Final Project Report

A comprehensive ergonomics strategy for the South African mining industry

TH de Koker
PC Schutte

Research agency : Ergotech Ergonomics consultants: a business unit of Gerotek Test Facilities (Pty) Ltd
Project number : GEN 603
Date : September 1999
Executive summary

This research report discusses the development of a comprehensive ergonomics strategy for the South African mining industry. The objective of the strategy is to introduce and implement ergonomics in the mining industry to improve occupational health and safety in compliance with the Mine Health and Safety Act (No. 29 of 1996), worker morale and well-being as well as productivity, efficiency and effectiveness on South African mines.

As a first phase in the development of the strategy, an extensive literature survey was conducted to gather relevant information on ergonomics strategies and other ergonomics implementation approaches, especially in mining industries. From the literature survey and personal communication with ergonomists in various overseas countries it became evident that a holistic ergonomics strategy, specifically for a mining industry, has not yet been developed or implemented in any country.

In view of the absence of a generic strategy, a formal strategy development process was followed to develop a draft ergonomics strategy for the South African mining industry. A representative sample of role players in the local mining industry was then consulted to determine the feasibility of the proposed strategy. Feedback from these role players was used to refine the proposed strategy whereafter proposals were formulated for the practical implementation of the strategy. Role players were again consulted to assess the feasibility of the implementation proposals.

The strategy to implement ergonomics in the mining industry will involve four groups of role players, namely the State, Employers, Employees and Manufactures/Suppliers of mining equipment, on the basis of participatory ergonomics. The specific involvement proposed for role players entail reviewing of existing legislation addressing ergonomics and the drafting of an ergonomics implementation plan in the case of the State, the establishment of formal ergonomics programmes on mines by Employers, the active participation and involvement in the ergonomics programmes by Employees, and the use of ergonomics design guidelines and specifications suitable for the local user population and mining conditions by Manufacturers/Suppliers of mining equipment.

Successful implementation of the strategy will depend on the effective introduction of the science of ergonomics and it is therefore of cardinal importance to raise the general level of awareness among all role players. This can be achieved through general information and promotional programmes to introduce ergonomics. Education and training in ergonomics will also be required to facilitate the active participation of all employees in the ergonomics programmes on mines.

Costs to implement the ergonomics strategy should be regarded as an investment with long-term benefits. There will also be benefits that could not be expressed in monetary terms such as improved health, safety, comfort and human well-being, which are actually the main aims of implementing ergonomics in the local mining industry.

This report contains recommendations regarding the specific aspects that will facilitate the successful implementation of the ergonomics strategy. Supplementary future research necessary to further enhance the implementation of ergonomics in the South African mining industry is also proposed.
Preface

This report contains a comprehensive ergonomics strategy for the South African mining industry. The strategy suggests a practical approach for the successful introduction and implementation of ergonomics in the local mining industry. This report is based on the following three Ergotech research documents compiled during the course of the research under SIMRAC project GEN 603.


Acknowledgements

The invaluable contributions and constructive reviews emanating from the following individuals and committees are acknowledged:

Mr R. Alcaraz : Rham Equipment (Pty)Ltd
Mr R.G.M. Barratt : AMPLATS (RPM)
Mr H. Beyers : Bucyrus Africa (Pty)Ltd
Mr F. Bond : Mine Workers Union
Mr J.J. Booysen : AMPLATS (Amandelbult Mine)
Mr D.J. Botes : Ergotech Ergonomics Consultants
Mr F. Buys : Mine Workers Union
Mr M. de Koker : AMCOAL
Mr L. Diack : Barlows
Mr J.R. Dixon : AVGOLD (Member: Occupational Health and Safety Policy Committee)
Mr T. Dow : Department of Minerals and Energy
Mr B. Doyle : Department of Minerals and Energy
Mr R.C. Dubber : Springlake Colliery
Mr G. Eaves : SACMA
Mr I Foster : Savmore Colliery
Mr T. Genis : Rham Equipment (Pty)Ltd
Dr M. J. Gouws : CoMSA (Member: Occupational Health and Safety Policy Committee)

Granite Forum
Mr G.J. Hayward : AMPLATS
Dr E.J. Hendrikse : Paragan Engineering Services Inc. (USA)
Dr J. Kielblock : ANGLOGOLD Health Services
Mr J. Legadima : AMPLATS (PPM)
Mrs C.N. Malapane : Ergotech Ergonomics Consultants
Mr P. Marais : Ergotech Ergonomics Consultants
Mr W. Mboniso : National Union of Mineworkers
Mr H. Moorcraft : AMCOAL
Mr T.C. Muntingh : Mine Welfare Services
Mr D.E. Pienaar : AMPLATS (Amandelbult Mine)
Mr N. Pienaar : ASPASA (Member: Occupational Health and Safety Policy Committee)

Mr L. Potgieter : MSA
Mr I. Pretorius : 3M
Mr D. Ramsden : MSA
Mr P. Retief : Long Airdox
Mr M.J.T. Roux : AMPLATS (RPM)
Mr D. Rowe : Department of Minerals and Energy
Mr M.N. Shaba : Ergotech Ergonomics Consultants
Mr C. Shaw : Premier Mine

SIMCOM
Mr J.R. Smith : Ergotech Ergonomics Consultants

Mr D.J. Stanton : AMPLATS
Mr A. Stockhusen : INGWE

Vanadium Forum
Mr J. van Eyssen : AMPLATS (Amandelbult Mine)
Mr D. van Greunen : Oryx Mine
Mr H.L. van Heerden : AMPLATS (RPM)
Mr H. van Loggerenberg : AMPLATS (RPM)
Mr D.J. van Niekerk : Iscor Mining (Member: Occupational Health and Safety Policy Committee)
Mr H.C. van Zyl : AMCOAL (Member: Occupational Health and Safety Policy Committee)
Mr C. Veldman : Joy Mining Machinery
Mr J Venter : AMPLATS (RPM)
Mr P. Venter : Voest Alpine
Mr J. Vermaak : Department of Minerals and Energy
Mr J. Wiggin : Bucyrus Africa(Pty)Ltd
# List of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive summary</td>
<td>2</td>
</tr>
<tr>
<td>Preface</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>4</td>
</tr>
<tr>
<td>Glossary of terms</td>
<td>10</td>
</tr>
<tr>
<td>Terminology</td>
<td>10</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>10</td>
</tr>
<tr>
<td>Ergonomics design guidelines and specifications</td>
<td>10</td>
</tr>
<tr>
<td>Ergonomics programme</td>
<td>10</td>
</tr>
<tr>
<td>Participatory ergonomics</td>
<td>10</td>
</tr>
<tr>
<td>Role players</td>
<td>10</td>
</tr>
<tr>
<td>Strategy</td>
<td>10</td>
</tr>
<tr>
<td>Strategy development</td>
<td>10</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>11</td>
</tr>
<tr>
<td>1.1 Research problem statement</td>
<td>11</td>
</tr>
<tr>
<td>1.2 Objectives and aims of this study</td>
<td>11</td>
</tr>
<tr>
<td>1.2.1 Main objective</td>
<td>11</td>
</tr>
<tr>
<td>1.2.2 Goals</td>
<td>11</td>
</tr>
<tr>
<td>1.3 Research design</td>
<td>12</td>
</tr>
<tr>
<td>1.3.1 Research context</td>
<td>12</td>
</tr>
<tr>
<td>1.3.2 Research design</td>
<td>12</td>
</tr>
<tr>
<td>1.4 Deployment of the study</td>
<td>13</td>
</tr>
<tr>
<td>2. Literature survey</td>
<td>14</td>
</tr>
<tr>
<td>2.1 Fatality and injury statistics</td>
<td>14</td>
</tr>
<tr>
<td>2.2 An introduction to ergonomics</td>
<td>20</td>
</tr>
<tr>
<td>2.2.1 Defining ergonomics</td>
<td>20</td>
</tr>
<tr>
<td>2.2.2 The focus of ergonomics</td>
<td>20</td>
</tr>
<tr>
<td>2.2.2 The objectives of ergonomics</td>
<td>20</td>
</tr>
<tr>
<td>2.2.4 The approach of ergonomics</td>
<td>21</td>
</tr>
<tr>
<td>2.2.5 A simple ergonomics model</td>
<td>23</td>
</tr>
<tr>
<td>2.2.6 The human-centred approach</td>
<td>24</td>
</tr>
<tr>
<td>2.2.7 The interdisciplinary nature of ergonomics</td>
<td>27</td>
</tr>
<tr>
<td>2.3 The strategy development process</td>
<td>30</td>
</tr>
<tr>
<td>2.3.1 Approach</td>
<td>30</td>
</tr>
<tr>
<td>2.4 Legislation</td>
<td>33</td>
</tr>
<tr>
<td>2.5 International ergonomics strategies</td>
<td>34</td>
</tr>
<tr>
<td>2.5.1 Australia</td>
<td>34</td>
</tr>
<tr>
<td>2.5.2 United Kingdom</td>
<td>35</td>
</tr>
<tr>
<td>2.5.3 United States</td>
<td>35</td>
</tr>
<tr>
<td>2.6 International related strategies</td>
<td>35</td>
</tr>
<tr>
<td>2.6.1 An occupational health strategy for Great Britain</td>
<td>36</td>
</tr>
<tr>
<td>2.6.2 Global Strategy for Health for All</td>
<td>37</td>
</tr>
<tr>
<td>2.6.3 Occupational Safety and Health Administration strategic plan</td>
<td>37</td>
</tr>
<tr>
<td>2.6.4 Australian national strategy for workplace health</td>
<td>38</td>
</tr>
<tr>
<td>2.6.5 Summary</td>
<td>38</td>
</tr>
<tr>
<td>2.7 Implementation programmes</td>
<td>38</td>
</tr>
<tr>
<td>2.7.1 Ergonomics programmes</td>
<td>39</td>
</tr>
<tr>
<td>2.7.2 Implementing an ergonomics programme</td>
<td>42</td>
</tr>
<tr>
<td>2.8 Participatory ergonomics (technology transfer)</td>
<td>46</td>
</tr>
<tr>
<td>2.8.1 Definition</td>
<td>46</td>
</tr>
<tr>
<td>2.8.2 Approach</td>
<td>47</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2.8.3 Participatory schemes</td>
<td>47</td>
</tr>
<tr>
<td>2.8.4 Participatory framework</td>
<td>48</td>
</tr>
<tr>
<td>2.8.5 Methods for implementing participatory ergonomics</td>
<td>50</td>
</tr>
<tr>
<td>2.8.6 The Role of the ergonomist in participatory ergonomics</td>
<td>51</td>
</tr>
<tr>
<td>2.8.7 Factors supporting participatory approaches</td>
<td>51</td>
</tr>
<tr>
<td>2.8.8 Benefits Of Participatory Ergonomics</td>
<td>52</td>
</tr>
<tr>
<td>2.8.9 Management commitment and support</td>
<td>52</td>
</tr>
<tr>
<td>2.8.10 Examples of participatory ergonomics</td>
<td>53</td>
</tr>
<tr>
<td>2.8.11 Participatory ergonomics in South Africa</td>
<td>54</td>
</tr>
<tr>
<td>2.9 Ergonomics design guidelines and specifications</td>
<td>54</td>
</tr>
<tr>
<td>2.10 Summary of literature survey</td>
<td>55</td>
</tr>
<tr>
<td>3. Research Methodology</td>
<td>57</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>57</td>
</tr>
<tr>
<td>3.2 The strategy development process</td>
<td>57</td>
</tr>
<tr>
<td>3.2.1 Approach</td>
<td>57</td>
</tr>
<tr>
<td>4. Research Results</td>
<td>60</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>60</td>
</tr>
<tr>
<td>4.2 Strategy formulation</td>
<td>60</td>
</tr>
<tr>
<td>4.2.1 Vision</td>
<td>61</td>
</tr>
<tr>
<td>4.2.2 Mission</td>
<td>61</td>
</tr>
<tr>
<td>4.2.3 Objectives</td>
<td>61</td>
</tr>
<tr>
<td>4.2.4 The draft ergonomics strategy</td>
<td>63</td>
</tr>
<tr>
<td>4.2.5 Policy</td>
<td>66</td>
</tr>
<tr>
<td>4.3 Strategy implementation</td>
<td>67</td>
</tr>
<tr>
<td>4.3.1 Programmes</td>
<td>68</td>
</tr>
<tr>
<td>4.3.2 Procedures</td>
<td>69</td>
</tr>
<tr>
<td>4.3.3 Budgets</td>
<td>76</td>
</tr>
<tr>
<td>4.4 Feedback from role players</td>
<td>76</td>
</tr>
<tr>
<td>4.4.1 Introduction</td>
<td>76</td>
</tr>
<tr>
<td>4.4.2 Sample</td>
<td>76</td>
</tr>
<tr>
<td>4.4.3 Support for ergonomics strategy</td>
<td>77</td>
</tr>
<tr>
<td>4.4.4 Legislation</td>
<td>77</td>
</tr>
<tr>
<td>4.4.5 Implementation plan</td>
<td>77</td>
</tr>
<tr>
<td>4.4.6 Participatory ergonomics</td>
<td>77</td>
</tr>
<tr>
<td>4.4.7 Ergonomics programmes</td>
<td>77</td>
</tr>
<tr>
<td>4.4.8 Ergonomics design guidelines and specifications</td>
<td>77</td>
</tr>
<tr>
<td>4.4.9 Implementation costs</td>
<td>78</td>
</tr>
<tr>
<td>4.4.10 Role player co-operation</td>
<td>78</td>
</tr>
<tr>
<td>4.4.11 General information and promotional programmes</td>
<td>78</td>
</tr>
<tr>
<td>4.4.12 Ergonomics information</td>
<td>78</td>
</tr>
<tr>
<td>4.5 Summary of strategy</td>
<td>78</td>
</tr>
<tr>
<td>5. Conclusions and Recommendations</td>
<td>80</td>
</tr>
<tr>
<td>5.1 Conclusions</td>
<td>80</td>
</tr>
<tr>
<td>5.1.1 Main objective</td>
<td>80</td>
</tr>
<tr>
<td>5.1.2 Goals</td>
<td>80</td>
</tr>
<tr>
<td>5.2 Recommendations</td>
<td>82</td>
</tr>
<tr>
<td>References</td>
<td>84</td>
</tr>
<tr>
<td>Appendix 1</td>
<td>88</td>
</tr>
<tr>
<td>ACTIVITY</td>
<td>101</td>
</tr>
</tbody>
</table>
List of figures

Figure 2.1: Fatality rate in South African mines
Figure 2.2: Fatality rate in gold mines and all mines
Figure 2.3: Injury rate in gold mines and all mines
Figure 2.4: Injury rate in South African mines
Figure 2.5: The objectives of ergonomics
Figure 2.6: Communication between human and machine viewed as an information flow loop
Figure 2.7: Human-technology-workspace-environment model
Figure 2.8: The human-centred approach
Figure 2.9: The interdisciplinary nature of ergonomics
Figure 2.10: Basic elements of the strategy development process
Figure 2.11: Strategic management model
Figure 2.12: Implement on ergonomics programme
Figure 4.1: Basic elements of the strategy development process (strategy formulation highlighted)
Figure 4.2: Strategy development model (strategy formulation highlighted)
Figure 4.3: Proposed draft ergonomics strategy for the South African mining industry
Figure 4.4: Basic elements of the strategy development process (strategy implementation highlighted)
Figure 4.5: Strategy development model (strategy implementation highlighted)
Figure 4.6: Graphical illustration of ergonomics strategy and implementation proposals
List of tables

Table 2.1: Workstation analysis outline
Table 2.2: Examples of human-environment interaction
Glossary of terms

Terminology

Ergonomics
The science that seeks to design tools, equipment, products, systems, tasks, procedures, and environments to be compatible with human capabilities and limitations.

Ergonomics design guidelines and specifications
Practical, detail design information on all aspects relevant to the interaction between people, technology, the workspace and the work environment relevant to the South African mining industry.

Ergonomics programme
A formal method to introduce and implement ergonomics in the workplace, based on participatory principles by involving persons from all levels in the organisation.

Participatory ergonomics
The active participation of all role players in contributing to improve the working environment through the process established by the ergonomics strategy.

Role players
Stakeholder groups in the South African mining industry who’s support, acceptance and involvement will be essential for the successful implementation and maintenance of the ergonomics strategy for the local mining industry. These role players are the State, Employers, Employees and the Manufacturers/Suppliers of mining equipment.

Strategy
A strategy forms a comprehensive master plan stating how the mission and objectives will be achieved.

Strategy development
The process of strategy development involves four basic elements, namely environmental scanning, strategy formulation, strategy implementation, and evaluation and control.
1. Introduction

The interaction between human, machine and environment results in many risks to workers while performing tasks in their work environment. In a recent industry-wide risk assessment conducted by Ergotech on behalf of the Safety in Mines Research Advisory Committee (SIMRAC), it was pointed out that poor ergonomics design and a lack of a strategy for introducing ergonomics into the South African mining sector was a major contributing factor to poor worker health and safety. A lack of ergonomics research pertaining to the local mining industry was also identified as a major shortcoming and contributing factor (Harper, 1997: SIMRISK 401). In the same project inappropriate ergonomics factors that contribute to hearing loss, and health risk aspects of bio-mechanical factors, vibration and heat stress were highlighted (Kielblock, 1997: SIMRISK 401).

Basic ergonomics is currently applied to a limited extent in the South African mining industry. There is however no structure or co-ordination in this effort and as a result no strategy. The science of ergonomics can make a major contribution to the management of significant risks in mines if applied in a co-ordinated and integrated manner. The main purpose of an ergonomics strategy would be to focus and align the application of ergonomics in the local mining industry.

As a result of the abovementioned findings, the need for a comprehensive ergonomics strategy for the South African mining industry was identified and it was decided by SIMRAC to approve a research project to satisfy this need. The research project to develop a comprehensive ergonomics strategy for the local mining industry was awarded to Ergotech.

1.1 Research problem statement

Poor ergonomics design and a lack of a strategy for introducing ergonomics into the South African mining industry have been identified as major contributing factors to poor worker health and safety in mines. A lack of ergonomics research focused on the local mining industry has also been identified as a contributing factor.

The specific problem that will be focussed on in this study, is the development of a strategy to facilitate the co-ordinated and integrated introduction and implementation of ergonomics in the South African mining industry. The successful implementation of ergonomics has the potential to improve occupational health and safety, worker morale and well-being, as well as productivity, efficiency and effectiveness in South African mines.

1.2 Objectives and aims of this study

1.2.1 Main objective

The main objective of this study is the development of a comprehensive ergonomics strategy for the South African mining industry. This will facilitate the introduction and implementation of ergonomics in the local mining industry on an integrated basis, thereby contributing to initiatives aimed at the management of health and safety risks in mines to the mutual benefit of all role players.

1.2.2 Goals
1.2.2.1 Theoretical goal

A comprehensive literature survey to investigate ergonomics strategies and other ergonomics implementation approaches developed and implemented overseas in various industries and specifically the mining industry. This information will form the basis of the ergonomics strategy that will be developed to facilitate the introduction and implementation of ergonomics in the South African mining industry.

1.2.2.2 Empirical goal

Evaluation by a representative sample of the main role players in the South African mining industry, namely the State, Employers, Employees and Manufacturers/Suppliers of mining equipment, of the feasibility of the draft ergonomics strategy and the implementation proposals.

1.3 Research design

1.3.1 Research context

This study will be of an exploratory nature with a view to:

- Investigate ergonomics strategies and other ergonomics implementation approaches used world-wide to implement ergonomics, especially in the mining industry.
- Explicate central concepts and issues.
- Develop a comprehensive ergonomics strategy for the South African mining industry.
- Develop proposals for the implementation of the strategy.

