Review of Significant Incidents to understand impact of planned/unplanned maintenance

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Abstract

The aim of Rio Tinto is to achieve zero harm to employees during operations. Although many improvements have been made in reducing harm, research is needed to identify opportunities for further improvements. Past work from the Department of Mines and Petroleum, WA and Rio Tinto Iron Ore (RTIO) suggests that maintenance and whether it is planned or unplanned is an area of investigation in relation to safety incidents. The project uses data mining to connect records on Significant Incidents (SI) from within RTIO during 2012-13 to maintenance activity records.

The results include the development of a repeatable process for this data mining as well as insights from the analysis. Two data sets are produced, the first contains only records of SI events and the second covers workorders that did and did not result in SI events. The results showed some interesting leads for further investigation particularly focussed on the SIs that involve simple maintenance work conducted by apprentices. Recommendations are made to improve the efficiency of the process so it can be expanded to other sites across the business.

1. Introduction

The aim of Rio Tinto is to achieve zero harm to employees, the environment and communities while undertaking operations. While many initiatives currently exist to support this aim, new analysis and potential controls to assist in achieving this goal are being sought. Previous work has prompted a review of safety incidents in regards to maintenance activities.

The tracking of safety incidents resulting in injuries in Australia is enabled through reporting of the Lost Time Injury Frequency Rate (LTIFR), which gives the number of injuries per million hours worked (Department of Mines and Petroleum 2014b). The LTIFR provides an indicator of risk and measure of harm to the workforce in industry.

The LTIFR average for mining in Australia for 2011-12 was 5.0 injuries/10^6 hrs worked, lower than the all industry average of 6.8 (Safe Work Australia 2013). The latest injury rate(2012-13) for Iron Ore mining in WA is 1.6 injuries/10^6 hrs worked is significantly lower LTIFR than both the average for Australia and the mining industry(Department of Mines and Petroleum 2014b). Rio Tinto uses a different measure, the All Injury Frequency Rate (AIFR) to track safety performance. The group average AIFR has seen a reduction of 20% over the

last five years (Rio Tinto Group 2014), and there is still a strong commitment continue with improvements to reduce this further, with the aim to achieve zero harm.

A recent review of safety data from 2000-2012 by the Department of Mines and Petroleum (Department of Mines and Petroleum 2014b)found that 36 of 52 (69%) of fatalities involved either maintainers or operators (Department of Mines and Petroleum 2014a). This review demonstrates the insights available from analysis of historical data and suggests that maintainers may be at a high risk of injury.

2. Process

To investigate the relationship between safety incidents and maintenance activities an appropriate set of data is needed. Within Rio Tinto there are two classes of records, Significant Incidents(SIs) and all Significant Potential Incidents(SPIs). An SI is an incident where the actual consequence is serious, major or catastrophic and the maximum reasonable outcome(MRO), based upon the likelihood and consequence of the incident, is high or critical, where as a SPI has a MRO of critical and actual consequence of near hit/miss minor, medium or serious, with SPIs being a subset of SIs. After considering a number of options, sample data was collected from the mobile maintenance group at a single site over the period 2012 to 2013.

As analysis of incidents in regards to maintenance had not been previously attempted a process for gathering and methods of matching data needed to be developed Figure 1 illustrates the complexity of the problem with information stored in data warehouse reports, enterprise software (SAP) tables, business solution attachments and HR documentation. Much of this collection, manipulation and matching was done manually with a starting data set of over 1,000 incident records and over 58000 maintenance records in the sample maintenance data.

