A booklet on

Behavioural causes and remedies associated with transportation accidents.

P.D Krige
Turgis Consulting

The Safety in Mines Research Advisory Committee

August 2003

Contents

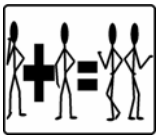
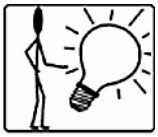
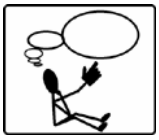
1 INTRODUCTION

The purpose of this booklet is to make a contribution towards improving safety standards in underground transportation. Its scope is limited to horizontal track-bound transportation on gold and platinum mines and its emphasis is on learning and behavioural causes and remedies for accidents rather than on technical and engineering related causes.

The booklet is a summary of the research project GAP857. It contains all the significant findings of the original research but excludes much of the background and supporting statistics. Its emphasis is on presenting the recommendations in an accessible format.

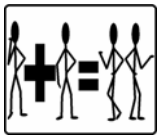
The booklet first identifies the key trends and hazards associated with track-bound underground transportation. It then explores what learning outcomes are needed to address these hazards and finally makes recommendations regarding the most appropriate and effective communication techniques to reduce transportation accidents.

Icons are used throughout the booklet for quick and easy reference.

	This icon represents key findings and conclusions.
	The most significant issues in the booklet are summarised in either a tabular or pictorial form. In fact the quickest way to gain an understanding of the contents of the booklet is to refer to the sections marked with this icon.
	The booklet makes several recommendations. These are indicated by this icon.
	Points to ponder.

2. ACCIDENT TRENDS ASSOCIATED WITH UNDERGROUND TRANSPORTATION

An analysis of transportation accidents over the last two decades shows some interesting trends that are not entirely congruent with current training and safety practices.



Human error

Since the 1980s improvements in engineering design have significantly reduced the number of accidents that result from technical failure. Good progress has been made in terms of transportation logistics that has lowered the risk of accidents resulting from poor planning. Recent data shows that the key issue is that human error, resulting from a lack of adherence to standards, is the major cause of transportation accidents. This has significant implications for designing learning outcomes that will reduce accidents. It shifts the emphasis from technical training to behavioural issues.

Location

Research has shown that most transportation accidents occur in haulages, cross cuts and stations and tips. Although this is an expected result, it has important ramifications. Its implication is that the vast majority of accidents occur in areas that are relatively isolated and away from direct supervision. This places a large responsibility on those who operate the transportation equipment to monitor not only their own compliance to safety standards but also that of those who move through the haulages.

Occupation of accident victims

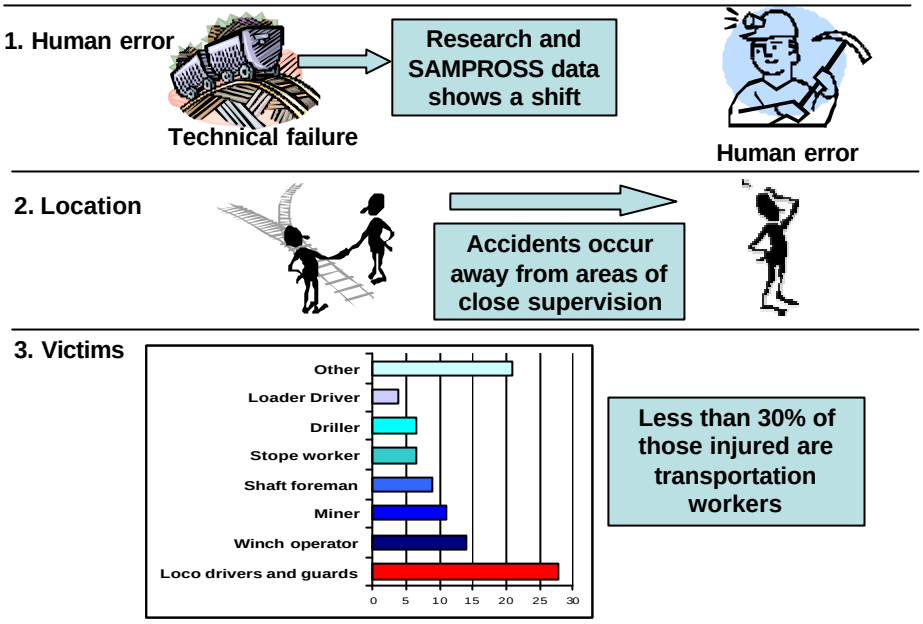
Earlier literature on transportation accidents placed little emphasis on the occupation of the victims. The adjacent table shows that less than 30% of those involved in accidents are transportation workers. The rest are passing through the transportation areas to reach their own place of work.

Table 1 – Occupation of accident victims

Occupation	Percentage of Total
Loco driver (underground)	25
Monorail winch operator	14
General miner	11
Shaft foreman	8.9
Stope team worker	6.2
Driller: hand percussion/jackhammer	6.2
Loader driver (trackless)	3.7
Loco guard (underground)	2.8
Lasher/loader	1.5
Pipes and tracks worker	1.3
Miner's assistant	1.3
Supervisor's assistant (underground)	1.2
General engineering worker	1.2
Unclassified occupation (unknown/unspecified)	1
Banksmen/onsetter	1

Pictorial review.

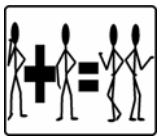
Figure 1: Accident Trends



Points to Ponder

It is interesting that training and learning have not often been identified as key areas that should be addressed in order to reduce the occurrence of transportation accidents. In fact Willis (1994) specifically highlighted that a lack of training was not amongst one of the common causes for accidents.

3. TRANSPORTATION HAZARDS

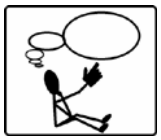


Previous research and current SAMRASS data ranks the relatively passive activities of walking, waiting, standing and sitting as the most hazardous situations. These are followed by coupling situations, derailing / re-railing situations and then mobile situations. The ranking of all hazards is given in table 2 below. The ranking is consistent with the fact that the majority of victims are not transportation workers. It is also significant that the pattern of accidents appears to have stabilised.

Table 2 - Hazards Associated with Underground Transportation.