1.3.2 Research design

1.3.2.1 Literature survey

In Section 2, a comprehensive literature survey pertaining to fatality and injury statistics, the science of ergonomics, the strategy development process, legislation, international ergonomics and related strategies, implementation programmes, participatory ergonomics, and ergonomics design guidelines and specifications will be presented. This information will establish theoretical foundation for the development of an ergonomics strategy for the South African mining industry strategy as well as the implementation proposals.

1.3.2.2 Empirical investigation

In Section 3, a draft ergonomics strategy for the South African mining industry will be formulated which integrates relevant aspects of the literature survey. This draft strategy will be presented to representatives of the four main role players in the South African mining industry, namely the State, Employers, Employees, and Manufacturers/Suppliers of mining equipment, with a view to elicit opinions concerning the general feasibility of the proposed strategy and implementation proposals, and to obtain their comments and suggestions. Opinions of individuals representing the main role players will be elicited. This part of the study could prove to be very time-consuming as long distances will have to be covered and rather lengthy interviews will have to be conducted. Feedback obtained from the role players in the selected sample will be assessed by the research team members and incorporated into the draft strategy and draft proposals for implementation.
1.4 Deployment of the study

Section 1: Introduction and background.

Section 2: Literature survey on ergonomics strategies and other ergonomics implementation approaches.

Section 3: Research methodology and experimental approach.

Section 4: Results of the strategy development and empirical verification of the ergonomics strategy by means of role player opinion.

Section 5: Conclusions and recommendations.
2. Literature survey

In this section fatality and injury statistics, ergonomics, strategy development, legislation, ergonomics strategies, ergonomics programmes, participatory ergonomics, and ergonomics design guidelines and specifications are discussed. This information will establish the theoretical foundation for the development of the ergonomics strategy and the implementation proposals.

Relevant information on ergonomics strategies and other ergonomics implementation approaches was obtained on an international as well as national level. Information sources that were consulted by the various research team members include libraries, the internet, research reports, newspaper articles, and the International Ergonomics Association (IEA).

International contacts of various research team members were communicated with via electronic mail, telephone calls, facsimilees and letters. Various experts in ergonomics were contacted in the United States (US), the United Kingdom (UK) and Australia.

In this literature survey, which is the first enabling output of the project, an introduction to ergonomics is provided to introduce the reader to the specific scientific field of study and to highlight the benefits which applying ergonomics principles may have for both the organisation and the individual workers.

The development of any strategy is not a simple task but part of a process. The development process of a strategy is discussed in detail.

Relevant legislation addressing ergonomics in the local mining industry and the relevance and the effectiveness thereof are discussed.

2.1 Fatality and injury statistics

Fatality rates in South African diamond, coal, gold and platinum mines for the past 15 years are presented graphically in Figure 2.1. On the same Figure 2.1, fatality rates in chrome, copper, iron, ore, granite, limestone and clay mines are also presented (Department of Minerals and Energy, 1999). The fatality rate in clay mines during 1997 and 1998 is quite alarming as is evident from Figure 2.1, increasing from 0,82 in 1996, to 2,42 in 1997 and 3,18 in 1998.

The overall number of deaths and injuries in South African mines declined by 11 percent to 371 (in 1998) from 415 the previous year. However, due to the fact that employment levels had also fallen at a similar pace the fatality rate, measured in terms of the number of employees killed for every thousand at work, had remained fairly constant at a rate 0,86. Gold mines became a little more dangerous (as illustrated in Figure 2.2) over the same period where the fatality rate increased from 0,95 to 1,09. (Department of Minerals and Energy, 1999; Hasenfuss, 1999; Rosenthal, 1999).

The overall fatality rate in the South African mining industry remained constant at 0,86 employees killed for every 1 000 at work in 1998 and in the previous year (see Figure 2.2). The number of employees seriously injured, such that they were incapacitated for at least 14 days, fell to 14,13 for every 1 000 employees at work, from 14,66 the previous year as illustrated in Figure 2.3 (Department of Minerals and Energy, 1999).

Although the local gold mining sector experienced the greatest fall in employment numbers (20 percent from 1997 to 1998), the fatality and injury rates increased from 0,95 gold miners killed per 1 000, in 1997, to 1,09 in 1998. In 1998, 19,88 per 1 000 gold miners were seriously injured compared to 19,53 the previous year (Department of Minerals and Energy, 1999).
Over the same period, the injury rate in the South African gold mining industry increased to 19.88 for every 1,000 employees at work, from 19.53 the previous year. There has in fact been a steady incline in the injury rate in gold mines since 1995 and a steady drop in the injury rate in the South African mining industry as a whole since 1996 as illustrated in Figures 2.3 and 2.4.

This increase breaks a steadily declining trend in the gold mining industry over the past few years as illustrated in Graph 2.1. According to Rosenthal, the general declining trend appeared to be as a result of a more co-operative approach between labour and employers on safety issues. The Mine Health and Safety Act (No. 29 of 1996), among other reforms, allows mineworkers to refuse to work in unsafe conditions.

The fact that gold mining was taking place at greater depths as well as the production pressures arising from the weak gold price, could possibly be the reasons for the increase in accidents on gold mines, in 1998. Although there was no measurable correlation between increased labour productivity and accidents, it must have some effect on safety (Derek Baker, a senior inspector of mines, quoted by Rosenthal, 1999).

According to the then Minister of Mineral and Energy Affairs, Penuell Maduna, the decrease in the absolute number of fatalities and injuries during 1998, is attributable to improved risk management and better health and safety measures (Rosenthal, 1999). Hasenfuss (1999), however, maintains that better health and safety measures had virtually nothing to do with the reduction in deaths on the local mines. He believes that the reduced number of mineworkers exposed to the dangers of working in mines was the main reason for this reduction in deaths.

South African mineworkers face a risk of one in a thousand odds that they will be killed on the job and an odds of just better than one in fifty of being seriously injured at work each year (Hasenfuss, 1999).

Hasenfuss believes that great progress has been made through better safety legislation and an improvement in the government inspectorate to enforce legislation, but that the battle is not over yet.

The development of a comprehensive ergonomics strategy for the South African mining industry could contribute significantly to carry on with this battle to improve health and safety and to ensure that the decline in accidents observed during 1998 continues in the future.

These fatality and injury figures mean great personal suffering and family hardship. They also mean economic costs to the health service, employers and society. There is a pressing need to address this problem as is evident by SIMRAC’s efforts to reduce accidents, injuries and fatalities on South African mines. Ergonomics is a unique science which could contribute to these efforts through the development and implementation of an ergonomics strategy for the South African mining industry.
Figure 2.1: Fatality Rate in South African mines
Source: Department of Minerals and Energy (1999)
Figure 2.2: Fatality rate in gold mines and all mines
Source: Department of Minerals and Energy (1999)
Figure 2.3: Injury rate in gold mines and all mines
Source: Department of Minerals and Energy (1999)
Figure 2.4: Injury rate in South African mines

Injury Rates

Source: Department of Minerals and Energy (1999)
2.2 An introduction to ergonomics

The term “ergonomics” was coined in 1949 by KFH Murrel from the two Greek words ergon, meaning work or effort, and nomos, meaning law or rule. Translated literally, ergonomics means “the laws of work” (Bridger, 1995; Galer, 1987; MacLeod, 1995; Murrel, 1965). This is actually a very good description or summary of ergonomics as it is mostly applied in the work environment to increase the comfort and efficiency with which work can be performed by individuals and groups.

2.2.1 Defining ergonomics

Sanders and McCormick (1987:5) capture the essence of the discipline of ergonomics in the following definition: “Human factors discovers and applies information about human behaviour, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use”.

A similar but more comprehensive definition of ergonomics is provided by Christensen, Topmiller and Gill (1988:7): “Ergonomics is that branch of science and technology that includes what is known and theorised about human behavioural and biological characteristics that can be validly applied to the specification, design, evaluation, operation and maintenance of products and systems to enhance safe, effective and satisfying use by individuals, groups and organisations”.

From the above definitions it is evident that “ergonomics” and “human factors” are interchangeable terms for the same discipline. The term “human factors” is preferred in the US, while the term “ergonomics” is preferred in Europe, the UK, Australia and South Africa.

A simplified definition for ergonomics could be as follows:

Ergonomics seeks to design tools, equipment, products, systems, tasks, procedures and environments to be compatible with human capabilities and limitations.

2.2.2 The focus of ergonomics

Ergonomics focuses on the interaction between humans and

- products
- equipment
- facilities
- procedures
- physical environment
- psychological environment

used at work and in everyday living. The emphasis is on humans and how the design and layout of the above influences them (Sanders & McCormick, 1987).

2.2.2 The objectives of ergonomics

The main objective of ergonomics is to change the things people use and the environments in which they use them to correspond with their capabilities, limitations and needs. Two clear sub-objectives of ergonomics can be distinguished.

- The first objective is to increase the efficiency and effectiveness with which work and other activities are performed.
The second objective is to enhance certain desirable human values. Examples of these are improved safety, reduced fatigue and stress, increased comfort, greater user acceptance, increased job satisfaction and improved quality of life (Sanders & McCormick, 1987).

The aims or objectives of ergonomics are summarised in Figure 2.5 below. The ultimate goal of ergonomics is to improve and maintain the well-being of the individual worker. At the same time the well-being of the organisation will also be improved and maintained. The application of ergonomics has certain advantages for the individual worker such as an improvement in the following:

- health
- safety
- comfort
- satisfaction
- convenience

For the organisation, on the other hand, there will be an improvement in the following:

- performance
- productivity
- effectiveness
- efficiency
- quality of the product or service

In this process, there will be a resultant drop in absenteeism and labour turnover, an increase in worker involvement, more commitment to change, as well as an increase in worker motivation and the purchase of the company’s products or services.

2.2.4 The approach of ergonomics

The human is very adaptable and adjusts easily to equipment and environments which are not optimally designed. Adaptations may take time when demands are placed on a human. Although it may not be noticed at first, there is a limit on the amount of adaptability which can be expected from a human. Some products, facilities and work environments are so unsuitable for the user that it is impossible to perform tasks comfortably and safely. In such an instance no amount of adaptation of the human will enable him or her to perform the task and the user may even be injured or may become extremely fatigued and frustrated in trying to compensate for the poor design (Galer, 1987).

If ergonomics is not applied by designers, planners and other decision makers, it may lead to a poor fit between the user and his or her equipment and environment. As a result of this it may take longer to perform tasks, more mistakes may be made, and the user will experience discomfort and dissatisfaction. All these factors may result in an unsafe work environment (Galer, 1987).

A holistic approach, where all aspects in the work environment are addressed, should be followed when ergonomics is applied to the design and layout of work environments and facilities. When the holistic approach is followed, the total environment should be considered and not just what is happening in the worker’s immediate environment.
Figure 2.5: The objective of Ergonomics

Adapted from Wilson & Corlett (1990, p. 6)
2.2.5 A simple ergonomics model

The most general approach to ergonomics is to think about a person interacting with technology. The interaction occurs by means of displays, whereby the machine or technology provides information to the user and controls whereby the user passes information to the machine (see Figure 2.6). There is therefore a complete information flow loop with a proper functioning of all the parts. To ensure successful, safe and effective use there should be no delays in the information flow (Galer, 1987).

A very important concept in ergonomics is the “human-technology system”. Whenever a human uses a product, equipment or system, we refer to this interaction as a “human-technology system”. Typical examples of this are a person driving a vehicle, a person using a hammer, a person speaking over a telephone and a person using a lift.

![Figure 2.6: Communication between human and machine viewed as an information flow loop (after Galer 1987:18)](image)

From a mechanical point of view, the human receives information, based upon which he or she takes certain actions. There is a mechanism in the human being which takes decisions and links incoming information to outgoing information. Such a simple presentation of the human can be useful in the division of perceptual (input), cognitive and motor (output) functions. It can be an indication whether a proposed solution to a human-technology problem is likely to work (Galer, 1987).

Tasks are not performed in a vacuum. The interaction between human and technology always takes place in a certain workspace which is located in a certain physical and psychological environment (see Figure 2.7). The characteristics of the workspace and the environment will affect the task performance of the human.

The workspace is described in terms of the size and layout of work benches, control desks, consoles and other mining equipment. Factors like size and layout will have an effect on the body position, body posture and reach distances of the expected user population and consequently on their comfort and efficiency.

The environment can be described in physical terms such as temperature, lighting, noise and vibration. The environment can also be described in terms of the presence and effect of chemical and biological agents, as well as in psychological terms such as teamwork, management structure, shift conditions and psycho-social factors (Galer, 1987).
The human-technology-workspace-environment model is useful in identifying the factors that will have an effect on comfort, task performance and safety. Applied consistently, this model will ensure that no potential ergonomic factors are omitted. It is, however, primarily a descriptive aid and does not specifically spell out how and in which sequence a system should be analysed and designed. This systems approach is a formal analysis method which has been used successfully in a large number of ergonomics investigations (Galer, 1987).

### 2.2.6 The human-centred approach

In the human-centred approach, the human is regarded as the centre of the whole ergonomics effort in designing and evaluating any system, equipment, task or product. Galer (1987) also refers to this approach as the “workstation analysis approach” as this method could be used to evaluate or analyse any system, workstation or product.

The interaction between the human and the equipment used, should be optimal for each part of the system in which the human is involved. The ergonomics approach on this level is to examine the task and operational procedure the person should follow. Since the focus is always on the human, the human is always considered first. Therefore one always starts with the human and work outwards from the centre of the human-centred approach model (see Figure 2.8 below), considering firstly, the interaction between the human and technology, then secondly, the interaction between the human and the immediate workspace, and finally, the interaction between the human and the general environment in which the task is performed (Galer, 1987).

This approach is applicable where separate workstations (micro) within any large system (macro) are considered as well as single human-machine combinations (micro). It can be used as an initial guide when new problems in an existing situation are studied, and in the design of new workstations. In this approach, the human is placed in the centre of the frame of reference (model) and one then works outwards, as described above, to consider the equipment, workspace and environment, and the interaction between all the elements.
This process of analysis proceeds through a series of questions and definition steps which lead to a formal statement of the situation. This forms the basis for the following phase which consists of a set of recommendations, initial design proposals or an evaluation of a complete design. The sequence of the analysis appears in Table 2.1. The sequence should not be seen as a set of independent units to be considered separately and only once. There will inevitably be an interaction between some aspects and answers in the first two main areas, which are the human user and the machine or technology. The analysis is likely to proceed through the various steps several times, and often aspects of two areas are covered simultaneously. This process is repeated until all the information is gathered for each area, and then the information is gathered under the successive headings of the framework.

**Table 2.1: Workstation analysis outline**

<table>
<thead>
<tr>
<th>SEQUENCE OF ANALYSIS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Human user</td>
</tr>
<tr>
<td>2</td>
<td>User-technology interaction</td>
</tr>
<tr>
<td>3</td>
<td>User-workspace interaction</td>
</tr>
<tr>
<td>4</td>
<td>User-environment interaction</td>
</tr>
<tr>
<td>5</td>
<td>Special questions</td>
</tr>
</tbody>
</table>

**2.2.6.1 Human user**

The first step in the process of studying the interaction between the human, technology, workspace and work environment, is to define the likely range of people who will use the workstation or equipment. In order to accommodate the human abilities and limitations of the human operator in respect of all facets of the task. The following important human characteristics of potential users should be considered when studying all facets of the task:

- age
- body size (anthropometry)
- physique
- strength (biomechanics)
mobility
intelligence
experience
training
motivation
skills
competencies
culture
psychology

Emphasis is placed on the range of any characteristic, rather than on its average value, because facilities designed for the average value are likely to be unsatisfactory for those at the extremes of the range. It is customary to attempt to accommodate at least 90 percent of the population within the design.

2.2.6.2 User-technology interaction

The next step in the process is to understand fully the operation of any machines or equipment (technology) involved, and the user’s interaction with them. “Machine” and “equipment” include any non-human aspect of the task. Typical examples of technology with which humans can interact include displays, controls and control panel layout.

2.2.6.3 User-workspace interaction

Moving outwards from the interaction between human and machine/technology, the interaction of the user with the immediate surrounding workspace is considered. The following factors influence an operator’s body position, posture and reach, and thus his or her comfort and efficiency when interacting with the workspace during the performance of a task:

- machine size and layout
- adjacent machines and equipment
- structures and materials
- work in progress
- desks and chairs
- space for people to move

2.2.6.4 User-environment interaction

Moving outwards from the centre of the model (see Figure 2.8), the interaction between the human and the general environment is considered, in both physical and psychological terms. In Table 2.2, examples of the four environmental categories that influence human behaviour, health and performance, are listed.
Table 2.2: Examples of human-environment interaction

<table>
<thead>
<tr>
<th>ENVIRONMENTAL CATEGORY</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICAL ENVIRONMENT</td>
<td>Noise, temperature, illumination, colour, vibration, barometric pressure, movement, radiation</td>
</tr>
<tr>
<td>CHEMICAL ENVIRONMENT</td>
<td>Toxic gas or liquids, pressure, smell, dust</td>
</tr>
<tr>
<td>BIOLOGICAL ENVIRONMENT</td>
<td>Microbes, insects, animals</td>
</tr>
<tr>
<td>PSYCHOLOGICAL ENVIRONMENT</td>
<td>Teamwork, management structure, pay and welfare, shift conditions, discomfort or risk, socio-psychological aspects of the work environment, neighbourhood, town and type of industry concerned</td>
</tr>
</tbody>
</table>

2.2.6.5 Special Questions

The analysis process discussed above tends to address normal conditions and regular, routine procedures. Other questions focus on what might go wrong, what exceptional circumstances might arise, what procedures and sequences are irregular, and what emergency conditions and procedures are needed. The essential questions asked here are of the “what happens if ...?” type, and the aim is to identify all the unusual events that might arise, and to make provision for them when designing the system.

Examples of unusual events that might give rise to problems are:

- the breakout of a fire
- the leakage of hazardous gases
- a power failure
- a bomb threat
- flooding
- an earthquake

2.2.7 The interdisciplinary nature of ergonomics

Ergonomics is an interdisciplinary science as it draws on principles and information from related disciplines such as engineering, physiology, industrial hygiene, psychology workstudy, time-and-motion study, etc.

Ergonomics is also a multidisciplinary science as specialists from various sciences contribute to the body of knowledge of ergonomics for example engineers, physiologists, medical practitioners, psychologists, industrial designers and technologists.

Information for ergonomics purposes can be broadly organised in three disciplines:

- The biological sciences
- The human/behavioural sciences
- The physical/natural sciences

The interdisciplinary nature of ergonomics and the integration of the various sciences and their application are illustrated in Figure 2.9.

Ergonomics should therefore not be viewed in isolation when applied in the work environment. Ergonomics application should be seen in context interlinking with the other established scientific fields such as industrial hygiene, physiology, engineering, medicine and psychology, contributing towards the improvement of the work environment, human well-being as well as organisational well-being.
Figure 2.9: Interdisciplinary nature of ergonomics
2.3 The strategy development process

Strategy development and strategic management are well-established sciences (Coskin, 1998; Pearce & Robinson 1988; Pearce & Robinson 1997). For the purposes of the current study the strategic management model of Hunger and Wheelen (1993) was found to be the most suitable approach to be followed in this research project to develop a comprehensive ergonomics strategy for the South African mining industry.

Since this project focuses on the development of a strategy and not the management of a strategy, this model will be adapted to suit the specific requirements of this project.

2.3.1 Approach

The process of strategy development involves four basic elements, namely environmental scanning, strategy formulation, strategy implementation, and evaluation and control (Hunger & Wheelen, 1993). The way these four elements interact is illustrated in Figure 2.10.