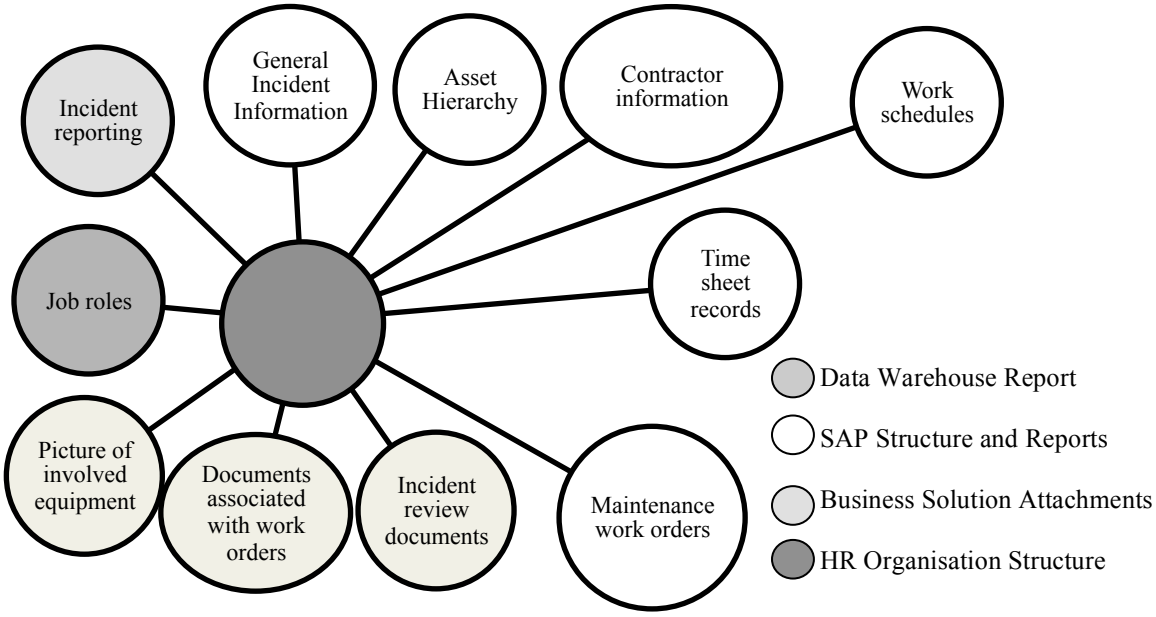

Figure 1 Data collected for investigation.

Once incident data had been collected analysis was performed to identify those in which maintenance occurred, and then work orders matched, producing the SI dataset. The sample dataset could then be extended, by including whether the maintenance led to an incident. This

allowed analysis of all maintenance incidents that occurred as well as statistical analysis of work being done and its relation to incidents occuring. The breakdown of incidents and work orders is illustrated below in Figure 2.

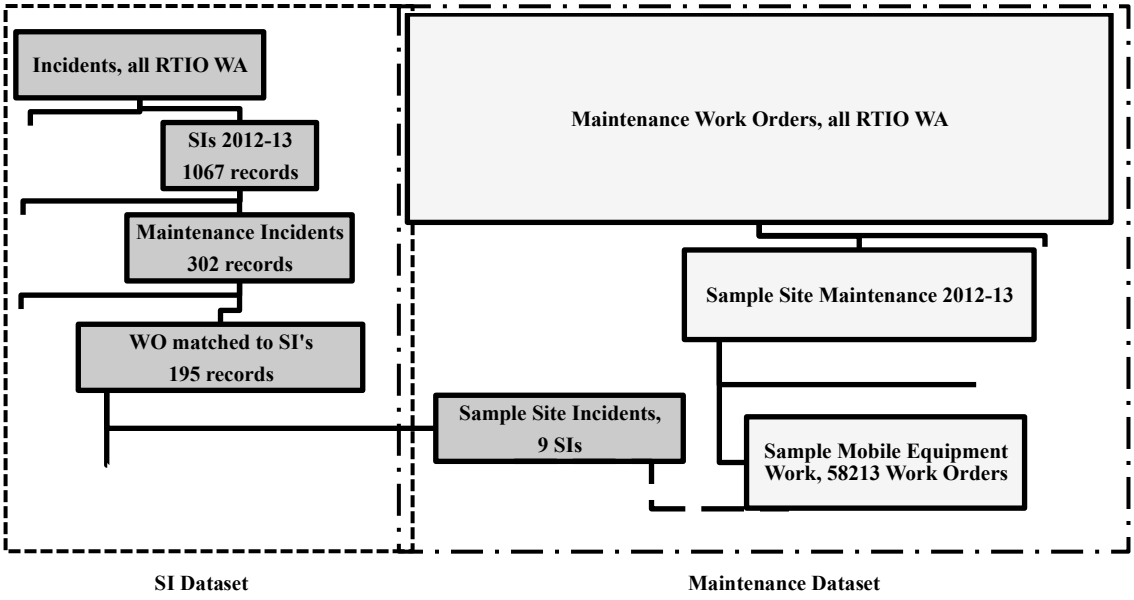

Figure 2 Breakdown of incident and maintenance data.