Ranking	Hazard	Description
1	Walking	Injuries to persons who were either walking or standing next to or on the track.
2	Derailment	Injuries, arising from a derailment, caused to persons who might have been on the train or next to the track.
3	Collision	A collision between a moving vehicle and another vehicle.
4	Travelling on	Injuries received while travelling on a vehicle.
5	Coupling	Injuries received while coupling vehicles.
6	Obstruction	Injuries to persons as a result if a collision some part

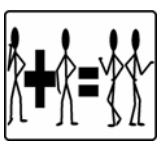
		of the transport system, such as a partially open ventilation door or a loading chute or with some permanent structure, the sidewall or hanging.
7	Re-railing	Injuries to persons while re–railing derailed equipment.
8	Trackwork	Injuries to persons working on the track. This did not include injuries caused by the trackwork, but only injuries that were caused by being struck by a vehicle.
9	Falling	Injuries resulting from people falling into a excavation forming a part of the transport system.
10	Tipping	Injuries that occurred at the tip excluding injuries listed as "Working on hopper ".
11	Lying	Sufficient information was supplied to determine that in some cases the injured party had been lying on or next to the track. In some cases the report stated that the person was asleep at the time of the accident.
12	Machine parts	Injuries caused by parts of the vehicle. This category excluded injuries caused by part of the vehicle during another event such as a collision or a derailment.
13	Material off	Injuries to members of the train operating team or a passenger on the train being struck by material at the track side.
14	Material on	Injuries to persons being struck by material being transported on a train.
Not ranked	Working on hopper	Injuries resulting from work on a hopper, such as clearing large rocks or mud from a hopper.
Not ranked	Moving vehicle	Injuries resulting from a person boarding, or alighting from, a moving vehicle.
Not ranked	Battery changing	Injury resulting from changing batteries



All previous research regarding transportation accidents is interesting silent on occupational health risks. It is probable that these risks result in injury over the longer term and so are more difficult to attribute directly to the transportation environment.

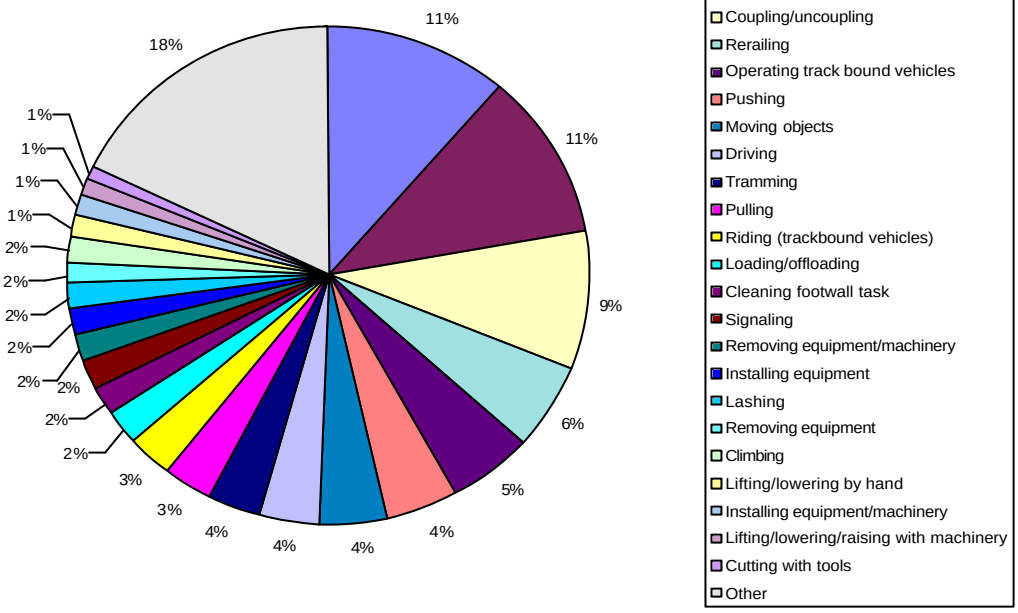
4 A BEHAVIOURAL ANALYSIS OF SAMRASS DATA

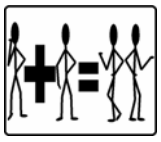
It is clear from the foregoing conclusions that accidents are more closely related to the behaviour of the victims than to their technical skills and competence. To explore this SAMRASS data was analysed from a behavioural perspective in order to determine what the victims were doing at the time that they were injured?



In total the data identified about 150 different activities. This indicates the wide range of situations during which people are injured. However, despite this range, 10 activities account for about 65% of the accidents as shown in the following chart.

Figure 2: Categorisation of Transportation Accidents by Activity at Time of Accident.





It is of interest that the two largest segments (standing/waiting/sitting -11% and walking –11%) are both relatively passive activities and have little to do with the actual operation of transportation machinery. The inference of these statistics is that for these two segments (22% of the total) most of the responsibility for the accident probably did not lie with the injured person. This has several implications in terms of learning and hazard recognition that is required from these people.

5 OCCUPATIONS, ACTIVITIES AND REASONS FOR ACCIDENTS

In section 2 the occupations of accident victims were identified. The previous section explored the most common activities of those involved in accidents. In order to be more specific, this section puts these two together. It identifies the activities per occupation and the reason for the accident. Figure 3 is a graphical representation of the analysis and tables 3 to 6 show the results for each group.

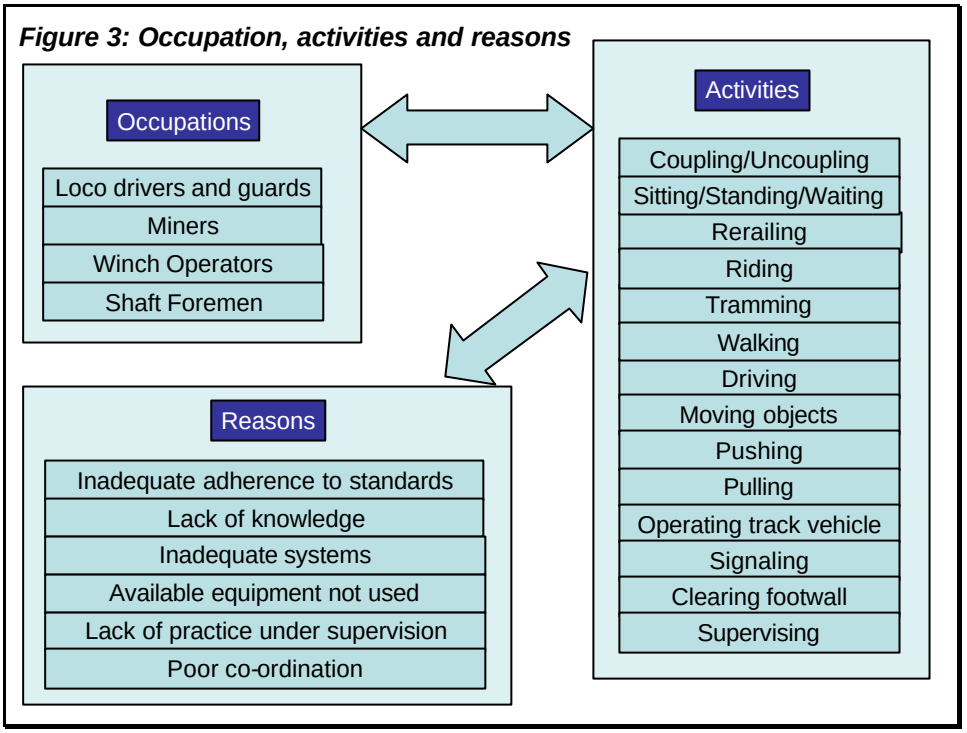
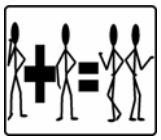


Figure 3: Occupation, activities and reasons



This cross referencing identified four distinct patterns:

