MMP THESIS

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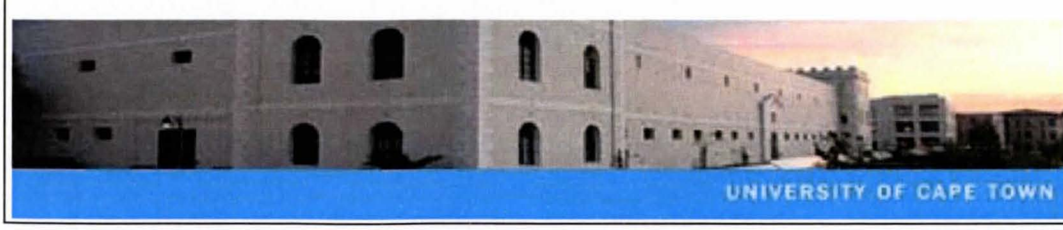

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DECLARATION

1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is your own.

2. I have used the *Council of Biology Editors (CBE)* style convention for citation and referencing. Each significant contribution and quotation from the works of other people has been attributed, cited and referenced.

3. I certify that this submission is all my own work.

4. I have not allowed and will not allow anyone to copy this essay with the intention of passing it off as his or her own work.

Signature: Hein Maree **Date:** 30-04-2010

For my children...

By wisdom the LORD founded the earth;
by understanding he created the heavens. - Proverbs 3:19[1]

[1] The Holy Bible - New Living Translation, 2004

DEVELOPING A SYSTEMIC DISASTER PREVENTION PARADIGM

EXECUTIVE SUMMARY

This research project's objective was the development of a systemic disaster prevention paradigm. Disasters can generally be classified as either natural or man-made, although hybrid disasters also do occur. The research effort focussed on man-made disasters and numerous past disasters in all spheres of life were investigated. Man-made disasters are complex, systemic phenomena that can only be understood by adopting a holistic and systemic view. This high stakes world constituted the *situation* to be dealt with in the research project. The research work started off with a fixation on disasters in the mining industry. It was however soon realised that in all man-made disasters there are factors and dynamics in force that are industry and context insensitive. In other words, it was realised early in the research process that there are some generic 'rules of the game' applicable to man-made disasters across all spheres of life.

Through evaluation of the complex situation of man-made disasters described above, a three-fold (research) *concern* emerged: these types of disasters occur randomly across all spheres of life and within all types of organisations; similar disaster occurs repeatedly; and (the same) organisations repeatedly cause disasters. It was therefore clear that the phenomenon of man-made disasters was experienced by many but understood by very few – a solid motivation for conducting management research in this field with the intent of developing theory that can assist with management's understanding of the phenomenon.

In order to address the concern delineated above, a (research) *question* was formulated to guide research efforts: How can man-made disasters be managed? The overall research project followed a well-known two-tiered research process whereby the 'correct' problem was firstly identified and then 'solved' during the second tier of the research endeavour. In addition, considerable effort was also spent to develop a specific and suitable research process for finding a satisfactory answer to the research question. This process involved a series of 'small wins', all building up towards the new management theory and research *answer*. Grounded theory, which is a qualitative management research methodology, was selected and applied as the technique for actually distilling the new management theory.

Finding the research answer and thereby developing the new research theory constituted the bulk of the research effort and also of this thesis.

The first small win of the answer-developing research process entailed analysis of the mechanics of man-made disasters to construct an understanding of how a disaster occurs and what exactly happens when a disaster does occur. A disaster was eventually modelled as a risk-dependent continuous process of energy and entropy exchange, requiring a continuous input of energy (management and otherwise) to prevent natural decay towards maximum entropy and chaos. It was discovered that a certain critical event, the so-called triggering event, is necessary in all instances to initiate energy shedding events – which then ultimately result in disaster. The so-called disaster potential can be construed as a function of energy and entropy and plotted over time to indicate the variance in disaster potential for a specific situation or context.

Subsequently this new knowledge regarding disasters was synthesised into the bigger systemic environment to gain an understanding of why any disaster comes to be in the first place. General systems theory and risk management were revealed as key constituents of the bigger realm of disasters and disaster management. Mindfulness, which is a three-tiered function of systemic thinking ability, experience and the appropriate attitude, crystallised as the crucial component of any disaster prevention initiative. During this phase of developing the research answer a new management theory was postulated and portrayed by means of a Causal Loop Diagram. The analytical models developed earlier in the first research small win are embedded in this new theory or paradigm.

The third small (research) win comprised stress-testing the newly developed theory with the aim of validating it and implementing any improvements required. This was done by evaluating the new theory and its components against a diverse selection of sixteen past and well-known man-made disasters from all walks of life. The theory was found to be generally applicable when compared to and tested against the past disasters. It is then argued that the theory does seem to provide a useful tool for identifying and therefore managing potential future disaster situations. Through integration of the first three small wins and continuous feedback between the processes, the final management theory was produced.

The *rationale* for the research answer and new management theory becomes clear as the research process and findings above are described in detail in the thesis. A literature review was then undertaken to further validate and locate the research answer within the wider literature. This review process actually resulted in an improvement of the new management paradigm as the previously omitted, but very relevant, process groups and knowledge areas for the new disaster management framework were developed.

The thesis is concluded with an *evaluation* of the research answer and research effort as a whole. It is proclaimed that a worthwhile contribution was made to the existing body of knowledge insofar as disaster management is concerned. Furthermore the relevance, utility, trustworthiness and ethical implications of the research project as a whole are evaluated. A final glimpse on the way forward in disaster management research recommends three potential future research topics:

- The detailed determination of the specific processes within the process groups and knowledge areas identified in this research project.
- The newly developed theory and models should be meticulously applied to a past disaster to foster understanding of what went wrong; and then also to an identified potential future disaster situation to gain understanding and a basis for management intervention.
- The question is asked whether there is not room for a formal Disaster Management Body of Knowledge (DMBoK), similar to the Project Management Body of Knowledge (PMBoK). The creation and management of such a document would require the establishment of a governing body similar to that of the Project Management Institute (PMI).

DEVELOPING A SYSTEMIC DISASTER PREVENTION PARADIGM

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1.1 Introduction

This research project investigates the phenomenon of disasters and how to deal with and manage this undesirable phenomenon. This first chapter of the thesis provides an introduction to the world of disasters and disaster management in its widest sense. A distinction is made between natural and man-made disasters and the research effort firmly directed towards the latter. The purpose of the whole research effort was to devise a management theory that, through its effective application, can prevent man-made disasters altogether or suitably address the problems associated with the unforeseen/uncontrolled occurrence of these disasters. A broad overview of the systemic and complex nature of man-made disasters is provided and the importance of disaster management as a topic that warrants further investigation or research is illustrated. Chapter 1 also discusses the personal reasons for choosing disaster management as a management practice research topic.

Furthermore the research dilemma, which constitutes some concern, a practical problem, a research question and finally a research problem, is comprehensively delineated. This section basically set the stage for the research effort and guided all research efforts. The chapter concludes with a description of the basic structure and content of the complete thesis and a concise overview of the various chapters of the thesis is provided.

1.2 The research topic - disasters

1.2.1 Definition of Disaster

The Oxford Dictionary [1] defines 'disaster' as *'a sudden accident or a natural catastrophe that causes great damage or loss of life'* or *'an event or fact leading to ruin or failure'.* Whilst the term *disaster* naturally conjures up images of human suffering and/or considerable loss of life, it also constitutes a great misfortune when an environmental disaster or a financial calamity occurs. By default, environmental and human disasters also often result in grave financial repercussions.

Disasters can generally be categorised into two distinct groupings, i.e. natural and man-made disasters. Man-made disasters in turn can be classified as either *Unintentional* or *Intentional* (Figure 1).

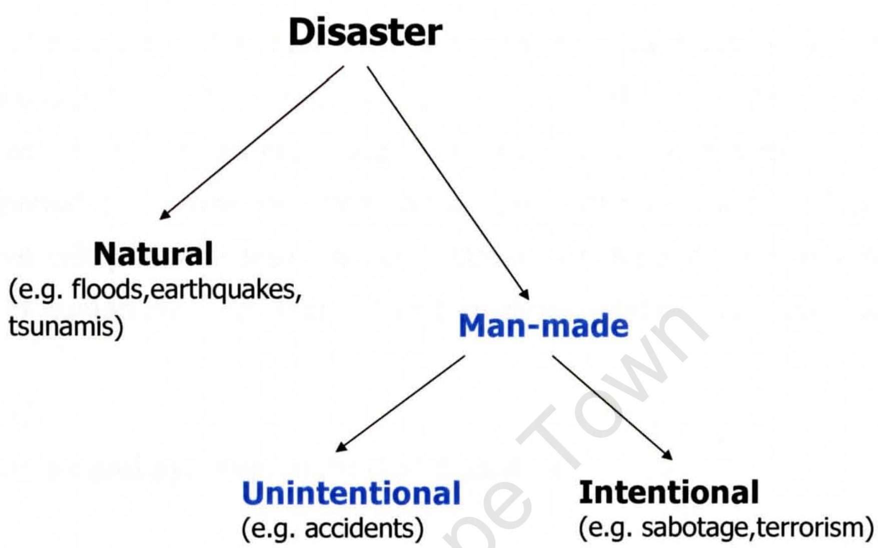

Figure 1: Second order classification of disasters

Natural disasters (ND's) are phenomena caused by the forces of nature and occur without any instigation or interference from humans. The best man can do is to identify the onset of such disasters and try to alleviate the consequences.

Unintentional man-made disasters (UMMD's), on the other hand, are undesirable and often unforeseen catastrophic outcomes where human error, through intervention - or a lack thereof - precipitated the event. Although the final disastrous event is normally caused by natural forces acting out of control (e.g. gravity, fire, weather, pressure, water etc) it is man's inability to recognise and deal with these forces that eventually leads to disaster. In addition, and perhaps most importantly, the failure to pre-empt and comprehend complex, unpredictable human behaviour and interaction with man-made and natural systems can lead to chaos. In short, man-made disasters can generally be traced back to management failure and hence a 'management problem' of some sort.

Intentional man-made disasters (IMMD's) are pre-conceived acts of terrorism or sabotage and defy explanation for the normal rational individual. Once an IMMD occurs or is initiated, the propagation thereof, and very importantly, the management or containment thereof, becomes disaster-type insensitive.

All three types of disasters follow their own routes towards the so-called *triggering event*[2], from where the ensuing disasters progress along similar paths. The focus in this research project will be on unintentional man-made disasters *(UMMD's)* or accidents. Due to the high value attached to human life, and more specifically the safety of people in the workplace, there will primarily also be concentrated on human disasters that result in extensive loss of human life, with financial and environmental repercussions as secondary considerations.

1.2.2 The complex and systemic nature of disasters

Disasters are usually multi-causal events [2] that can rarely be attributed to a single fundamental cause. *"While human error often precipitates an accident or crisis in an organisation, focussing on human error alone misses the systemic contexts in which accidents occur – and can happen again in future"* [3][4]. The final cataclysmic event is normally the result of a series of sequential failures that culminate in the great mishap. Perrow's *Normal Accident Theory* [3][5] maintains that within complex systems, the unexpected interactions between independent failures and tight coupling between sub-systems propagate and escalate initial failures into a general (catastrophic) breakdown.

Layers of multiple pathogens within organisations and systems combine to produce situations and operations that are *'riddled with holes'* [2]. Reason [6] describes this phenomenon in his *Dynamics of Accident Causation (DAC)* model, where a number of latent and active failures come together, or line up, to produce the impossible, the unthinkable, accident and disaster. The so-called *Swiss Cheese Accident Model* [2] (Figure 2) is based on Reason's DAC model and graphically illustrates the concept of defect alignment as a pre-requisite for disaster.

