Chapter 3

THE EMPIRICAL INVESTIGATION - METHODOLOGY

3.1. BACKGROUND

There are three major differences between scientific and non-scientific research identified by Boyd et al. (1989:23-37). They are of the opinion that the objectivity of the investigator, the accuracy of the measurement and the degree to which all pertinent facts are considered, distinguishes scientific from non-scientific research. Objectivity is the extent to which the researcher bases judgements on facts and not on preconceived sentiments or intuition. Accuracy of measurement differs widely, depending on the field of research. It is also important to keep in mind that business research is typically less exhaustive than research in science.

The researcher complied with the requirements set out by Barzun and Graff (1985:56-59) that include a love of order, accuracy, a logical approach, honesty, self-awareness and creativity to ensure objectivity.

The validity and reliability of an empirical investigation are authenticated by the scientific accountability of the researcher. Validity is said to be an attribute of research methods that measure what they claim to measure. Reliability, on the other hand, is an attribute of research methodology that allows any researcher to repeat the procedure with the same or very similar results (Gregory and Ward 1974).

3.2. THE DATA LIFE CYCLE

According to Lehtonen and Pahkinen (1995), their data life cycle model, depicted in figure 3.1, consists of three steps, namely planning, implementation and assessment. This data life cycle model was utilised as the basis of the empirical investigation part of this research.

Lehtonen and Pahkinen (1995) explain that during the planning phase a systematic planning procedure should be used to define quantitative and qualitative criteria for determining when, where, and how many samples (measurements) should be collected to a desired level of confidence.

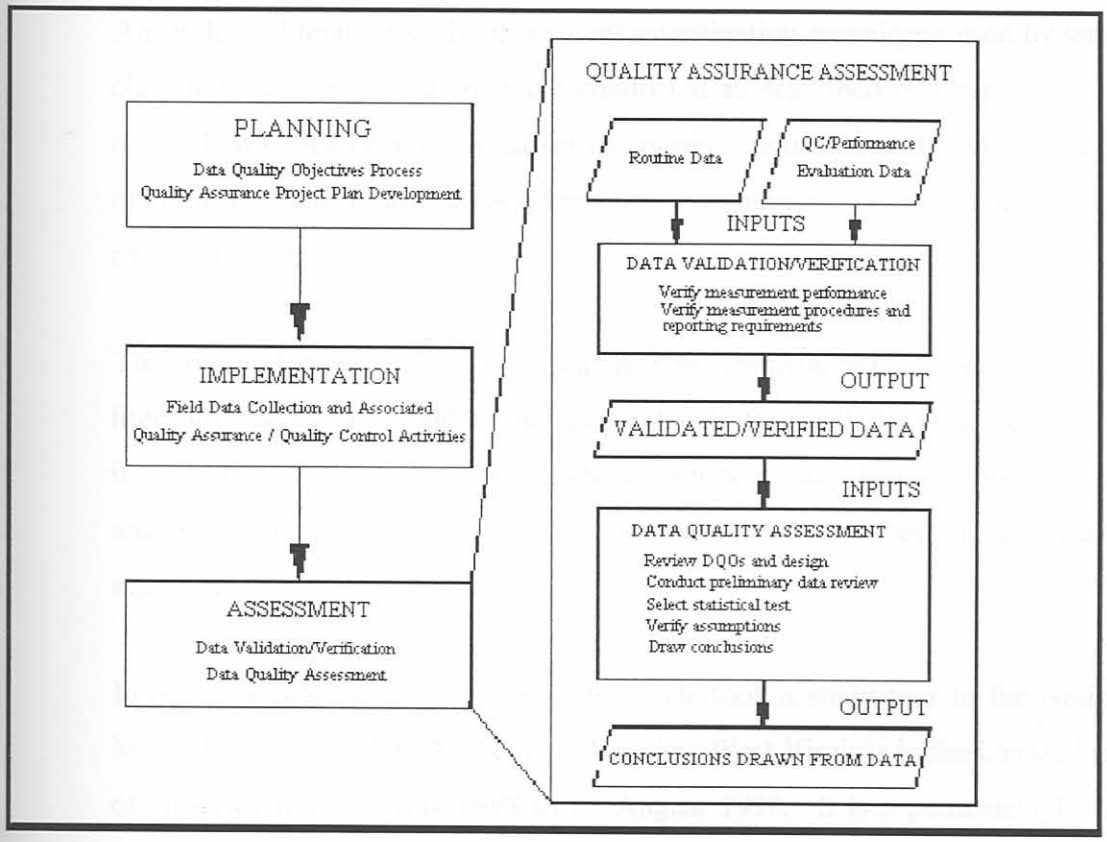

Figure 3.1 - Data life cycle (from LEHTONEN and PAHKINEN 1995)