![Figure 2.10: Basic elements of the strategy development process (after Hunger & Wheelen, 1993:12)](image)

2.3.1.1 Environmental scanning

- **External and Internal Environment**

  In strategy development, the external environment is scanned for opportunities and threats, and the internal environment for strengths and weaknesses (Hunger & Wheelen, 1993).

  In the context of this project, the main role players in the South African mining industry constitute the internal and external environment of a typical mine. The main role players are the following four main groups in the local mining industry:

  - Government
  - Employers
  - Employees
  - Manufacturers and suppliers of mining equipment

  The opportunities, threats, strengths and weaknesses are encompassed in these four groups of role players. For the proposed ergonomics strategy for the South African mining industry to be implemented and maintained successfully, the support, acceptance and involvement of these four main groups will be essential.

2.3.1.2 Strategy formulation
According to Hunger and Wheelen (1993), strategy formulation is the development of long-range plans for the effective management of the environmental opportunities and threats, in light of corporate strengths and weaknesses.

Developing an actual strategy, is only one of four steps in the formulation of a strategy. In this process of strategy formulation it is important to also define the mission, specify achievable objectives and to set policy guidelines. The strategy formulation process is illustrated in Figure 2.11.

**Figure 2.11: Strategic management model (after Hunger & Wheelen, 1993:13)**

- **Mission**

The mission of an organisation is the purpose or reason for the organisation’s existence (Hunger & Wheelen, 1993). In this first step of the strategy formulation process, the mission of the ergonomics strategy for the local mining industry will be defined. A well-conceived mission statement should define the fundamental, unique purpose of the ergonomics strategy.

- **Objectives**

The mission of an organisation determines the parameters of the specific objectives to be defined by top management (Hunger & Wheelen, 1993). The objectives are listed as the end results of planned activity. The objectives state what is to be accomplished by when and should be quantified if possible (Hunger & Wheelen, 1993).

- **Strategy**
The strategy forms a comprehensive master plan stating how the mission and objectives will be achieved. Strategies can be derived from corporation policies, approved programmes and authorised budgets (Hunger & Wheelen, 1993). A key part of strategy formulation is the development of alternative courses of action that specify the means by which the mission and objectives are to be accomplished.

- **Policies**

Flowing from the strategy, policies provide broad guidance for decision making. Policies are therefore broad guidelines that serve to link the formulation of strategy with its implementation. Corporate policies are broad guidelines for divisions to follow in compliance with corporate strategy. These policies are interpreted and implemented through each division’s own objectives and strategies. Divisions may then develop their own policies that will be guidelines for their functional areas to follow (Hunger & Wheelen, 1993).

The policy should give clear guidance to the persons responsible for the implementation of the strategy.

**2.3.1.3 Strategy implementation**

The third stage in the strategy development process is strategy implementation. According to Hunger and Wheelen (1993), strategy implementation is the process by which strategies and policies are put into action through the development of programmes, budgets, and procedures. They maintain that this process might involve changes within the overall culture, structure, and/or management system of the entire organisation. Strategy implementation is sometimes referred to as operational planning and often involves day-to-day decisions in resource allocation.

- **Programmes**

A programme is a statement of the activities or steps needed to accomplish a single-use plan. It makes the strategy action-orientated and may involve restructuring the corporation or changing the internal culture concerning how people get things done. Implementation might also include a series of advertising and promotional programmes to boost the interest of everybody involved (Hunger & Wheelen, 1993).

- **Budgets**

The budget is the statement of the programmes in financial terms. It is used in planning and control and lists the detailed cost of each programme. Top management will often only approve a new programme if there is a certain percentage return on investment. The budget therefore provides a detailed plan of the new strategy in action and it also specifies the expected financial impact through pro-forma financial statements (Hunger & Wheelen, 1993).

- **Procedures**

Procedures are a system of sequential steps or techniques that describe in detail how a particular task or job is to be performed. The various activities that must be carried out for completion of a programme are typically detailed in procedures (Hunger & Wheelen, 1993).

**2.3.1.4 Evaluation and Control**

The fourth and last stage of the strategy development process is evaluation and control. Evaluation and control is the process in which activities and performance results are monitored in
order to compare actual performance with desired performance. The resulting information are used to take corrective action and to resolve problems. Evaluation and control can also pinpoint weaknesses in previously implemented strategic plans and this stimulate the entire process to begin again (Hunger & Wheelen, 1993).

Effective evaluation and control require clear, prompt and unbiased feedback. Feedback in the form of performance data and activity reports should run through the entire process as indicated in Figure 2.11. This feedback can be used to compare what is actually happening with what was originally planned in the formulation stage. To monitor and evaluate broad-scale results, periodic reports with key performance indicators could be used. From what these reports indicate, further action could be taken (Hunger & Wheelen, 1993).

Hunger & Wheelen (1993) maintain that activities are harder to monitor than performance results because of the many difficulties in deciding which activities to monitor and because of the bias inherent in evaluating job performance.

2.4 Legislation

The Mine Health and Safety Act (Act No. 29 of 1996) is the only legislation in South Africa that specifically addresses ergonomics or mentions the term “ergonomics”. According to Section 21(1)(c):

“any person who designs, manufactures, erects or installs any article for use at a mine must ensure, as far as reasonably practicable, that ergonomic principles are considered and implemented during design, manufacture, erection or installation”.

This section of the Act only applies to the duties for health and safety (and ergonomics) of manufacturers and suppliers. Louw (1999) maintains that a court of law will be very reluctant to institute prosecution due to the fact that there are currently no regulations to provide the manufacturers of mining equipment with more specific guidance on ergonomic principles and how to apply them.

Furthermore, Section 21(1)(c) applies only to manufacturers and suppliers of mining equipment. What about the employer’s duty to provide a work environment that conforms to good ergonomic principles?

Section 2 (1) of the Act stipulates the following employer duties:

“The employer of every mine that is being worked must:

(a) ensure, as far as reasonably practicable, that the mine is designed, constructed and equipped.

i. to provide conditions for safe operation and a healthy working environment; and

ii. with a communication system and with electrical, mechanical and other equipment as necessary to achieve those conditions;

(b) ensure, as far as is reasonably practicable, that the mine is commissioned, operated, maintained and decommissioned in such a way that employees can perform their work without endangering the health and safety of themselves or of any other person”.

Although the term “ergonomics” does not appear in the abovementioned Article, ergonomics could be read into it as objectives similar to those of ergonomics are contained therein.
Articles 5 and 11 of the Act stipulate the duties of the employer with regard to health and safety risks and hazards, and the identification, assessment and recording thereof. Therefore ergonomics could also be read into Articles 5 and 11 of the Act.

The main objectives of this Act are:

- to protect the health and safety of persons at mines;
- to require employers and employees to identify hazards and eliminate, control and minimise the risks relating to health and safety at mines;
- to give effect to the public international law obligations of the Republic that concern health and safety at mines;
- to provide for employee participation in matters of health and safety through health and safety representatives and the health and safety committees at mines;
- to provide for effective monitoring of health and safety conditions at mines;
- to provide for enforcement of health and safety measures at mines;
- to provide for investigations and inquiries to improve health and safety at mines; and
- to promote:
  - a culture of health and safety in the mining industry;
  - training health and safety in the mining industry; and
  - co-operation and consultation on health and safety between the State, employers, employees and their representatives.

A number of the above objectives of this Act are very similar to the objectives of ergonomics and an ergonomics strategy for the implementation of ergonomics in the local mining industry will facilitate the fulfilment of the main objectives of the Act. The ergonomics strategy could also provide guidance in the development of a code of practice for occupational hygiene as well as the drafting of ergonomics regulations for the Act and ergonomics standards for the South African mining industry.

2.5 International ergonomics strategies

The literature survey and personal communication with ergonomists in other countries have revealed that a holistic ergonomics strategy for the mining industry specifically has not yet been developed or implemented in any country as far as could be established.

2.5.1 Australia

According to Joy (1999), ergonomics strategies of sorts have been developed by some mining companies and related agencies in Australia. However, these strategies are not clearly documented. This casts some doubts on the scientific nature of these so-called “strategies”. The main strategic focus in the Australian mining industry is currently on “major hazards” that have immediate and traumatic results such as roof falls, explosions etc. Joy has done work in South Africa previously and maintains that interest in health and occupational hygiene in South Africa is stronger than in Australia.

Instead of having an ergonomics strategy for the mining industry in Australia, a management model for engineering risk in mining has been developed. This model includes systematic
decisionmaking considering ergonomics as well as a strategic plan to improve minerals industry competency in this area (Joy, 1999).

It can be deducted that the “strategies” that Joy is referring to, is actually ergonomics programmes and not ergonomics strategies. To date, there has not been a single comprehensive ergonomics strategy for the total Australian mining industry.

Joy has been involved in the development of mine specific ergonomics programmes. In all cases the mine issues were identified by some sort of historical and team-based risk assessment. This was followed by the application of an ergonomics risk assessment tool for looking at the issue (such as a mock transport vehicle in a coal mine). The risk assessment tool is typically in the form of a work book. In addition to this, Joy believes that the “selling” of mining ergonomics is very important and has been rare to date.

2.5.2 United Kingdom

British Coal’s ergonomists developed an ergonomics strategy that was mainly focused on improvements to equipment design at the direct requests from their mining industry. They developed a range of approaches to provide the designers and buyers of mining equipment with specification and design information. Systems were then developed to check that the equipment delivered to the mines fully met the mine’s expectations (Mason, 1999). The Bretby Operability Index was developed to help ergonomists with the evaluation of major items of underground machinery before they were approved for use underground. This index helped ergonomists to provide a service to industry which was both consistent and reliable. Ergonomists also provided the designers of mining equipment with detailed criteria on which their machines were assessed (Mason, 1992). Unfortunately the British Coal Corporation no longer exists.

A second strategy was adopted by the European Coal and Steel Community (ECSC) which was primarily focused on ergonomics research (basic and applied) that could improve health and safety in both industries. Productivity and quality were specifically excluded from ECSC research. The main function of the ECSC was to identify areas for future ergonomics research and to ensure past research was implemented. One of the shortcomings of this system was the inability to “ensure” implementation of research findings (Mason, 1999).

Both of the abovementioned strategies focus exclusively on health and safety but excluded the important issues of productivity and quality. Any comprehensive holistic ergonomics strategy should include all four these aspects, an approach that will be followed in the development of an ergonomics strategy for the South African mining industry.

2.5.3 United States

According to Gallagher (1999) and Leamon (1999), there is no formal programme or strategy to introduce ergonomics in the US mining industry. Gallagher cites the variability in organisational and environmental conditions, which contribute to the uniqueness of each mine, as the main reason for not having a formal ergonomics strategy.

Gallagher identifies certain key ingredients which need to be present in order for ergonomics to take hold in a company. According to him, the most important of these are management commitment and worker participation in the process. However, these elements lie on the ergonomics programmeme level which is at a lower level than an ergonomics strategy, and as discussed earlier in this document, is only one of the elements in the strategy development process.

2.6 International related strategies
A number of strategies developed for the improvement of occupational health and other related aspects are to be found in the literature. A number of the more relevant strategies related to this research project will now be discussed.

2.6.1 An occupational health strategy for Great Britain

The Health and Safety Executive (HSE) in Great Britain compiled a discussion document in preparation of a ten year occupational health strategy for the UK which will help all those involved in preventing ill health caused by work, to work towards common aims and targets. The HSE endeavours to produce a strategy which can be shared by all, which will identify clearly what they will do, and who is involved in doing what (Health and Safety Executive, 1998).

In order to obtain inputs, comments and recommendations from interested parties in the UK to the HSE for a strategy, representatives from various professional and other bodies active in occupational health were invited to provide inputs with regard to future challenges, how they see their role and work development. In order to provide opportunities for discussion of the ideas in the document and to give people the opportunity to share their views in an open forum, conferences, seminars and open meetings were held in different parts of the UK during 1998. Interested parties were also invited to comment on the document by letter, facsimile or e-mail.

The development of an occupational health strategy for Great Britain is seen as an important complementary part of the wider agenda for public health. The Health and Safety Commission (HSC) in the UK intends to publish a national strategy for occupational health in that country, in the light of recommendations from HSE, based on the discussion process. The proposed occupational health strategy will contain targets and objectives for specific actions, which will contribute to the public health initiatives.

In the discussion document in preparation of a ten year occupational health strategy for the UK, a prediction is made of how the future workplace may differ from the present in the following aspects:

- how industry and work are expected to change;
- how workplaces will adapt; and
- which new health issues may emerge at work.

The HSE has analysed technological, political, economic and social trends, and the views of stakeholders to make this prediction. Occupational health is properly defined in the discussion document to ensure that everybody has the same understanding of the term. A vision of what is hoped to be achieved in ten years time is a prerequisite for the development of this strategy. It is important that all interested parties share the values and aspirations that the vision represents.

Although there has been a continuous decline in accident rates over the past 20 years, various sources of information in the UK reveal that there are still significant levels of occupational ill health despite a comprehensive legal framework and measures to enforce this legal framework. The work to develop a new occupational health strategy for Great Britain should help to identify what can be done over the next ten years towards a time when no person will be made ill by work. In the discussion document, key reasons are provided why people are still being made ill at work. In the discussion document seven clear strategies to achieve the vision aims for the proposed strategy are stated. The seven aims are as follow:

- To achieve suitable procedures, systems and campaigns in place to address occupational health issues.
- To decide which occupational health issues should be targeted for action.
- To offer ways of providing relevant sound advice on occupational health.
- To collect and make available essential occupational health information.
• To raise awareness of occupational health and to make training and education on this subject available to everyone.
• To provide systems to assess the effectiveness of actions taken.
• To gain commitment from interested parties.

In the discussion document the scope of each aim is examined and examples are provided of some tasks to consider for each aim. Resources required to make the strategy successful are, however, not addressed because more work has still to be done on the detail, and the contributions that interested parties can make to the developing strategy need to be identified.

2.6.2 Global Strategy for Health for All

In 1979, the World Health Assembly launched the Global Strategy for Health for All (HFA) by the year 2000 by adopting resolution WHA32.30. In this resolution the Health Assembly endorsed the Report and Declaration of the International Conference on Primary Health Care, held in Alma-Ata, USSR, in 1978. In the same resolution, the Health Assembly invited the Member States of the World Health Organisation (WHO) to act individually in formulating national policies, strategies and plans of action for attaining this goal, and collectively in formulating regional and global strategies, using as a basis the guiding principles issued by the WHO’s Executive Board in the document entitled Formulating Strategies for Health for all by the Year 2000. A large number of countries in all regions have since formulated national strategies, and all regions have drafted regional strategies (World Health Organisation, 1981).

The global strategy for HFA has been based on the Alma-Ata Report and Declaration on regional strategies as seen from a global perspective. This health strategy provides the broad lines of action required in all sectors to give effect to health policy. The strategy describes the broad lines of action to be undertaken at policy and operational levels to attain health for all by the year 2000.

The strategy is based on the concept of countrywide health systems based on primary health care as described in the Report of the International Conference on Primary Health Care, Alma-Ata, 1978. It relies on concerted action in the health and related socio-economic sectors following the principles of the Alma-Ata Report.

The strategy includes the development of the health system infrastructure by means of countrywide programmes to reach the whole population. These programmes include measures for health promotion, disease prevention, diagnosis, therapy and rehabilitation. The strategy involves specific actions to be taken, the selection of appropriate technology, control measures as well as support measures which include information exchange, promoting research and development, technical support, training, and co-ordination between various sectors.

An inseparable part of the strategy is the action required to promote and support it on various levels such as government, political, economic, professional and managerial level. Also inseparable from the strategy is the action required to generate and mobilise all possible resources.

The role of the WHO is to promote, co-ordinate and support efforts by the countries of the world to implement successfully the strategy for health for all.

A document containing the plan of action for implementing, monitoring and evaluating the Global Strategy for Health for all by the year 2000, was also prepared in 1982 (World Health Organisation, 1982).

2.6.3 Occupational Safety and Health Administration strategic plan
The Occupational Safety and Health Administration (OSHA) in the United States prepared a Strategic Plan which establishes OSHA's strategic direction over the five year period from 1997 to 2002. OSHA's Strategic Plan has the following three strategic goals:

- To improve workplace safety and health for all workers, as evidenced by fewer hazards, reduced exposures, and fewer injuries, illnesses, and fatalities.
- To change workplace culture to increase employer and worker awareness of commitment to, and involvement in safety and health.
- To secure public confidence through excellence in the development and delivery of OSHA's programmes and services.

These strategic goals are further elaborated in a series of strategic objectives and specific, quantified performance goals (OSHA, 1998).

### 2.6.4 Australian national strategy for workplace health

Worksafe Australia, one of the ten occupational health and safety authorities in Australia, was tasked, in collaboration with other interested parties (e.g. non-government organisations, College of Occupational Physicians), to co-ordinate the development of a national strategy for workplace health in Australia. This strategy will fit in with the existing strategic approach to occupational health and safety adopted by Worksafe Australia. The strategy should build on existing occupational health and safety priorities, the potential for workplace health promotion, and continuing workplace reforms. The strategy should also take up the challenge of health promotion in small-medium sized business.

There are currently various health promotion programmes in workplaces in Australia. There is also a growing evidence that these programmes prevent work-related injury and disease and that some can yield a cost-benefit (Australian Department of Health and Aged Care, 1997).

### 2.6.5 Summary

In the literature on the abovementioned strategies a specific development process is not described as provided in paragraph 6 of this document. However, all of the strategies contain some of the important elements as discussed in paragraph 6. Examples of these elements are targets, objectives, goals, actions, visions, aims, strategies, procedures, evaluation, scope, resources, programmes, control, support and performance.

The strategic management model of Hunger and Wheelen (1993) discussed in paragraph 6, arranges all of the abovementioned elements of the strategy development process in a logical order. As mentioned earlier, this model will be used for the development of a comprehensive ergonomics strategy for the South African mining industry as it provides a proper and sound structure.

Although not one of the strategies discussed is an ergonomics strategy, much could be learned from them in the development of an ergonomics strategy.

### 2.7 Implementation programmes

From the literature survey it is evident that programmes are the most suitable manner to implement a specific strategy. This approach is adopted by most of the organisations and agencies that have created or established formal strategies as discussed in the previous paragraphs. Even organisations who have not established formal strategies, employ formal programmes to put specific plans and policies into action.
Whether it is for the promotion of health, or the reduction of accidents, injuries and fatalities, formal programmes seems to be the preferred way to implement the actions of a strategy.

In the following paragraphs ergonomics programmes and the concept of participatory ergonomics will be explored.

### 2.7.1 Ergonomics programmes

The establishment of ergonomics programmes in organisations is a relatively new method currently employed for the development and implementation of ergonomics. Wilson (1994) also refers to this method as “ergonomics management or intervention programmes”, which is perhaps a more accurate description of this approach. Ergonomics programmes should be based on participatory principles to ensure successful implementation. A major task facing ergonomists is to assist companies with the development, installation and maintenance of a full ergonomics programme (Wilson, 1994). Wilson (1994: 580) believes that ergonomics can be applied successfully “through individuals doing something about their own jobs”. To do so, he maintains that they need a changed attitude, some ergonomics knowledge, and a back-up resource. He further states that ergonomics programmes are particularly suitable for industries where issues of concern are performance (quality and output), health and safety, flexibility and managing of change.

A growing number of reports on the successful implementation of ergonomics programmes are to be found in the literature (Macleod, 1995; Parenmark, Malmkvist & Örtengren, 1993; St. John, Tayyari & Emanuel, 1993; Tapp, 1994; Wilson, 1994). Hendrikse (1994) and Bridger (1995) also propagate the implementation of ergonomics programmes in South Africa in order to promote the development and implementation of ergonomics in this country.