[2] See Section 3.2.4.2, page 63

The Swiss Cheese model illustrates that although it seems unlikely that a number of events could sequentially occur or exist (demonstrated by the holes lining up) in order to allow an accident to happen, the possibility does exist. All disasters are infrequent, unusual events that are unlikely to occur in exactly the same fashion again [2]. The stark reality and irony evident from this model is the fact that if any one of the contributing events/factors had been timely identified and eliminated **the disaster would not have occurred**.

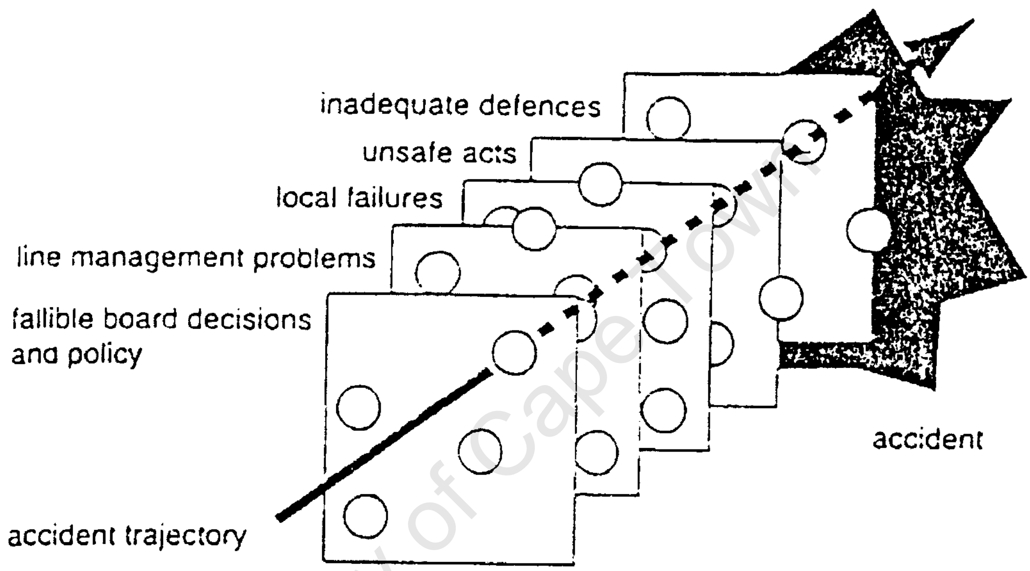

Figure 2: Swiss Cheese Accident Model [2]

Disasters can therefore be seen as events that normally unfold over a period of time, gaining momentum as the systemic failures accumulate towards the critical combination and interact to set the stage for mayhem – which is finally triggered by a specific necessary and critical event. Disaster prevention is therefore clearly a complex systemic issue that can only be understood and managed by adopting a holistic and systemic approach.

1.2.3 The management predicament

Modern management practice and the rules of global competition dictate that enterprise executives and managers today not only have to manage the financial well-being of their company but also have legal and moral obligations towards all stakeholders as well as the natural or physical environment in which they operate. Modern managers therefore need to manage their organisations with respect to the so-called *'Triple Bottom Line',* or the three *P's* [7]:

- Profit - sound financial management of the reason for the (capitalistic) organisation's existence;

- People - managing the organisation's human capital, which includes taking care of the safety, health and general well being of affected persons, i.e. employees and affected communities;

- Planet - responsible interaction with, and management of, the physical environment and its resources.

A *disaster* within any one of these three modern management spheres normally has far reaching negative implications for an organisation and in extreme cases and contexts may very well lead to the ultimate demise of such an enterprise.

The only difference between an incident, an accident and a disaster is the extent of the loss incurred, be it human harm, environmental damage or financial cost. The insurance industry has created the concept of *'Maximum Probable Loss'* to quantify the financial repercussions - and hence the amount to be insured - of a possible disaster within a specific context. Apart from the moral and legal issues associated with loss of human life and environmental damage, these unfortunate occurrences normally also ultimately result in significant financial loss; e.g. through restitution and environmental rehabilitation costs, compensation, payment of fines, and reduction in share value.

1.2.4 Disasters in the mining industry

Mining by its very nature is an extremely hazardous endeavour that represents enormous challenges and huge risk to all stakeholders. Not surprisingly then is history littered with accounts of disasters within the mining industry.

Some of the better-known (South African) mining disasters include:

- Vaal Reefs 2# (1995)[3]

  Huge *people* (loss of life) and *profit* (financial) consequences resulted when 104 mine workers were killed in a hoisting accident on May 10,1995. Operations were suspended for a long period of time to effect shaft repairs.
- Coalbrook[4]

  Enormous *people* and *profit* loss resulted form a massive cave-in in large parts of the coal mine on January 21, 1960. 437 miners were killed and this disaster remains South Africa's largest mining tragedy.
- Kinross[5]

  Great *people* and *profit* loss resulted after an underground fire at the mine released toxic fumes that killed 177 workers on September 16,1986.
- Merriespruit[6]

  Large *people*, *profit* loss and *planet* (environmental) repercussions ensued when a tailings dam collapsed on February 22, 1994. The nearby village was largely destroyed and 17 people were killed. Extensive environmental clean-up operations were required to restore the environment to an acceptable condition.

The post-accident investigations for these disasters all revealed numerous issues (latent pathogens) within the organisations that combined to culminate in the final catastrophic events. With hindsight - which is often claimed to be a perfect science, depending on your perspective - <u>all these accidents could have been prevented</u> and therefore constitute managerial failures in some form across all layers of organisational management. Either the latent defects had not been recognised (lack of management vigilance), or recognised but not acted upon (lack of management will). In any event, appropriate management action could have saved the day and prevented the specific disasters.

This research project started off with a fixation on mining industry related disasters because I am employed within the gold mining industry. I have been in the industry for 19 years and keeping it 'close to home' seemed the natural and sensible thing to do. I have extensive

[3] Appendix A - Disaster N° 1
[4] Appendix A - Disaster N° 2
[5] Appendix A - Disaster N° 3
[6] Appendix A - Disaster N° 4

engineering experience across the whole spectrum of gold mining operations and remain fascinated by the complex and interactive nature of the overall gold mining process. Safety and risk management have always formed part of my management responsibilities during my career, particularly so whilst appointed in operational and production portfolios. I have also closely experienced one of the major South African mining disasters (Disaster N°1, Appendix A).

Part of the original research concept proposal was the decision regarding research boundaries, i.e. what do I limit my research to - one mine, one mining company or one or more processes within the generic gold mining process (e.g. stoping, vertical transport, metallurgy, etc)? Without knowing what I didn't know, the original strategy was to consider the mining industry in general and see where the research process leads to.

However, due to the systemic nature of (mining) disasters, coupled to the systemic approach of this research project, it was soon realised that man-made disasters share commonalities and attributes that transgress industrial and/or corporate boundaries. It was found that by rationalising a particular mining disaster, other man-made disasters were also rationalised. Conversely, by looking holistically at a spectrum of disasters, individual (mining and other) disasters could also be logically explained. Although the initial research work therefore had disasters within the mining industry as the reference background, a conscious decision was taken early on in the research project to not focus only on the mining industry alone, but on man-made disasters in the wider spectrum. Boundaries would be defined once more information and knowledge about the disaster phenomenon became available. A wider focus would also give more credibility to the outcome of the research project and it was therefore decided to investigate and prove that man-made disasters adhere to physical and systemic laws that are insensitive to the type of industry, organisation or environment.

1.2.5 Why the pre-occupation with disasters?

Three distinct incidents in my life had planted the seeds of interest, left more questions than answers and gradually gave rise to the desire to attempt an explanation of the disaster phenomenon - and eventually culminated in this research topic and project:

i) A personal need for understanding

In 1985, as a first year engineering student at the (then) Rand Afrikaans University (RAU) in Johannesburg I closely experienced the Westdene bus disaster[7]. The Westdene dam is situated less than 1 kilometre from the University, next to one of the routes we frequently travelled to and from University. The Vorentoe High School, where all the victims were learners, is adjacent to one of the entrance roads to the University and driving past the school was a daily occurrence for me. I was therefore very familiar with the social context of the victims as well as the locale of the accident.

I can clearly recall the afternoon of Wednesday 27 March 1985. During lunch hour, whilst waiting for chemistry practical class to start, the shocking news started filtering in: a school bus laden with school children had driven into the Westdene dam. The exact scene of the accident was clearly discernible in my mind and I can to this day recall the picture of the road on the Westdene dam wall: only a metre high diamond wire fence separated the road from the dark waters of the dam. Not even a kerbstone separated the road from the water a few metres lower.

News and rumours poured in and as the afternoon progressed it became clear that a grave and tragic disaster was unfolding. After class I drove down to the dam where hundreds of people had gathered and just stood there - silently watching the clinical recovery operation. By that time it was too late to rescue anybody. All that remained to do was to recover the remaining bodies of the 42 school children that could not escape from the bus and consequently drowned. The roof of the yellow double decker bus was visible inches below the water surface. I watched until the bus was eventually lifted from the dam with a large mobile crane. (Whilst visiting the official website of the disaster [8] as part of my research, I actually identified myself and some of my friends in one of the newspaper photographs on the website – an eerie discovery 24 years later!)

Two thoughts kept turning over in my mind: 'How could this have happened? Surely it could/should have been prevented?' At that stage of my life I had not yet been exposed to the concepts of risk and risk management techniques and only experienced a tragic sense of bewilderment. Although not directly involved in the calamity, I could relate to the feeling

[7] Appendix A - Disaster N° 5

of *'Vu jade'* as proclaimed by Weick [9], when people experience only bewilderment with no sense of understanding of the happenings around them. Only much later in my life and career could I appreciate the fact that the application of a simple technique such as risk assessment would have highlighted the obvious hazard presented by the unprotected drop into the dam and the high risk associated with large numbers of people frequently travelling the route. Incidentally, one of the first visible actions after the disaster was the erection of a sturdy crash barrier all along the side of the road on the dam wall, presumably to prevent inadvertent entry of vehicles into the dam. It was however a case of too little too late.

ii) Disaster in my close working environment

My first appointment as Section Engineer on the (then) Vaal Reefs Gold Mine was in 1994 in the position of demolition engineer. My job comprised the demolition of redundant metallurgical plants and the associated environmental rehabilitation activities. During the very early hours of the morning on May 11, 1995 I was awakened by a phone call from the complex's workshop engineer who enquired as to whether I had access to lifting equipment such as hoists and chain blocks that could be used for some sort of rescue operation at the N° 2 Shaft. The Vaal Reefs N°2 Shaft disaster[8] had occurred a few hours earlier at the start of the night shift and first attempts were being made to access the shaft bottom and assess the extent of the accident. I was therefore amongst the initial group of officials that were informed about the disaster. The full extent of the tragedy only became apparent after daybreak when the whole Vaal Reefs community awoke: 104 people had plummeted to their death at the bottom of the N° 2 Shaft that is more than 2 kilometres deep.

I knew the N°2 Shaft fairly well and had spent some time there prior to the accident during my training period as Junior Engineer. Although not within my direct working environment, the accident occurred within my bigger frame of reference - I knew some of the people very well, specifically the shaft engineer, who was at the centre of the disaster due to his legal appointment and responsibilities. The Vaal Reefs Exploration & Mining Company was a massive organisation that comprised 11 shafts at the time. This accident brought the whole complex to a standstill and every employee of Vaal Reefs experienced the tragedy of this traumatic event in some way or another.