This information, along with the sampling methods, analytical procedures, and appropriate quality assurance and quality control procedures, must be documented in a Quality Assurance Project Plan. Data is then collected following the Quality Assurance Project Plan specifications. Carrying out the assessment needed to determine if the planning objectives were achieved completes the data life cycle process.

During the assessment phase, the data is validated and verified to ensure that the sampling and analysis protocols specified in the Quality Assurance Project Plan were followed, and the measurement performed in accordance with the criteria

specified in the Quality Assurance Project Plan. The researcher then proceeds using the validated data set to determine if the quality of the data is satisfactory.

3.3. CONFIRMING THE DRAFT MODEL

An in depth literature study of accident investigation techniques used by world-class industrial organisations were conducted as described in Chapter 2. This research was not only focussed on the mining industry, as the author quickly realised that all industrial accidents have a number of common elements, irrespective of industry.

The researcher identified the fundamental contributing factors during the literature survey that could be included in the draft model. It was concluded that it would be necessary to probe these factors in accident investigations by analysing the procedures utilised by international companies and government agencies.

In order to achieve this, the researcher undertook a study tour to the National Mine Health and Safety Academy in Beckley, West Virginia in the United States of America from 13 July 1998 to 07 August 1998. It is a permanent Federal academy responsible for training the mine safety and health inspectors and technical support personnel of the Mine Safety and Health Administration.

During this visit the researcher interviewed the accident investigation lecturers at the academy as well as specialist accident investigators from the Washington DC Federal Inspectorate. The researcher was also requested to present a lecture on the conclusions of his literature survey to advanced accident investigation students.

The legal system utilised in the United States of America for regulating occupational health and safety, is based on the principle of specific compliance. This implies that the owner of the mine has to specifically comply with each and every specification contained in the Act. By utilising this type of legislation the legislator prescribes, in detail, to the owner how safety and health should be

achieved.

In contrast to this, the South African Mine Health and Safety Act is based on the principle of placing a duty of care on the owner. This type of legislation is outcomes-based and prescribes what should be achieved while leaving the method/s up to individual mines.

Despite the fact that the basic legal systems differ, the elements present in accidents are the same, irrespective of the country where the accident occurred.

The system utilised by the United States Department of Mines to conduct investigations into accidents has a two-tiered approach. During this process two independent investigations are conducted in parallel. The one investigation aims to determine the elements contributing to the accident in order to prevent future accidents, while the other, called a special investigation, aims to determine culpability under the Act. In practice, to two investigations are totally isolated from one another and are conducted by different government agencies to ensure that the different goals can be achieved.

Interviews with members of the agency responsible for special investigations contributed very little to this research, as the aim of this research is to develop an accident investigation system that will focus on establishing fundamental contributing factors. The interviews however, confirmed that this aim would not be achieved in an investigation environment where prosecutions are a possible outcome.

The interviews with the other accident investigators confirmed without a shadow of a doubt that the elements identified from the literature should indeed be included in accident investigations.

In addition to the study tour to the USA, the researcher interviewed and discussed fundamental contributing factors with the Chief Inspector of Mines from the United Kingdom Health and Safety Executive, Mr Brain Langdon, during a study tour of the United Kingdom.

The legal system in use by the United Kingdom for regulating occupational health and safety is based on the principle of the duty of care placed on the manager of the mine. In the South African mining industry the duty of care is statutorily placed on the owner of the mine.

During the same study tour of the United Kingdom, from 27 January to 12 February 1999 the theory was also discussed with Mr HC Evans and Mr RJ Cole, both Principal Inspectors of the Health and Safety Executive and Mr G Goodlad, a Principal Inspector of Engineering of the Health and Safety Executive. All confirmed the usefulness of the inclusion of the said fundamental contributing factors in accident investigations.