- The first pattern consists of Loco Drivers and Guards. Activities that led to their injuries are associated directly with the performance of their normal duties. These include coupling / uncoupling, re-railing, driving, tramming and riding on vehicles.
- The second group is Drillers, Stope Workers and General Miners. It is an interesting group since the activities that led to their injuries tend to be more passive activities such as sitting, standing, waiting and walking. They are also a group that represents occupations that are not specifically trained for tasks relating to transportation. In general they are on route to their workplace or returning to the shaft when they are injured.
- The third group is Winch Operators. The activities of this group when injured differ from the second group in a few significant ways. Whilst passive activities of sitting, standing, waiting and walking rank highly so do active roles such as operating track bound equipment, pulling and signalling. These activities are of particular importance because they do not form part of the normal training for Winch Operators yet Winch Operators appear to be required to perform them fairly regularly. This seems to indicate a certain degree of informal multi-skilling.
- The forth group is Shaft Foremen. It is surprising that a supervisory occupation ranks so high amongst those injured particularly since the major activities when injured are the more passive ones. This is significant because it implies that this first level of supervision, and the one most closely associated with transportation activities, is not itself adhering to standards and setting the example that it should.

The following tables give the detail for each of these groups.

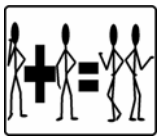


Table 3: Loco Drivers and Guards

Occupation Group: Loco Drivers and Guards (2175 of 7797 – 28%)				
Activities when injured	**Reasons for accident**			
Coupling / uncoupling 21%	Inadequate adherence to standards - 49%	Available not used – 21%	Lack of knowledge – 14%	Poor co-ordination – 4%
Rerailing 13%	Inadequate adherence to standards – 47%	Inadequate systems – 21%	Lack of knowledge – 13%	Available not used – 6%
Tramming 9%	Inadequate adherence to standards – 50%	Poor co-ordination – 10%	Lack of knowledge – 8%	Not registered at planned maintenance – 7%
Driving 7%	Inadequate adherence to standards – 49%	Lack of knowledge – 11%	Available not used – 11%	Poor co-ordination – 8%
Sitting/standing/waiting 6%	Inadequate adherence to standards – 55%	Lack of knowledge – 11%	Poor co-ordination – 11%	Available not used – 8%
Riding 5%	Inadequate adherence to standards – 57%	Inadequate systems – 8%	Lack practice under supervision – 7%	Lack of knowledge – 7%
Walking 5%	Inadequate adherence to standards – 58%	Poor co-ordination – 12%	Lack of knowledge – 10%	Wrong equipment – 4%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 50%
- A lack of knowledge – 12%
- Available equipment not used – 11%
- Inadequate systems - 6%
- Poor co-ordination – 5%

A lack of practice under supervision – 4%

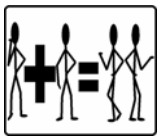


Table 4: Miners

Occupation Group: Miners (Stope Team Workers, Drill Operators, General Miners) 1858 of 7797 – 24%)				
Activities when injured	**Reasons for accident**			
Sitting/standing/waiting 16%	Inadequate adherence to standards - 48%	Poor co-ordination - 12%	Lack of knowledge – 11%	Lack of practice under supervision – 10%
Walking 15%	Inadequate adherence to standards – 51%	Lack of practice under supervision – 11%	Lack of knowledge – 9%	Available not used – 7%
Moving objects 6%	Inadequate adherence to standards – 41%	Lack of practice under supervision – 13%	Lack of knowledge – 10%	Available not used – 10%
Pushing 5%	Inadequate adherence to standards – 51%	Lack of practice under supervision – 17%	Available not used – 9%	Poor co-ordination – 8%
Coupling / uncoupling 4%	Inadequate adherence to standards – 47%	Available not used – 27%	Lack of knowledge – 8%	Lack of practice under supervision – 6%
Pulling 3%	Inadequate adherence to standards – 47%	Lack of knowledge – 10%	Available not used – 10%	Lack of practice under supervision – 6%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 48%
- A lack of practice under supervision – 10%
- A lack of knowledge – 11%
- Available equipment not used – 8%
- Poor co-ordination – 6%
- Inadequate systems - 2%

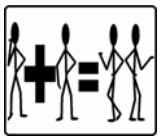


Table 5: Winch Operators

Occupation Group: Winch Operators (1101 of 7797 – 14%)				
Activities when injured	**Reasons for accident**			
Operating track bound vehicles – 15%	Inadequate adherence to standards - 51%	Lack of knowledge – 8%	Wrong equipment – 7%	Poor training – 6%
Walking 13%	Inadequate adherence to standards – 63%	Lack of practice under supervision – 9%	Poor co-ordination – 6%	Lack of knowledge – 6%
Standing/ Sitting/Waiting 13%	Inadequate adherence to standards – 59%	Lack of knowledge – 14%	Poor co-ordination – 5%	Lack of practice under supervision – 4%
Pulling 7%	Inadequate adherence to standards – 62%	Lack of knowledge – 10%	Lack of practice under supervision – 5%	Available not used – 5%
Signalling 5%	Inadequate adherence to standards – 49%	Lack of knowledge – 16%	Poor co-ordination – 9%	Lack of practice under supervision – 8%
Clearing footwall 4%	Inadequate adherence to standards – 64%	Lack of practice under supervision – 7%	Lack of knowledge – 5%	Available not used – 5%
Moving Objects 4%	Inadequate adherence to standards – 41%	Available not used – 15%	Wrong equipment – 8%	Lack of practice under supervision – 8%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 54%
- A lack of knowledge – 10%
- A lack of practice under supervision – 8%
- Available equipment not used – 7%
- Poor co-ordination – 4%
- Inadequate systems - 3%

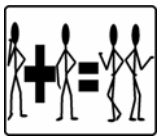
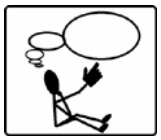


Table 6: Shaft Foremen

Occupation Group: Shaft Foremen (697 of 7797 – 9%)				
Activities when injured	**Reasons for accident**			
Standing/Sitting/Waiting 13%	Inadequate adherence to standards - 54%	Lack of knowledge – 12%	Poor co-ordination – 9%	Poor training – 7%
Walking 12%	Inadequate adherence to standards – 59%	Lack of practice under supervision – 8%	Wrong equipment – 8%	Poor co-ordination – 6%
Coupling / uncoupling 7%	Inadequate adherence to standards – 49%	Lack of knowledge – 20%	Available not used – 18%	Damaged material – 4%
Supervising 7%	Inadequate adherence to standards – 50%	Poor co-ordination – 11%	Available not used – 8%	Poor training – 6%
Rerailing 6%	Inadequate adherence to standards – 60%	Available not used – 12%	Lack of knowledge – 9%	Inadequate systems – 7%

Key areas that require attention, in order of significance, are:

- Adherence to standards – 55%
- A lack of knowledge – 9%
- A lack of practice under supervision – 6%
- Available equipment not used – 6%
- Poor co-ordination – 5%
- Inadequate systems - 4%



It is important that the above causes are related to the activity. For example Loco Drivers need to adhere to standards concerning the operation of transportation equipment whereas in the case of Miners it is more general safety awareness within the transportation environment that requires attention. Similarly for 'lack of knowledge'. In the case of Loco Drivers it is knowledge about their job whereas with Miners it is knowledge about the safety requirements in an environment different from where they actually work.