Wilson (1994) maintains that there is a huge need for ergonomics programmes, within which ergonomics can be devolved to all concerned or effected, doing this within the normal organisation channels and structures. He suggests that an ergonomics programme must be built upon the notions and practice of participation on both organisational and individual levels.

#### 2.7.1.1 Organisation Commitments

According to Wilson (1994), there are four commitments which must be accepted by the organisation which underlie the successful incorporation of such a programme into an organisation's activities. He regards the acceptance of these commitments as a precondition for a company to implement an ergonomics programme. These commitments will now be discussed.

- **Ergonomics is a value adding activity**

  Ergonomics has to be seen as a vital component of the value adding activities of an organisation and not as a cost on production or the business. In strictly financial terms, the costs of an ergonomics programme will far outweigh the costs of not having one.

- **Ergonomics should be based on a participative culture**

  The organisation must be prepared to accept a participative culture and to utilise participative techniques. This will not always be easy and it may not solve all problems, but it will be the way to establish a programme of ergonomics interventions and to implement and support any changes made.

39
Ergonomics interventions can be found across all company activities

Ergonomics-related problems and consequent interventions must not be seen in purely engineering terms; improvements or solutions can be found within programmes of design for manufacture or concurrent engineering, total quality management, and work organisation, as well as via more traditional routes of workplace design or worker training. Ergonomics interventions and improvements can indeed be found across all the activities of a company.

Ergonomics interventions is part of good organisational and management practice

There is nothing proposed in a comprehensive and well thought-out ergonomics programme which is not part of what should be good modern organisational and management practice. The concerns and initiatives of ergonomics are increasingly compatible with those of management theorists and organisation strategists, although from a different perspective. Good ergonomics should be a central part of any organisation's total quality programme, and can be greatly assisted by the existence of such a programme.

2.7.1.2 Devolving ergonomics

Wilson (1994) proposes the following three-part process as the basis of an ergonomics management programme.

Provide a foundation

Wilson believes that it is firstly necessary to provide a foundation for ergonomics programmes by ensuring support from the top management and the grass roots, allocating sufficient resources (people, time and money), encouraging iteration and adaptability, seeking widespread consultation and agreement, attempts made to see all perspectives, and establishing a robust but flexible base. Wilson maintains that the best way to promote ergonomics and give it a foundation is an ergonomics design review process and the setting up/establishment of task forces is probably the best way to achieve this.

The driving force behind task forces for workplace ergonomics is the eventual spread of knowledge and input amongst all the workforce, and the team must be set up with this in mind. The task force should consist of representatives from all levels in the organisation such as management, human resources, engineering, maintenance, health and safety, legal, procurement, and finance departments. By forming a task group responsibility and workload are diffused and a range of perspectives and abilities are introduced to the change process (Wilson, 1994).

Members of the task force should be provided with a set of tools and techniques (such as checklists) to allow them to make initial assessments but they should know when they need to call in specialist ergonomics advice. This should motivate team members in ergonomics input and also allow early ergonomics analysis. This should become the basis of a coherent ergonomics programme across the organisation's activities generally and the foundation is now layed (Wilson, 1994).

Spread ergonomics throughout the organisation

After laying a foundation, the understanding and ownership of the ergonomics programme must be spread throughout the organisation. The ergonomics programme must itself support the spread of ergonomics throughout the organisation. For long term survival, the expertise available to the programme should be transferred widely across the organisation. This will necessitate awareness raising at all levels, the development of appropriate tools and techniques, and a training programme to support widespread but skilled use of the tools and
techniques. Cascaded training gives motivation, practical knowledge and some skills to spread the training further. This can ensure the spread of ergonomics within the ergonomics programme and at the same time further strengthen its foundation (Wilson, 1994).

**Embed the ergonomics programme**

Wilson (1994) maintains that if the first two actions of providing a foundation and the spreading of ergonomics have been successful, the third action of embedding ergonomics firmly within the organisation, will already be underway. Wilson points out that an ergonomics programme must not remain a special or unusual, "imported" one-off activity. The goals and methods of the programme must be such as to embed it within the organisation. It should become a part of the normal roles and duties of all personnel within the organisation. This should be done in an active and operational sense, in such a way that carefully planned participation in work analysis and design by workers, is supportive of the participative process. Participative processes and techniques, as discussed in paragraph 10.2, are effective mediums by which to embed ergonomics in the organisation.

Wilson (1994) believes that the successful use of participation in workplace ergonomics and health and safety audits can lead to workforce participation in system implementation, job design developments, self directed work teams and production groups, and eventually to a participative culture throughout the organisation. Wilson further believes that by embedding ergonomics in an organisation in the right way can support the foundation and spread of the ergonomics programme as well. This is the essence of what Wilson call “devolving ergonomics”.

**2.7.1.3 OSHA Ergonomics Programme Standard**

In 1996, US workers experienced more than 647 000 lost workdays due to work-related musculoskeletal disorders (WMSDs) which now account for 34 percent of all lost workday injuries and illnesses. These injuries cost US businesses between $15 and $20 billion in workers' compensation costs each year. It is estimated that indirect costs may run as high as $45 to $60 billion (OSHA, 1999a & 1999b).

Many employers in the US have already developed and implemented ergonomics programmes to address WMSDs in their workplaces. Often WMSDs can be prevented by simple and inexpensive ergonomics interventions. As a result of successes already obtained, OSHA is developing a programme that calls for employers to establish ergonomics to prevent ARMSDs. OSHA has pledged to focus on jobs where there are injuries and solutions are well demonstrated. In consultation with stakeholders, OSHA has identified significant problems for workers involved in production operations in manufacturing and manual handling throughout general industry in the US. Many employers have proven that establishing a systematic programme to address such issues as repetition excessive force, awkward postures and heavy lifting, results in fewer injuries to workers.

OSHA has identified the following critical elements of the ergonomics programme:

- Management leadership and employee participation
- Hazard identification and information
- Job hazard analysis and control
- Employee training
- Medical management
- Programme evaluation

OSHA regards an ergonomics programme as a systematic approach for anticipating, identifying, analysing and controlling WMSD hazards.
Although it is not stated specifically in any of the available literature, this proposed Ergonomics Programme Standard of OSHA is in essence a strategy since it will be effective on a national level in the US.

OSHA plans to publish their proposal in the Federal Register in September 1999. During the US spring and summer, the rule will go through small business and governmental review. The regulatory text will be revised and the preamble, economic analyses and other supporting material developed. OSHA’s goal is to take public comments, hold hearings in several cities in late 1999 and publish a final rule in 2000 (OSHA 1999a).

OSHA has made a working draft available of the proposed ergonomics protection standard to invite and obtain comment from small business representatives and other interest groups (OSHA, 1999c).

2.7.2 Implementing an ergonomics programme

It is clear from the literature that the key ingredient of any successful ergonomics programme are top management commitment and the support of people from all other levels in the organisation. Top management must approve and support such a programme and the programme should be part of an organisation’s mission. The active involvement of employees on all levels must be accomplished during each phase of the programme (Hendrikse, 1994; NIOSH, 1997; Jensen, 1997; Imada, 1991).

The implementation of an ergonomics programme is illustrated in Figure 2.12. Once the decision has been reached and the policy statement formalised, and management and employees have been orientated, an ergonomics workgroup must be established in order to develop and implement the ergonomics programme. Hendrikse (1994) suggests the following steps for the development and implementation of an ergonomics programme.
Figure 2.12: Implementing an ergonomics programme (after Hendrikse, 1994:21)
2.7.2.1 Steps for the implementation of an ergonomics programme

- Define the programme goals, priorities and objectives. Also define the budgets, resources and limitations.

- Select a qualified ergonomics resource in order to achieve the programme goals and objectives.

- Conduct a professional ergonomics need assessment to help with the identification of priority problem areas.

- Utilise the ergonomics resource to train supervisors, safety personnel and engineers in the principles of ergonomics.

- The ergonomics consultant should, together with safety personnel and engineers, conduct systematic workplace need assessments.

- Develop and implement practical and cost-effective engineering solutions where possible or plan other preventative activities, e.g. adjustment of procedures.

- Evaluate the programme, as well as the impact of the changes that were implemented. Conduct a cost/benefit analysis of the solutions.

- Refine the solutions on an ongoing basis.

2.7.2.2 Composition of the ergonomics workgroup

The ergonomics workgroup requires the talents of persons from every level of the organisation. Hendrikse (1994) believes the essential multi-disciplinary approach to ergonomic problem solution can be accomplished by involving the following persons in the work group:

- senior management
- engineers
- health and safety personnel
- ergonomics consultant or resource
- human resource practitioners
- employees
- union representatives
- procurement personnel

According to Hendrikse, this approach may initially present challenges in terms of how information is requested and presented, meetings are scheduled, responsibilities are delegated and new ideas are solicited. The solving of these problems should lay the foundation for a successful programme.

All members of the workgroup must be informed about the scope and extent of the programme, the programme objectives, timescales, individual responsibilities, external resources and evaluation methods. The members of the workgroup should also be properly trained in the principles of ergonomics and the practical application thereof. The training must teach them when and how to use ergonomics tools and techniques, and when they can not. They must also be taught when to request specialist assistance from outside if the in-house ergonomics resource is not formally qualified in ergonomics (Hendrikse, 1994).

Engineers may require an intensive course on facility planning as well as workstation, tool and equipment design. Employee representatives and health and safety personnel should learn
techniques to identify ergonomic problems, as well as techniques regarding training methods and injury analysis.

2.7.2.3 Responsibilities of the ergonomics workgroup

The ergonomics workgroup has the following responsibilities:

- To identify and prioritise problem areas and the implementation of ergonomic control measures in order to reduce injuries and/or accidents and to increase productivity.
- The establishment of resources in order to develop solutions and to monitor the programme.
- The development of in-house ergonomic skills.

2.7.2.4 Infrastructure of an ergonomics programme

Hendrikse maintains that a long term corporate ergonomics programme must supply a support structure for the members of the group. The members of the group must meet on a regular basis to ensure programme continuity. During these meetings project results should be discussed, problems identified and suggestions made to improve programme effectiveness and to refine the programme goals and objectives on an ongoing basis.

2.7.2.5 Information

To implement an ergonomics programme the information that will be used should be determined first. Accurate data with regard to incidents, injuries, illnesses, complaints and productivity are essential. Relevant records should be competently reviewed and analysed. Rapid rectification of hazards will improve safety and health significantly. The effectiveness of task performances can also be improved.

This type of information:

- Helps to define problems.
- Helps to indicate areas that need ergonomics attention.
- Provides baseline information to evaluate the effectiveness of ergonomic solutions at a later stage.
- Indicates the way in which this type of information is documented, as well as the way in which injury prevention is monitored.
- Gives an indication as to how the current safety programme incorporates ergonomics.

2.7.2.6 Ergonomics need assessment

In respect of the ergonomics needs assessment the following steps should be followed:

- Identify high-risk areas for complaints, incidents, injuries, accidents or illnesses.
- Prioritise risk areas.
- Develop action plans to reduce or eliminate risks.
• Implement the action plans.

• Conduct cost/benefit analyses with respect to the following:
  - reduced injuries and health problems
  - increased productivity
  - increased product quality
  - compliance with health and safety legislation.

2.7.2.7 Participation

As discussed in paragraph 2.8, the fundamental strategy of an ergonomics programme is based upon participation and accountability. This participation should be sought on three levels, namely the executive level, the management/union level and the supervision/employee level. However, to build trust and avoid potential adversary relationships, it must be stressed that the ergonomics programme’s function in general and that of the workgroup in particular is to provide assistance in establishing a satisfactory, safe and efficient work environment.

As discussed earlier, the use of participative techniques in change analysis and implementation may produce benefits in terms of feelings of solution ownership and therefore commitment to change, generated amongst those affected. This results in better information in the overall process and faster, more effective, eventual use of a new system by the participants.

Participative process can facilitate the spread of interest and expertise in ergonomics and can help embed on ergonomics perspective within the organisation if people really are allowed to contribute and influence affairs (Wilson, 1994).

2.7.2.8 Summary

A successful corporate ergonomics programme is dependent on the participation of all the people concerned.

An ergonomic process should be established to monitor the work process in order to increase comfort, safety, health and productivity and to ensure products of higher quality. Employees will be more motivated and productive, injuries will be reduced and profits will increase. From a business viewpoint a corporate ergonomics programme makes a great deal of sense.

Training programmes are an essential part of an ergonomics programme since employees are taught healthy, proper and effective work practices which develop a consciousness of ergonomics.

2.8 Participatory ergonomics (technology transfer)

2.8.1 Definition

Participatory ergonomics is a relatively new concept within ergonomics which became established within the ergonomics community during the last ten to 15 years (Jensen, 1997). The concept of participatory ergonomics originated from discussions between Dr Andrew Imada and Dr Kazutaka Kogi in 1983. The term “participatory ergonomics” was first coined by them in 1984 (Imada, 1991; Noro & Imada, 1991). Kuorinka (1997:268) defines participatory ergonomics as “...practical ergonomics with participation of the necessary actors in problem solving”. Kuorinka maintains that participation is not limited to worker participation nor to formal, representative participation. In principle, all levels of the hierarchy are covered. The participation of those who may have first-hand experience about the problem in question is invited.
Wilson (1995:30) formulated the following working definition of participatory ergonomics reflecting the broad range of potential ergonomics initiatives:

“The involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals”.

Noro (1991) regards participatory ergonomics as a new technology for the dissemination of ergonomic information. Imada (1991) maintains that information sharing can motivate people involved in the solving of problems. Imada (1991) strongly believes that it is vital for the end-users or the beneficiaries of ergonomics to be involved in the development and implementation of this technology. According to Algera et al. (1990), the term "users" covers all groups in the organisational unit that are responsible for the system, from operators to production management. They belief that basic philosophy behind user participation is that both the quality and the acceptance of decisions are enhanced. Getting time from future users to be involved in the design process, and the communication gap between technical experts and the future users are serious threats for effective user participation (Algera et al., 1990).

2.8.2 Approach

According to Noro (1991), the breadth and knowledge required to improve human-machine working relationships make it difficult to confine ergonomic activities to any one organisational or even academic field. It is therefore necessary that ergonomists should work together with non-experts on an organisation-wide basis in the implementation of ergonomic principles. This procedure or approach is called “participatory ergonomics”. The participatory process of involving ergonomic experts as well as non-experts is important for the rapid progress of ergonomics. Noro (1991) stresses that this participatory process should be followed by all workers on an organisation-wide basis. Scott (1997) also believes that everyone within the worksite should be involved in ergonomics as well as ongoing evaluations of the site in their particular work situation. St. John, Tayyari and Emanuel (1993) highlight the fact that the application of ergonomics principles is not a one-time activity, but a process that requires continual attention, commitment and respect of everybody involved in the ergonomics programme.

Jensen (1997) believes that participation is a ambiguous concept. Jensen maintains that participatory ergonomics can be typified as direct participation in contrast to indirect or representative participation. It is important to clarify the role of the end-user (the people that directly benefit from ergonomics) in the decision-making process. There are different forms of participation. According to Jensen, articles on participatory ergonomics are not always very specific in describing the discussions and negotiations necessary to establish a set of participatory activities. In the cases described in the literature, the impression is that information and experience are gathered from workers and they (end-users) are consulted to make suggestions and present their points of view. Worker’s suggestions are directly accepted by management in the cases described (Jensen, 1997). Workers at grass-roots level should be empowered and encouraged to be part of the development and conceptual planning of the industry, and to help identify problem areas and offer solutions (Scott, 1997).

2.8.3 Participatory schemes

Participatory schemes can be based on legislation, collective agreements at national or at local level, and on management decisions. Most of the case studies seem to be established on management decisions. The Scandinavian countries are characterised by the highest degree of consensus between employer and employee-organisations and the state on nationwide agreements and legislation to motivate for local agreements establishing indirect and direct participation (Jensen, 1997). Representative participative schemes are negotiated between the
labour market parties and often also the state, and the schemes are signed in agreements or stated in laws. This implies that management is obliged to follow the schemes negotiated. Unions can identify the worker representatives and qualify them through their educational system to enter the negotiated participative schemes. Jensen believes that indirect participatory mechanisms provide a good foundation for the introduction of direct participatory ergonomics. He further maintains that participatory ergonomics is a strategy for change, while representative participatory schemes can be an organisational arrangement promoting this strategy.

Similar to occupational health and safety at work legislation in Scandinavian countries, in South Africa, the Occupational Health and Safety Act (Act 85 of 1993) and the Mine Health and Safety Act (Act 29 of 1996) indirectly provide the mechanisms for representative participatory schemes through the establishment of safety committees and the appointment of safety representatives in organisations (to ensure a continuous monitoring of the working environment). According to these Acts, the management of a firm is responsible for ensuring healthy and safe working conditions. However, these Acts also imply that this responsibility has to be fulfilled in co-operation with the people employed in the firm (i.e. participation).

Wilson (1994) believes that instead of setting up new structures from the beginning, all the organisation's existing structures, processes, and resources should be employed to assist organisational participation with an ergonomics effort. He maintains that both organisational and individual participative efforts are required, the organisation should provide the fertile ground needed by the individual, and should also enable people to give concrete expression to the hopes and expectations raised by the organisation.

Although the Scandinavian countries are characterised by regulatory efforts to promote participatory ergonomics in organisations by mandatory representative participatory institutions, they have not fulfilled the expectations. As a result, these countries have chosen to focus on the same factor. They try to establish a higher commitment from top management by introducing the notion of formalised management systems corresponding to quality control systems (ISO 9001, 1994) and environment management systems (BS 7750, 1992; ISO 1400, 1996). These systems emphasise the responsibility of management in establishing a policy, a well-defined organisational structure and a survey of work environment problems linked with plans of action (Jensen, 1997).

According to Noro and Imada (1991), the specific applications of participatory ergonomics demonstrate how participation can be used to enhance the positive effects that ergonomics can have. Kuorinka (1997) regards problem-solving as the main goal of participatory ergonomics. Participatory processes are, however, also used in the design and planning of completely new systems.

In order to realise the full effects of participatory ergonomics an organisational change rather than a change in technology is required. It means a shift in power, organisational design, and the way business was conducted in the past. Consistent organisational change, at a governmental level or at the very least a managerial level, may in fact be required and created for the effective implementation of participatory ergonomics (Imada, 1991). This matching of humans and technology into a larger organisational context ties up with Hendrick's (1991) macroergonomics. Kuorinka (1997) also maintains that the identification and understanding of organisational, technological and individual component roles in industry has shifted the emphasis to macroergonomic issues.

### 2.8.4 Participatory framework

Wilson and Haines (1998) have developed a framework within which to understand and promote participatory ergonomics. Their framework is based on the perspectives of Western industrialised countries and within that of a health and safety perspective. They acknowledge that the
dimension of their framework may look quite different under different circumstances. The dimensions that they include in their framework for participatory ergonomics are discussed below.

2.8.4.1 Extent/level

This first dimension is concerned with where participatory ergonomics is applied, whether across on organisation, a work system or a single workstation or product.

2.8.4.2 Purpose

The second dimension of participatory ergonomics concerns its purpose. It must be determined whether it is being used to implement a particular change or to be the method of work organisation.

2.8.4.3. Continuity

A further dimension is provided by the continuity of use of participation. It must be determined whether the process has got a continuous or discrete timeline, whether participation is to be used as an everyday part of an organisation’s activities or whether it will be applied from time to time as a one-off exercise.

2.8.4.4 Involvement

This dimension concerns who will actually take part in the process, from full direct participation to representative participation.