[8] Appendix A - Disaster N° 1

For a second time in my life, now within the context of my working environment, a calamity of unprecedented scale had occurred. I again wondered about the logic and driving forces behind the event and the actions and occurrences that preceded the tragedy. Again the nagging feeling of failure in a wider sense persisted as I felt that somehow, somebody ought to have seen this disaster coming and ought to have done something to prevent it from happening.

The 1995 Vaal Reefs N°2 Shaft disaster culminated in an intensive investigation by the Leon Commission[9] and was largely responsible for the promulgation of the *Mine Health and Safety Act, Act 84 of 2000*, five years later. Risk assessment and risk management were also catapulted to the forefront of management responsibilities by this tragic event, as they became legal responsibilities when the act was promulgated.

iii) Contextualisation of a disaster scenario

During December 1995 and January 1996 I had the privilege to visit the USA on a seven-week holiday. The first few days I spent in New York City with visits to well-known tourist attractions like the Statue of Liberty, the Empire State building and also the World Trade Centre.

On September 11, 2001, the unthinkable happened when terrorist attacks using passenger planes destroyed the Twin Towers in a matter of hours. I felt a strange sense of association with the victims of the attack. I had been in the same situation, in the same location, as many of the people that perished that day. An 'accidental tourist', I had also decided to visit the Twin Towers on the spur of the moment and spent a considerable amount of time on the viewing deck atop the South Tower. It was a different time and a different context, when the terrorists attacked nearly six years later. However, except for the political climate that had changed for the worse, all other conditions were the same. I could just as well have been caught in or on top of the South tower. The sense of disbelief and association that I experienced was stronger than ever before.

This act of terrorism was clearly an intentional man-made disaster (IMMD) and as stated IMMD's fall outside the scope of this research project. However, after the initial impact of

[9] A Commission of Enquiry, chaired by Judge R.N.Leon and appointed to investigate and make recommendations as to what should be done to prevent such accidents in future.

the planes with the towers, the disaster unfolded without further undermining interference from man – hence there were similarities with UMMD's from here-on forward and therefore lessons to be learned.

1.2.6 Commitment to understanding and explanation

As described above I have had a personal yearning to understand the 'workings' of disasters for a very long time. As my career progressed and my knowledge and experience accumulated I began assimilating conceptual and intellectual tools and abilities that slowly enabled rationalisation of the 'mechanics' of disasters. The exposure to risk and risk management enabled many of the accidental occurrences that I wondered about to be explained *post de facto*. Practical and management experience gained in the mining industry over the years also provided me with a thorough understanding of the dangers and complexity associated with the gold mining process and also, very importantly, of the unpredictability of human behaviour. Whilst attending the Management Development Program (MDP) at the Graduate School of Business (GSB) of the University of Cape Town (UCT), I was exposed to systemic management thinking theory and techniques. This additional knowledge seemed to be the final intellectual tool I was looking for and again fuelled the long simmering desire to attempt a rationalisation of the topic that had been haunting me for a very long time – disasters, how they occur and how they can be prevented. This research effort, which in reality is an extension of the work started at the GSB whilst completing the MDP, is therefore the culmination of years of looking for answers in a domain understood by very few.

In addition to satisfying a personal desire by 'solving' the disaster riddle (to my satisfaction at least), gaining insights into the world of disaster management quickly became necessary in my professional life. I had been appointed in various managerial positions over the years, most of them in areas that had the potential for yielding a disaster if not properly managed. Some of the positions in which more knowledge of disaster management would have been extremely useful included demolition engineer, metallurgical plant engineer, underground production engineer and shaft engineer. All of these positions carried legal appointments and the responsibility for the safe operation of machinery and processes and hence the safety and health of hundreds of employees.

Lastly, by gaining insight into disasters and their management, and hopefully contributing to the existing *body of knowledge*, general understanding of the phenomenon could be enhanced. If one manager could prevent a disaster by utilising some of the insights gained through this research effort, it would constitute a useful exercise.

1.3 The research dilemma

1.3.1 The concern

From the aforementioned, as well as additional research, a three-fold concern crystallises:

- *Disasters seem to occur randomly across all spheres of life and within all types of organisations, be it (capitalistic) enterprises or public service organisations*

  The man-made disaster phenomenon seems to have no preference for any type of environment and strikes in the most unimaginable places and at the most unexpected times. It is as if there is an invisible 'force' that waits to be released and create havoc at the slightest 'slip' from man or failure of man-made systems. The complex activities, extreme conditions and large number of people involved in mining operations and other high-risk industries constitute good breeding grounds for disasters. Catastrophes have previously occurred in these environments and will occur again in future – unless they can be prevented by management intervention.

  The reference list of disasters contained in Appendix A provides a diverse collection of disasters that occurred within various industries, environments and countries of the world.

- *Similar disasters occur repeatedly*

  Through researching a number of global mining disasters a shocking observation was made: certain disasters or types of disasters are allowed to happen again and again. By 2005, only twenty years since the Stava disaster[10] in July 1985, no less

[10] Appendix A - Disaster N° 6

than 33 major failures of residue disposal dams had occurred worldwide [10], each resulting in varying degrees of human loss/suffering, financial loss and impact on the environment. South Africa's Merriespruit disaster[11] of 1994 brings home this concern very clearly. An even more accusing example of this phenomenon is provided by the two Vaal Reefs cage disasters (Vaal Reefs 2# (1980)[12] and Vaal Reefs 2# (1995)[13]). Although under different circumstances, on two separate occasions, conveyances filled with people were dislodged from the hoisting ropes and plummeted to shaft bottom. These two disasters, 15 years apart, not only occurred within the same mining company, but also at the very same shaft! Numerous other gruesome examples of cages plummeting down mine shafts with their human cargo exist.

The mining industry seems to have a propensity for calamity - the *'monster'* waits and will strike again and again if not constrained. Once, after a fatal accident on one of the shafts, I had a discussion with a contractor underground and we contemplated the accident that was prevalent in most peoples' minds. The contractor mentioned *"the mine was hungry and had to eat"*. A thought-provoking analogy for the *'monster'* mentioned above.

As another example of type-recurring disasters, the Saulspoort bus disaster[14] occurred in 2003, 18 years after the Westdene disaster[15]. Although under different circumstances and in a completely different environment, the fact however remains that a bus full of passengers (again) drove into a dam and 51 people perished.

- *Organisations repeatedly cause disasters*

A third and final concern is the fact/phenomenon that disasters occur repeatedly within the same organisations. The two Vaal Reefs disasters referred to earlier clearly illustrate this concern. Like lightning, which is (apparently) not supposed to strike twice in the same spot, a conveyance (or cage as it is commonly known in the industry) full of mine workers plummeted to the bottom of the exact same shaft, 15

[11] Appendix A - Disaster N° 4
[12] Appendix A - Disaster N° 7
[13] Appendix A - Disaster N° 1
[14] Appendix A - Disaster N° 8
[15] Appendix A - Disaster N° 5

years apart. Although totally different factors and conditions caused the two accidents, it remains a silent indictment of the organisation, or rather of organisational management, that two disasters occurred at the very same shaft. Obviously little 'systemic learning' resulted from the first disaster, at least not enough to prevent the tragic re-occurrence 15 years later.

As a further illustration of this concern, a sobering revelation was stumbled upon during the research process: The Bhopal disaster[16], or Union Carbide disaster as it is also referred to, is widely recognised as the worst industrial disaster in history [11]. Thousands of people lost their lives in this disaster and the financial repercussions of the event will never be fully known - suffice to say it ran into billions of dollars. What is however less well known is that Union Carbide was also responsible for the Hawk's Nest disaster'[17], which has been cited *'the worst industrial disaster in America'* [12], forty odd years earlier than Bhopal. More than 700 contract workers employed by the company lost their lives as a result of ignorance about silicosis, and gross negligence in general, on the side of company management. Although under totally different conditions, even in totally different industries as a result of company diversification and obviously under completely different management, the same company was responsible for the two largest industrial disasters in the world and the USA, respectively. Not surprising then that some sources refer to Union Carbide's *'History of Massacre'* [13].

Industrial organisations and their managers seem to not learn from mistakes and misfortune and similar crises are allowed to re-occur. Industrial organisations, which have a huge propensity for disasters, therefore have a long way to go before they can be viewed as *learning organisations* [14] - from a disaster prevention perspective at least.

1.3.2 The practical problem

As pointed out earlier all man-made disasters can be traced back to a 'management failure' of some sort. Whether it is within industry, government or other organisational entities, the occurrence of a disaster signifies a lapse of performance, for whatever reason, from people

[16] Appendix A - Disaster N° 9
[17] Appendix A - Disaster N° 10

in positions with the power to influence real-life occurrences, i.e. it represents decision-making, or then management, failure.

A somewhat outdated management cliché states that "you can't control what you can't measure and you can't manage what you can't control". This mindset is a remnant of the well-known Planning, Organising, Leading, Controlling (POLC) management paradigm. Although still relevant, the POLC model fails to address the complete spectrum of demands of modern Total Management Practice (TMP). Controlling (subsequent to measuring) is but one of the actions that occur at the later stages of the complex total management process. From a TMP perspective certain aspects within a given situation or context will always fall outside of the control of the manager. Important then is the cognitive ability to analyse and understand the total context of a situation, in order to effectively manage the situation - including the uncontrollable aspects. The important point here is to realise that whilst you perhaps cannot control all aspects of a situation, you can certainly manage the overall situation – if the full context in which the situation occurs is understood.

The practical problem, or management practice problem that emanates from the situation as described in Section 1.1 of this research project report can be described as follows:

Management in its broadest sense does not understand the mechanics of disasters, i.e. how disasters unfold and how to contain or minimise consequential losses/damages after the occurrence of a (potential) disastrous event. Without proper understanding of the disaster phenomenon, within the appropriate context, no effective preventive or counter measures and systems can be devised and implemented to prevent new disasters from occurring and eliminate the re-occurrence of similar disasters.

1.3.3 The research question

Part of understanding a situation and addressing a related real-life concern comes from the asking of relevant questions. In order to address the practical management problem identified above the following questions were derived:

i) Why do disasters occur?
ii) How do disasters progress and/or unfold?

iii) How can potential man-made disasters be timely identified in order to:

a. Address the situation and prevent the disaster from occurring altogether; and/or
b. Mitigate the outcome or consequences of an incident/accident thereby preventing the event from becoming disastrous?

As pointed out earlier, it is clear that disasters are not single cause, instantaneous events. The actual out-of-control occurrences where natural forces cause havoc are but the tip of the iceberg. All disasters have a ramp-up period where various systemic factors combine and contribute towards the eventual calamity. Furthermore, some (potential) disasters could be contained to minimise damage, financial repercussions and loss of life, i.e. to become only a high potential incident or accident.

The all-encompassing question that needs to be answered - and hence the research question that needs to be satisfactorily addressed - can be concisely worded as follows:

How can man-made disasters be managed?

'Managed' in this sense encompasses the identification, understanding, processing and actioning of the disaster phenomenon in its widest, systemic sense – all with the obvious aim of eliminating the occurrence of disasters altogether or preventing otherwise insignificant incidents from becoming disastrous. Herein also lies the *paradox of prevention*: if no disaster occurs, how would one know that it was actually prevented? Was there ever a disaster in the making and if so, was it prevented through good management or good luck, or both? On the other hand, the *certainty of failure* is extremely evident when a disaster actually occurs. There can be no denying the confirmed death tolls, financial repercussions and other grave consequences of actual disasters when they do occur.