Based on this a table can be constructed that identifies the fields in which learning is required in the three most significant areas.

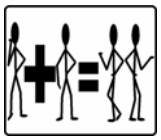


Table 10: Fields of Learning

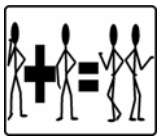
	Loco Drivers and Guards	Miners	Winch Operators	Shaft Foremen
Adherence to standards	Ways of improving adherence to standards relating to the job.	Ways of improving adherence to standards in workplaces other than their own.	Ways of improving adherence to standards relating to jobs that they do but for which they are not specifically trained.	Ways of improving adherence to standards for which they should be responsible.
Knowledge	Improve knowledge of their own job.	Improve knowledge of the work environment of others.	Improve knowledge of work for which they are specifically trained.	Improve knowledge of work for which they are responsible.
Practice under supervision	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.	Create more opportunities to gain confidence under supervision.

Of these fields of learning the first, 'adherence to standards', is the most significant by a large margin. Much of the rest of this booklet is focused on this aspect as it has the most potential for affecting a change to accident statistics. It is important to explore why standards are not followed. There are two distinct possibilities. The first is that standards are not adequately learned. The second is that despite sufficient knowledge other attitudinal factors influence behaviour.

6 CURRENT PRACTICE ON SOUTH AFRICAN MINES

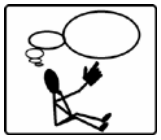
As mentioned earlier in this booklet, poor training was not often identified as a cause of accidents in the SAMRASS data. Three fundamental questions regarding current training practices therefore require answers:

- Does insufficient knowledge and skills regarding the technical operation of equipment, as a result of poorly designed training courses, lead to 'a lack of adherence to standards'?
- Is there sufficient emphasis on the potential hazards associated with the machinery the workers were being trained to use? Does a lack of training on safety procedures and accident prevention contribute to 'a lack of adherence to standards'?
- Are the training methods that are employed effective in ensuring that trainees acquire the knowledge and skills with regard to both the technical and safety aspects of the machines and working environments for which they are being trained?



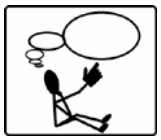
Visits to several mines led to the following conclusions:

? A lack of competence in the specific job for which workers are trained is not a significant cause of the lack of adherence to standards for the following reasons:
  - The technical content of training courses is comprehensive. It is designed in consultation with operational staff and is reviewed frequently to ensure that it remains current.
  - Instructors are all ex operators of the equipment they are training others to use. They understand the technical and safety intricacies of their tools and the environment in which they are used.
  - Training content is professionally presented in training manuals and is implemented via checklists that ensure that all technical and safety aspects are covered each time the course is run.
  - The use of underground training environments greatly improves the trainee's appreciation of the risks and hazards associated with the production environment.
  - Workers are finally declared competent by the production staff. In other words the final test of their ability is in the workplace.
? There are gaps in training in situations where informal multitasking is occurring. Other than the general induction, all training is very specific to the actual job for which the worker is being trained. The accidents statistics, however, indicated that many workers are injured in other situations. Training programmes do not take cognisance of this fact.
? Trainees themselves believe that the training methods employed are effective in developing the appropriate skills and knowledge. Much of the training on mines is behaviourist in its approach. For example signs are designed to produce a specific response. Training techniques are repetitive thereby ensuring that knowledge and the appropriate response to a situation become automatic. The main language used is fanakalo. Workers feel comfortable with this approach. In general they are confident that they understand what is being taught.
? Training designed to influence attitudes is emerging but is not directed and still in its infancy. Some examples of this are the following:
  - Discussion, rather than repetition, as a method of learning is being used by instructors who possess impressive multilingual capabilities.
  - Team based training is being piloted by some training centres.
  - Some thought is being given to broadening the educational base of workers by providing business-related training.



The overall conclusion is that whereas there are some gaps in the training of workers, training as a whole is thorough and well integrated into the production environment. This confirmed the findings of the data analysis that a lack of competence is not a significant reason why workers do not adhere to standards relating to their own job. The reasons for this need to be sought elsewhere.

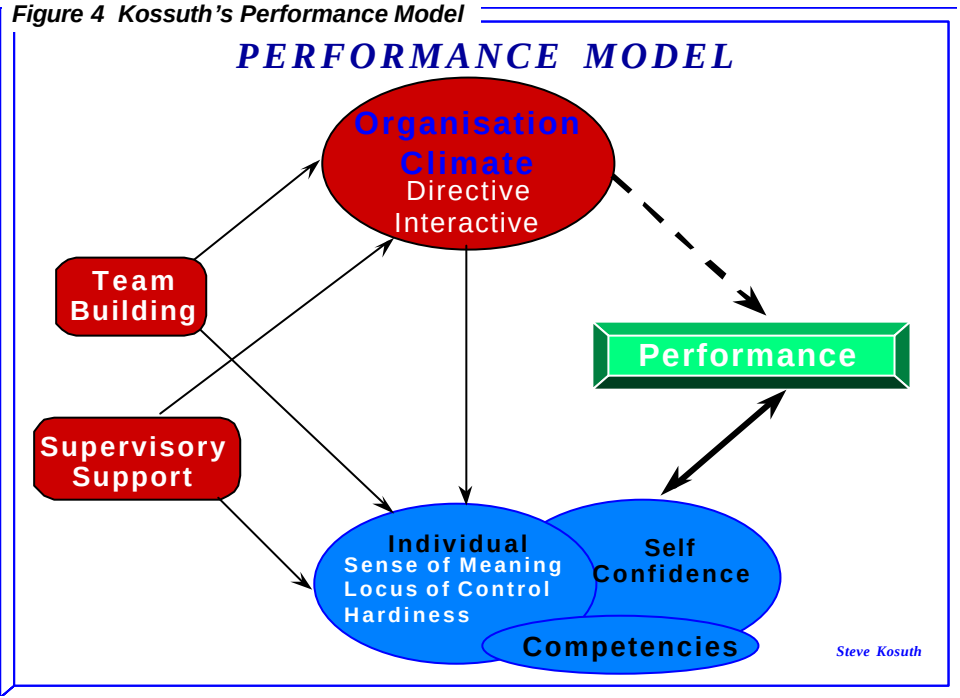
7 MODELS OF ORGANISATIONAL LEARNING AND PERFORMANCE



The question the above conclusions raise is how to improve adherence to standards in a situation where training content is not the issue?

Research relating to individual and organisational performance provides some insight into this question. Based on research conducted largely within the mining industry, Dr S Kossuth has developed and validated a useful Performance Model. The premise of the model is that organisational performance can only be achieved through individual performance. One therefore needs to identify and understand the factors that influence individual performance.