The theory was also discussed with Mr David Brown, Health and Safety Director British Petroleum, and other members of the Health and Safety division in London who also supported the inclusion of these fundamental contributing factors in accident investigations.

The above study tours confirmed that the fundamental contributing factors isolated during the literature study should be included in the questionnaire developed for the research.

3.4. DEVELOPING OF THE QUESTIONNAIRE

Most modern investigation systems require the investigation of unsafe acts and unsafe conditions. In general these techniques only broadly describe what is meant. A number of the more modern models identify that the energy source is of importance during investigations. Most systems analysed during the research are based on a time line approach. This approach was found to be extremely limiting during investigations utilising any of the recognised accident investigation systems. This led the researcher to conclude that a different methodology would be required to remove some of the more serious stumbling blocks created when utilising a time line approach.

Some of the more important models analysed include:

Various cause effect models,

Energy threshold models,

Probability and risk models, and some

Psychological models.

All the models analysed were found to be true to the claims made by their authors. The author believes, however, that none of them truly identify the fundamental contributing factors of accidents and that a different approach would be required to achieve this.

It was established that all accident investigation systems focus on trying to determine the cause or causes of accidents. This approach has a basic conceptual problem in that, if causes of accidents are to be determined, it implies that accidents are not unplanned events but brought about events.

An accident is generally defined as an unexpected, unplanned and undesirable event that results in harm to people, damage to property or breakdown of production systems or something very similar (MIL-STD-882C, BS 8800:1996 and OHSAS 18001:1999).

The definition of an accident as developed by this researcher (chapter 2 page 31) is:

> *The final event in an undesirable, unexpected and unplanned event sequence that interrupts an activity, and directly or indirectly results in immediate or delayed injury or illness to an employee, and may or may not result in property damage or loss in production.*

The definition use terms that may need further explanation:

FINAL EVENT

The final event is the simultaneous, interconnected, cross-linked

occurrence that takes place when the last of the fundamental contributing factors interact dynamically with other contributing factors in a four-dimensional space-time continuum.

FUNDAMENTAL CONTRIBUTING FACTORS

A fundamental contributing factor is a feature or condition required before and/or during an accident, that plays a part during the dynamic interaction of the fundamental contributing factors in such a way that an accident results.

This definition conforms to the basic principles contained in most definitions given to accidents. It excludes "causes" and therefore it is concluded that any "accident" that was "caused" can no longer be called an accident.

The Concise Oxford Dictionary of Current English (1995:208) gives the following meaning for the word cause.

> ***Cause*** *n. & v.* • *n.* ***1 a*** *that which produces an effect, or gives rise to an action, phenomenon, or condition* ***b*** *a person or thing that occasions something* ***c*** *a reason or motive; a ground that may be held to justify something (no cause for complaint).* ***2*** *a reason adjudged adequate (show cause).* ***3*** *a principle, belief, or purpose which is advocated or supported (faithful to the cause).* ***4 a*** *matter to be settled at law* ***b*** *an individual's case offered at law (plead a cause).* ***5*** *the side taken by any party in a dispute.* • *v.tr.* ***1*** *be the cause of, produce, make happen (caused a commotion)* ***2*** *(foll. By to + infin.) induce (caused me to smile; cased it to be done).* □ ***cause and effect 1*** *a cause and the effect it produces; the doctrine of causation.* ***2*** *the operation or relation of a cause and its effect* ***in the cause of*** *to maintain, defend, or support (in the cause of justice).*

Not any of the explanations in this section align with the notion that an event sequence was interrupted, resulting in loss, further supporting the notion that an

accident investigator should not be focussing on trying to determine the "cause" or "causes" of accidents.

As the focus of the research is on accidents and not on some other entity that results in harm to people, damage to property or breakdown of production systems, it was determined that a new paradigm is required when trying to analyse accidents with the aim to prevent them.

For this reason it is considered more appropriate to focus on the identification of the fundamental contributing factors of accidents. Once this paradigm shift is made, it is quite easy to conduct an analysis of the existing models and extract the appropriate fundamental contributing factors utilised by each of the systems analysed, while eliminating the search for causes.

Based on the in-depth literature study of accident investigation techniques and having confirmed the draft model as used by world class mining and industrial organisations and government agencies, a questionnaire was developed to confirm the importance of the identified fundamental contributing factors to conduct effective accident investigations.