Investigation was completed on both datasets compiled from incident and maintenance data. The dataset of SIs was explored to find common factors within the data and logistic regression analysis performed on the sample of maintenance data.

3. Results and Discussion

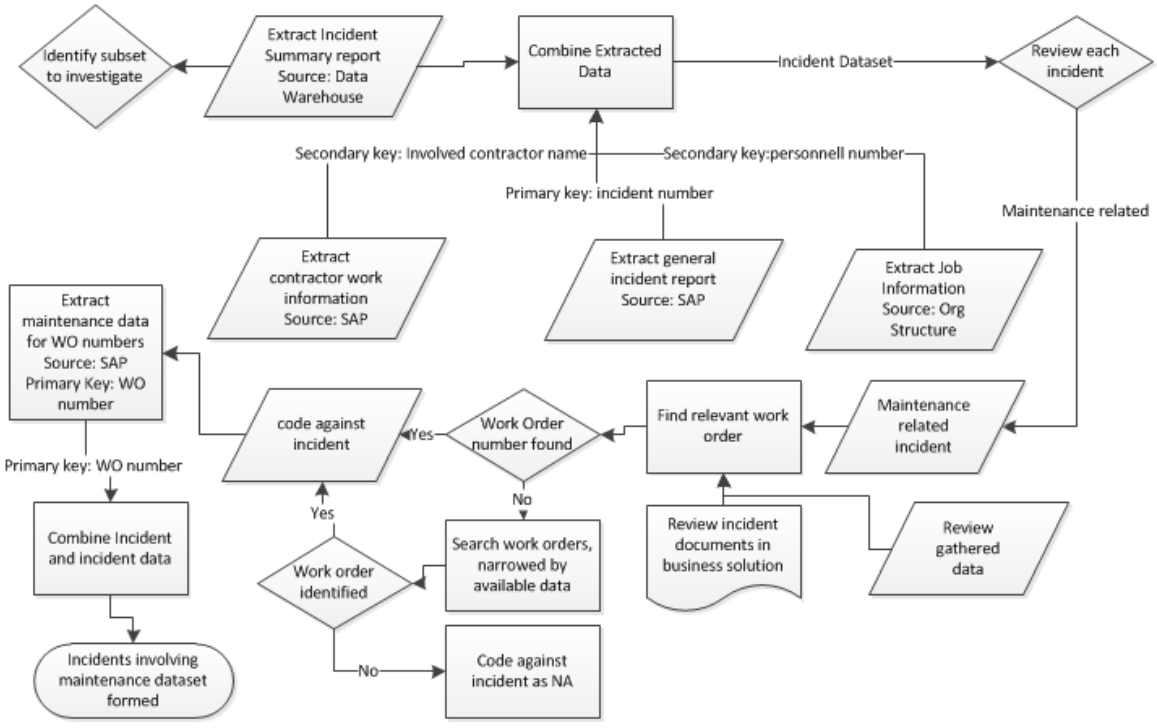

Figure 3 Process for matching incidents to work orders.

A major outcome from the investigation performed is the development of a process to identify and link incidents where maintenance was a factor to the relevant maintenance workorder. This process is illustrated in Figure 3.

3.1 SI Dataset investigation

The dataset of 195 Significant Incidents has been examined using exploratary data analysis techniques. Initial investigation has revealed that the SIs contain a significant proportion of corrective or breakdown work, based upon maintenance control keys assigned based upon the maintenance being primary or corrective. Similarly investigation around the priority of the work orders during which the incident occurred was analysed, with priority based upon the impact of the maintenance not occuring. This also suggests that a high proportion of incidents occur during high priority work orders. The initial exploratory analysis has suggested that common sets of factors may exist in the dataset of maintenance SIs.

To identify common combinations of factors in maintenance incidents ongoing analysis is needed. Future work will use the technique of frequent set mining to explore this. The use of the market-basket model to identify common combimations of factors or “items” occuring in each incident or “transaction” allows the use of the dataset where only incidents occur to provide insight into possible causal factors (Borgelt 2012)

3.2 Maintenance Dataset investigation

This data set contains 58,213 records of which 9 are associated with SIs and 58,204 were executed without incident. This data set was cleaned and reduced to a set containing 21266 records of which 9 are SIs. As this is a binary data set logistic regression was used to explore the influence of various factors on the occurrence of an SI. Factors examined include the mobile vehicle type, labour cost, material cost, breakdown (yes/no), shift (day/ night) and workorder priority.