2.8.2.5 Formality

The fifth dimension acknowledges that the formality of worker participation in ergonomics may vary. In many cases involvement will be arranged through formal mechanisms such as teams or committees but in other cases worker participation will take place on an informal basis.

2.8.4.6 Requirement

The sixth dimension of participatory ergonomics is concerned with the requirement whether participation should be voluntary or compulsory. Voluntary participation is usually the most preferred form. Compulsory participation is normally employed in organisations with quality circles or production groups, where involvement in troubleshooting and continuous improvement is an obligatory part of job specification and worker roles.

2.8.4.7 Decision-making Structures

The seventh dimension concerns decision-making structures. The scale vary from worker consultation on the one end (although decision rest with management) to decision-making by workers on the other end of the scale.

2.8.4.8 Coupling

The final dimension is concerned with how directly participative methods are applied, a concept referred to as “coupling”. Participative methods may be directly coupled, where participants' views and recommendations are applied relatively directly (e.g. work groups redesigning their own
Remote coupling involves some filtering of participants’ views, the use of company-wide questionnaires, for example.

The general framework described above may be used by an organisation to initiate and structure participatory ergonomics initiatives. The framework help in the identification of the main factors which may motivate its decision to employ participatory ergonomics. The eight dimensions may help to structure the implementation of the initiative. An evaluation of the initiative will contribute to any further motivation to employ participatory ergonomics (Wilson & Haines, 1998).

Wilson and Haines warn, however, that the framework for now is speculative and provisional, and that much more detail and systematic study of how participatory programmes function is required. They further stress the importance of recognising and dealing with organisational influences and constraints within any participatory ergonomics framework and programme. They believe that organisations planning for participatory ergonomics should ensure appropriate inputs in terms of management commitment and resources, and also have policies and mechanisms in place to incorporate outcomes within the business.

### 2.8.5 Methods for implementing participatory ergonomics

Basic introductory training in ergonomics seems to be a prerequisite for the successful implementation of an ergonomics programme or to foster participatory ergonomics (Jensen, 1997; Laitinen, Saari & Kuusela, 1997; St. John, Tayyari & Emanual, 1993). Kuorinka (1997) also regards participatory ergonomics as a learning process. Participants learn technical issues (at a professional level) about the problem at hand and they also learn to communicate (at a social level) their knowledge and experience across the professional boundaries. The interprofessional communication dictates the nature of the conceptual tools of participatory ergonomics. The tools must be practical and concrete but also hierarchical, allowing for a progression from concrete to abstract. As the process advances, the methods should allow for progressive dealing with abstract and conceptual issues (Kuorinka, 1997).

According to Kuorinka (1997), the methods used to implement participatory ergonomics in organisations do not form a coherent set of conceptual tools. Kuorinka maintains that the methods used are merely a collection of techniques and approaches often used in solving workplace and organisational problems and in conducting working groups. These techniques come from various sources like rationalisation and organisational development. There are however issues such as the analysis of work activity, and the balancing of the roles of the ergonomics specialist and the non-expert worker in the implementation of participatory ergonomics that are specific to participatory ergonomics. Kuorinka further beliefs that the methodology in participatory ergonomics depends on the social, organisational and industrial context.

Small group activities such as quality-control circles used in Japan (Laitinen, Saari & Kuusela, 1997; Nagamachi, 1991), and design decision groups (Wilson, 1991) are the more popular ways of implementing participatory ergonomics. These small groups make suggestions for ergonomic improvements in the workplace. Among the techniques used in small group activities include the cause-and-effect diagram, Pareto diagram, histogram, scatter diagram, control chart, various graphs, check sheet, stratification (Noro, 1991) and full-size or scale mock-ups and simulations (Algera, Reitsma, Scholtens, Vrins & Wijnen, 1990; Kuorinka, 1997). An important characteristic of participatory ergonomic techniques is that they enable people to understand and apply ergonomics to their work (Imada, 1991). A precondition for successful participatory ergonomics through small groups is mutual trust between management and workers (Laitinen, Saari & Kuusela, 1997).

Regular ergonomics group discussions enable the groups to increase their ability to work more safely and to improve their own working conditions. This is achieved through the exchange of
experiences and ideas with fellow workers. This is an ongoing continuous process which increases efficiency and reliability, while at the same time reducing physical and mental stress and injuries, so creating an optimal working environment (Scott, 1997b).

2.8.6 The Role of the ergonomist in participatory ergonomics

The role of the ergonomist has changed from a specialist to a change agent, which in turn influences the practice of participatory ergonomics (Kuorinka, 1997). Co-operation between the ergonomics expert and the non-expert is a prerequisite for the effective implementation of participatory ergonomics. There should also be a trade-off between values produced by different solutions and drawing one conclusion. Obviously the advantages of participatory ergonomics are essential for attracting people from different fields to find common solutions to problems (Noro, 1991). Participation recognises the worker as a valuable resource for solving problems in the working environment (Imada, 1991).

A major task of the ergonomist is also to assist companies with the development, installation and maintenance of a full ergonomics programme (Wilson, 1994). The ergonomist should also acquire marketing and selling skills in order to sell ergonomics and the approach of participatory ergonomics and ergonomics programmes.

Hains and Carayon (1998) propose a combination of expert-guided and participatory work organisation interventions to evolve over time. They maintain that the proportions of each will vary depending on the type of intervention, the organisational members and the organisational context. Outside experts should design for internal control and a programme should progress from being expert-guided to self-guided through learning, feedback, control and action over time.

Scott (1997b) believes that the ergonomist needs to make an immediate and lasting impact, preferably at minimal cost and with maximal benefit to both worker and organisation.

2.8.7 Factors supporting participatory approaches

There have been a number of factors identified which support the implementation of participatory approaches in organisations. An organisation with a good economy has in general been found to be at an advantage for dealing with work environment issues. Issues concerned with improving the work environment are generally considered to be a cost to the organisation and are therefore not implemented. The size of an organisation is also of importance, successful cases often come from larger organisations (more than 50 to 100 employees). The labour market position of the different groups of employees determines the willingness of management to implement participatory schemes. Management are more sensitive to the views of employees with qualifications in great demand on the labour market. Management support is probably the most important issue in developing and implementing participatory schemes. Support from colleagues is also important. Active, well-educated and qualified representatives are important to develop the participative activities. Furthermore, the participative scheme in the work environment is subordinate to the general co-operative climate in the organisation (Jensen, 1997).

St. John, Tayyari and Emanual (1993) identify two major obstacles to the implementation of a pro-active ergonomics program. Since ergonomics is a new idea to many people resistance to change should be expected since it is a natural human reaction to change. They maintain that the best way to convince people to change is to show the costs of the present problem and the potential benefit from change. They further believe that it is difficult to sell ergonomics to management (as mentioned elsewhere) because the economic impact usually may be evaluated over a lengthy time period.
2.8.8 Benefits Of Participatory Ergonomics

Noro (1991) sites at least three advantages of employing participatory ergonomics. Firstly, participation contributes towards the efficient utilisation and integration of people and information. Secondly, participatory ergonomics provides a framework that utilises the knowledge, skill and experience of all participants. Thirdly, participatory ergonomics can play a major role in meeting the changes in workers' opinion and expectations. Participatory ergonomics basically empowers and enables people to apply ergonomics in order to solve problems in the working environment successfully. It also involve small groups and individuals in discussions and organisational decisions.

Other positive effects of participatory ergonomics include improved productivity and quality, reduced absenteeism and grievance rates, better working conditions, improved job satisfaction and organisational commitments. Participation may also be an excellent vehicle for helping people meet their individual needs for meaningful and rewarding work and, at the same time, helping organisations meet needs created by increased market competition, technology, and change (Imada, 1991).

Kuorinka (1997) warns, however, that participatory processes may create expectations and social forces which, if not properly controlled, may backfire. He maintains that participatory tools and means should not be seen as tricks and techniques but part of a complex set-up which should be used with honesty, diplomacy and tact, supported by sufficient knowledge about participatory processes.

The participation by workers also contributes to a high degree of acceptance of changes and improvements, which could be attributed to their participation in the origination of ideas and concept development. The participants are the owners of the ideas and solutions (Garmer, Dahlman & Sperling, 1995).

2.8.9 Management commitment and support

Algera et al. (1990) are convinced that the marketing of ergonomics from within an organisation can only be successful if a high level of expertise is provided by the ergonomist. Kuorinka (1997) believes there is no specific methodology for "selling" participatory ideas to management. He regards personal relations and mutual respect between technical experts, management and ergonomists as more important than formal procedures. The support of management at every level is a basic condition for the implementation of participatory ergonomics. Management should be fully convinced of the direct benefits of the practice of participatory ergonomics and they should participate in the process and certify the process properly (Algera et al., 1990; Garmer, Dahlman & Sperling, 1995). Participative methodology should be able to demonstrate the added value of the participative process to produce relevant solutions and "sell" the idea and demonstrate the need for a participatory approach to management (Kuorinka, 1997).

In order to facilitate the successful management of change, (ergonomics application or participation) top management should be committed, all persons affected by the change should participate in the change, and all persons affected should be trained for their roles in the change and the new procedures they will be using (Garmer, Dahlman & Sperling, 1995). Top management commitment, basic ergonomics training, and a participative task force structure provide the knowledge base for workplace design, foster communication and co-operation between departments, provide incentives to individuals involved in the programme, and help to gain commitment of all persons involved.

Participatory ergonomics is actually all about change in an organisation. It entails the application of ergonomics principles and techniques by workers and management to improve
the working environment. Participation should, however, be effectively managed to ensure the success of such a programme.

For an ergonomics programme to be effective and successful, existing material, financial and human resources must be mobilised and the commitment of all parties involved must be gained (Garmer, Dahlman & Sperling, 1995).

2.8.10 Examples of participatory ergonomics

Examples of ergonomics programmes and participatory ergonomics in a number of countries are presented below.

2.8.10.1 Sweden

A co-education programme was designed and implemented in a Volvo car assembly plant in Sweden to serve as a support for the creation of a participatory ergonomics process, intended for continuous use at the plant. The programme involved operators, manufacturing engineers and managers. The programme consisted of a basic ergonomics knowledge package, and a dialogue module defining the roles and relations of persons involved. The main, long term objective of the project was to start the participants co-operating in a continuous change and development process on the shop-floor. The programme proved to be successful and as a result the co-operation between operators and manufacturing engineers increased steadily. The co-education programme proved to be a good starting point for a process of participation. However, in order to ensure a permanent impact, the whole organisation must nourish and support the further development and implementation of the process (Garmer, Dahlman & Sperling, 1995).

2.8.10.2 United States

The Internal Revenue Service (IRS) in the US has developed and implemented an ergonomics programme with the objective to optimise the interface between employees and their workstations, their technologies, tools, jobs and their organisation so as to promote safety, health, and well-being of the workforce, and maximise efficiency of processes, products and services. The three groups of efforts of this programme are maintenance and support of daily operations, ergonomic hazard analysis and interventions/control, and ergonomics training for the workforce (Cohen & Schleifer, 1998).

Cohen and Schleifer report that the IRS ergonomics programme has made significant progress in the development of guidelines, procedures, and strategies for workstation design, job design and employee training and education.

In two automotive plants in the United States, participatory ergonomics programmes were implemented with the aim of facilitating worker participation in the design or redesign of repetitive, manual jobs in order to minimise cumulative trauma disorders. This approach proved to be effective in the improvement of jobs and the work environment to reduce risk factors associated with physical stress (Liker, Joseph & Ulin, 1991). This process must however be properly managed to keep participants motivated.

St. John, Tayyari and Emanual (1993) established an ergonomics programme in a truck manufacturing company in the United States with the aim to reduce carpal tunnel syndrome injuries among workers. They also utilised the existing safety committee structure as the primary body to identify, analyse, and address ergonomic problems and to run the ergonomics programme.

2.8.10.3 Netherlands
Algera et al. (1990) utilised user participation in an ergonomic design process to develop a new cabin of a coking car. They also made use of this approach to facilitate changes in machine and individual tasks as well as changes in organisational structures invoked by the implementation of new technology in the steel-making industry in the Netherlands.

2.8.10.4 Finland

Liatinen, Saari and Kuusela (1997) employed a behaviour modification programme based on participatory principles and performance feedback to improve order and tidiness (housekeeping), and at the same time improve ergonomics in a Finnish state railway company metal workshop.

The Finnish project was implemented by small groups in which workers, supervisors and management were represented. Only one department took part in the first phase of the project but within two years the whole workshop was covered by the programme. The programme was successful in every department. There was a significant increase in the housekeeping index, teams carried out numerous technical innovations in the work environment which improved ergonomics, safety and productivity. Sick leave decreased, and the workshop's ability to compete on the market improved greatly. There was also a positive change in climate, more cooperation between people, more management commitment and an improvement in trust between workers and management.

2.8.11 Participatory ergonomics in South Africa

In South Africa today, participatory ergonomics is fitting in with the new non-racist, non-sexist, less authoritarian, more egalitarian socio-political ethos of the country. South Africa's rapidly evolving ethos should speed up the acceptance and usage of new ideas and systems. The abovementioned changes in the country are also reflected in the working environment (Scott & Kleiner, 1997). This development should pave the way for the promotion and implementation of participatory ergonomics in local industry to help spread the word of ergonomics as well as the implementation of ergonomics principles.

Ergonomics programmes have been developed and implemented with success by Ergotech at a mine in Kleinzee and at Nissan SA. The implementation of an ergonomics programme and sound ergonomic principles in the layout of a new assembly line in the Rosslyn plant of Nissan near Pretoria contributed to an increase in productivity on this specific production line, by 30 percent (Motors, Bylae tot Beeld, Thursday, 13 February 1997, p.5).

2.9 Ergonomics design guidelines and specifications

Section 21 (1)(c) of the Mine Health and Safety Act forces designers and manufacturers of mining equipment and machines to ensure that their products comply with ergonomic principles. As discussed in paragraph 7, there are currently no regulations in the Act to guide them. There is a obvious need among these local designers and manufacturers for ergonomics design guidelines and specifications.

Ergonomics design advice should be practical to use and there should be a minimum need for the designer to reinterpret the data. It would therefore be helpful if the ergonomics information has already been tailored by ergonomists for groups of machines and equipment with similar ergonomics features and functions (Mason, 1992).

Ergonomists in the UK mining industry have compiled a range of different design handbooks for locomotives, free-steered vehicles, drill-loaders, continuous miners, roadheading machines, coalwinning machines, and designing for maintainability. This enabled ergonomists to tailor the ergonomics advice specifically to the individual designer’s requirements. Checklists and data
sheets in these handbooks allowed the ergonomics to be easily applied both at design and prototype stages (Mason, 1992).

In order to complement existing designer guidelines and provide a mechanism for improving the consistency of ergonomics appraisals of machines by both ergonomists and non-specialists, the Bretby Operability Index was developed by ergonomists in the UK. The Index provides a fast track means of identifying where a more detailed assessment by ergonomists is required in order to generate design recommendations. The Index also provides results which allow designers to identify individual features which would benefit from improved ergonomics. The Index gives buyers a means to compare different machines and select those with better operability characteristics (Mason, 1992).

Mason rightly remarks that the operability of a complete machine will be dependent on the quality of the ergonomics of many aspects of its design. The Index uses the following 12 ergonomic design features by which to assess the overall operability of a machine:

- Driver sightlines
- Workspace
- Driver protection
- Access/egress facilities
- Control and display location
- Control design
- Display design
- Labels and instructions
- Seating
- Machine lighting
- Thermal and auditory environment
- Warning systems

The scoring system of the Index allows an operability score to be generated for complete machines. A standard reporting style coupled with scores for the 12 individual design features enable buyers to see which machines have the overall best ergonomic features (Mason, 1992).

Ergonomists in the UK also developed the Bretby Maintainability Index which can be used with the Operability Index to provide a total human machine interface appraisal package.

The design features listed above could typically be included in ergonomics design guidelines and specifications for local designers and manufacturers. These documents could also include checklists and data sheets to help non-specialists in applying the ergonomics design guidelines in the design of new systems and the assessment of existing systems.

2.10 Summary of literature survey

A literature survey was conducted to obtain relevant information on ergonomics strategies and other ergonomics implementation approaches, especially in mining industries. The literature survey and personal communication with ergonomists in various overseas countries have revealed that a holistic ergonomics strategy for the mining industry specifically has not yet been developed or implemented in any country as far as could be established. From the literature survey it is evident that formal ergonomics programmes, based on participatory principles, is an effective method for the introduction and implementation of ergonomics in the workplace.

A review of fatality and injury statistics for South African mines over the last 15 years revealed the risks facing mineworkers. A thorough introduction to the science of ergonomics highlighted the benefits to both employee and organisation of implementing sound ergonomics principles in the workplace and in the design of equipment. A discussion of the strategy development
process provides the methodology which will be followed in the development of the ergonomics strategy.

The objectives of the Mine Health and Safety Act are very similar to the objectives of ergonomics and the implementation of ergonomics in the local mining industry will facilitate the fulfilment of the main objectives of the Act.
3. Research Methodology

3.1 Introduction

In this section the strategy development process, which will be followed to develop a comprehensive ergonomics strategy for the South African mining industry, is presented. The various steps in the development process are discussed below.

3.2 The strategy development process

For the purposes of the current study, the strategic management model of Hunger and Wheelen (1993) was found to be the most suitable approach to be followed in order to develop a comprehensive ergonomics strategy for the South African mining industry.

Since this project focuses on the development of a strategy and not the management of a strategy, this model was adapted to suit the specific requirements of this project.

3.2.1 Approach

The process of strategy development involves four basic elements, namely environmental scanning, strategy formulation, strategy implementation, and evaluation and control (Hunger & Wheelen, 1993). The way these four elements interact is illustrated in Figure 3.1.

![Figure 3.1: Basic elements of the strategy development process (after Hunger & Wheelen, 1993: 12)](image)

3.2.1.1 Environmental scanning

The external environment is scanned for opportunities and threats, and the internal environment for strengths and weaknesses (Hunger & Wheelen, 1993).

In the context of this project, the main role players in the South African mining industry constitute the internal and external environment of a typical mine. The following main role players in the local mining industry were identified:

- Government
- Employers
- Employees
- Manufacturers and suppliers of mining equipment

The opportunities, threats, strengths and weaknesses are encompassed in these four groups of role players. For the proposed ergonomics strategy for the South African mining industry to be implemented and maintained successfully, the support, acceptance and involvement of these four main groups will be essential.
3.2.1.2 Strategy formulation

During **strategy formulation** (enabling output number 2), a vision and mission will be defined, achievable objectives will be specified, a draft strategy will be formulated and policy guidelines will be set as illustrated in Figure 3.2. A representative sample of role players in the local mining industry will be selected from the four main role players, namely State, Employers, Employees and Manufacturers/Suppliers of mining equipment to test and evaluate the draft strategy with respect to the feasibility and implications thereof in terms of their own perspectives. Comments, suggestions and feedback received from them will be assessed by the research team members and incorporated into the draft strategy (enabling outputs numbers 3 and 4). This information will also be used to shape the final strategy as well as the proposals for implementation.

3.2.1.2 Strategy implementation

During the third stage of the strategy development process, **strategy implementation** proposals in the form of programmes, procedures and budgets will be developed as illustrated in Figure 3.2 (enabling output number 5). The proposals for implementation of the strategy will be discussed with representatives from the four main role players to determine the feasibility of the proposals (enabling output number 6). Feedback received from them will be assessed by the research team members and incorporated into the draft proposals for implementation.

The final comprehensive strategy for the South African mining industry will comprise of the elements of the strategy formulation phase, namely a vision, mission, draft strategy and
policies, as well as the elements of the strategy implementation phase, namely programmes, procedures and budgets (enabling output number 8).