It is therefore clear that in answering this research question both tangible and intangible entities will have to be explored and dealt with. It is then also fair to expect that the journey of discovering the answer to this question would entail the interaction with both concrete and abstract concepts in order to arrive at a plausible systemic solution.

1.3.4 The research problem

Booth et al [15] states the following: *"When faced with a practical problem whose solution is not immediately obvious, you usually ask yourself a question whose answer you hope will help you solve the problem. But to find that answer, you must pose and solve a problem of another kind, a research problem defined by what it is that you do not know or understand, but feel you must."* Following this line of reasoning the seemingly simplistic research question posed above requires the following research problem to be resolved:

In order to be able to manage man-made disasters managers need a framework to guide and facilitate their understanding of the phenomenon. More specifically a disaster occurrence and propagation model needs to be created, i) that takes the systemic nature of disasters into account, and ii) from which the potential for management intervention and leverage with the aim of prevention or mitigation should be evident. In short, a systemic disaster prevention paradigm needs to be created.

This problem then focuses the research effort and funnels all efforts towards understanding of the disaster phenomenon. But, with understanding comes the responsibility of (management) action. Therefore, an inherent part of the solution to this problem is to devise a methodology for disaster recognition and/or prevention that can actually be implemented in real life.

1.4 Outline of report

1.4.1 Basic structure and content

This research report is loosely structured in accordance with the style convention Perry [16] suggests for post-graduate research theses. A five-chapter layout is recommended, the chapters being:

- Introduction
- Literature review
- Description of research methodology

- Analysis of data
- Conclusion

In addition, the *SCQARE* reporting format as proposed by Ryan [17], is integrated into this overall format of the research report. The *SCQARE* process consists of:

- A description of the *Situation* in which the
- *Concern* resides;
- The *Question* of which the
- *Answer* will address the concern mentioned earlier;
- The *Rationale* that explains the answer, and
- An *Evaluation* of the answer and rationale described earlier.

The *Concern-Question-Answer* combination constitutes the core of the thesis and holds the whole research project together. This triad is gradually developed through Chapters 1 to 3.

Moses [18] argues that by using a well-devised structure for the final research report a student will ensure that his/her thesis demonstrates the key requirements of post-graduate research, i.e.

- a distinct contribution to a body of knowledge through an original investigation or testing of ideas
- competence in research processes, including an understanding of, and competence in, appropriate research techniques and an ability to report research
- mastery of a body of knowledge, including an ability to make critical use of published work and source material with an appreciation of the relationship of the special theme to the wider field of knowledge

Adopting a recognised structure for this thesis assists in ensuring that the report on the work done is to an academically acceptable standard. In addition, the risk of doing injustice to (potentially good) research work through unclear or incongruent reporting of the results is reduced or minimised. The layout of this thesis is henceforth succinctly discussed in chronological order of the chapters.

1.4.2 Chapter 1 – Introduction to research project (retrospectively)

The first part of Chapter 1 serves as the description of the *Situation* as required by the SCQARE reporting process referred to earlier. Considerable effort was then spent to delineate the research dilemma, which comprises the *Concern*, the practical problem, the research *Question* and then the research problem to be addressed.

1.4.3 Chapter 2 – Research process and methodology

It was decided to deviate slightly from the sequence of chapters suggested in Section 1.4.1 and deal with the literature review in Chapter 4 instead of Chapter 2, for reasons that will be discussed within Chapter 4 itself.

Chapter 2 explains the general research process adhered to during this research project. The eclectic 'figure of eight' research process that was adopted is described in some detail and it is shown that the overall research process followed a two-tiered approach, i.e. one of finding a problem – the right problem – and then solving that problem. Furthermore the specific process designed and utilised for deriving the research Answer is also explained. By describing the non-linear route of accumulating small (research) wins, an early and partial glimpse of the research *Answer* is provided.

The research methodology applied throughout this research project is then also discussed in detail. This chapter introduces *Grounded Theory* as the research methodology of choice and provides arguments for the applicability of this methodology, which is qualitative by nature, to this research effort. Evidence is provided of competence in engaging with this methodology and the practical application of the grounded theory method to the research problem is described in detail. The chapter concludes with some comments on theoretical sensitivity.

1.4.4 Chapter 3 – Analysis of data

This chapter can be viewed as the heart of the thesis as it is here that the actual management research work is presented in a clear and coherent manner. The chapter contains a detailed record of the *Answer* to the research question and the underlying

Rationale for this Answer. The cumulative result of the three small wins achieved during the research process is presented and a new (grounded) theory or management paradigm proposed. This systemic disaster management paradigm presents a plausible way of dealing with the disaster phenomenon and its applicability to past known disasters is comprehensively demonstrated. The consistent application of the grounded theory method whilst unpacking the disaster phenomenon is also portrayed throughout this chapter.

The new disaster management theory is presented in the final form of a Causal Loop Diagram (CLD) that incorporates all the relationships identified and models created during the paradigm development process. Finally this new theory is then stress-tested against past known disasters in order to validate its completeness and then importantly, its usefulness as a forward-looking or predictive tool for actually preventing man-made disasters in the first place.

1.4.5 Chapter 4 – Literature review

Instead of attempting to identify potential knowledge gaps in the published literature prior to the start of the research project – and possibly be influenced towards a certain research route - it was rather decided to conduct the literature study upon completion of the research and theory creation process. The review therefore comprised a reflective exercise rather than an informative and guiding one. With the research concluded and the new theory postulated a review of the relevant literature was conducted in order to:

- locate the newly developed theory within the wider Disaster Management body of knowledge
- verify the comprehensiveness of the new management framework against other well-known management frameworks and models
- validate some findings and elements of the new disaster management paradigm through a process of triangulation with other published resources
- high light possible inconsistencies of the thesis with other published works
- (still) identify potential gaps in the study field for future research

It was therefore deemed more appropriate to record this literature review in Chapter 4 of the thesis, rather than in Chapter 2 as originally proposed in Section 1.3.1.

1.4.6 Chapter 5 - Conclusion

The final chapter of this research thesis contains the *Evaluation* of the research Answer and the research project as a whole. It comprises three sections:

i) An evaluation of the contribution made towards the existing body of knowledge.

ii) A critical evaluation of the research work and the new theory or paradigm. The thesis is evaluated in terms of
   - Relevance, i.e. is the concern relevant in the situation?
   - Utility, i.e. does the answer adequately deal with the concern?
   - Validity or then trustworthiness, i.e. does the rationale adequately explain the answer?
   - Ethics, i.e. is the answer derived at the right thing to do within the situation?

iii) Finally a view is taken on possible future research that may complement or provide substance to this new disaster management paradigm.

2. RESEARCH PROCESS AND METHODOLOGY

2.1 Introduction

Chapter 1 described the Situation, Concern and (research) Question pertinent to this research project in detail. Chapter 2 now builds further on this basis and establishes the *Concern (the occurrence of man-made disasters) – Question (how can these disasters be managed?) – Answer (the management paradigm developed)* triad that constitutes the core of the thesis. The role of this chapter is to design the research process that will be followed to construct the Answer in the C-Q-A core. By describing the overall and specific research processes employed, a partial and early glimpse of the research Answer is provided.

Chapter 2 also explains the research methodology applied whilst following this research process. The chapter deals with the fundamentals of qualitative research and to a lesser extent with that of quantitative research. *Grounded Theory*, which is a type of research that resorts within the field of *Qualitative Research* was the research methodology selected and applied. The tenets of grounded theory and the reasons for engaging this particular research methodology are discussed in some detail in this chapter. Furthermore the (minimum) criteria for proclaiming a grounded theory study are explored and the suitability of this research methodology to the world of disaster management is evaluated.

The tools used for gaining insight and progressively developing a new management paradigm, whilst meandering along the route map towards the strategic intent, is explained and explored.

2.2 The research process

2.2.1 Overall process

The research process followed during the execution of this research project was based upon the process suggested by Booth et al in their reference work *'The Craft of Research'* [15], adapted by Ryan [19] as a guideline for this post-graduate research effort. The single loop research process of Booth et al is depicted in Figure 3.

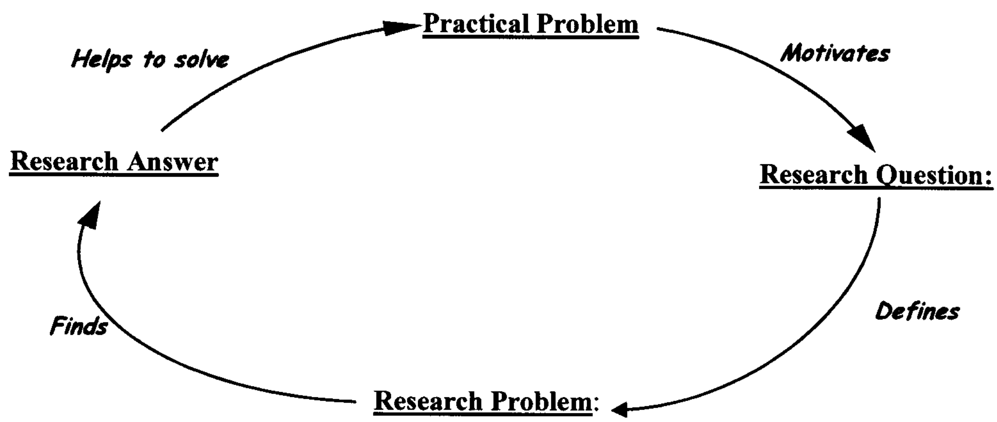

Figure 3: Single loop research process [15]

This single-loop research process was then expanded to a twin-loop process [19] which effectively guides the research effort within a certain research field or topic. This enhanced process is displayed in Figure 4. It consists of two distinct stages:

1) A problem 'identification' stage and
2) A problem 'solution' stage

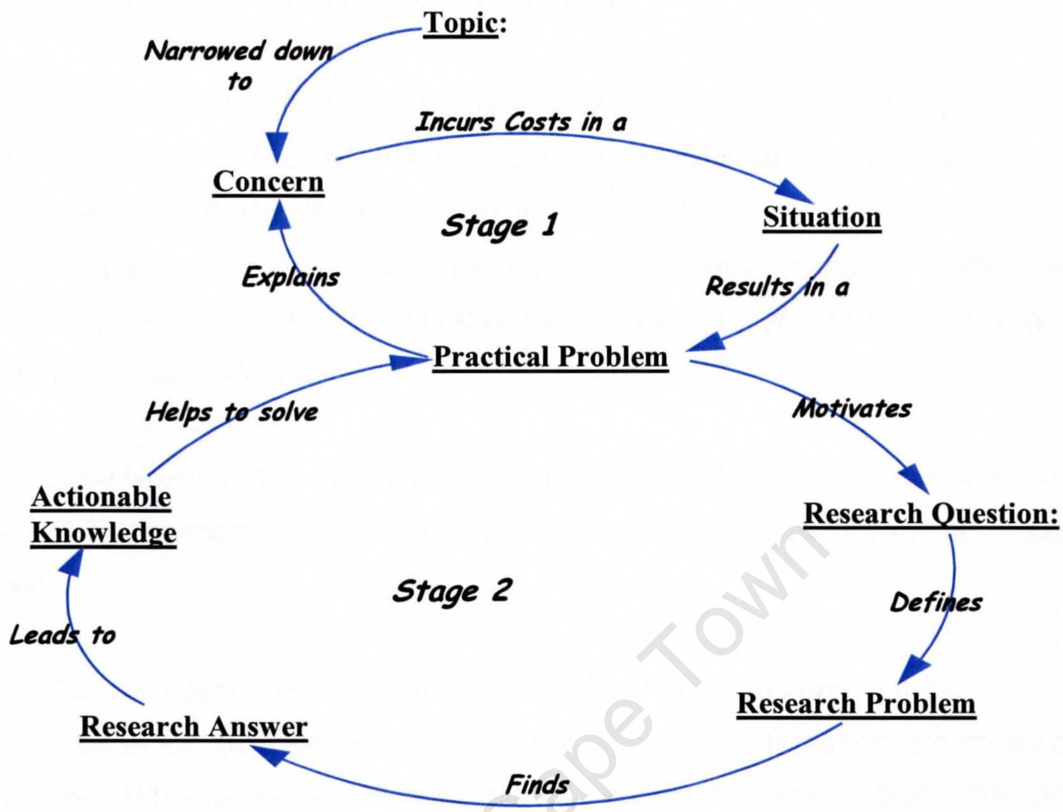

Figure 4: Twin loop research process [19]

Figure 4 clearly depicts the logical sequence of the various sub-processes within the overall research process. It prescribes the formulation of a concern and definition of a practical problem within a certain situation (or context), embedded within the wider field of the research topic (disaster management in this instance). This problem identification stage is then followed by a problem solution stage wherein a research question and problem are contrived. The research answer and hypotheses in turn constitute the solution to the identified research problem. The knowledge gained through arriving at the research answer then needs to be converted to 'actionable knowledge', i.e. knowledge that not only remains a theory/hypothesis but which can actually be applied in (management) practice in general and in addressing the identified practical problem in particular.

