A SYSTEMS BASED ANALYSIS OF 25 SYSTEM SAFETY ACCIDENT INVESTIGATIONS (SSAIS) OF MAJOR MINING EVENTS

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SUMMARY

This paper discusses the causes of major mining incidents and accidents, especially the balance of human error and management system failures in causal information. It examines data from 24 serious mining losses over the past 10 years. All 24 investigations were facilitated by the author using System Safety Accident Investigation (SSAI) methods. All but one occurred in Australia. The paper concludes by clarifying the relevance of management systems failures and the need to learn more from serious events in the future.

INTRODUCTION

Despite the size of the Australian mining business, the people who manage mines are a relatively small and sociable group. Put a few together in one room and it's almost guaranteed that a debate will occur if the causes of major mining accidents are discussed. A usual point of contention involves the degree to which the individual is responsible versus the management system.

It has been clearly demonstrated that human error is a contributor to 80% or more of incidents and accidents. (1, 2)

An unpublished study commissioned by the Coal Mines Inspectorate of the New South Wales Department of Mineral Resources in 1993-1994 examined the nature of human error in 75 Serious Bodily Injuries (SBI). SBI events are reportable to the government and they usually involve more detailed investigation than less severe events. Analysis of the 75 events was done by four Mines Inspectors, one from each of the inspection regions of that period. The inspectors were selected based on their personal familiarity with the recorded events. The author of this article facilitated the analysis.

A method derived by James Reason (3) was used to identify human error and classify the type of error. As a result the team concluded that 71 of the 75 SBIs had an element of active error. Active error involves an error due to an immediate decision, such as that by the victim or a person in the event location. In other words, it was determined that about 95% of the SBIs involved a person at or near the event behaving differently from expectations, contributing to the event.

Minimally, it can be concluded that human error in mining, at least coal mining in NSW, is no different from other industry.

Reason also supplies a framework to analyse the rationale for error. This paper will deal with that subsequently. Before we do that, let's revisit the debate between the individual and the management system.

It's clear that individual or active error is a significant contributor in most unwanted mining events but how much is the management system responsible?

Firstly, what is the management system? For the purposes of this paper the management system is defined as the set of mining engineering and management activities that provide the right people, the right equipment and materials, the right methods, and the right physical and supervisory environment for the mining process.

Reason also suggests a term for errors in the management system. Latent errors derive from decisions made in the management system, such as design, planning, acquisition or maintenance planning errors.

Most people in a mine management group would agree that latent or systems errors exist. However, it's common for some to feel that active or immediate errors are the priority issue rather than latent error.

Again, Reason, one of the most quoted researchers in the human error area, offers his perspective.

> *"Rather than being the main instigators of an accident, operators tend to be inheritors of 'pathogens' created by poor design, incorrect installation, faulty maintenance, inadequate procedures and management decisions and the like. The operators part is usually that of adding the final garnish to a lethal brew that has been cooking. In short: unsafe acts in the 'frontline' stem in large measure from bad*

decisions made by the rear echelons". (4)

Here's where the discussion can start to heat up. Who is really to blame when a major unwanted event occurs? The legal system leaves no doubt that blame is a part of reality. Hence, the sometimes-heated debate is often driven by the "don't-blame-me" factor, a natural reaction when the latent causes of events are not clear to engineers and managers.

The debate becomes even more important if we look at the magnitude of unwanted losses.

THE PROBLEM: FATALITIES STILL OCCURRING

A recent article published on the Internet by the British Nuclear Power Industry notes the following figures for risk of death per year by various causes.

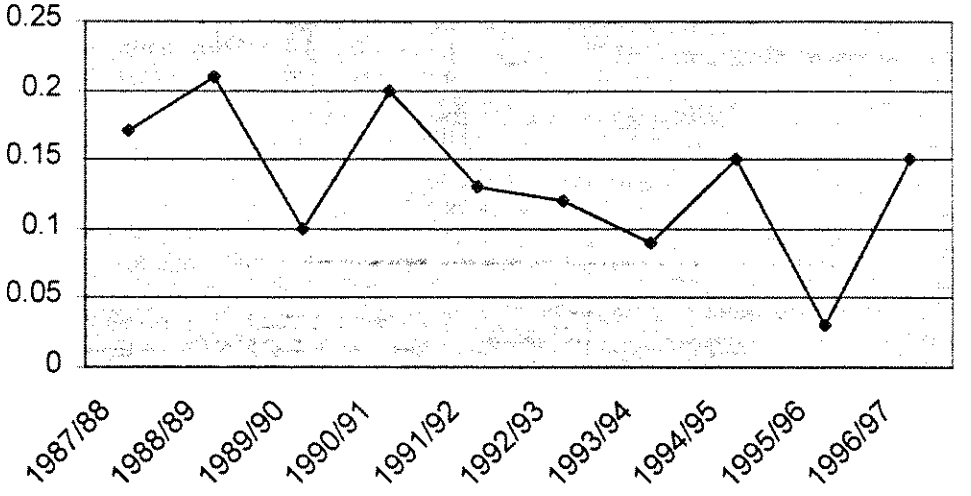
Risk of being killed by lightning - 1 in 10 million
Risk of death by fire or explosion at home - 1 in 1m
Risk of death in a 'safe' industry - 1 in 100,000
Risk of death in a road traffic accident - 1 in 10,000
Risk of death in mining - 1 in 1,000