3.2.1.4 Evaluation and control

The fourth and last stage of the strategy development process is evaluation and control, as illustrated in Figure 3.2. Since the strategy will not be implemented during this project, it will not be possible to **evaluate and control** the strategy where activities and performance results are monitored to compare actual performance with desired performance. Once the strategy has been implemented, evaluation and control will be very important to determine the success and progress of the ergonomics strategy in introducing and implementing ergonomics in the South African mining industry.
4. Research Results

4.1 Introduction

In this section the strategy formulation process for the development and the detail of an ergonomics strategy for the South African mining industry is presented (Enabling output number 2 of the project). The process for the development and detail of proposals for the implementation of the strategy is also presented (Enabling output numbers of the project). The elicitation of role player opinions concerning the general feasibility of the proposed strategy and implementation proposals is also presented (Enabling outputs numbers 3 and 6 of the project respectively).

The South African mining industry comprises of various types and size mines such as gold, diamond, coal, etc. The operational processes, machines, equipment, environments and worker skills vary considerably. This ergonomics strategy will be of a holistic nature and will be generically applicable to the South African mining industry as a whole.

4.2 Strategy formulation

Strategy formulation is the second step in the strategy development process as illustrated in Figure 4.1. In the process of strategy formulation it is important to define the vision and mission, specify achievable objectives, derive the actual strategy and to set policy guidelines. The strategy formulation process is illustrated in Figure 4.2. In the following sections the vision and mission are defined, specific objectives are stated, the strategy is formulated and policy guidelines are set.

The strategy formulation was determined during work group meetings attended by the research team members.

![Figure 4.1: Basic elements of the strategy development process (strategy formulation highlighted)](image-url)
4.2.1 Vision

The following vision is defined for an ergonomics strategy for the South African mining industry:

To implement ergonomics in the South African mining industry.

4.2.2 Mission

The following mission statement is defined for an ergonomics strategy for the South African mining industry:

The mission of the ergonomics strategy is to introduce and implement ergonomics in the South African mining industry on an integrated basis, thereby contributing to initiatives aimed at the management of health and safety risks in mines to the mutual benefit of all role players.

This mission statement defines the purpose or reason for the ergonomics strategy and states the fundamental, unique purpose of the strategy.

4.2.3 Objectives

4.2.3.1 Overall objective

The overall objective of the strategy is to facilitate the co-ordinated and integrated implementation of ergonomics by the four main role players (State, Employers,
Employees and Manufacturers/ Suppliers) to improve occupational health and safety, worker morale and well-being, as well as productivity, efficiency and effectiveness in South African mines in compliance with the Mine Health and Safety Act.

A general awareness regarding ergonomics must be created and the commitment of all role players must be secured.

The ergonomics strategy aims to achieve the above objective through the application of sound ergonomics principles in the design and procurement of mining equipment and the design of the physical work environment. This must be achieved through the integration and correct combination of people, the technology used to perform tasks, and the environment in which this interaction takes place to the benefit of all role players in the South African mining industry. All of this must be conducted within a legal framework and should provide a win-win situation for all the role players.

From the overall objective specific objectives for each of the four main role players were deducted, synthesised and formulated. The objectives listed below are envisaged as end results of planned activity, in other words, what is to be accomplished by the ergonomics strategy.

4.2.3.2 State

The objectives of the strategy for the State (Department of Minerals and Energy) (DME) is:

To develop comprehensive and appropriate legislation with regard to ergonomics.

4.2.3.3 Employers

The objective of the strategy for Employers is:

To improve health and safety conditions and productivity in South African mines.

Realisation of this objective will culminate in the following benefits:

- Improved working environment
- Reduced health and safety risks
- Fewer errors, accidents, injuries and fatalities
- Improved utilisation of resources
- Development of selection and placement criteria based on the physical and psychological abilities and limitations of employees
- Development of ergonomics equipment specifications
- Improved effectiveness
- Improved productivity
- Improved efficiency
- Improved worker involvement
- Reduced absenteeism
- Reduced labour turnover
- Reduced damage to equipment
- Improved economy of production and maintenance

4.2.3.4 Employees
The objective of the strategy for Employees is:

*To improve occupational health, safety and worker well-being in South African mines.*

The realisation of this objective will culminate in the following benefits:

- Improved health and safety practices and conditions
- Improved personal well-being
- Improved social well-being
- Improved user acceptance
- Improved satisfaction
- Improved ease of use
- Increased motivation
- Improved quality of working life and environment
- Reduced physical stress and fatigue
- Improved task performance
- Improved morale
- Empowerment/enrichment by continuous employee participation through increased competence

4.2.3.5 Manufacturers/suppliers

The objective of the strategy for the Manufacturers and Suppliers of mining equipment and machines is:

*To comply with legislation and to improve design to optimise human-equipment – environment interaction in South African mines.*

The abovementioned objectives state what is to be accomplished by the ergonomics strategy for the South African mining industry to the benefit of all role players.

4.2.4 The draft ergonomics strategy

The proposed strategy forms a comprehensive master plan stating how the mission and objectives will be achieved. The strategy itself addresses the needs and role of the four main role players identified in the South African mining industry. This could be achieved in the manner discussed below. The draft strategy is graphically illustrated in Figure 4.3. In the illustration the basic principles of ergonomics is depicted where the human uses technology to perform a task in a specific workspace, and physical and psychological work environment. The four role players are also depicted to illustrate their involvement and co-operation in implementing ergonomics. The goal of the strategy would be to bring together and integrate these elements to produce an industry which is productive and provides a safe and healthy work environment. The specific involvement method proposed for each role player is also included, i.e. legislation and an ergonomics programme plan for the State, ergonomics programmes for employers and employees, and ergonomics design guidelines, specifications and checklists for manufacturers and suppliers of mining equipment. Since the strategy is based on participatory principles, participatory ergonomics appears in each block representing a role player.

The State will be responsible for initiating, implementing and monitoring of the ergonomics strategy. The strategy involves specific actions to be taken by each role player, as well as support measures and co-ordination between the role players.

A vital part of the strategy are the various actions required to promote and obtain support from all role players. An important aspect of the strategy is the action required to generate and mobilise all possible resources.
Figure 4.3: Proposed draft ergonomics strategy for the South African mining industry

Although ergonomics is addressed in Section 21(1)(c) of the Mine Health and Safety Act (Act No 29 of 1996) (MHSA), it only applies to the duties of manufacturers and suppliers of mining equipment with respect to ergonomics. There are currently no regulations to provide the manufacturers and suppliers with more specific guidance on ergonomics principles and the application thereof.

Although the term “ergonomics” does not appear in any other Section of the Act, ergonomics could be read into Sections 2, 5 and 11. This would address the duties of the employer with respect to ergonomics. Once again, there are currently no regulations to provide the employer with more specific guidance on ergonomics principles and the application thereof. The term “ergonomics” should be included in Articles 2, 5 and 11 of the Act.

4.2.4.1 Department of Minerals and Energy

- **Ergonomics Programme Plan**

  An ergonomics programme plan must be developed to assist DME with the planning initiation monitoring of the introduction and implementation of the ergonomics strategy in the South African mining industry.

- **Legislation**

  Legislation addressing ergonomics should be improved and not increased. Legislation should be expanded to include issues such as the establishment of ergonomics programmes on mines, participatory ergonomics and more specifically the duties and responsibilities of all role players.
The State must be informed and sensitised with regard to the necessity and potential benefits to the mining industry and the workers of including ergonomics in existing legislation.

4.2.4.2 Employers

- **Ergonomics Programmes**

  In order to assist employers with the introduction and implementation of ergonomics in the South African mining industry and to comply with legislation in this regard, ergonomics programmes are regarded to be the most suitable method to achieve this.

  The establishment of ergonomics programmes is an effective method currently employed by numerous organisations internationally for the development and implementation of ergonomics. Ergonomics programmes should be based on participatory principles to ensure successful implementation and participation/representation from persons at all levels in the mining industry.

- **Implementation Structure**

  Instead of setting up new structures from the beginning, the industry’s existing structures, processes, and resources should be employed to assist organisational participation with the ergonomics effort. Both employer and individual employee participative efforts are required. The employer should provide the fertile ground needed by the individual for participation, and should also enable employees to give concrete expression to the hopes and expectations raised.

  The MHSA indirectly provides the mechanisms for a representative participatory approach through the establishment of safety committees and the appointment of safety representatives. Existing structures should be considered for implementing participatory ergonomics.

- **Participatory Framework**

  A specific framework needs be developed for each individual mine to develop and implement an ergonomics programme and to promote participatory ergonomics suited to the mine’s specific needs and circumstances.

- **Management and Employee Commitment and Support**

  The commitment and support of management at mine level is a basic condition for the implementation of participatory ergonomics. Management should be fully convinced of the direct benefits of the practice of participatory ergonomics and they should participate in the process and certify the process properly.

  The key ingredients of a successful ergonomics programme are management commitment and the support and participation of people from all other levels. Management must approve and support the programme and the programme should be part of a mine’s mission. The active involvement of employees on all levels must be accomplished during each phase of the programme.

Employers must be informed and sensitised with regard to the potential benefits of implementing ergonomics in the working environment.

4.2.4.3 Employees
• **Ergonomics Programme**

   *It is management’s responsibility to establish the ergonomics programme and to develop the framework to promote participatory ergonomics to ensure worker participation in the programme.*

Employees must be informed and sensitised with regard to the potential benefits of implementing ergonomics in the working environment.

4.2.4.4 Manufacturers/Suppliers

• **Ergonomics Design Guidelines and Specifications**

   *Manufacturers and suppliers of mining equipment must be provided with ergonomics design guidelines and specifications.*

Manufacturer management, decision makers and designers must be informed and sensitised with regard to the potential benefits of incorporating ergonomics in the design of mining equipment.

4.2.5 Policy

Specific policies for each of the role players are required which should serve as broad guidelines to link the formulation of the strategy with its implementation and to provide guidance for decision making. The following policies are set for each of the four main role players:

4.2.5.1 Department of Minerals and Energy

*The Mine Health and Safety Act must be reviewed to fully address ergonomics.*

4.2.5.2 Employers

*Every employer should be encouraged to have an ergonomics policy within his health and safety and risk management system in compliance with the Mine Health and Safety Act.*

4.2.5.3 Employees

*Every employee should be encouraged to partake in the participatory ergonomics process through the existing health and safety structures required by the Mine Health and Safety Act.*

4.2.5.4 Manufacturers/Suppliers

*All equipment or machinery designed or procured for use in the South African mining industry must comply with good ergonomics principles in accordance with the Mine Health and Safety Act.*

The proposed draft ergonomics strategy was evaluated by a representative sample of the main role players to determine their opinions with regard to the feasibility of the strategy. Feedback received from them was used to update the proposed draft strategy. Feedback related mainly to the proposed vision, mission, objectives and policy guidelines which were all updated to reflect the opinions of the majority of role players consulted.
It was initially planned to consult the same role player representatives during the second round of consultations to determine the feasibility of the implementation proposals. However, to increase the number of role player representatives, it was decided to consult with different representatives during the second round of consultations.

4.3 Strategy implementation

The third stage in the strategy development process is strategy implementation, as illustrated in Figure 4.4. In developing the proposals for strategy implementation, it is necessary to develop programmes, budgets and procedures. The strategy implementation process is illustrated in Figure 4.5.

The proposals for implementation of the strategy were determined during work group meetings attended by the research team members.

Strategy implementation can also be referred to as operational planning.

![Figure 4.4: Basic elements of the strategy development process (strategy implementation highlighted)
In the following paragraphs proposals for the implementation of the ergonomics strategy in the South African mining industry are presented and discussed in terms of the programmes, procedures and budgets required for successful implementation. The role, responsibilities and function of each of the four main role players, namely State, Employers, Employees and Manufacturers/Suppliers of mining equipment are also addressed.

4.3.1 Programmes

A programme is a statement of the activities or steps required to facilitate the implementation of the strategy. Programmes make the strategy action-orientated and may include a series of advertising and promotional programmes to raise the interest of all the role players. These programmes will be aimed at creating general awareness and will also be focussed on the respective role players.

4.3.1.1 General information and promotional programmes

Although ergonomics is an established science, the industry is largely uninformed and as a result, ergonomics is not being implemented to its full potential in the South African mining industry. It is therefore necessary to introduce the science of ergonomics to the various role players.

The following programmes of a general and/or promotional nature to introduce ergonomics to the various role players are proposed:
• Ergonomics introductory programme.
• Ergonomics promotional programme.
• Ergonomics education and training programme.

4.3.1.2 State

The State (DME) will be responsible for the following programmes to ensure implementation of the ergonomics strategy:

• Macro plan for the implementation of the ergonomics strategy.
• Legislation generation programme.

4.3.1.3 Employers

Employers will be responsible for the establishment of the following programme to facilitate the implementation of the ergonomics strategy:

• Formal comprehensive ergonomics programme for the workplace.

4.3.1.4 Employees

The following employee programme should be established to ensure the success of the ergonomics strategy:

• Participation programme in the ergonomics initiatives.

4.3.1.5 Manufacturers/Suppliers

Manufacturers and suppliers of mining equipment will be responsible for the following programmes to ensure the success of the ergonomics strategy:

• Ergonomics design criteria programme.
• Ergonomics information flow programme.

4.3.2 Procedures

Procedures are a system of sequential steps or techniques that describe in detail how a particular task or job is to be performed. The various activities that must be carried out for completion of a programme are typically detailed in procedures.

The procedures required for each of the programmes listed in section 4.3.1 of this document are discussed below:

4.3.2.1 General information and promotional programmes

Ergonomics Introductory Programme

In order to inform and sensitise all role players about the ergonomics strategy and to increase the general level of awareness with respect to ergonomics, the following communication mediums may be considered:

• SIMRAC symposia
• Conferences
• Seminars
Presentations  
Workshops  
Personal interviews  
Road shows  
Courses  
Introduction programmes on mines

The ergonomics introductory programme should be focused on the lowest level in the mine and should be conducted in various indigenous languages.

**Ergonomics Promotional Programme**

In order to actively promote ergonomics among all the role players in the South African mining industry, the following promotional aids could be considered:

- A video and leaflets in various indigenous languages which provide a general introduction to ergonomics and illustrate the practical application and benefits of applying basic ergonomics principles in the workplace.
- Posters in various languages introducing the concept of ergonomics and stressing the benefits of applying basic ergonomics principles in the workplace.

Suitable channels to promote ergonomics should be selected. Typical examples are:

- SIMRAC symposia  
- Introduction programmes on mines  
- Sessions at training centres on mines  
- Technology transfer in all mining areas  
- Mining health and safety, and equipment exhibitions

**Ergonomics Education and Training Programme**

Basic education in ergonomics provides a basis for training in ergonomics to empower and enable people to practically apply the basic principles of ergonomics.

With the imminent introduction of ergonomics programmes on mines it is of cardinal importance to provide all role players with a practical understanding of key ergonomics principles. This will enable them to actively participate in the process, to identify potential ergonomic risk factors, and also to understand general methods of controlling them.

The specific needs of role players will determine the level of knowledge required to practically implement ergonomics. As a result the content of ergonomics training courses will differ from role player to role player.

Ergonomics training courses should *inter alia* address the following aspects to a more or lesser extent:

- Defining ergonomics  
- Scope of ergonomics  
- Objectives of ergonomics  
- Interdisciplinary nature of ergonomics  
- The role of the ergonomist  
- The human-machine - environment system  
- The workstation analysis process  
- Applicable legislation
4.3.2.2 State (DME)

Macro plan for the implementation of the Ergonomics Strategy

It is the State’s responsibility to initiate the implementation of the ergonomics strategy. An ergonomics programme plan must be developed to enable the Department of Minerals and Energy (DME) with the planning, initiation and monitoring of the introduction and implementation of the ergonomics strategy in the South African mining industry. This plan should describe each of the steps required to achieve the above.

The first step would be to initiate and revise existing ergonomics legislation. The DME will then give notice of implementation to the mining industry by suitable means such as a Directive, which will address timescales, responsibilities as well as the participatory approach by utilising existing health and safety structures as far as practicable.

The new legislation should make provision for the establishment of appropriate ergonomics design guidelines, to specifically suit South African mining conditions and the user population.

The State will be responsible for compliance monitoring of the ergonomics strategy implementation.

Legislation generation programme

Although ergonomics is addressed in Section 21(1)(c) of the Mine Health and Safety Act (Act No. 29 of 1996), it only addresses the duties of manufacturers and suppliers of mining equipment with respect to ergonomics. There is currently no guidance on ergonomics principles and the application thereof to assist manufacturers and suppliers to comply with legislation. Therefore legislation should be expanded to include issues such as the establishment of ergonomics programmes on mines, participatory ergonomics and more specifically the duties and responsibilities of the various role players.

All the role players should be involved in this expansion of legislation addressing ergonomics (at least in the drafting process). This process should include amendments to the Act, the drafting of regulations, and Codes of Practice.

4.3.2.3 Employers

General

Employers will be responsible for the establishment of formal ergonomics programmes in the workplace. Ergonomics programmes is an effective method for the introduction and
implementation of ergonomics in the workplace. It will also assist employers to comply with legislation in this regard.

Mine management should acquire assistance from specialists in the field of ergonomics to assist with the development, implementation and maintenance of an ergonomics programme.

Ergonomics programmes should be based on participatory principles to ensure successful implementation and participation from persons on all levels in the mine.

Both employer and employee participative efforts will be required. The employer should provide the fertile ground needed by the individual for participation in the ergonomics programme.

**Legal requirements**

The ergonomics effort from the employer should be linked to Section 11 of the Mine Health and Safety Act. This section addresses the employers’ responsibilities with respect to identification, assessment, and recording of health and safety hazards in the workplace.

Section 11 also addresses the employers’ responsibilities with respect to recording, control and minimisation of risks in the workplace. It further specifies that the employer must periodically review the hazards and risks assessed, including the results of occupational hygiene measurements and medical surveillance, to determine whether further elimination, control and minimisation of risk is possible.

The Mine Health and Safety Act already provides the mechanisms for a representative participatory approach through the establishment of health and safety committees and the appointment of health and safety representatives. These existing structures should be utilised as a vehicle for the implementation of ergonomics.

Most mines have as a result of the requirements of Section 11 established risk management systems which include elements such as hazard identification, risk quantification, training, audit, feedback and a management system. A formal ergonomics programme should ideally be attached to and integrated in existing risk management systems.

Initially the ergonomics programme efforts should be focussed on the significant health and safety risks (e.g. operator workstations, noise, vibration, dust and illumination) already identified.

**Management commitment**

In order to raise the general level of awareness among mine management regarding ergonomics and to obtain their commitment to the ergonomics programme, they must be informed and sensitised with regard to the potential benefits of implementing ergonomics in the working environment. Management commitment demonstrates the employer’s belief that ergonomic efforts are essential to a safe and healthy work environment, and the welfare of all employees.

**Implementing an ergonomics programme**

- Establish ergonomics workgroup

Once the decision has been reached and the policy statement formalised to establish an ergonomics programme, the following steps should be followed. Firstly, an ergonomics workgroup must be established in order to develop and implement the ergonomics programme.
This workgroup should ideally consist of individuals from every level at the mine. Existing health and safety structures, resources and procedures should be considered for this purpose.