Figure 4 Kossuth's Performance Model



This model identifies organisational climate and individual self confidence as the two drivers of performance. What is critical are the factors that determine self confidence. Competence is only one. The others relate to how an individual perceives himself/herself within the context of the organisation. They include issues such as:

- Individual worth, which is a measure of the extent to which a person sees meaning in his/her job and can understand how what they do, contributes to the organisation.
- Whether the person is internally or externally motivated. Internally motivated people are confident and therefore perform better than those who rely on external instructions before they will act.
- An individual's hardiness or toughness. This is a measure of an individual's ability to remain positive despite working in a negative environment. Tough or resilient people have a higher degree of self-confidence.

What is interesting in the performance model is how an individual's self confidence is influenced by organisational factors. Factors such as organisational climate, the style of supervision and management and team dynamics all impact directly on 'sense of meaning' and the resilience of staff.

Within the context of this project the performance issue that has been identified is a lack of adherence to standards. To change this performance it is necessary that both competence and confidence be addressed. Competence is relatively straightforward and has been addressed by professional training staff on the mines and formally by the MQA. Confidence is a much more complicated issue. The specifics of how confidence increases an individual's performance can only be determined after a thorough study of the complexities of dynamics within a particular organisation.

Other research that has a direct bearing on understanding performance is work done by Booysens (1999). Booysens maintains that because of cultural differences within the South African workforce and diverse management structure, diverse styles and behaviours are emerging. Her research, for her DBL, shows that there are differences in the way that South African leaders of different races and genders perceive the importance of leadership practices and beliefs. These beliefs and practices are based on Hofstede's eight cultural dimensions, and have a significant impact the functioning of racial and gender sub-groups. In general whites tend to be Eurocentric and the other groups are mainly Afrocentric.

Eurocentricism is based on strong beliefs that Performance, Assertiveness and a Future Orientation are very important with less of an emphasis on a Humane Orientation and Collectivism. Afrocentrics, on the other hand, place more emphasis on a Humane Orientation and Collectivism and place less store on Assertiveness, Future Orientation and Power distance (hierarchy). These belief systems have an important impact on how people react to different managerial and leadership styles. Where belief systems are strongly divergent there is a distinct possibility of misunderstanding and conflict.

8 FRAMEWORK FOR LEARNING OUTCOMES

The arguments developed thus far in this booklet are summarised in the following diagram. It shows that performance, both safety and production, is a product of competence and confidence and that confidence is influenced by the complex interaction of organisational and cultural issues.

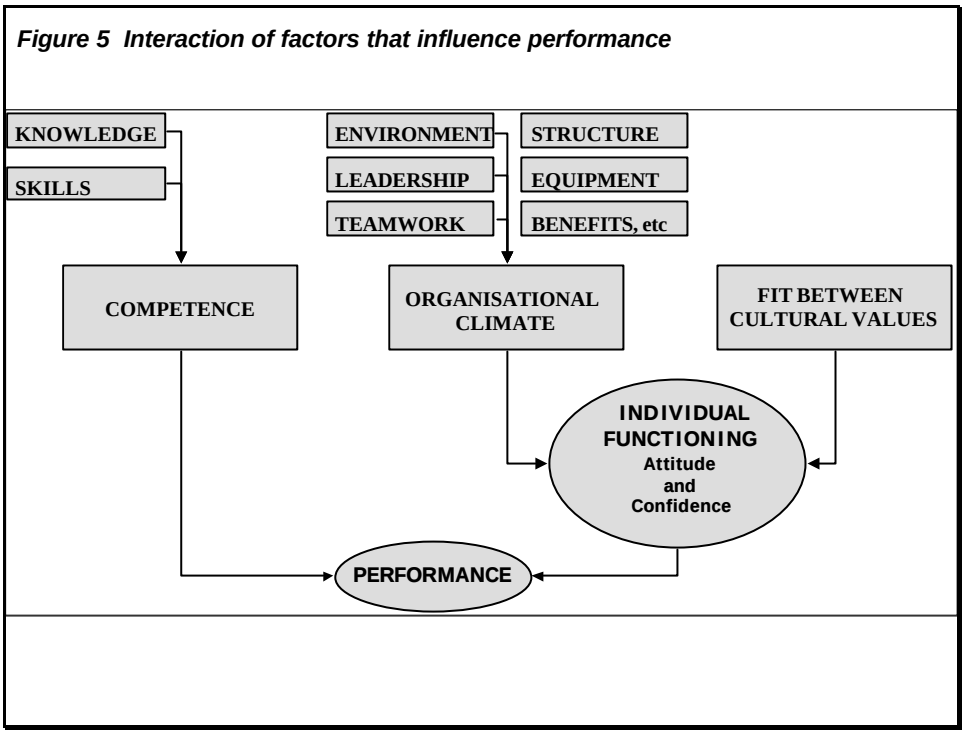


Figure 5 Interaction of factors that influence performance

The accident data indicated that a 'lack of adherence to standards' is the overwhelming cause of injury. The research into training systems confirmed that competence per se was not a significant contributing factor. The cause of accidents must therefore be sought in organisational and cultural issues.

Research conducted recently by the Sociology of Work Unit at the University of the Witwatersrand for the Deepmine project (Webster et al, Aug 2001) arrived at similar conclusions. Their research found that despite impressive programmes and skilled trainers, work place practices had not changed significantly. They identified several organisational issues such as shortages of materials, breakdown of machinery, and staffing levels as reasons why teams and individual workers were not performing optimally. The Kossuth model suggests that while these operational issues have a direct impact on the ability of workers to perform, they also undermine self-confidence and impact on the attitude that workers have towards their work. It is important that, at the supervisory and organisational levels, these operational issues are identified and addressed.

As a result the learning outcomes that are deemed to be significant are those associated with attitude and confidence. They are identified in Table 11.

The three columns in the table relate to the most common reasons given for transportation accidents. By far the most significant issue is 'lack of adherence to standards'. It is given as the reason for the accident in more than 50% of the cases. Hence most of the learning is directed towards addressing it.