According to the Minerals Council of Australia, there are about 26 fatalities in Australian mining and minerals processing each year, based on a ten-year average. The mining workforce totals approximately 60,000 people. This means that Australian miners face a risk of death of about **1 in 2,300 per year**. This figure has not been normalised to consider exposure hour differences between British and Australian figures. If we accept that it is generally comparable, 1 in 2,300 is a lower risk than the British figure of 1 in 1,000 but still a much higher risk than 'safe' industry, 1 in 100,000.

If we were to examine the trend in Australian mining fatalities over a recent ten-year period using the graph below, we might conclude that there is a slight downward trend. This should be expected after considerable efforts to improve across the industry.

However, the 1 in 2,300 risk figures indicates that considerable improvement is still required to be a 'safe' industry.

Australian Mining Industry Fatality Rate per Million Man Hours Exposure



Source of data – Minerals Council of Australia

If we add up the costs of all losses and examine them in relation to operating budgets we can expand our image of unwanted events. One detailed study looked at all sources of unnecessary financial loss over a six week period at a US underground coal mine owned by BP (5). The study identified that 25% of the mine's operating budget was spent on

avoidable losses. This was several times higher than results indicated in other business units such as oil refining or offshore oil extraction. Discussions with many Australian mine managers and mining executives have indicated that the BP study may also be generally indicative for Australian mines.

In summary, there is still a major problem with unwanted events in Australian mines, demonstrated by the fatality rate and, if we accept the BP study as indicative, major loss-related operating costs.

Returning to our group discussion, we can introduce some new issues. If we have so many unwanted events, why don't we investigate them to demonstrate the relevance of active and latent errors? That information would not only help clarify our "blame" concerns but also help us avoid future unwanted events.

INVESTIGATIONS OF MAJOR MINING ACCIDENTS

Of course, every mining fatality has some form of in-depth investigation by the regulatory authority and, usually, the involved mining company. In the past few years even the occasional "near miss" has been investigated with similar methods.

The author has been involved in facilitating a large number of major investigations in Australian and overseas mining. Techniques derived from System Safety Accident Investigation (SSAI) (6), sometimes referred to as the MORT approach, were used to analyse and develop relevant outcomes.

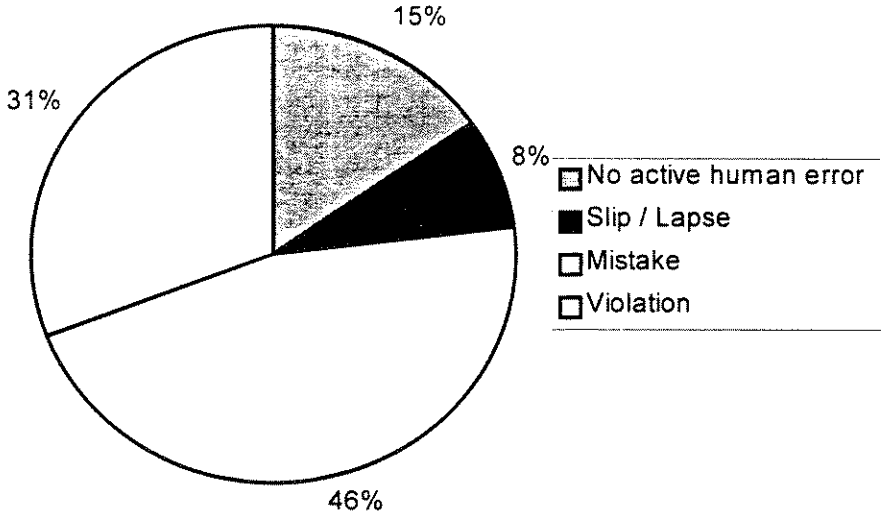
SSAI techniques have also been applied to some losses by the major mining inspectorates in Australia, as well as at least 3 major mining companies. The technique uses a series of analytical tools to examine the nature of the event and the causal factors, including human error, quality of the immediate work process and contributions from the management system.