2.2.2 Route map to the strategic (research) intent

Although the logical sequence in the overall research process is clearly depicted by the diagram of Figure 4, the actual research endeavour is/was anything but linear or clearly structured. Although it had its linear moments, the actual process was a more organic one of meandering along a loosely guided research path and assimilating the building blocks of the research effort along the way – whilst remaining focused upon and progressing towards the strategic (research) intent.

These building blocks of the research work constitute 'small wins'[18] – a concept formulated by Weick [20]. Amongst other, Weick provides the following descriptions or definitions of 'small wins':

- A small win is a concrete, implemented outcome of moderate importance.
- Once a small win has been accomplished, forces are set in motion that favour another small win. When a solution is set in place, the next solvable problem often becomes more visible.
- A series of small wins can be gathered into a retrospective summary that imputes a consistent line of development.
- Small wins provide information that facilitates learning and adaptation.

This research project was executed as a series of <u>three distinct research cycles, or *Small Wins*</u> – each in turn consisting of one or more internal small wins. All this seemingly random research work and gathering of information always had one clear strategic intent: that of solving the research problem as defined in Section 1.2.4. The actual research route map is depicted in Figure 5 (Adapted from [19]):

[18] See Section 3.2.4.1, page 60

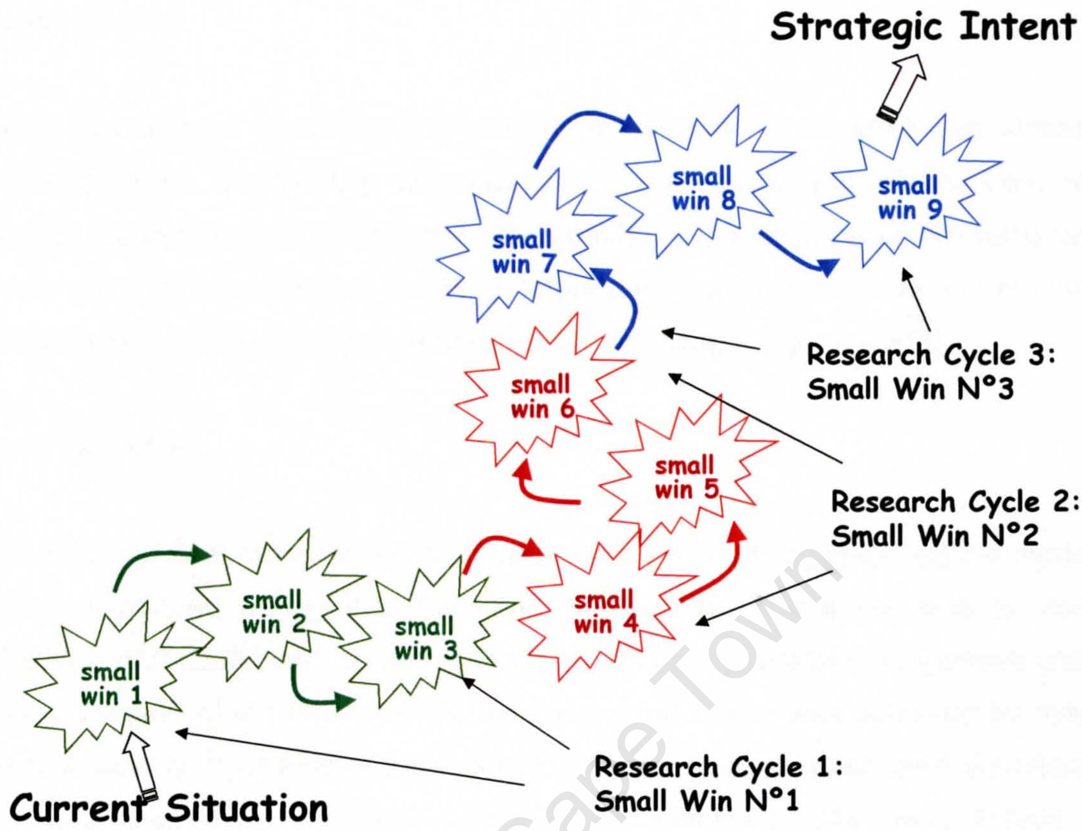

Figure 5: Route map to strategic research intent [19]

The three Small Wins of the research project comprised the following:

- Small Win N° 1:

  Research was focused on the *analysis* of the physical occurrences surrounding a disaster situation. Attention was given to the actual incidents and events that lead up to, directly cause, and eventually result from, disasters. Two disaster propagation models were developed and these were found to generically and plausibly portray and explain the events and circumstances surrounding the physical occurrence of a disaster.

- Small Win N° 2:

  During this round of research a higher level, or meta view of disasters was adopted. The systemic issues surrounding disasters were investigated and efforts were directed towards the *synthesis* of the disaster phenomenon within larger encompassing systems. A new disaster management theory, incorporating the models developed in Small Win N°1, was developed and represented by a Causal Loop Diagram (CLD).

- Small Win N° 3:

  The third and final round of research comprised an effort to *stress test* the models and theory developed during the preceding two rounds. The intent was to verify the relevance and usefulness of the research results as a practical management paradigm. This evaluation of the newly developed theory and model was achieved by evaluating the individual components of the theory/framework against known past disasters. The disasters referred to and listed during the compilation of this thesis served as the reference disasters.

2.2.3 Project specific research process design

From the afore-mentioned a view of the design of the specific research process employed during this research project can be constructed. This is the process followed to 'find' (refer to Figure 4), or construct the (research) *Answer* to the research problem and ultimately the research *Question*. Figure 6 depicts this interactive research model.

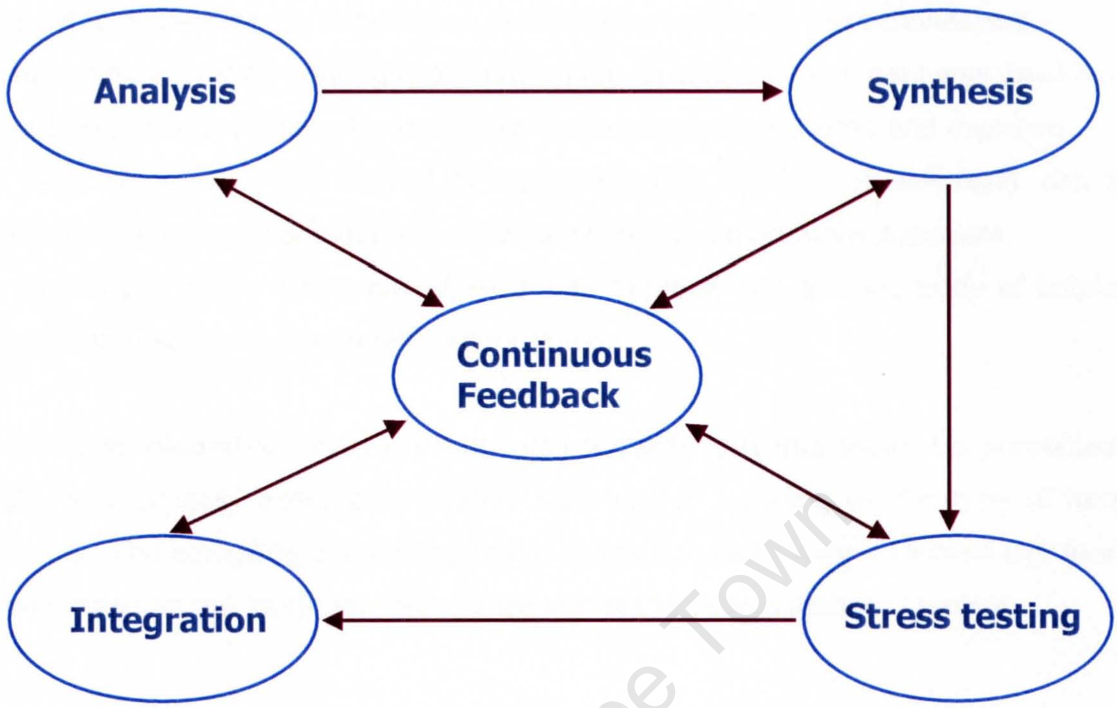

Figure 6: Interactive research process model

This interactive research process model was designed to develop the *Answer* in the *Concern-Question-Answer* body of the thesis. It shows the process of firstly analysing the 'problem' under study, i.e. man-made disasters, then synthesizing the partial answer into a bigger realm. Subsequently the newly developed knowledge, or theory, is then stress-tested to confirm its validity before being integrated into the final disaster management paradigm, or Answer. Throughout this total process continuous feedback between all the components ultimately ensures a well-developed research Answer.

2.2.4 Integration of research effort

The final part of the research project entailed the *integration* of the three individual Small Wins into a sensible whole, as depicted by Figure 4. Through this integration effort the strategic intent of the overall research project was eventually accomplished:

- A clear understanding of the disaster phenomenon was achieved.
- Plausible models for the explanation of disaster propagation were developed.
- A new theory, or then paradigm, for man-made disaster management was developed.
- The Concern - Question - Answer trilogy was suitably constructed and explored.
- A research answer was arrived at that, if sensibly applied (or actioned), can aid in solving (or managing at least) the practical problem of man-made disasters.
- It stands to reason that a contribution was made to the existing body of knowledge insofar as disaster management is concerned.

The research integration effort however also required that this thesis be presented in a specific, academically acceptable manner suitable for reporting on the type of research conducted. The compiling and editing of this thesis into its final report format can therefore also be viewed as the fourth and final *Small Win* of the overall research project.

2.3 The research methodology

2.3.1 Basic nomenclature of research methodologies

Research methodologies can essentially be classified as either quantitative or qualitative by nature. In simplistic terms *qualitative research* means '*any research where number counting and statistical techniques are not the central issues, where an attempt is made to get close to the collection of data in their natural setting*' [21]. Straus & Corbin [22] loosely defines qualitative research to mean '*any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification'.* Conversely, quantitative research implies methodologies where manipulation of numerical data, in whichever format, plays a central role.