The table rows are divided into two groups of occupational categories. The first group is the four occupational categories that are prone to injury in transportation accidents. This is the primary group. Their learning is specific to their work environment and as such has a direct impact the reduction of accidents. The second group is those who have a significant influence on the first group. The learning they need to acquire is associated with ways in which they can influence the behaviour of the primary group. For example, the learning required by instructors on adherence to standards is not to do with how they can better adhere

to standards but how they can influence the primary group to adhere to standards. This is an important distinction. The learning in Table 11 is therefore all directly linked to hazard recognition and accident prevention. It is not directly associated with producing better instructors, supervisors or organisations

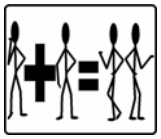
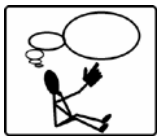


Table 11 - Learning Outcomes Associated with Underground Transport Hazards

	Adherence to standards	**Knowledge**	**Practice under supervision**
Loco Drivers and Guards	Improve adherence to standards relating to their own job.	Improve knowledge of their own job.	Create more opportunities to gain confidence under supervision.
Miners	Improving adherence to standards in workplaces other than their own.	Improve knowledge of the work environment of others.	Create more opportunities to gain confidence under supervision.
Winch Operators	Ways of improving adherence to standards relating to jobs that they do but for which they are not specifically trained.	Improve knowledge of work for which they are specifically trained.	Create more opportunities to gain confidence under supervision.
Shaft Foremen	Ways of improving adherence to standards for which they should be responsible.	Improve knowledge of work for which they are responsible.	Create more opportunities to gain confidence under supervision.
Instructors	Develop training methods that build confidence and produce a constructive attitude.	Improve their knowledge about training techniques.	
First line supervisors	Develop leadership styles that address worker attitude.	Understand the operational issue that impact on workers ability to perform. Understand issues of cultural diversity within the context of a work environment.	
Organisat-ional learning	Develop organisational values that encourage commitment and participation and	Identify organisational factors that impact on safety and performance. Build a 'business	

	hence influence worker attitudes.	culture' that encompasses the diverse values of individuals.	



The outcomes in Table 11 become important only once the specific technical and safety knowledge is in place. Competence remains crucial and the learning associated with particular working environments and items of machinery is a prerequisite to these learning outcomes.

9. LEARNING AND COMMUNICATION TECHNIQUES

Earlier this booklet concluded that training systems on South African mines produce knowledgeable and competent workers. This section reviews the actual training techniques used by instructors.

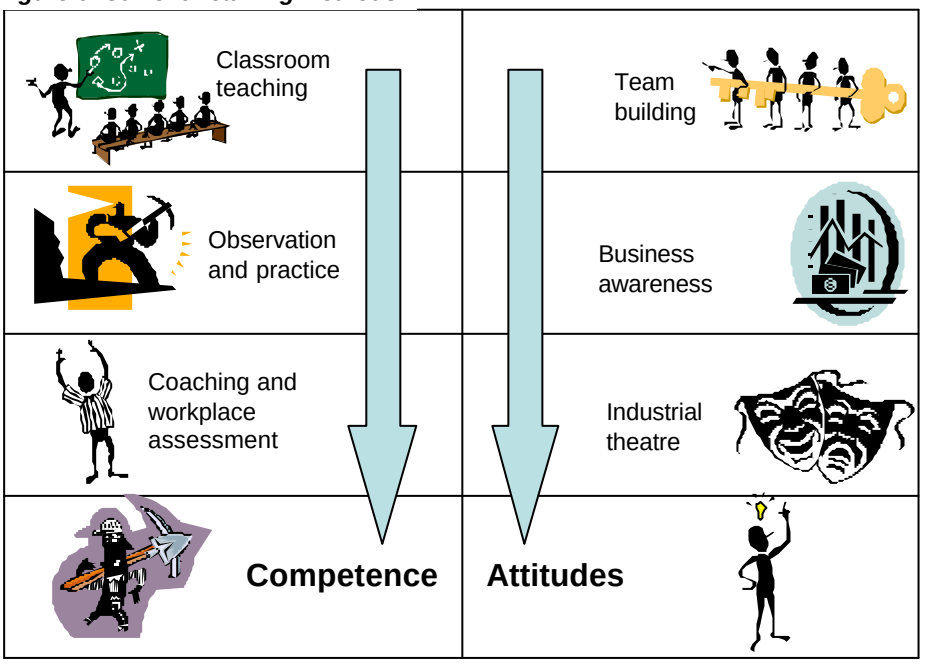
9.1 Current Practice on South African Mines

Behaviour modelling techniques are thoroughly embedded in much of the training on mines. Signage has been standardised in line with national and international conventions. The content of training courses has been refined through the development of extensive checklists and the identification of comprehensive cues in all areas of underground production.

Three techniques, i.e. classroom theory, observation and practice, and workplace assessment, address the development of competency and have proved to be effective techniques

Mines have also introduced techniques and programmes to address issues of commitment, business understanding, attitude and confidence. These include team building and workplace coaching, business awareness and industrial theatre.

Figure 6 Current Learning Methods



9.1.1 Building competence

Classroom theory

Classroom sessions are used to transfer or refresh knowledge, particularly regarding mine and safety standards. Sessions often involve repetitive chanting where trainees are expected to repeat checklists and safety procedures. These concentrate on ensuring that trainees know 'what' has to be done. An emerging trend, however, is theory sessions that involve more discussion and question and answer interchanges. There is more emphasis in these sessions on developing understanding through 'why' and 'how' questions as well as modelling behaviour through the 'what' questions. Knowledge levels are assessed by using questionnaires. These are administered verbally by instructors for non-literate workers.

Observation and practice

Observation and then practice follows theory. Trainees are given the opportunity to observe safe operating procedures and then to work through operational checklists themselves. Once these and all safety precautions are completed they are given the opportunity to operate the equipment. Considerable peer learning occurs during these sessions. Assessment is practical and trainees have to demonstrate that they can perform all the safety checks and operate the machinery effectively and safely.

Workplace competency assessment

The final technique used is workplace assessment where production staff make the final judgment regarding the competence of workers. A vital ingredient of this technique is the professionalism and thoroughness of those performing the assessment. A precursory 'observe and tick' approach to ensure that the trainee returns to production as soon as possible adds no value to the process.

9.1.2 Building commitment

Workplace team development and coaching

A team of trainers / coaches work with the team until a high level of expertise is developed and all aspects of the work environment are of a high standard. The coaching team then withdraws but knows that it leaves behind a competent team.

Business awareness programmes

The purpose of business awareness programmes is to build commitment to the mine through creating an understanding of business principles. Most programmes are designed to show how attention to cost saving and better production will prolong the life of the mine and therefore ensure greater job security.

Industrial theatre

This appears to be an effective communication technique but has limited value as a training tool. It does not enhance the longer-term acquisition of knowledge and plays no role in the development of skills. On the other hand it has been effectively used for conveying changes in company policy, changes to condition of service and for awareness programmes regarding safety and aids. The downside of industrial theatre appears to be that it is viewed as entertainment and therefore does not produce a lasting impact.

Although several of these techniques have produced positive results, they are often implemented in an ad hoc way and are always separated from technical training. As a result the impact on the actual workplace performance of workers has not been significant.

South African mines have developed successful techniques for behaviour modeling. These have resulted in knowledgeable and competent workers. However, questions of confidence and motivation, as reflected by issues such as contribution, a sense of meaning and cultural fit, are not catered for in the training techniques used by mines. It is techniques that address these aspects that require attention in the future.