The questionnaire, which is included as annexure "A", consisted of three sections.

Section 1 consists of 13 questions developed to establish which issues of importance should be established during accident investigations. These questions were developed to confirm which of the factors should be included in accident investigations. Question 14 was included in order to establish the ranked importance of each of the factors and the open-ended question 15 allowed any other factors deemed necessary for inclusion in the accident investigation process to be reported on by the respondents.

Section 2 consisted of ten questions designed to determine how effective information regarding accident investigations are utilised by production

personnel to improve safety and one open ended question to determine any other important issues.

Section 3 of the questionnaire consisted of seven demographic questions designed to establish the demographic profile of the respondent in order to effectively subdivide the respondents into the various subgroups included in the study.

In sections one and two the 5-point Lickert scale was selected for the respondents to record their view by indicating their choice with an X in the appropriate box. In addition to the 5 choices a 6th choice namely "No opinion" was provided as an option to prevent respondents to leave out any response. It was also included in an effort to reduce the central tendency normally associated with a 5-point scale. It was expected that the inclusion of this option would improve the useable returned questionnaires.

3.5. THE SAMPLE

According to Smit (1993:16-19) research is a method to obtain insight and knowledge, to describe observed phenomena, to arrange it in an understandable way and to explain it. In order to ensure that the research findings are sustainable he states that the sample should be representative and of sufficient size to truly represent the population.

According to Caulcutt (1983:53), the cost of conducting research is normally directly proportional to the sample size while the amount of information obtained from the sample, only increase to the square root of the sample size. It is therefore important to use the smallest possible sample size that will allow confidence in the results obtained.

The size and magnitude of the questionnaire was taken into account when the physical design was made as the questionnaire was posted to 858 management representatives and 388 mine workers were interviewed giving a total of 1 246 persons potentially participating in the study.

To be representative the sample had to contain respondents from the management echelons as well as from workers, spread across the three main commodity types being mined in South Africa. To this end six sub-groupings were identified as follows: coalmine management, goldmine management, platinum mine management, coalmine workers, goldmine workers, platinum mine workers.

3.6. THE DATA COLLECTION PROCESS

It was anticipated that during this research process, the researcher would encounter a combination of quantitative and qualitative data derived from the same research instrument. The relationship between the type of research method used and the type of data that was obtained during the process was carefully separated to ensure accuracy of interpretation.

The data collection process was conducted in a two-phased approach. The first phase consisted of postal questionnaires sent to persons from the middle management echelons of the mining industry. The second phase of the study had the intention to capture the views of the mineworkers. Conducting structured interviews with mine workers were utilised to complete the questionnaires on their behalf.

This phased approach was decided upon, as it was necessary to get the views of a vertical slice of employees in the mining. As a large part of the lower level workers is functionally illiterate it was necessary to provide assistance in the completion of the questionnaires. Personal experience of the researcher in the mining industry guided him to decide that structured interviews will be best suited for this purpose, while postal questionnaires would be best suited for the management component of the sample.

3.7. THE COLLECTION PLAN

In order to ensure that the collection of data could be completed in a reasonable time it was decided to create a formal collection plan. The following is a brief description of the process followed during the collection of the data.

The first step was to finalise the questionnaire before it was sent out via the post to the identified sample. This implied that the editorial and layout of the questionnaire needed to be done in order to ensure that it was going to fit into the envelopes without making it appear cramped or having the font size to small. Once the researcher was satisfied a few samples were printed and colleagues not being part of the sample were requested to complete it. This was done to correct any practical problems that may have been present in the design.

The questionnaire was field tested by distributing copies to 50 fourth year mining students from the University of the Witwatersrand. The comments and replies were evaluated and included where appropriate prior to finalising the questionnaire.

3.7.1. PHASE 1

For phase 1 the mailed questionnaire was selected for the collection of the research data from the management and supervisory section of the sample. In this survey the respondents was required to complete the questionnaire without any intervention from the researcher.

This part of the sample consisted of all the applicants for the Mine Overseers and Mine Managers certificates of competency form January 1996 to December 1997. A total of 1 246 persons were registered as applicants for these two certificates on the database of the Chief Inspector of Mines for this period. The inclusion of these individuals in the sample ensured that the participants had a certain minimum experience as well as some previous training relevant to the research.