The ergonomics workgroup require the talents from every level at the mine. The following persons should ideally be involved:

- Senior management
- Engineers
- Health and safety personnel
- Ergonomics specialist
- Human resource practitioners
- Employees from all disciplines of both production and services fraternities
- Union representatives
- Procurement personnel

All members of the workgroup must be informed about the scope and extent of the programme, the programme objectives, timescales, individual responsibilities, external resources and evaluation methods. The members of the workgroup should also be properly trained in the principles of ergonomics and the practical application thereof. The training must teach them when and how to use ergonomics tools and techniques, and when to request specialist assistance from outside if the in-house ergonomics resource is not suitably qualified in ergonomics.

Engineers may require an intensive course on facility planning as well as workstation, tool and equipment design to enable them to select appropriate engineering controls. Employee representatives and health and safety practitioners should learn techniques to identify potential ergonomic problems and risks, as well as techniques regarding training methods, and injury analysis.

- Responsibilities of the ergonomics workgroup

The ergonomics workgroup has the following responsibilities:

To identify and prioritise potential problem areas and the implementation of ergonomic control measures in order to improve health, reduce injuries and/or accidents, resulting in increased productivity.

The development of in-house basic ergonomics skills.

The establishment of resources necessary to develop solutions and to monitor the programme.

- Infrastructure of an Ergonomics Programme

The ergonomics programme should supply a support structure for the members of the group. The members of the group will have to meet on a regular basis to ensure programme continuity. During these meetings project results should be discussed, problems identified and suggestions made to improve programme effectiveness and to refine the programme goals and objectives on an ongoing basis.

- Information

To implement an ergonomics programme the information that will be used should be determined first. Accurate data, from medical surveillance and other sources, with regard to incidents, injuries, illnesses, complaints and productivity are essential. Relevant records should
be competently reviewed and analysed. Rapid rectification of hazards will improve safety and health significantly. The effectiveness of task performances will also be improved.

The above information:

- Helps to define problems and problem areas.
- Helps to indicate areas that need ergonomics intervention.
- Indicates the way in which this type of information is documented, as well as the way in which injury prevention is monitored.
- Gives an indication as to how the current health and safety programme incorporates ergonomics.
- Provides baseline information to evaluate the effectiveness of ergonomic solutions at a later stage.

• Ergonomics need assessment

In respect of the ergonomics needs assessment the following steps should be followed:

- Identify all risks
- Categorise all risks into high (significant), medium and low risk categories
- Prioritise risks
- Develop action plans to reduce or eliminate risks
- Implement the action plans.
- Conduct performance analyses with respect to the following:
  - injuries and health problems
  - productivity
  - product quality
  - compliance with health and safety legislation
  - cost benefits
  - social and welfare aspects

Procurement of mining equipment

Employers should ensure that any mining equipment procured comply with ergonomics design guidelines and specifications to suite the South African user population and local mining conditions.

4.3.2.4 Employees

Participation programme in the ergonomics initiatives

• Ergonomics Programme

It is mine management’s responsibility to establish the ergonomics programme, utilising existing structures and other channels as discussed in section 3.2.3 above, and to develop the framework to promote participatory ergonomics.

• Motivation

Workers must also be motivated by mine management to actively participate in the ergonomics programme by informing and sensitising them with regard to the potential benefits of applying ergonomics in the working environment.

• Participatory Ergonomics
The ergonomics programme should facilitate participatory ergonomics by involving the employees in planning and controlling a significant amount of their own work activities. They should be provided with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals.

- **Training**

Basic introductory training in ergonomics is a prerequisite for the successful implementation of an ergonomics programme and to foster participation. All workers (not only those involved in the ergonomics workgroup) should be enabled to understand and apply ergonomics to their work to help themselves to improve their own work environment and to identify situations which require expert intervention. Workers should utilise the ergonomics tools, aids and techniques (e.g. checklists, data sheets, etc.) provided, to enable them to achieve this objective.

**4.3.2.5 Manufacturers/Suppliers**

**Ergonomics design criteria programme**

Ergonomics design guidelines and specifications for mining equipment must be developed for use by manufacturers and suppliers of mining equipment. These guidelines and specifications must be based on ergonomics legislation.

The ergonomics design advice should be practical and easy to use and there should be a minimum need for the designer to reinterpret the data. The ergonomics design guidelines and specifications should provide detail design information on all aspects relevant to the interaction between people, technology, the workspace and the work environment relevant to the South African mining industry.

Ergonomics information should be tailored for categories of machines and equipment with similar ergonomics features and functions. The ergonomics advice should be tailored specifically to the individual designer’s requirements and needs. Checklists and data sheets could be included to help non-specialists in applying the ergonomics design guidelines in the design of new systems and the assessment of existing systems.

The suitability of existing international standards addressing ergonomics of mining equipment, should be considered for use in the South African mining industry. Such standards selected for local use should be adapted to suit South African mining conditions and the local user population (“cultural and environmental calibration”).

Ergonomics design guidelines and specifications should be focussed on two broad areas, namely mining equipment operated by people and equipment worn by people (e.g. personal protective equipment).

The following ergonomic design features and aspects should *inter alia* be addressed in the ergonomics design guidelines and specifications:

- South African anthropometry
- South African population stereotypes
- Driver sightlines
- Workspace
- Driver protection
- Access/egress facilities
- Control design
- Display design
• Control and display location
• Labels and instructions
• Seating
• Machine lighting
• Environmental stressors
• Warning systems
• Proper fitting of PPE

Previous related SIMRAC research conducted in this regard should also be reviewed and relevant information should be included in the ergonomics design guidelines and specifications to ensure proper transfer of technology.

Ergonomics information flow programme

Manufacturers and suppliers of mining equipment should inform the end-users of their products on the ergonomics aspects thereof. Similarly, manufacturers should obtain information, feedback and user requirements from the end-user. This will enable prospective buyers to make informed decisions when procuring mining equipment and manufactures to design equipment optimally. It will also assist with the selection of equipment most suitable for the South African user population and local mining conditions.

Relevant information will culminate in combined training by the employer and manufacturer.

4.3.3 Budgets

Budgets are used in planning and control, and lists the detailed cost of each programme. The budget therefore provides a detailed plan of the new strategy in action and it also specifies the expected financial impact through pro-forma financial statements. In this project, budgets are regarded as planning for all the necessary resources for successful implementation of the ergonomics strategy.

There will obviously be costs involved in implementing the ergonomics strategy in the South African mining industry. At the time of implementation the site specific characteristics will determine the budget. Costs to implement the ergonomics strategy should be regarded as an investment with long-term benefits. There will also be benefits that could not be expressed in monetary terms such as improved health, safety, comfort and human well-being, which are actually the main aim of implementing ergonomics in the local mining industry.

4.4 Feedback from role players

4.4.1 Introduction

Enabling outputs numbers 3 and 6 of this research project entailed the consultation with main role players. In the strategy development process it was endeavored to make the consultation procedure as thorough and open and possible, therefore a representative sample of role players in the local mining industry was identified and selected from the four main role players, namely the State, Employers, Employees and Manufacturers/Suppliers of mining equipment. These individuals were interviewed by research team members to obtain their comments, suggestions and feedback with respect to the draft strategy and the proposals for implementation of the strategy.

4.4.2 Sample
Individuals and two forums representing the Department of Minerals and Energy Inspectorate, the gold, platinum, diamond, coal and quarrying mining sectors, organised labour (NUM and MWU), ergonomics specialists, and manufacturers of mining machinery and equipment as well as personal protective equipment, were consulted.

Feedback obtained from the selected sample was incorporated into the draft strategy and the proposals for implementation.

4.4.3 Support for ergonomics strategy

The majority of persons consulted recognize the need for an ergonomics strategy and support the implementation of such a strategy. Many individuals were initially somewhat skeptical due to their limited knowledge on the subject. However, their attitude changed after being informed on ergonomics and the benefits of applying ergonomics. Role players indicated that the graphical presentation of the strategy illustrating ergonomics, the role players and the implementation programmes is logical and user friendly (see Figure 4.6).

4.4.4 Legislation

In principle, nobody was against legislation addressing ergonomics. Representatives from Employers and Manufacturers of mining equipment preferred less prescriptive legislation which is more appropriate and flexible. Representatives from the State and Employees preferred more comprehensive legislation in the form of regulations, standards, directives, guidance notes or specifications, addressing detailed ergonomics principles for application and implementation by employers, employees and manufacturers/suppliers of mining equipment.

4.4.5 Implementation plan

The majority of role players agree that the State should be responsible for introduction and implementation of the ergonomics strategy. They supported the development of an implementation plan by DME to assist the State with the planning, initiation and monitoring of the introduction and implementation of the ergonomics strategy.

4.4.6 Participatory ergonomics

Everybody support the participatory ergonomics approach to facilitate the active participation of all role players in contributing to improve the working environment through the process established by the ergonomics strategy. Commitment from all role players was regarded as a prerequisite for the successful introduction and implementation of the ergonomics strategy.

There was general consensus that the proposed participatory ergonomics approach would link up with the current team approach in the local mining industry.

4.4.7 Ergonomics programmes

Role players support the idea of formal ergonomics programmes as a method for the introduction and implementation of ergonomics in the workplace. There was agreement that existing health and safety structures, resources and procedures should be considered for this purpose.

4.4.8 Ergonomics design guidelines and specifications

Role players, especially manufacturers and suppliers of mining equipment, welcome the development of ergonomics design guidelines and specifications for mining equipment.
Manufacturers and suppliers suggested that existing international standards addressing ergonomics of mining equipment, be considered for use in the local mining industry. Such standards should be adopted to suit South African mining conditions and the local user population. They expressed a need for ergonomics design advice which is practical and easy to use and which provide detailed design information.

4.4.9 Implementation costs

Employer representatives expressed some concern about the costs of implementing ergonomics as proposed by the strategy. They feel that cost-benefit analyses should demonstrate as early as possible the tangible benefits of applying ergonomics in the South African mining industry. It was implied/suggested that no-cost or low cost ergonomics interventions initially be considered.

4.4.10 Role player co-operation

Role players support the idea of more co-operation between the manufacturers of mining equipment and the end-users of the equipment (i.e. employers and employees). End-users should be consulted in the design and modification of mining equipment to accommodate their preferences and needs in the design and to ensure user acceptance of the end product.

A large percentage of employer representatives indicated that they would be interested to co-operate in the establishment of a pilot ergonomics programme on their mines. Employee representatives pledged their willingness to muster support among trade union members to partake in the establishment of ergonomics programmes and training courses. Consultation between employers and employees on ergonomics aspects of equipment and the work environment was also requested by role players.

4.4.11 General information and promotional programmes

There was general consensus that the ergonomics strategy should include general information and promotional programmes to raise the general level of awareness with regard to ergonomics, to change attitudes and to provide education and training in ergonomics to all role players.

4.4.12 Ergonomics information

Employers should consider effective ergonomics design principles in the specification of mining equipment. Manufacturers should also inform employers on the ergonomics characteristics of their products and tenders for new equipment should include the ergonomics characteristics of the equipment. During the deliberations with role players numerous practical problem areas requiring ergonomics intervention surfaced.

4.5 Summary of strategy

The final proposed ergonomics strategy for the South African mining industry with implementation proposals are graphically illustrated in Figure 4.6. The basic principles of ergonomics (human-machine interface) are illustrated, depicting a human using technology to perform a task in a workspace, and physical and psychological work environment. The four main role players and their specific involvement methods are also illustrated, namely ergonomics legislation and an ergonomics implementation plan for the State; ergonomics programmes for Employers and Employees; and ergonomics design guidelines, specifications and checklists for Manufactures and Suppliers of mining equipment. Since the strategy is
based on participatory principles, participatory ergonomics appears in each of the four role player blocks.

Implementation proposals in the form of specific programmes for each role player are also provided in the graphical illustration, namely a macro plan for the implementation of the ergonomics strategy as well as a legislation generation programme for the State; a formal comprehensive ergonomics programme for the workplace which is the responsibility of Employers; a participation programme for Employees; and an ergonomics design criteria programme and an ergonomics information flow programme for Manufacturers/Suppliers. General information and promotional programmes to inform and sensitise role players about the ergonomics strategy and to increase the general level of awareness with respect to ergonomics, to actively promote ergonomics among role players, and to educate and train people in ergonomics are listed in the outside frame of the graphical illustration.

![Figure 14: Graphical illustration of ergonomics strategy and implementation proposals](image-url)
5. Conclusions and Recommendations

5.1 Conclusions

The ultimate goal of ergonomics is to improve and maintain the health and safety and well-being of the individual worker. At the same time the well-being of the organisation will also be improved and maintained, which is of particular relevance in a challenging economic climate where management is required to use existing resources optimally. The strategy developed in this study will contribute significantly to the implementation of ergonomics in the South African mining industry. In this section of the report conclusions which could be inferred from the research are discussed.

5.1.1 Main objective

The development of a comprehensive ergonomics strategy for the South African mining industry to facilitate the introduction and implementation of ergonomics in the local mining industry on an integrated basis to contribute to the management of health and safety risks in mines to the mutual benefit of all role players.

An extensive literature survey was used to investigate ergonomics strategies and other relevant ergonomics implementation approaches developed and implemented overseas in industries, especially in mining industries. The literature survey and personal communication with ergonomists in various overseas countries have revealed that a holistic ergonomics strategy (on a national level) for the mining industry specifically has not yet been developed or implemented in any country.

A formal strategy development process (Hunger & Wheelen, 1993) was followed to formulate a draft ergonomics strategy for the South African mining industry. The development process involved three basic elements, namely environmental scanning, strategy formulation and strategy implementation. During the environmental scanning phase four main role players were identified, all of which are crucial for the implementation of ergonomics in the South African mining industry. The strategy was therefore formulated to involve these role players, and also to establish feasible proposals to implement the strategy.

The ergonomics strategy was rated feasible by representatives of all four main role players in the local mining industry namely State, Employers, Employees and Manufacturers/Suppliers of mining equipment. The implementation proposals for the strategy are also regarded as practical and feasible by the role player representatives. It can be concluded from the support for the strategy among the representative sample of role players, that the main objectives have been met.

5.1.2 Goals

5.1.2.1 Theoretical goal

The literature survey established the theoretical foundation for the development of a draft ergonomics strategy for the South African mining industry.

An extensive literature survey and communication with international ergonomics experts allowed the formulation of a draft ergonomics strategy. The draft strategy forms a comprehensive master plan stating how the defined vision, mission and objectives of the strategy will be achieved. The role and needs of the four main role players in the South African mining industry are also
addressed. The basic principles of ergonomics form the central focus of the draft strategy. All the aforementioned elements are integrated in a logical manner in the strategy.

5.1.2.2 Empirical goals

Evaluation of the feasibility of the draft ergonomics strategy and the implementation proposals by main role players.

Representatives from the groupings identified as the four main role players in the South African industry were interviewed to obtain their comments, suggestions and feedback with respect to the feasibility of the draft ergonomics strategy as well as the proposals for the implementation of the strategy. Feedback obtained from the selected sample was incorporated into the draft strategy and the proposals for implementation.

- **Support for ergonomics strategy**: the majority of persons consulted recognise the need for an ergonomics strategy for the local mining industry and support the implementation of such a strategy.

- **Legislation**: in principle, nobody was against legislation addressing ergonomics. There was general agreement that existing legislation should be reviewed to address the duties and responsibilities of all role players with regard to ergonomics. Representatives from Employers and Manufacturers/Suppliers of mining equipment prefer less prescriptive, more appropriate enabling and flexible legislation while representatives from the State and Employees prefer more comprehensive and prescriptive legislation.

- **Implementation plan**: role players support the development of an implementation play by DME to assist to the State with the planning, imitation and monitoring of the introduction and implementation of the ergonomics strategy.

- **Participatory approach**: everybody support a participatory ergonomics approach to facilitate the active participation of all role players in contributing to improve the health and safety well-being and productivity in the work environment through the process established by the ergonomics strategy.

- **Ergonomics programme**: role players support the idea of formal ergonomics programmes as a method for the introduction and implementation of ergonomics in the workplace. There is agreement that existing health and safety structures, resources and procedures should be utilised for establishing and running ergonomics programmes.

- **Ergonomics design guidelines and specifications**: role players, especially manufacturers and suppliers of mining equipment, welcome the development of South African ergonomics design guidelines and specifications for mining equipment.

- **Implementation costs**: employer representatives are concerned about the costs involved to implement the proposed ergonomics strategy. Some of them question the cost-benefits of applying ergonomics in the South African mining industry.

- **Role player co-operation**: role players support the idea of more co-operation between the manufacturers of mining equipment and the end-users of the equipment in the design and modification process. The majority of employer representatives indicated that they would be interested to co-operate in the establishment of a pilot ergonomics programme on their mines. Employee representatives are willing to motivate trade union members to partake in the establishment of ergonomics programmes and in training causes in ergonomics.

- **General information and promotional programmes**: there is general consensus among role players that the ergonomics strategy should include general information and
promotional programmes to raise the general level of awareness with regard to ergonomics, to change attitudes and to provide education and training in ergonomics to all role players.

- **Ergonomics information**: role players agree that employers should consider effective ergonomics design principles in the specification of mining equipment. They also agree that manufacturers should inform employers on the ergonomics characteristics of their products and that tenders for new mining equipment should include the ergonomics characteristics of the equipment.

### 5.2 Recommendations

In this section of the report, recommendations are made with respect to specific aspects that will determine the successful implementation of the ergonomics strategy.

- A “champion” is needed to take the responsibility to plan, initiate and monitor the introduction and implementation of the ergonomics strategy in the South African mining industry. Ideally this “champion” should come from the DME to perform the above functions.

- DME should develop a **macro plan for the implementation of the ergonomics strategy**. This plan should address the timescales, responsibilities, and legislation generation.

- The **Mine Health and Safety Act** should be reviewed to address ergonomics comprehensively.

- At mine level the successful introduction and implementation of the ergonomics programme will depend heavily on **management commitment and involvement**. It is recommended that an ergonomics workgroup be formed involving senior management, health and safety personnel, and employees from all disciplines of both production and service fraternities.

- It is recommended that existing health and safety structures and resources be utilised to **establish mine specific ergonomics programmes**. The ergonomics programme should facilitate participatory ergonomics by involving employees in planning and controlling a significant amount of their work activities. They should be provided with sufficient knowledge to influence both processes and outcomes in order to achieve desirable goals. This will ultimately contribute to the creation of healthier and safer workplaces, an improvement of the safety culture as well as improved productivity.

- An **ergonomics introductory programme** should be developed to inform and sensitise all role players about the ergonomics strategy and to increase the general level of awareness with respect to ergonomics. The following communication mediums may be considered: SIMRAC symposia, seminars, workshops and purpose developed presentations in Mining regions. The above should assist with the technology transfer of ergonomics in the mining industry.

- An **ergonomics promotional programme** consisting of a video, leaflets and posters in various indigenous languages should be developed to actively promote ergonomics among all role players.

- An **ergonomics education and training programme** should be developed to provide role players with a basic knowledge of ergonomics to enable them to practically apply the principles of ergonomics. The content of ergonomics training courses will be determined by the level of knowledge required by various role players.
• **Ergonomics design guidelines and specifications** for mining equipment should be developed for use by manufacturers and suppliers of mining equipment. Detail design information on all aspects relevant to the interaction between people, technology, the workspace and the work environment relevant to the South African mining industry, should be included in the design guidelines and specifications.

• Based on the feedback received from role players, the following **additional research** is deemed necessary and essential to facilitate the introduction of **ergonomics programmes** on an industry-wide basis:

  A pilot study to identify the most suitable structure and requirements of an ergonomics programme on a mine. The pilot study could also be used to identify potential problem areas which could hinder the implementation of such a programme in the actual work environment.