9.2 People development and training techniques associated with confidence, attitudes and leadership

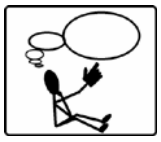
There is a vast body of literature that addresses the question of leadership and how to build successful organisations. Most recent authors and academics have shifted the emphasis of successful leadership in organisations away from a 'management' style of planning, organising and controlling to a 'leadership' style that seeks to build confident and productive people. This trend is evident in the works of popular writers such as Tom Peters, John Kotter, Bernard Bass, Peter Senge, Stephen Covey and many others. Guy Charlton, a South African author, has expressed is trend as follows:

> "The new competitive agenda has become clear. The old strategies and attitudes of changing the hard organisational 'levers' (structure, strategy, updated information technology) and emphasis on cost cutting have at best delivered short-term results."

He goes on to say:

> "One of the hardest tasks confronting an organisation is the conscious development of the human habits in a team, let alone an entire organisation."

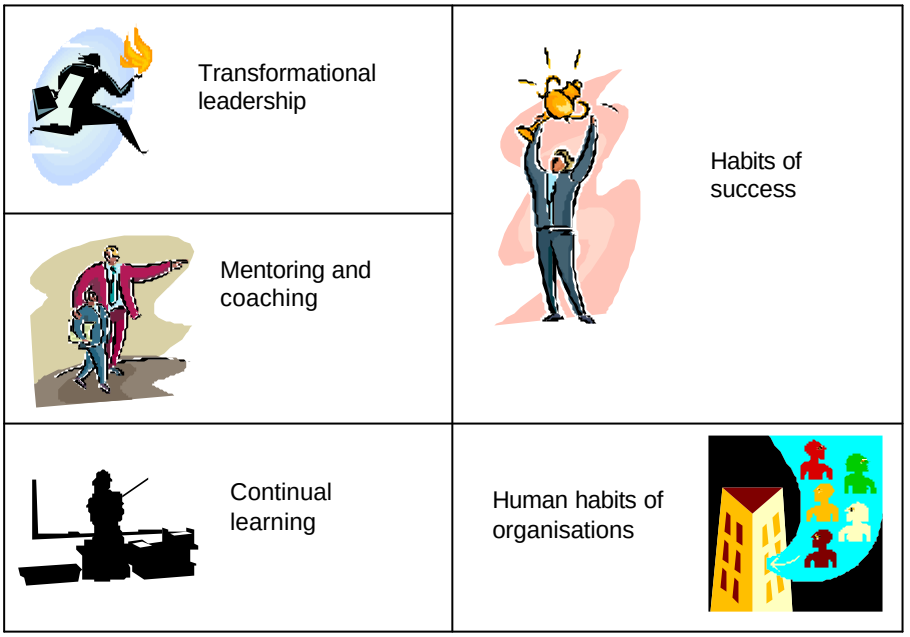
Within the terms of reference of this research there are two questions. Firstly, what tools and techniques are there that can influence a worker's confidence and hence his / her attitude to safety standards? Secondly, what role must the organisation play to create the environment where the learning associated with these techniques can be effectively implemented in the workplace?

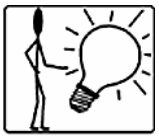


There are no 'quick fix' answers to these questions but the authors mentioned above provide some insight into the kind of organisational culture that is conducive to developing confident workers.

Some of the more successful techniques are summarised below.

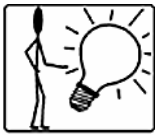
Figure 7 Learning methods associated with confidence, attitudes and leadership





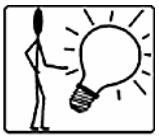
Transformational leadership

Kotter makes a clear distinction between transactional leadership and transformational leadership. Transformational leadership equates to qualities such as developing vision, effective communication and empowering individuals. Currently the fact that, on many mines, transformational type training does not transfer into the workplace implies that leadership on mines is still rooted in the transactional model. Transactional leadership is required but should be exercised alongside transformational leadership. A deliberate shift, at all levels, to a transformational leadership style is one technique / programme that will improve self-confidence levels.



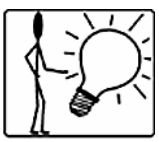
Mentoring and coaching

A second technique is the introduction of mentoring and coaching at all levels. If it is viewed as an intervention aimed at developing staff and not as a mechanistic exercise, then it has the potential to become a powerful tool in the long-term sustainability of an organisation.



Continual learning

Senge emphasises the need for individuals and organisations to be continually learning. He stresses learning directed towards self-mastery and organisational 'interconnectedness' as well as technical and product knowledge. He sees the development of 'learning organisations' as the only sustainable competitive advantage that an organisation can have.



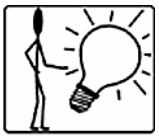
Individual habits of success

Covey stresses the need for individuals to develop habits of success. He identifies his well known seven habits that lead to confident and successful people. These are:

- Be proactive
- Begin with the end in mind
- Put first things first
- Think win / win
- Seek first to understand, then be understood

- Synergise
- Sharpen the saw, i.e. revitalise and reinvent oneself

A key component of his argument is that production must be balanced with production capacity. Developing the seven habits in a workforce builds production capacity and thus builds sustainability.



Human habits of organisations

Charlton's thesis is centred more on organisational human habits than on the individual. He provides insight into the learning that organisations require to develop a productive workforce and thereby ensure their sustainability. His key components are:

- Leadership
- The diversity habit
- The habit of sustained change
- Sustained performance
- A strategic human resources perspective that unifies the human habits

This brief review of some of the approaches to building successful organisations through developing confident people indicates that there are no magical solutions. In fact none of these ideas are new. They have all been around in one form or another for years. It is valuable to revisit them because they address issues that influence attitudes to safety.

9.4 Recommended learning techniques associated with hazard recognition

It should be clear from this booklet that the identification of learning and communication techniques that reduce accidents through improved learning can never be a simple checklist. Past literature, data analysis and the observation of training all point to issues of attitude rather than knowledge and skills. The work of Kossuth, Booysens and Webster indicated that to address this issue involves understanding a complex interaction of organisational and individual factors. It is imperative that the interaction between these factors be measured. This will ensure that the correct factors impacting on attitude and thus safety and production performance will be identified by well-researched measurement techniques. An ad hoc or generic approach is unlikely to produce a sustainable change in attitudes and behaviour.

The table below is thus not the 'final solution' but rather an indication of how some of complexities could be approached. It must also be remembered that these learning techniques are directly solely at hazard recognition and accident reduction with regard to lateral rail bound transportation. For example, winch drivers must also learn to operate winches and the safety aspects associated there with but these considerations are not specifically mentioned in the table.

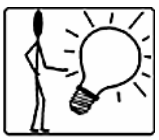


Table 12 - Recommended Learning and Communication Techniques

Occupation Group	Key learning areas	Learning and Communication Techniques

Loco Drivers and Guards	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to address these specific issues. These programmes could include: - Activity based team building - Business understanding. - Ongoing life skills learning (individual habits)
	Knowledge of their own work environment.	? Interactive classroom sessions with an emphasis on 'why' and 'how'. ? Repetitive practice and observation. ? Professional workplace assessment.
	Practice under supervision.	? Workplace training and coaching.
Drillers, Miners and Stope Workers	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to address these specific issues. These programmes could include: - Activity based team building - Business understanding - Ongoing life skills learning (individual habits) - Create an understanding of workplaces other than their own.
	Knowledge of workplaces other than their own.	? Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. ? Extensive observation of transportation procedures and safety practices. ? Professional workplace assessment, relating to transportation procedures and safety standards.
	Practice under supervision.	? Observation of workplace behaviour in all environments with which the worker interacts. (Role of Safety Officers and Shift Leaders.)