The selected method provides greater privacy for the respondent than other instruments. As no intervention from the researcher took place during the

collection of information during phase 1, it was imperative that the questionnaire was designed to reduce misunderstanding to the utmost minimum. In addition to this the design had to ensure the minimum incomplete responses possible.

In order to ensure that the maximum possible response would be achieved the covering letter was drafted under the signature of the Chief Inspector of Mines Mr D Bakker as well as Prof N Alberts of the University of Pretoria, a copy of which is included as annexure "B".

Before the questionnaires could be posted the names and addresses of the sample was entered into a database and the database converted to a mail merge file. The covering letter was also converted into a mail merge letter and the letters printed with the correct addresses by merging the mail merge file and the converted letter.

The printing of the questionnaires was conducted and the addressed covering letters attached to them.

The postal questionnaires were posted while keeping a record of each addressed questionnaire posted. After a 4-week period follow up notices were sent out to all the original recipients. A second reminder followed this a further 4 weeks later.

As the completed questionnaires were received back the questionnaires were carefully filed after receiving a unique reference number, to ensure that no returned response was lost.

3.7.2. PHASE 2

An attempt was made to ensure that the responses received from the management component in each commodity constituted a similar relative size to the responses from the workers from that commodity. As a result of the unpredictability of the number of replies received from a postal questionnaire

replies from the interviews only represent approximate similar relative sizes. The relative sizes are deemed to be sufficiently similar to draw statistically meaningful results.

Phase 2 consisted of interviews with workers selected randomly as they were clocking out at the end of the shift. This type of selection was deemed to be sufficiently random to ensure that the sample will be representative. The mines selected to obtain the worker views through interviews were selected to provide a similar commodity distribution as achieved with the postal questionnaires.

The clocking out process at the mines selected has a duration of between 2 and 4 hours. During this period workers are hoisted to surface with the aid of large cages that can hoist between 20 and 150 workers at a time. The hoisting plan normally starts at the upper levels end progressively moves down to finish up at the lower working level. The mines selected for the survey are designed to clear all workers from underground in about two hours. A structured interview conducted to complete one questionnaire was timed to take about ten minutes on average. Each interviewer therefore conducted about twelve interviews per mine.

The respondents were invited to the interview rooms based on the time they arrived on surface. There is normally a continuous stream of workers flowing through the clocking out point at the end of the shift. The interviewers invited the next person who clocked, to the interview room as they completed each questionnaire.

This ensured that the sample did not only contain workers from a specific area or type of work.

The persons selected to conduct the interviews were well versed in mining terminology and were trained to conduct interviews correctly, on the content of the questionnaire as well as the methodology necessary to ensure that the interviewee gives an objective answer to each question. They could also speak the language of the respondents. They were instructed to establish a rapport

with each mineworker to be interviewed prior to providing them with the instructions for the interview. In addition, the interviewers were instructed on an approach to follow when asking the questions and on the methodology for recording responses. The answers were recorded on questionnaires by the interviewers on behalf of the interviewees.

3.8. ANALYTICAL APPROACH

The original questionnaire was utilised to develop a codebook to interpret the responses. This was simply a completion of the questionnaire with values entered into each of the possible choices.

Utilising the codebook, the raw data of each returned questionnaire was entered into an Excel spreadsheet. This was necessary in order to ensure that the data supplied to the statistical section of the University of Pretoria was user-friendly. This implied that questionnaires not being fully completed and others with multiple answers for the same question had to be removed.

The spreadsheets together with the original questionnaires were provided to the statistical section of the University of Pretoria who further cleaned the data and then utilised a statistical analysis package to make recommendations to the researcher in respect of the responses received from the respondents.

The study consists of 591 useable replies from the two phases. Each phase contained replies from three distinct groupings, namely the commodity being mined coal, gold and platinum.

3.8.1. INTERPRETATION OF RESPONSES AND GRAPHS OF RESPONDENTS

The interpretation of the results of the individual questions contained in the questionnaire will be discussed in chapter 4. At the conclusion of each section an overall conclusion of that section will be given.

The graphs constructed using the responses on questions are reflected in column charts with corresponding titles. On these graphs the responses of the six different groupings are individually displayed as a percentage of the group. This was done to assist with comparison across groups.