Although single event reports have been produced, the results of past serious investigations have not been analysed to examine the degree to which individual (active) versus management system (latent) error contributed to the outcome.

To identify possible information from trend analysis of serious accidents, the author applied basic analysis methods to 24 mining SSAIs he facilitated from 1990 to 1998. All but one occurred in Australia and most in coal mining. The analysis was done by reviewing information recalled by the author in his role as the process facilitator. The three parts of the analysis included human error issues, work process issues and management system issues.

The first analysis identified any unexpected active errors and the type of error based generally on Reasons' three categories (3, 7).

Human Error in SSAI Analysis



Slip / Lapses are active errors which involve unintentional deviation from expected behaviour due to typical human fallibility such as lack of attentiveness, distraction or forgetfulness.

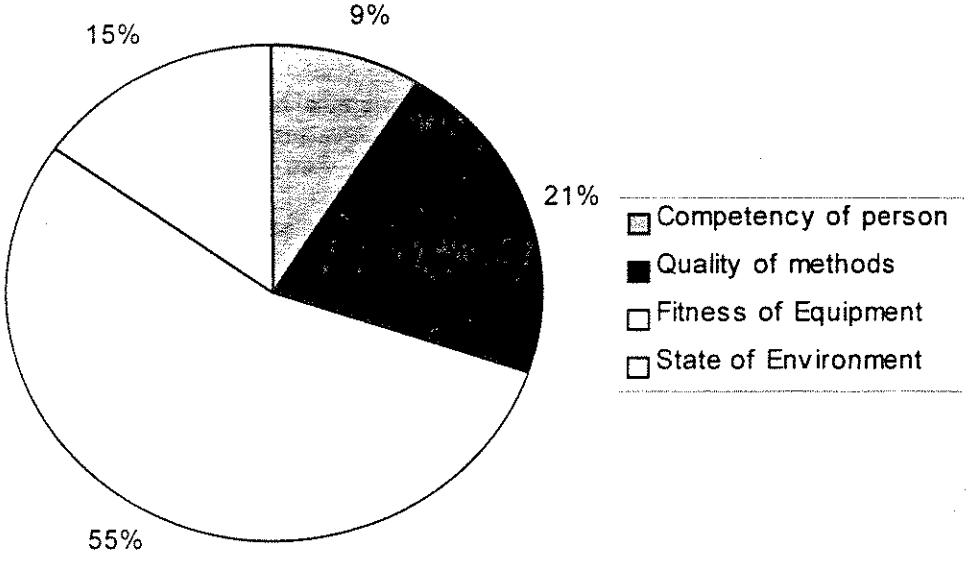
Mistakes are also unintentional active errors; in this case due to decisions where the individual has selected the wrong action based on incorrect information or inadequate competency.

Violations are intentional deviations from expected and known requirements. Often these are culturally influenced. In other words the rule or procedure involved is often compromised as part of the accepted local "set of unwritten rules". Sometimes a violation error is a deliberate, deviant behaviour that the culture would not support.

This analysis appears to demonstrate the magnitude of active error in mining events (approx. 85%), as well as the observation that unintentional error is the major issue.

The next level of SSAI looks at the quality of the work process, considering the quality of competency, methods, equipment / materials and the work environment.