Types of qualitative research include: grounded theory, ethnography, phenomenology, life histories and conversational analysis [22]. Quantitative methodologies comprise amongst others statistical analysis and mathematical modelling.

Figure 7 depicts this second-order breakdown of research methodologies:

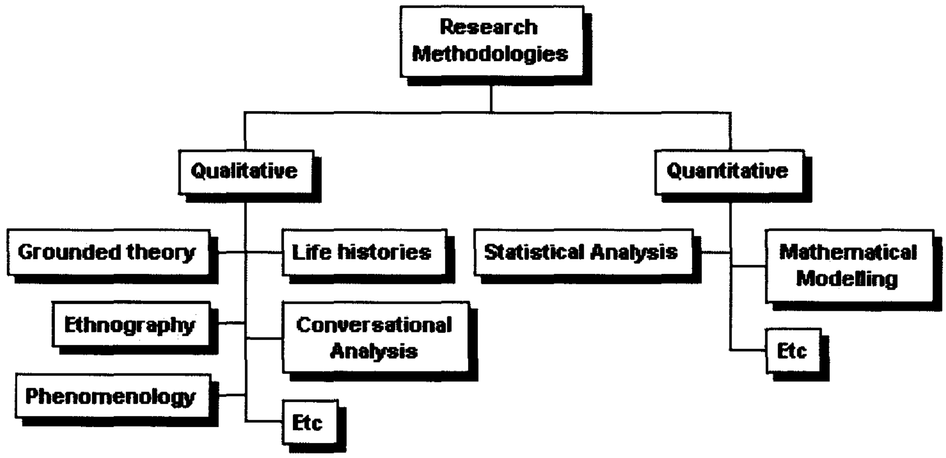

Figure 7: Second order breakdown of research methodologies

Table 2.1 displays the underlying assumptions of quantitative and qualitative research methods [23]:

Quantitative research	Qualitative research
Independence	Interdependence
Linear	Linear and non-linear
Cumulative, additive	Multiplicative, interactive
Deriving realities from measures of other	Independent measures of various realities
Deductive	Inductive

Table 2.1 Quantitative vs qualitative research [23]

For this research project a qualitative research approach was followed for reasons that will be discussed later in this chapter.

2.3.2 Research and risk assessment

Risk assessment[19] methodologies can also essentially be categorised into two distinct categories [24]:

- Qualitative risk assessment, i.e. when the experience, knowledge and skills of people are used for ascertaining risk
- Quantitative risk assessment is data based, i.e. accident data and statistics, records and documentation is used for evaluating risk

It may not be too far-fetched then to also view risk assessment as a form of 'research'. In essence an analysis is made (quantitatively or qualitatively) of a certain phenomenon and an attempt made to predict a possible future, with or without addressing the risk under scrutiny. This process is not far removed from 'traditional' research whereby it is attempted to predict future behaviour of systems based on some theory developed or verified during the actual research process.

Risk and risk assessment are comprehensively explored in Chapter 3 and the relevance of risk in any theory regarding disaster management is clearly demonstrated.

2.3.3 Why choose Qualitative Research in Management Practice?

Punnett & Shenkar [21] cite both theoretical and practical reasons for utilising qualitative research methodologies in management (practice) research. The following are some of the theoretical motivations proclaimed:

- Management is still a field characterised by a lack of theoretical understanding. This is apparently the strongest theoretical reason for utilising qualitative research in this field, since *"qualitative research is the most robust way of generating theory".*
- Theory generated form data (inductive) has greater staying power than theory generated from deductive hypothesis because even though it may be modified by input from later data, it is very unlikely to be proved totally wrong. It is therefore again implied

[19] See Section 3.3.5, page 78

that qualitative research methods yield more robust theory that should withstand rigorous verification.

- Qualitative management research has the potential for minimising (cultural or other) bias on the part of the researcher.
- The processes of data collection and analysis and theory creation are much more closely linked in qualitative than in quantitative research.
- Qualitative research emphasizes comprehensive, independent, holistic studies that are dynamic and predictive. It is therefore able to reconcile contradictory findings of individual studies because the role of any given variable is seen as the outcome of different contributions of variables, and what is most important is the interaction.

In addition to the theoretical reasons for choosing qualitative methodologies in management research, the following practical reasons are also advocated [21]:

- Management practice involves *'messy[20] problems and complex issues'.* The burning questions and complex situations that are important in management are not always amenable to neat statistical analysis. Qualitative research allows the researcher to take advantage of the richness of actual data and thus to obtain more meaningful results. It affords the opportunity to examine the processes 'why and 'how' and not just 'what', to explore the complex, interdependent issues that constitute management practice.
- Case or field studies are holistic, so that one can see the relation of the parts to the whole and not just as collections of parts. This makes for better interpretation of the phenomenon under study. The danger in using a single case study lies in not being able to generalise to larger populations. This drawback can however be minimised by using more than one case and matching cases as far as possible along some common variables.

Strauss & Corbin [22] motivate amongst others the following four reasons for conducting qualitative research (as opposed to quantitative research):

- The nature of the research problem. Some areas of study (like management practice) markedly lend themselves more to qualitative types of research.

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[20] See Section 3.3.2, page 70

- Qualitative methods can be used to uncover and understand what lies behind any phenomenon about which little is yet known.
- Conversely, it can be used to gain novel and fresh slants on phenomena about which a lot is already known.
- Qualitative methods can yield the intricate details of phenomena that are difficult to convey with quantitative methods.

In summary, perhaps the best reason for utilising qualitative research methods in management research, is provided by the 'parents' of grounded theory (Glaser & Strauss) in their seminal work on grounded theory [21]. They provide a succinct explanation for the difference between verification of theory, to which rigorous quantitative methods are more germane, and the important prior step of generating theory, to which qualitative methods are more appropriate [25].

Taking cognisance of the above elucidation it stands to reason that a qualitative, rather than quantitative, methodology is better suited for exploring management practice research in general, and for delving into the realm of disaster management in particular. The endeavour to create a (new) systemic disaster management paradigm will clearly best be addressed by employing a qualitative research approach and methodology.

2.3.4 What is *Grounded Theory*?

Having established that qualitative research is the appropriate type of research for this research project, a clear understanding must be obtained of why Grounded Theory was the chosen research methodology. This can best be achieved through understanding the nature and characteristics of grounded theory.

Strauss & Corbin [22] explain grounded theory as follows: *'A grounded theory is one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis and theory stand in reciprocal relationship with each other. One does not begin with a theory then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge'.* Furthermore, *'the grounded theory approach is a qualitative research* *method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon'.*

Stern [26] differentiates grounded theory from other qualitative methodologies by quoting five basic attributes:

- The conceptual framework of grounded theory is generated from the data rather than from previous studies.
- The researcher attempts to discover dominant processes in the social scene rather than describe the unit under investigation.
- The researcher constantly compares all data with all other data.
- Data collection may be modified according to the advancing theory, that is, the researcher drops false leads or asks more penetrating questions as needed.
- The investigator examines data as it arrives and begins to code, categorise, conceptualise and writes the first few thoughts concerning the research report almost from the beginning of the study. (This attribute, in particular, was employed extensively during the actual compilation of this research thesis).

Why then is the term 'grounded' justified as a description of this specific sub-set of (developed) theories? Because the information pertinent to the emerging theory comes directly from the data, the generated theory remains connected to or grounded in the data [22], [25], [26].

2.3.5 Practical application of the grounded theory method

2.3.5.1 Defining the research question and research problem

Applying the grounded theory methodology in practice entails a number of clearly defined actions. First and foremost a phenomenon or area of research obviously needs to be identified. That is, a research question and a research problem need to be defined in order to focus the research effort within the boundaries of a real life phenomenon about which more understanding is desired. Strauss & Corbin [22] devote the second chapter of their book on grounded theory procedures and techniques on 'getting started' with a grounded theory development exercise. The chapter deals in its entirety with deciding on and defining an appropriate research question/problem combination. Importantly, the following statement is made: *'The research question in a grounded theory study is a statement of the phenomenon to be studied'* [22].

Having defined the research question and problem[21] comprehensively therefore sets the stage for unwrapping the phenomenon of disasters in order to attempt the creation of a plausible (grounded) management theory.

2.3.5.2 Framework for grounded theory development

The systematic and sequential steps followed during the development of grounded theory is depicted in Figure 7 [27], [28]:

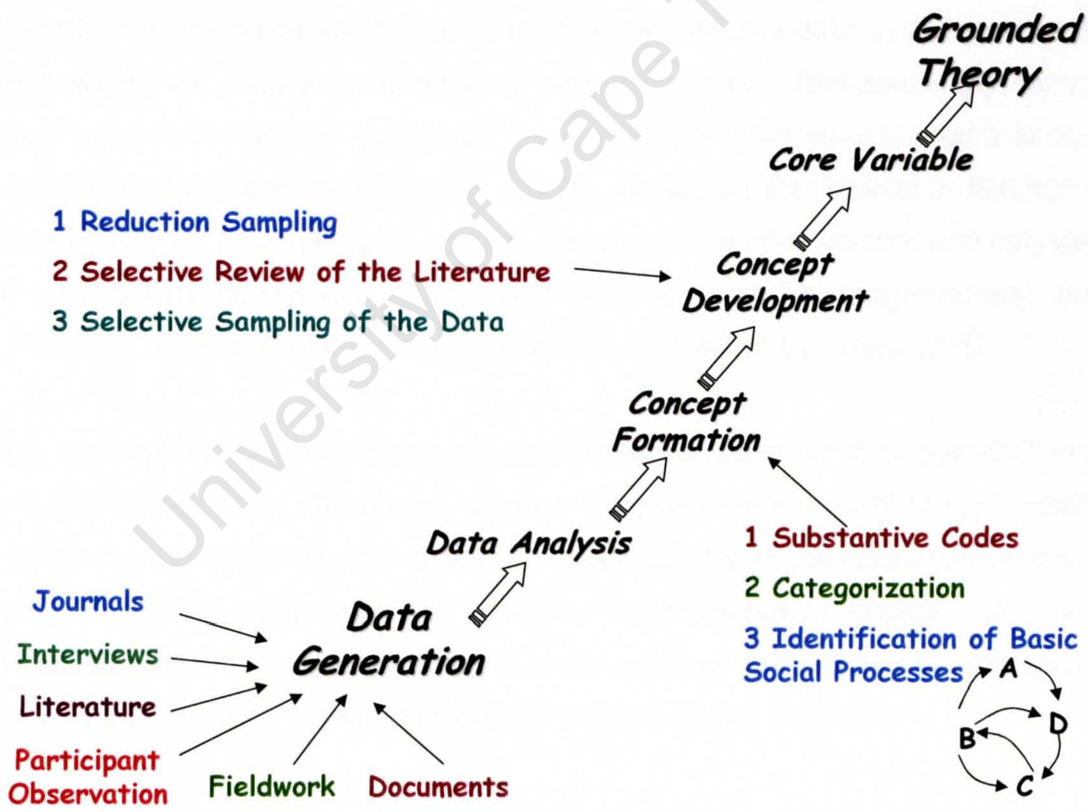

Figure 8: Development of grounded theory [27], [28]

[21] See Section 1.3.3 & 1.3.4, pages 27-29

During the actual theory development process the linear and non-linear aspects[22] of this methodology was experienced first-hand. Progress was achieved through a combination of periods of pure systematic progress on the one hand; and then discovery and exploration of unique contributors to the theory in a random and unpredictable manner. Out of this 'messiness' a new management theory was eventually distilled.

