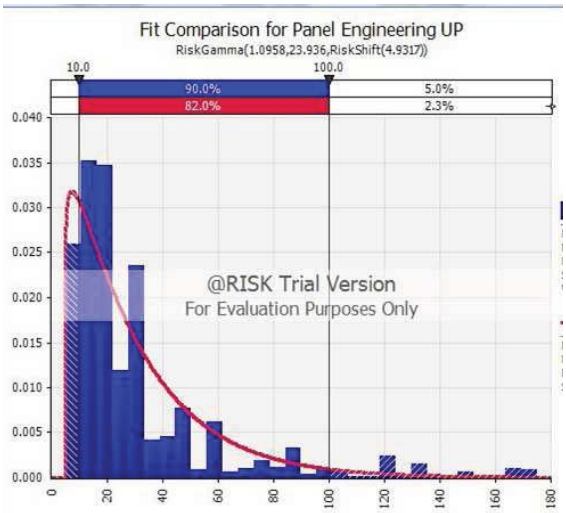


Figure 7 Distribution of Unplanned Panel Engineering delays

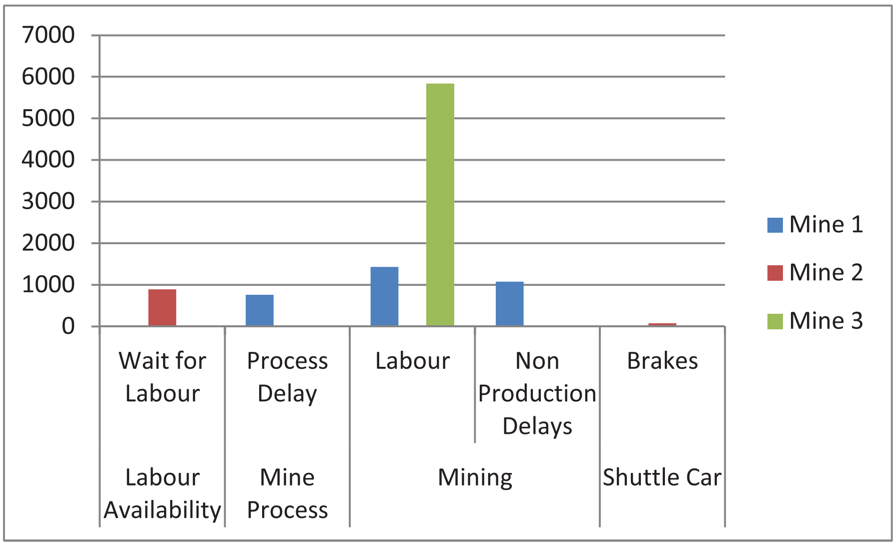


Figure 8: Summary of Mine Unplanned Process delays of three mines