It is recognised that the class imbalance ratio between the amount of maintenance work orders completed in the sample and the amount of incidents occuring is an issue for analysis, with only 0.015% of work orders completed resulting in a safety incident occuring. The problem of class imbalance has become a recent focus of research, as it is responsible for a reduction in performance of prediction models, in which binary outcomes are significantly disproportioned(Marqués, García & Sánchez 2013).

However upon review of the incidents occuring within the sample, tabulated below in Table 1, areas for further investigation are identified. It is noted that several of the incidents occur during low cost both in terms of labour and materials and involve apprentices. This suggests that further investigation should be completed beyond the sample to see if this trend continues at other sites, and if so potential changes investigated.

Table 1 Incidents from sample of work orders

Incident Description	Involved Job	Control Key	Priority	Labour Cost	Material Cost	Breakdown	Asset	Shift
Apprentice Maintainer lacerates thumb on lighting plant fan	Maintainer Mechanical Apprentice	PMO2	LOW	500-2000	<500	O	EQUIPMENT	DAY
Maintainer exposed to open edge w/o WAH protection	Maintainer Mechanical Apprentice	PMO3	HIGH	<500	<500	YES	LOADER /DOZER	DAY
MEM employee injures right hand ring finger	Maintainer Mechanical Apprentice	PMO1	MEDIUM	10000-20000	>20000	NO	HEAVY TRAILER	DAY
Dozer Falls from Jacks while removing track	Maintainer Mechanical	PMO2	HIGH	500-2000	<500	NO	LOADER /DOZER	DAY
Loss of steering on Haul truck	Operator	PMO3	HIGH	<500	<500	YES	OFF H/WAY TRUCK	NIGHT
Maintainer injures R/H Ring Finger	Maintainer Mechanical	PMO1	MEDIUM	5000-10000	>20000	NO	LOADER /DOZER	DAY
Maintainer struck in face by sledgehammer	Maintainer Mechanical	PMO3	HIGH	500-2000	<500	YES	OFF H/WAY TRUCK	DAY
Maintainer entered restricted work area unauthorised	Fitter Tyre	PMO1	MEDIUM	2000-5000	>20000	NO	GRADER	DAY
Haul truck wheel motor cover fire	Maintainer Electrical	PMO3	HIGH	500-2000	>20000	YES	OFF H/WAY TRUCK	DAY

4. Conclusions and Future Work

4.1 Conclusions

The two data sets show some interesting features. The SI-only set of 195 suggests that maintenance work associated with high priority corrective work is more highly represented in SI events. The Workorder data set appears to confirm this with high and medium priority work and corrective (PM02 and PM03) work represented. However the Workorder data set also has three of the nine records associated work done by apprentices.

Initial findings also suggest that breakdown work, and work of a high priority, indicators of the level of planning being low, present a higher risk of a safety incident occuring. However it must also be recognised that the vast majority of maintenance is completed without a significant incident occuring, within the sample investigated 99.99% of maintenance occurs without incident.

The development of the capability to link incidents and maintenance data is a critical development in allowing future work to develop a deeper understanding of common factors amongst maintenance related incidents and potential controls to reduce harm to maintainers.

4.2 Recommendations and Future Work

Recommendations, resulting from work throughout the project, for RTIO for changes and improvements are made with the aim to increase the ease the process of conducting future investigations regarding safety and maintenance, aid repeatibility of work and provide capability for other possible investigations. These include;

- Addition of check box and numerical field to record maintenance work order number, the primary key for maintenance data, as a secondary key in incident reports.
- Review of data captured in incident reporting, with the aim of removing redundant and misunderstood data fields, hence improving data quality.
- Creation of specialist maintenance reports to extract data for incident investigation.
- Education around importance of data quality and value it can add in both incident and maintenance reporting.

As the results of statistical analysis are preliminary due to their basis on a small sample it would be of valuable to extend this analysis, while taking into consideration of the class imbalance between occurrence of incidents and maintenance work.

5. Acknowledgements

As well as acknowledging the input from both the client and academic supervisor, I would like to acknowledge the input, support and vast knowledge of others who have assisted with this project, including RTIO WA staff and UWA subject matter experts.

6. References

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