2.3.5.3 Data generation and analysis

The sources of data for grounded theory development are described by Struebert & Carpenter [28] as journals, literature, documents, interviews, participant observation and fieldwork. With closer examination the first three sources can be categorised as 'historic' references and the latter three as 'current' or 'live' references. Further reflection - and remembering the risk assessment classification delineated in Section 2.3 - then reveals that the 'historic' references can in fact be viewed as quantitative data sources whilst the 'live' references may be considered qualitative sources of data. This seemingly contradictory situation is not uncommon in qualitative research. It must be remembered that qualitative research refers to *'a non-mathematical analytic procedure that results in findings derived from data gathered by a variety of means. These include observations and interviews, but might also include documents, books, videotapes (or television programmes), and even data that have been quantified for other purposes such as census data'* [22].

For this research study data was mostly obtained from historic or then quantitative records of past known disasters. A copious amount of case studies and historical recordings of past disasters was identified and studied during the course of this research project. (All the disasters that were researched and analysed are reflected in Appendix A). Excellent recordings of past disasters and various authors' opinions or theories on a specific disaster and/or the subject matter in general were found to be readily available.

To a lesser degree 'live' or qualitative data sources were explored. This modus operandi can be explained by the fact that no actual or real disaster was experienced and/or investigated during the research project. Also, persons with an informed opinion regarding the actual occurrences in past disasters were found hard to come by. Interactions with, and observations of, role players in potential disaster situations were relied on for

[22] See Table 2.1, page 42

accumulating qualitative data for this study. These interactions were normally of a fleeting and fragmented manner and provided partial glimpses of phenomena that might, or might not have, featured in potential disaster situations.

As mentioned in Chapter 1 the research effort initially focussed only on the mining industry and hence the initial histories or case studies analysed were all mining industry related. As the building blocks and pattern(s) of the new theory however crystallised, man-made disasters in other spheres of industry - and in life in general - were also explored. Analysis of the data was carried out continuously and randomly as new data was obtained.

2.3.5.4 Concept formation and development

With the disaster-related information accumulating, the search for meaningful relationships commenced. As Mullen & Reynolds [29] states: *'From the beginning of the study, grounded theorists attempt to discover as many categories as possible and to compare them with new indicators to uncover characteristics and relationships'*. From the onset of this research project the analysis process revealed two distinct categories of phenomena/concepts that are prevalent in <u>all</u> man-made disasters:

- A 'hard' physical world where the laws of nature rule. Here the irrefutable, and often fatal, relationship of cause-and-effect dominates. After all, disasters are by definition occurrences where physical happenings result in chaos and mayhem.

- A 'softer' world where human behaviour and the understanding – or more often the misunderstanding – there-of is reflected in management action. As previously indicated, all man-made disasters have their origin in some human (read management) error, after which the unfolding of the disasters are driven by the forces of nature acting out of control.

Disaster-related data was therefore predominantly 'coded' and categorised into these two main spheres of influence. Internal to these two spheres various other sub-categories were identified and data associated accordingly. <u>Constant comparison</u> of data slowly revealed certain relationships that enabled early hypotheses to be generated. Through this ongoing process an interactive pattern that encompasses the prevalent physical processes on the one hand and the underlying or basic social processes (BSP's) [30] on the other, was distilled.

Subsequent to the initial bouts of data collection and analysis a reiterative process developed from the research activities: as data analysis resulted in refined concept identification and development, the emerging patterns of thought initiated more selective and effective data acquisitions. In this manner the data acquisition and analysis, coupled to concept formulation and refinement, eventually culminated in a virtuous cycle whereby the concepts or building blocks of the new theory were constantly improved through selective sampling of new data to a better fit within the new paradigm. As the concepts matured, verification and enhancement of the emerging theory were assisted by an even more selective review of the literature in order to confirm resonance with existing theory, indicate rogue concepts, and facilitate elimination of false leads. This selective and reductive sampling process enabled saturation [31] of the identified categories to occur.

2.3.5.5 Determining the core variable(s)

A *core variable* in any process can be defined as the entity that has the largest potential for affecting the outcome of the process under scrutiny. It is the variable that will be highlighted during a sensitivity analysis as being the most sensitive and therefore the most influential. By manipulating this core variable the largest swing in process results can be obtained – positively or negatively.

The discovery of a core variable is the goal of grounded theory and this core variable serves as the foundational concept for theory generation [28]. Glaser [30] states that '*the researcher undertakes the quest for this essential element of the theory, which illuminates the main theme of the actors in the setting, and explicates what is going on in the data*'.

This sometimes elusive core variable is said to have six essential characteristics [28]:

- It recurs frequently in the data
- It links various data
- Because it is central, it explains much of the variation in all the data
- It has implications for a more general or formal theory

- As it becomes more detailed, the theory moves forward
- It permits maximum variation and analyses

An unique core variable was then also isolated during this research exercise and it stands central to the newly developed management theory. The concept of *mindfulness*[23] - with regards to and within the context of disaster management - was identified as the critical component within the new theory. When interpreted and evaluated as *'the level of mindfulness',* it emanates from the theory that the manipulation of this variable has the greatest potential for preventing disasters altogether, or then for ameliorating the consequences of (potential) disastrous occurrences. This core variable was also found to provide the bridging link between the 'softer' world of human and management interaction and then the 'harder' world of physical manifestation.

Second to the core variable a number of sub-variables that are directly driven by basic social processes (BSP's) and basic physical processes (BPP's), were identified and incorporated into the disaster management paradigm.

2.3.5.6 The Grounded Theory

The final management theory represents complex interactions between the core variable and the sub-variables, the lubricant for integration being provided by the basic processes mentioned above. This new theory can therefore best be visualised by means of a *Causal Loop Diagram*[24] which illustrates the various effects that the theorem variables have on one another.

Whilst the process of arriving at this new disaster management theory followed the route maps and utilised the techniques described in the preceding sections of this thesis, the final product also substantially relied upon personal reflection and <u>creativity</u>. Strauss & Corbin [22] reckon that creativity is a vital component of the grounded theory method *'that manifests itself in the ability of the researcher to aptly name categories, to let the mind wander and make the free associations that are necessary for generating stimulating questions and for coming up with the comparisons that lead to discovery'.* Many of the relationships established and resonances discovered during this research project could

[23] See Section 3.3.8, page 84
[24] See Section 3.3.9. page 86

only be ascribed to intuitive and reflective mental gymnastics where episodes of seemingly dead-end exploration culminated in jubilant 'eureka!' moments when connections between haunting concepts were finally made. As such the origins of some of the insights achieved are very difficult to explain mechanistically - although the eventual inter-relationships with other theorem variables are clear to observe in the final hypotheses. This phenomenon was actually supported by the following research idiosyncrasy: as the structure of the theory emerged from the analysis and grouping of data, 'open spaces' or 'missing links' were often encountered[25]. These spaces were then usually bridged through reflection and relative discoveries that were later confirmed through reductive data sampling and concept verification.

As described above the new disaster management theory set out in this thesis developed, progressed and emerged through a non-linear, reiterative process of analysis, synthesis, hypothesis, verification and improvement, until a plausible systemic management paradigm was eventually construed. Chapter 3 contains the record of this core of the research effort and documents the development of the new theory.

2.3.6 Theoretical sensitivity

A final note on grounded theory relates to the notion of theoretical sensitivity. Strauss & Corbin [22] defines theoretical sensitivity as *'the attribute of having insight, the ability to give meaning to data, the capacity to understand and capability to separate the pertinent from what isn't'*. In short, it is the ability to recognise what is important in data and to give it meaning, in order to formulate theory that is faithful to the reality of the phenomena being studied [22], [30].

According to Strauss & Corbin [22] theoretical sensitivity has two main sources:

- The background that the analyst brings to the research situation. This attribute comes from:

[25] See Section 4.3.2, page 112

- o Being well 'grounded' in the relevant technical literature, i.e. having a familiarity with the research topic through readings on theory, research and study of other documents[26].
- o Professional experience, i.e. the exposure to the study field that a researcher gains through his working career[27]
- o Personal experience, i.e. any occurrences related to the research problem that the researcher had experienced first-hand[28]

- The analytical process itself, as insight and understanding about a phenomenon increase through interaction with and analysis of the acquired research data.

The presence of these basic requirements for theoretical sensitivity during the research endeavour is adequately illustrated throughout this thesis. The extent to which it assisted in formulating a robust grounded theory will become evident in Chapter 3.

26 See Section 2.3.5.3, page 48
27 See Section 1.2.5 (ii), page 21
28 See Section 1.2.5 (i) & (iii), pages 20 & 22

3. ANALYSIS OF DATA AND THEORY CREATION

3.1 Introduction

Chapter 1 introduced the three-fold research Concern, i.e. man-made disasters occur randomly across all spheres of life and within all types of organisations; similar disasters occur repeatedly; and organisations repeatedly cause disasters. The concern was followed by the (research) Question: *How can man-made disasters be managed?* The Answer to this question was then concisely provided in Chapter 2, i.e. in order to address the man-made disaster phenomenon the research project had developed a new management theory through a process of analysis, synthesis, stress testing and integration.

The role of Chapter 3 is to now comprehensively construct the (research) Answer - and in so doing divulge the Rationale behind it - by utilising the specific research process designed and introduced in Chapter 2 and portrayed by Figures 5 & 6. The core of the research work conducted is therefore documented in Chapter 3. This chapter delineates the mental processes followed to arrive at the new disaster management paradigm and a detailed description of the new theory is provided. The results of the three research cycles are described in the actual sequence that the cycles were conducted – as a series of small wins. The sub small wins, or actual building blocks of the new theory, are presented as they were derived internally to the three distinct cycles.

It is attempted to present the concepts/sub small wins/variables in a coherent manner – although the process of identifying them in the first place for further development may not be immediately clear to the first time reader. This possible dislocation can only be ascribed to the 'creative theory generation process' as described in Chapter 2. The relevance of the various theory components however become increasingly clear as the theory is developed in more detail. The final verification that the theory is in fact grounded in these components – which were identified through creative analysis of selected data – comes from the 'stress-testing' of the new management model against the very disasters from which the data for its generation was distilled. The grounded theory creation process had therefore in essence gone full circle: analysis of disaster related data yielded concepts for the creation of a new theory, which in turn was examined against the very disasters from which the data was 'milked' in the first place. Through this reiterative process the theory was developed and refined, more selective data selection ensued and theory validation was achieved.

The new management theory or paradigm was found to provide a plausible framework for explaining past disasters and it stands to reason that the model can therefore also be applied as a 'forward-looking' or predictive management tool for dealing with potential disaster situations. Chapter 3 therefore provides a comprehensive answer to the research question posed in Section 1.3.3.

3.2 Research Cycle N°1

3.2.1 Goal of Small Win N°1

From the onset it was intuitively recognised that a thorough appreciation of the mechanics of disasters, i.e. the physical processes involved when things go wrong in a big way, would be required if any attempt is to be made to rationalise disaster situations by means of a management model. After all, if the physical mayhem cannot be prevented, what would the use of any management theory be then? Research cycle N°1 therefore focussed on the analysis of the disaster unfolding or propagation process in itself.

The first research cycle attempted to find a generic answer to the questions 'How do disasters unfold and propagate? And 'What happens when disasters occur?' This was achieved through the process of analysis whereby [32]:

- the entity that we want to understand is first taken apart;
- an understanding of the behaviour of each part of this system/entity separately is obtained; and
- the understanding of the parts of this system to be understood is then aggregated in an effort to explain the behaviour or properties of the whole.