  Results obtained during the pilot study could be monitored in order to compare actual performance with desired performance. The outcomes of the pilot study could also be used to develop a practical structure for an ergonomics programme, and to provide guidelines for the installation and maintenance of a full ergonomics programme. Mines could then use this structure and guidelines as a basis for their mine-specific ergonomics programmes.
References


Appendix 1

Mine Safety Research Project GEN603 Contract
1. **PROJECT SUMMARY:**

**PROJECT TITLE:** A comprehensive ergonomics strategy for the South African Mining Industry.

**PROJECT LEADER:** Mr TH de Koker

**ORGANIZATION:** Ergotech - Ergonomics Consultants: a business unit of Gerotek Test Facilities (Pty) Ltd

**ADDRESS:** PO Box 6264, Pretoria, 0001

**TELEPHONE:** (012) 428-3084  
**TELEFAX:** (012) 347-1132

**PRIMARY OUTPUT**¹: A report providing a comprehensive ergonomics strategy and proposals for the implementation of the strategic directives and guidelines.

**HOW USED?**²: As scientific basis for effectively introducing ergonomics to all major role players in the South African Mining Industry and guide future research.

**BY WHOM?**³: Government, Employers, Employees, Employee organizations, Manufacturers/suppliers of mining equipment as well as SIMRAC and MRAC.

**CRITERIA FOR USE**⁴: The strategy must be based on sound ergonomic principles and integrate human factors, technology and the environment in which it is to be used. Furthermore it must seek congruence of the goals of the individual units or main role players. Lastly it must provide sufficient information to develop a support system to provide guidance and control to the industry.

**POTENTIAL IMPACT**⁵: Improved safety performance  
Improved health practices and conditions  
Improved personal well-being
**CONFIDENTIAL**

| Improved utilisation of resources, productivity and maintenance |
| Reduced costs of education and training |
| Improved user acceptance |

<table>
<thead>
<tr>
<th>FUNDING REQUIREMENTS (R 000s)</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PROJECT COST</td>
<td>566.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL SUPPORT REQUESTED FROM SIMRAC</td>
<td>566.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DURATION (YY/MM):**

<table>
<thead>
<tr>
<th></th>
<th>99/01</th>
<th>TO</th>
<th>99/09</th>
</tr>
</thead>
</table>

**SIMRAC SUB-COMMITTEE:**

| AU/PT | COAL | OTHER | GENERIC |
2. PROJECT DETAILS

2.1 PRIMARY OUTPUT

A Report providing a comprehensive ergonomics strategy and proposals for the implementation of the strategic directives and guidelines.

2.2 OTHER OUTPUTS (deliverables)

- Assessment and summary of relevant ergonomic strategies within the international mining industry.
- Focus areas for future research.

2.3 ENABLING OUTPUTS

<table>
<thead>
<tr>
<th>NO.</th>
<th>ENABLING OUTPUT</th>
<th>MILESTONE DATE</th>
<th>MAN DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Literature survey</td>
<td>99/03</td>
<td>30</td>
</tr>
<tr>
<td>2.</td>
<td>Develop strategy</td>
<td>99/04</td>
<td>60</td>
</tr>
<tr>
<td>3.</td>
<td>Check with main role players</td>
<td>99/05</td>
<td>32.5</td>
</tr>
<tr>
<td>4.</td>
<td>Refine strategy</td>
<td>99/05</td>
<td>10</td>
</tr>
<tr>
<td>5.</td>
<td>Develop proposals for implementation</td>
<td>99/06</td>
<td>34</td>
</tr>
<tr>
<td>6.</td>
<td>Check with main role players</td>
<td>99/07</td>
<td>40</td>
</tr>
<tr>
<td>7.</td>
<td>Refine proposals for implementation</td>
<td>99/08</td>
<td>10</td>
</tr>
<tr>
<td>8.</td>
<td>Generate final report</td>
<td>99/09</td>
<td>20</td>
</tr>
</tbody>
</table>

A Report providing a comprehensive ergonomics strategy and proposals for the implementation of the strategic directives and guidelines.
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### METHODOLOGY

<table>
<thead>
<tr>
<th>NO. OF ENABLING OUTPUT</th>
<th>STEP NO.</th>
<th>METHODOLOGY TO BE USED TO ACCOMPLISH THE ENABLING OUTPUT (INDICATE STEPS/ACTIVITIES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.1</td>
<td>Obtain relevant information on international as well as national level from libraries, Internet, International Ergonomics Association, other Mining industries, international contacts</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>Assess information and draft a report stating the relevant ergonomic strategies within the international mining industry as well as other industries where available</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>Disseminate information/report to relevant parties</td>
</tr>
<tr>
<td>2.</td>
<td>2.1</td>
<td>Analyse the structure of the SA Mining Industry, technology used, all mining related processes and operations as well as the people involved</td>
</tr>
<tr>
<td></td>
<td>2.2</td>
<td>Information obtained during analyses phase (2.1) will be used to describe the complexity of the SA Mining industry</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>Develop strategy based on output of previous activities</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>Provide first draft (Report)</td>
</tr>
<tr>
<td>3.</td>
<td>3.1</td>
<td>Identify a selected sample of people to consult with from all the main role players i.e. Government, employer, employees and manufacturers/suppliers.</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>Circulate draft strategy document to people identified.</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>Conduct interviews with the selected sample of people from role players and obtain inputs/feedback</td>
</tr>
<tr>
<td>4.</td>
<td>4.1</td>
<td>Incorporate suggestions/inputs into draft strategy</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Produce report containing strategy</td>
</tr>
<tr>
<td>5.</td>
<td>5.1</td>
<td>Develop a proposal for implementation of strategy</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>Provide first draft (Report)</td>
</tr>
<tr>
<td>6.</td>
<td>6.1</td>
<td>Circulate draft implementation proposals to same sample identified in 3.1</td>
</tr>
<tr>
<td></td>
<td>6.2</td>
<td>Conduct interviews with selected sample of people from role players and obtain inputs/feedback</td>
</tr>
<tr>
<td>7.</td>
<td>7.1</td>
<td>Incorporate suggestions/inputs to draft proposals</td>
</tr>
<tr>
<td>8.</td>
<td>8.1</td>
<td>Generate final Report and disseminate information</td>
</tr>
</tbody>
</table>
## Key Facilities and Procedures to be used in the Project

The key to success is the professionally qualified ergonomics expertise of the project team and experience of similar strategies developed for the defence, manufacturing and forestry industries in South Africa.

Supporting disciplines such as engineering, industrial psychology, occupational medicine, occupational hygiene and work physiology with specific reference to the Mining Industry is well represented in the project team in order to cover all relevant aspects.
2.5 TECHNOLOGY TRANSFER

The results of this study i.e. an ergonomics strategy for the SA Mining Industry as well as proposals for implementation thereof will be contained in a report. The information shall be presented in a reader friendly format. Presentations/personal interviews and workshops can be held with interested parties at SIMRAC, MRAC, DME and other main role players after completion of the project.

3. FINANCIAL SUMMARY

3.1 Financial Summary

<table>
<thead>
<tr>
<th></th>
<th>R 000s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YEAR 1</td>
</tr>
<tr>
<td>Project staff costs (from 3.2)</td>
<td>473.0</td>
</tr>
<tr>
<td>Other costs:</td>
<td></td>
</tr>
<tr>
<td>Operating costs (from 3.3)</td>
<td>14.0</td>
</tr>
<tr>
<td>Capital &amp; plant costs (from 3.4)</td>
<td>0.0</td>
</tr>
<tr>
<td>Sub-contracted work (from 3.5)</td>
<td>8.0</td>
</tr>
<tr>
<td>Presentations and Papers (from 3.6)</td>
<td>2.0</td>
</tr>
<tr>
<td>Value added tax*</td>
<td>69.58</td>
</tr>
<tr>
<td>TOTAL COST OF PROJECT</td>
<td>566.58</td>
</tr>
<tr>
<td>Less funding from other sources (from 3.6)</td>
<td>-</td>
</tr>
<tr>
<td>Support requested from SIMRAC</td>
<td>566.58</td>
</tr>
</tbody>
</table>
* Only for VAT registered concerns
### 3.2 Project Staff Costs

Reflect Man Days and Costs separately

<table>
<thead>
<tr>
<th>NAME AND DESIGNATION</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MD</td>
<td>COST</td>
<td>MD</td>
</tr>
<tr>
<td>Mr TH de Koker (Ergonomist/Industrial Psychologist) - Project Leader</td>
<td>62.2</td>
<td>5</td>
<td>124.5</td>
</tr>
<tr>
<td>JR Smith (Bio-medical Engineer)</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Dr EJ Hendrikse (Ergonomist)</td>
<td>40.5</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Mr PC Schutte (Occupational Hygienist/Work Physiologist)</td>
<td>49.7</td>
<td>5</td>
<td>99.5</td>
</tr>
<tr>
<td>Mr JDR Beukes (Occupational Hygienist)</td>
<td>40.5</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Mr MN Shaba (Ergonomist)</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Mrs CN Malapane (Ergonomist)</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Dr F Fox (Medical Practitioner)</td>
<td>13.5</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL (R 000s)** 236.5 473

* Man-hour rate R250/hour

### 3.3 OPERATING COSTS (Running)

<table>
<thead>
<tr>
<th>ACTIVITY/EQUIPMENT (Items above R10 000)</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Costs</td>
<td>14.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other miscellaneous items
### 3.4 CAPITAL AND PLANT COSTS

#### (i) ITEMS TO BE PURCHASED OR DEPRECIATED FOR MORE THAN R10 000 PER ITEM

<table>
<thead>
<tr>
<th></th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td></td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Other miscellaneous items**

**TOTAL**

#### (ii) ITEMS TO BE MANUFACTURED WITH ASSEMBLED COST OF MORE THAN R10 000 INCLUDING MATERIAL AND LABOUR

<table>
<thead>
<tr>
<th></th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Other miscellaneous items</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL (i) and (ii)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3.5 SUB-CONTRACTED WORK

<table>
<thead>
<tr>
<th>SUB-CONTRACTOR</th>
<th>ACTIVITY</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodes University (Postgraduate Students of the Ergonomics Unit)</td>
<td>Literature survey</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.6 PRESENTATION AND PAPERS

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>COST (R000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation materials</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
</tr>
</tbody>
</table>

### 3.7 OTHER FUNDING

<table>
<thead>
<tr>
<th>ORGANISATION</th>
<th>NATURE OF SUPPORT/COMMITMENT</th>
<th>AMOUNT (R000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. MOTIVATION

Ergonomics can be defined as the detailed study of human attributes, abilities and limitations as applied to the living and working environment. It’s primary objective is to maximise human health, safety and well-being while promoting performance, efficiency and effectiveness through the integration and correct combination of people, the technology that they use to perform their tasks and the environment in which this takes place both in physical as well as organizational terms. Ensuring a good health and safety record, high productivity and high worker morale requires the support from all the major role players in the industry, as depicted in the diagram shown below, i.e. government, employers, employees and manufacturers/suppliers of mining equipment.

The goal of an Ergonomics strategy for the South African Mining Industry would be to bring together and integrate these elements to produce an industry which is productive and provides a safe and healthy environment.

The benefits of applying sound ergonomics principles through the design of equipment and the physical and organizational environment, training of the workforce and the physical and culture free psychological selection of the right person for the job is well established and generally would result in the following:

- Improved quality of working life and environment
- Less physical stress and fatigue
- Better human performance
-Fewer errors, accidents and injuries
- Improved economy of production and maintenance
• Improved user acceptance
• Improved worker satisfaction and morale
• Reduced training costs

In a recent industry-wide risk assessment conducted on behalf of SIMRAC (Simrisk 401) it was pointed out that poor ergonomic design and a lack of a strategy for introducing ergonomics into the mining sector was a major contributing factor to poor worker health and safety. A lack of ergonomics research pertaining to the mining industry was also identified as a major shortcoming.
The objective of this proposal is to develop a comprehensive ergonomics strategy for the South African Mining Industry. The Ergonomics strategy will largely be determined by the complexity of the industry i.e. structure, technology used, processes used in the various commodities and people involved, to effectively introduce Ergonomics.

To be successful such a strategy must address mechanisms which will aid in the installation and maintenance of the planned intervention. It must anticipate the nature and strength of forces expected to resist or impede change and develop strategies for overcoming them. The strategy must seek congruence of organisational and personal goals with those of the individual units, i.e. government, employers, employees and manufacturers/suppliers of mining equipment. A note of warning though that it may not be possible to obtain a 100% acceptance of the strategy and implementation proposals from all main role players due to the complexity of the industry and the lack of awareness and understanding of ergonomics in general. The strategy must furthermore address the development of an information and education program, which provides for information dissemination and feedback. It must plan for monitoring performance (effectiveness of implementation). Lastly, it must address the development a support system to provide guidance and control.

Success will not only be reliant upon a strategy but also upon the effective implementation of such strategy. Tactics that can be followed during implementation could include: Involve all parties, inform and educate, negotiate, built coalitions, use feedback, facilitate and support, spread success quickly, co-opt, coerce and regulate/legislate.

To establish such an ergonomics strategy would require the involvement of a multi-disciplinary team under the guidance of professionally trained ergonomists with experience in establishing and the implementation of such strategies in an industrial setting. Other disciplines involved must include specialists in occupational hygiene, work physiology, occupational medicine, engineering, industrial psychology and education/training.

We believe that an integrative approach to the strategy would lead to a reduction in safety and health risks associated with poor ergonomics and ultimately improve occupational health, safety and the general well-being of workers and also improve productivity in all sectors of the mining industry of South Africa. The integrative approach would provide a win-win situation to all the major role players, i.e. government, employers, employees and the manufacturers/suppliers of equipment in the South African Mining Industry.

To summarize we feel that a strategy must include the following to be implemented effectively:

- It must address mechanisms for implementing the planned changes and providing guidance.
- It must anticipate and accommodate diverse opinions and objectives.
- It must seek congruence of organisational goals.
- It must provide for an education/training program.
• It must monitor performance.
• It must address support systems for control.
5. CURRICULA VITAE OF PROJECT LEADER AND RESEARCH STAFF

5.1 SUMMARY INFORMATION

<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>Project Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME &amp; INITIALS</td>
<td>De Koker TH AGE : 39 years</td>
</tr>
<tr>
<td>QUALIFICATIONS (e.g. degree/diploma, issuing institution and date)</td>
<td>M.Comm (Industrial Psychology), University of Pretoria, 1992</td>
</tr>
<tr>
<td></td>
<td>M.Sc (Ergonomics), Loughborough University of Technology, 1989</td>
</tr>
<tr>
<td></td>
<td>B.Comm (Industrial Psychology), University of South Africa, 1984</td>
</tr>
<tr>
<td></td>
<td>Higher Diploma (Mechanical Engineering), Pretoria Technikon, 1982</td>
</tr>
<tr>
<td>SPECIAL AWARDS AND MEMBERSHIP</td>
<td>Honorary academic colours, University of Pretoria, 1993</td>
</tr>
<tr>
<td></td>
<td>R.Erg - ESSA (Council Member - 1994 to 1998)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>Principal Project Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME &amp; INITIALS</td>
<td>Hendrikse EJ (Dr) AGE : 45 years</td>
</tr>
<tr>
<td>QUALIFICATIONS (e.g. degree/diploma, issuing institution and date)</td>
<td>BA (Stellenbosch University) 1983</td>
</tr>
<tr>
<td></td>
<td>Msc Ergonomics (Loughborough University of Technology- UK) 1985</td>
</tr>
<tr>
<td></td>
<td>PhD Ergonomics (Rhodes University) 1994</td>
</tr>
<tr>
<td>SPECIAL AWARDS AND MEMBERSHIP</td>
<td>R.Erg - ESSA (Council Member - 1994 to 1998)</td>
</tr>
<tr>
<td></td>
<td>Ergonomics Society (UK) 1985 - up to date</td>
</tr>
</tbody>
</table>

| NAME & INITIALS | Schutte PC AGE : 48 years |
| QUALIFICATIONS (e.g. degree/diploma, issuing institution and date) | BSc (University of Potchefstroom) 1973 |
| | BSc Hons (University of Potchefstroom) 1977 |
| | MSc (University of Potchefstroom) 1983 |
| SPECIAL AWARDS AND MEMBERSHIP | SAIMM (1983) |
| | AS and TS (1989) |
| | MVS (1998) |

| NAME & INITIALS | Beukes JDR AGE : 57 years |
| QUALIFICATIONS (e.g. degree/diploma, issuing institution and date) | Chamber of Mines Certificate in Colliery Ventilation - 1973 |
| | Chamber of mines Certificate in Mine Environmental control - 1974 |
| | Mine Overseer’s Certificate (Coal) - 1975 |
| | Diploma in Business Management - 1980 |
| | Mine Manager’s Certificate (Coal) - 1982 |
Certificate in Isokenetic Sampling, Tech Pretoria - 1994
Certificate in Occupational Hygiene, Tech Pretoria - 1987
Psychology II, Sociology II and Criminology I - Tukkies Witbank Campus

SPECIAL AWARDS AND MEMBERSHIP:
Fellow - Mine Ventilation Society of SA
Registered Professional Occupational Hygienist, Institute of Occupational Hygienists of Sa (IOHSA)
Full Member of Occupational Hygiene Association of SA
Registered Diplomatic Mining Engineer, Engineering Council of SA (ECSA)
<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malapane CN</td>
<td>47</td>
</tr>
</tbody>
</table>

**QUALIFICATIONS (e.g. degree/diploma, issuing institution and date):**
- Diploma in General Nursing - 1977
- Midwifery - 1978
- Psychiatric Nursing - 1989
- M.Sc Ergonomics (Lulea University, Sweden) - 1997

**SPECIAL AWARDS AND MEMBERSHIP:**
- Merrit Award for Excellent Nursing Performance - 1995
- Member of south African Nursing Council
- Member of ESSA

<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith JR</td>
<td>37</td>
</tr>
</tbody>
</table>

**QUALIFICATIONS (e.g. degree/diploma, issuing institution and date):**
- B.Eng (University of Stellenbosch) 1984
- MSc Med in Biomedical Engineering (University of Cape Town) 1991

**SPECIAL AWARDS AND MEMBERSHIP:**
- MSAIMechE
- ECSA
- Commendation. SAI, Soldier 200
- Technology project of the Year, Dendex, Denel (Pty) Ltd

<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaba MN</td>
<td>42</td>
</tr>
</tbody>
</table>

**QUALIFICATIONS (e.g. degree/diploma, issuing institution and date):**
- M.Sc (Ergonomics) 1992 - Loughborough University of Technology, UK
- B.Sc (Biology & Chemistry) 1980, University of Malawi

**SPECIAL AWARDS AND MEMBERSHIP:**

<table>
<thead>
<tr>
<th>NAME &amp; INITIALS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fox FH</td>
<td>43</td>
</tr>
</tbody>
</table>

**QUALIFICATIONS (e.g. degree/diploma, issuing institution and date):**
- MB.ChB (Rhod) 1978, LRCS (Edin) LRCP (Edin) LRCP&S (Glas) 1978
- DOH (Wits) 1985
- AFOM (Lond) 1990

**SPECIAL AWARDS AND MEMBERSHIP:**
- South African Society of Occupational Medicine (SASOM)
- British Society of Occupational Medicine (SOM)
6. **DECLARATION BY THE PROPOSING ORGANISATION**

I, the undersigned, being duly authorized to sign this proposal, herewith declare that:

- The information given in this proposal is true and correct in every particular.

- This Organization has the basic expertise and facilities required for satisfactory completion of the project and will adhere to the program of activities as set out in this proposal.

- The costs quoted are in accordance with the normal practice of this Organization and can be substantiated by audit.

Signed on this ____________ day of ____________ ___ 19 for and behalf of

________________________________________

SIGNATURE: __________________________________________

NAME: ________________________________________________

DESIGNATION: _________________________________________