Winch Operators	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to address these specific issues. These programmes could include: - Activity based team building - Business understanding - Ongoing life skills learning (individual habits) - Create an understanding of workplaces other than their own.
	Knowledge	? Specific classroom sessions on high priority transportation activities such as rerailing and coupling, i.e. selective multi skilling. (Winch operators seem to perform these activities even though they are not supposed to. Perhaps it is better to accept this reality and train for it than to try and enforce standards that forbid it.) ? Practice of these selected activities. ? Workplace assessment of these activities. ? Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. ? Extensive observation of transportation procedures and safety practices. ? Professional workplace assessment, relating to transportation procedures and safety standards.
	Practice under supervision.	? Workplace training and coaching on the selected activities. ? Observation of workplace behaviour in all environments with which the worker interacts. (Role of Safety Officers and Shift Leaders.)

Shaft Formen	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to address these specific issues. These programmes could include: - Activity based team building. - Business understanding. - On going life skills learning (individual habits) - Cultural diversity and an appropriate 'business culture' - Principles of supervision, including styles of leadership and types of role models.
	Knowledge	? Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. ? Extensive observation of transportation procedures and safety practices. ? Professional workplace assessment, relating to transportation procedures and safety standards. (Supervisory levels should not be exempt from this.)
	Practice under supervision.	? Formal mentoring and coaching with regard to the role of supervisory.
Instructors	Adherence to standards – how to develop attitudes that will achieve this.	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated training approaches to address these specific issues. These programmes could include: - Classroom techniques. - Use of case studies. - Ways of increasing participation. - Assessment techniques. - Integration of technical and development training.
	Knowledge of training techniques	? Formal 'train the trainer' sessions including approaches to theoretical teaching and practical instruction. ? Peer observation and team teaching. ? Professional workplace assessment, including trainee assessment of performance as instructors.

	Practice under supervision.	? Formal mentoring and coaching.
Front-line supervisors	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to address these specific issues. These programmes could include: - Activity based team building. - Business understanding. - Cultural diversity and an appropriate 'business culture'.
	Knowledge	Knowledge of the transportation environment ? Broad based awareness classroom sessions with an emphasis on 'why'. Use of case studies that encourage interaction and discussion. ? Extensive observation of transportation procedures and safety practices. ? Professional workplace assessment, relating to transportation procedures and safety standards. (Supervisory levels should not be exempt from this.) Knowledge of supervision ? Principles of supervision, including styles of leadership and types of role models. ? Transformational leadership.
	Practice under supervision.	? Formal mentoring and coaching.

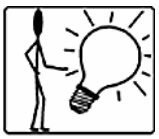
Organisational learning	Adherence to standards	? Measure and identify the specific organisational and individual factors that impact on attitudes and safety performance. ? Design integrated programmes to these specific issues. These programmes could include: - Developing a business culture (organisational habits) - Addressing environmental issues - Addressing workplace frustrations (materials and equipment) - Review organisational structures (levels of authority, team vs individual responsibilities and rewards, staffing levels, etc.) - Review of HR policies - Benefits and rewards structure - Employee assistance programmes - Training and education programmes - Community development - Housing and social activities Where the purpose of all of these programmes is to improve the worker's attitude and thereby impact on safety and production performance. It is not in terms of social responsibility or shareholder perceptions.
	Knowledge	? The organisation can only improve its knowledge of human dynamics and interaction through measurement. Tools and methodologies need to be developed for this.

10. FINAL CONCLUSIONS

This booklet set out to establish the learning associated with hazard recognition in the transportation arena in gold and platinum mines and the findings are set out in tables 2, 11 and 12. However, tabulating the findings runs the risk of over simplifying very complex issues. Hazard recognition and safety awareness will not be adequately addressed by following a tabulated list of recommendations for the following reasons:

1. SAMRASS accident data show that the chief cause of accidents is 'a lack of adherence to standards".
2. An analysis of actual training practice shows that a lack of competency, i.e. knowledge and skills, is not a major contributing factor.
3. Organisational factors have made multi-skilling an informal reality underground and workers need to be trained accordingly. Current job specific training has led to gaps in their safety knowledge.
4. Various research models, i.e. Kossuth and Booysens, indicated that organisational issues and a lack of confidence are major contributors to individual performance.

5. These models point to the need to measure and understand the complex interaction of organisational and individual issues prior to designing learning programmes that will successfully address these non-technical aspects of adherence to safety standards.



These findings indicate the need for further research that will identify and develop comprehensive tools and techniques for measuring organisational and individual factors that impact on performance. Statistical methods need to be introduced that will correlate these factors with safety, environmental, staffing, production and performance measures. A well packaged set of tools of this nature will enable South African mines to identify and then address the underlying issues in each operational area that are hindering safety and production. Intervention programmes will then be targeted at the correct issues and not implemented in an ad hoc fashion. Research of this nature would be a relatively long-term project. It would require input from organisational development experts and industrial psychologists, from sociologists, from statisticians and IT experts, from trainers, and from mining and engineering staff. Its end product should be a highly practical tool that could be used by current human resources staff on the mines, without the need for extensive assistance from external consultants.

11. RELATED SIMRAC RESEARCH PROJECTS

Ref No	Project Title
COL 203	Engineering and human factors in machinery and transport accidents
COL 341	Guidelines for the development of safer use of mobile machines
COL 416	The influence of ergonomics of trackless machines on safety and health
COL 506	Investigate the causes of transport and tramming accidents on collieries
GAP 520	Investigate safety of rail vehicles and systems operating in South African
GAP 704	The ergonomics of locomotive design in mines
GAP 857	Hazard recognition learning programmes in transportation thrust area
GEN 702	Criteria: safe use of commercial personnel transportation underground
OTH 202	Transport & tramming accidents on mines other than gold, coal and plat.
OTH 308*	Influence of road design and construction on transport accidents
02 05 04	Ergonomics of machinery and transport
02 05 02	Factors affecting driver alertness
GAP 609b	Technology transfer and human interface in the gold and platinum sector
GEN 203	Artificial intelligence & virtual reality to aid training & hazard identification
GEN 213	Reasons why safety and work standards are not complied with in mines
GEN 504	An investigation into the problems associated with technology transfer
GEN 604	A strategy for the transfer of health and safety technologies
GEN 511	A behaviour-based health and safety model for pro-active management
SIM 02 01 01	Safety culture in the SA mining industry
SIM 02 01 02	Industrial Technology, rights & politics of transformation

SIM 030502	Transport and Tramming accidents in trackless vehicles
SIM 030503	Loco design for the South African Mining Industry (Ergonomics)