Work Process Issues in SSAI Analysis



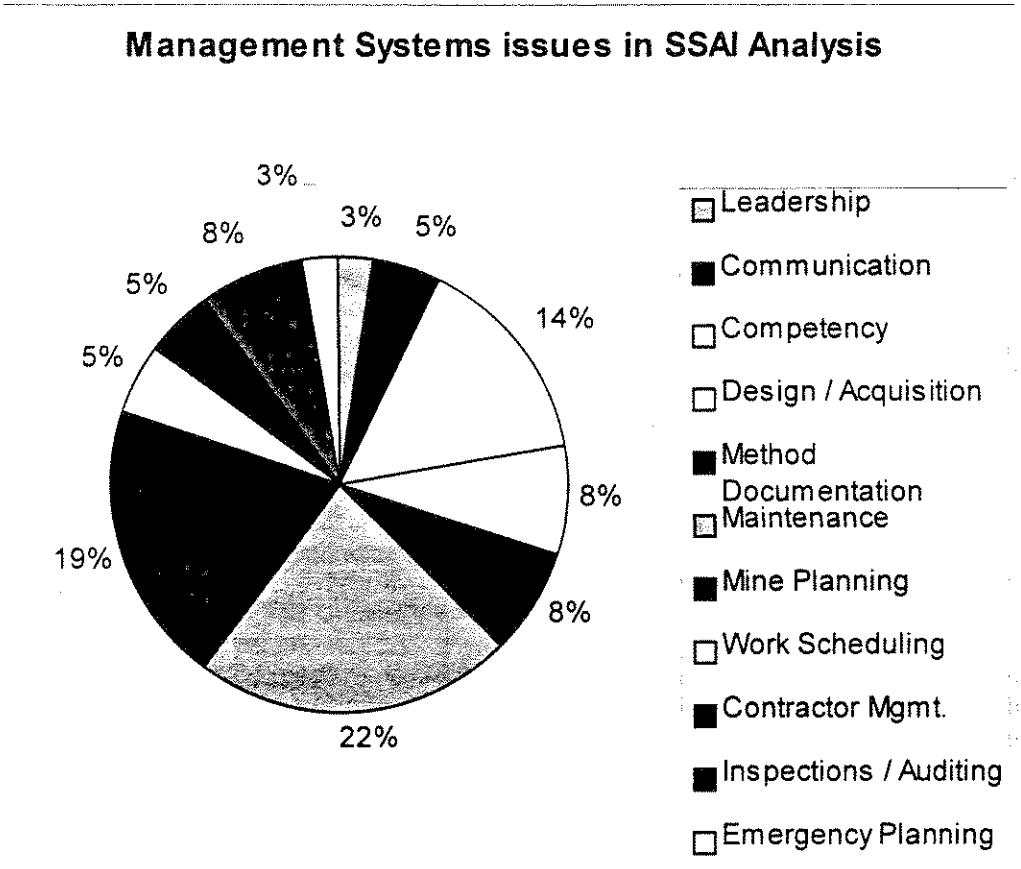
Competency of person	3	9%
Quality of methods	7	21%
Fitness of Equipment / Materials	18	55%
State of Work Environment	5	15%
	33	

This part of the analysis indicates that "fitness" of equipment or materials is the main contributing factor to the sample of serious events. Note that the State of the Work Environment includes the physical work environment (ventilation, traffic, roof/ high wall, etc.), as well as supervisory control of the work.

Finally, possible management systems contributions need to be considered. The SSAI process suggests that the quality of the work process is a result of the management system. Therefore, the degree to which the systems contributed must be assessed.

In an SSAI, management systems review is done by applying a Gap Analysis technique. This technique requires definition of the expected relevant management system and comparison to the actual status of that system in relation to the event.

For the purpose of this analysis, the author defined a set of management activities that might make up a generic mine management system. This set was then used to review the causal information identified by the 24 SSAIs.



Leadership	1	3%
Communication	2	5%
Competency	6	14%
Design / Acquisition	3	8%
Method Documentation	3	8%
Maintenance	9	22%
Mine Planning	8	19%
Work Scheduling	2	5%
Contractor Mgmt.	2	5%
Inspections / Auditing	3	8%
Emergency Planning	1	3%
	40	

Maintenance and Mine Planning appear to be the most common sources of latent errors. Note that this analysis did not include the relevance of corporate or local management commitment. "Leadership" in the above information refers to the direction provided within a supervisory relationship.

WHAT DOES ALL THIS MEAN?

Going back to our fictitious discussion with mining personnel, the above analysis provides some reasonable evidence for the argument that unwanted events involve management system failures. This reinforces the previous quote from James Reason.

Of more importance perhaps is the fact that it may also demonstrate how little the mining industry knows about its unwanted events. Did the reader already know or suspect that an analysis of serious accidents would yield these results?

As previously mentioned, many companies and investigating agencies use detailed investigation methods that, to varying degrees, yield useful information about accidents. However, this information is shared only on a limited basis and no attempt is made to analyse trends or industry needs based on any detailed causal information.

A PATH FORWARD

In this brief paper it is impossible to develop the many intertwining factors that effect our comprehension of the causes of major unwanted events in mining. However, the brief discussion above suggests there are several directions that the industry should take in the future.

1. Recognise that active human error is a major issue but that error is not usually intentional. In other words, it appears that most active human error occurs where the person intended to do things correctly.

2. Recognise that Management Systems failures or latent errors are at least as significant an issue as active human error.

The absence of past trend analysis in mining accident information may also suggest that we should also consider the following.

3. Develop and consistently apply a national mining serious incident or accident investigation method that, like SSAI, effectively examines the full range of causal factors from operator error through to failures in the management system.

4. Develop a national database of causal information which can be reviewed and trended to supply the industry with timely, clear priority concerns for effective solution development.

5. Support the investigation of major actual or potential unwanted events that did not lead to serious personal damage or death in order to make information unfettered by legal processes available in a timely manner to the industry.

These suggestions are intended to serve as a basis for further discussion.

Returning to our gathering of mining people, one more discussion point could be made. They might all agree on one basic human characteristic, we learn very effectively from our mistakes.

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