Ackoff [32] states that *'analysis of a system reveals its structure and how it works. Its product is know-how, knowledge, not understanding'.* The research effort in Cycle 1 was therefore inwardly focused on the physical phenomenon of disasters to gain knowledge of its physical workings. A simplistic analogy would be to view the concept of 'disasters' as an onion that one takes in your hand and starts peeling away the layers to determine answers to 'what' is this and 'how' does it look/fit together/work? As previously alluded to the research project had organically grown to include the wider spectrum of man-made disasters and not only mining industry related disasters. It was therefore attempted to gain insight into the mechanics of unintentional man-made disasters (UMMD's) in its widest sense.

3.2.2 Energy and Entropy

As this research project dealt with the (unforeseen, uncontrolled) behaviour of physical systems the importance of the ever-present concepts of energy and entropy were rapidly identified, categorised and earmarked as concepts for further development. The Oxford Dictionary [1] defines *energy* as '*the property of matter which is manifested as a capacity to perform work*' and *entropy* as '*a measure of the disorganisation or degradation of the universe*'. What follows are mostly quotations and adaptations from the literature (where indicated) to illustrate the application and importance of these well-established concepts within the context of this disaster research project.

'The laws of thermodynamics are special laws that sit above the ordinary laws of nature' [33], [34]. '*It can be shown that without the first and second laws of thermodynamics there would be no other laws at all*' [34]. The concept of energy arises from the first law of thermodynamics and the concept of entropy from the second law [35]. In essence the first law – the law of energy conservation – states that **all real world processes involve transformations of energy**. Energy cannot be created or destroyed but only transformed from one form to another. The second law – the law of entropy creation – postulates that in all natural processes the entropy of the world always increases. Van Wylen & Sonntag [35] refer to the principle of increase of entropy and declare that '*the great significance is that the only processes that can take place are those in which the net change in entropy of the system plus its surroundings increases*'. In its most general form the law states that **the world acts spontaneously to minimise potentials (or maximise entropy)** [34]. *'The key insight into this second law of thermodynamics is that the world is inherently active and whenever an energy distribution is out of equilibrium a potential or thermodynamic 'force'*

exists that the world acts to dissipate or minimise. All real world changes or dynamics are seen to adhere to this law' [34].

There also exists a third law, the law of maximum entropy production [34]. This law is in addition to, and expands upon, the second law. (It should however not be confused with the third classical law of thermodynamics, which deals with the entropy of substances at the absolute zero of temperature [35]). The classical second law does not expand upon the question of which out of available paths a system will take to accomplish the end goal of maximising entropy. The law of maximum entropy supplies this answer [34]: '*The system will select the path or assembly of paths out of otherwise available paths that minimises the potential or maximises the entropy at the fastest rate – given the constraints'.* What we know intuitively, and can confirm by experiment is that whenever a constraint is removed and a new path or drain is provided that can increase the rate at which a potential is minimised, the system will (invariably) seize the opportunity [34]. **The universe therefore perpetually strives to dissipate or minimise potential energies and create maximum disorder at the fastest rate possible.** This axiom is true for all systems, i.e. natural and man-made.

It is common knowledge that electricity and water flows through, or follows, the paths of least resistance. These phenomena are nothing more than confirmation of the energy and entropy laws in action. When dealing with disasters - which are the results of natural processes acting out of control, or without restraint, in an effort to reduce potential energies - the interplay between different levels of energy and entropy becomes particularly relevant. Also, it seems as if the concept of entropy provides a plausible explanation for the 'monster'[29] that always waits to strike within potential disaster situations.

3.2.3 Systemic nature of disasters

3.2.3.1 Creating Order

Man can be seen as the great 'order creator', putting structures and systems (constraints) in place to channel, re-direct, utilise and contain nature's energy to his advantage. A conscious decrease in entropy occurs when such man-made systems are created [35]. It is

[29] See page 25

however when these man-made systems falter and constraints unravel that the universe seizes the opportunity to rapidly re-assert itself in its preferred position of lowest energy and maximum disorder. Alternatively, through their own doing and ignorance, humans often find themselves in the way of natural energy-dissipating processes. In both instances *cosmology*[30] episodes ensue, often with disastrous results, and man is (again) left bewildered at the power of nature and the 'unimaginable' occurrences. The stark irony however is that nature behaves in exactly the same way as it has always done, in accordance with the relevant natural systems laws and fuelled by the three thermodynamic laws[31] as described above.

3.2.3.2 Understanding systems

The term 'man-made disaster' by definition implies some form of deficient human interaction with one or more man-made systems, which may or may not in turn be interacting with some natural system(s)[32]. In order to prevent a disaster these interactions need to be understood. From a systemic perspective three fundamental rationality tenets can be proclaimed:

i) Understanding of the basic laws of nature and natural system response

The universe was created to function in an orderly and, important for organic survival, repetitive manner. Over thousands of years mankind has managed to discover and decipher most (?) of the laws and behaviours of his natural environment in order to survive and prosper. Once the basic behaviours of natural systems were understood it was realised that its repetitive nature provided tremendous opportunities for mankind. So was fire discovered and put to good use over the ages. Electricity was discovered and its laws distilled to the extent that it can today be safely controlled and be seen as man's silent, obedient (but lethal) servant. The understanding of the repetitive nature of our solar system eventually enabled man to travel to the moon and back.

[30] A cosmology episode occurs when people suddenly and deeply feel that the universe is no longer a rational, orderly system [9].

[31] These three laws will be referred to as the E^3 laws from here on.

[32] The different types of systems are comprehensively discussed in Section 3.3.3

Although new discoveries about our universe will always be made and it is doubtful whether we will ever know everything about our physical environment, enough knowledge has been amassed to enable humans to relatively safely negotiate and apply natural systems' behaviour to their advantage. The point to make here is that the human response of *"Oops, we did not know that would happen!"* is ludicrous and has no substance. Aeroplanes and shaft conveyances will fall, space shuttles will explode, boats will sink and electricity will arc across open space – if adequate designs and constraints are not put into place by their creators. It should also be borne in mind that the E^3 laws govern these natural responses and at all times stand poised to pounce on any systemic constraint slip to create maximum disorder in an 'orderly' fashion (according to natural system behaviour laws) and at the fastest rate possible (given the constraints).

ii) Understanding the functionalities, operational characteristics and failure modes of man-made systems

These knowledge areas centre on the discipline of systems engineering, '*a process employed in the evolution of systems from the point when a need is identified through production/construction and ultimate deployment of that system for consumer use*' [36]. Systems engineering also pre-supposes a life-cycle approach whereby any system must be managed from 'cradle to grave'. Blanchard & Fabrycky [36] define the following generic steps or sub-processes within the systems engineering process:

- Definition of need
- Preliminary system design
- Detail system design and development
- Production and/or construction
- Utilisation and support/maintenance
- Phase-out and disposal

iii) Understanding the interaction of such systems with other (man-made and natural) systems

Sound systems engineering should also take into account the inter-action of man-made systems with the environment - and other relevant systems. A good example of dysfunctional interaction between systems is provided by the Mann Gulch[33] disaster. Here a man-made system, the smoke jumper platoon, was overwhelmed by the behaviour of a natural system, i.e. a forest fire. The fire fighters failed to 'make sense' [9] of the rapidly changing circumstances, they were incompatible with the environment to which they were applied, and as a result of this mismatch thirteen young men died a fiery and premature death.

The disaster-averse perspective insofar as systems go should always be a holistic, critical view with regards to the system in question. A thorough understanding of the dominant system behaviour, in conjunction with other systems and its natural environment, represents the crucial cognitive ability requirement for management.

3.2.4 Disaster propagation

3.2.4.1 Analogy between small win/loss and large win/loss

Weick [20] defines a *small win* as a concrete, complete, implemented outcome of moderate importance. It is seen as a controllable opportunity that produces visible results [20]. A number of distinct characteristics of small wins are defined, with a very important one being *'they preserve gains, they cannot unravel, each one requires less coordination to execute'* [20]. Commensurately, a large win can be seen to *'require much greater coordination because interdependencies are more dense, timing is more crucial and defections are a greater threat. If one crucial piece is missing the attempted solution fails and has to be re-started'* [20].

From an opposing or negative point of view, the concepts of small losses and large losses can be derived. In this analogy a *small loss* would represent an undesirable, unplanned occurrence of moderate criticality or irritation, e.g. an incident or accident. Further

[33] Appendix A - Disaster N° 11

extrapolation would reveal that a large loss, e.g. a disaster, by default requires great coordination as a result of dense inter-dependencies amongst its building blocks. If one crucial event (small loss) is missing, the would-be great loss is prevented and has to be re-initiated. Timing is in fact critical and any defection (small win) constitutes an intervention that derails or interrupts the propagation of the large loss (or imminent disaster).

Congruent with the Swiss Cheese accident model [2] a twin stream win/loss model can be created (Figure 9). One line indicates the successive small losses required to generate a large loss, whilst the opposite line portrays the series of small wins that can culminate in a large win. The *loss* line strives towards maximum chaos whilst the *win* line aims towards maximum order. At the very least a small loss can derail the strive towards zero risk whilst the inverse holds true for a small win: **it can actually curtail a developing disaster**.

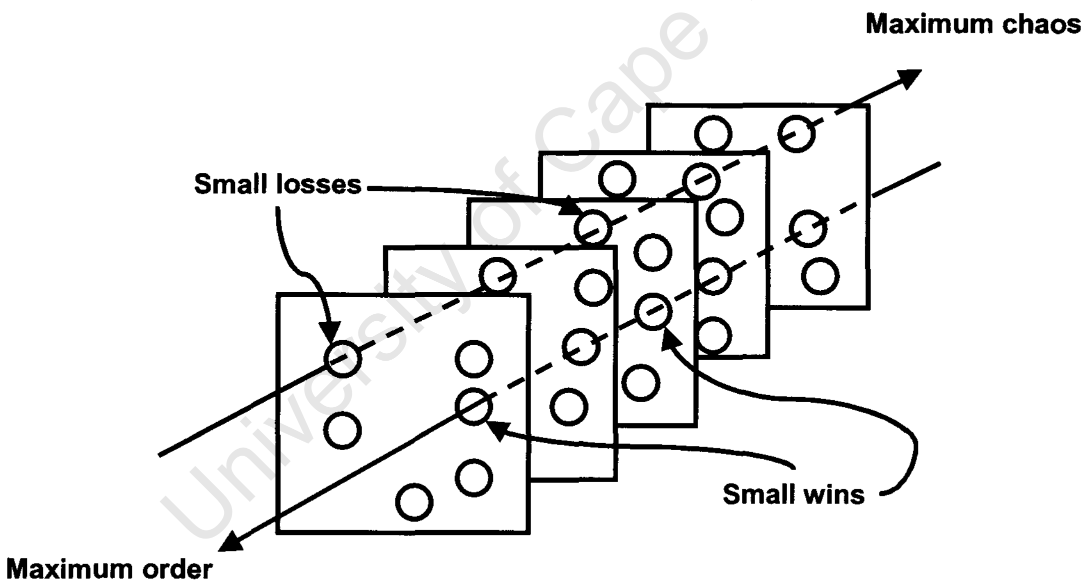

Figure 9: Twin Stream Accident Model

It is important to realise that '*small wins do not combine in a neat, linear serial form with each step being a demonstrable step closer to some predetermined goal. More common is the circumstances where small wins are scattered and cohere only in the sense that they move in the same general direction or all move away from some deplorable condition*' [20] (i.e. a disaster). Similar reasoning holds true for small losses that propagate in the general direction of mayhem. In the words of Weick [37]: '*Small events are carried forward,* *cumulate with other events, and over time systematically construct an environment that is a rare combination of unexpected simultaneous failures'.* The development and alignment of these small losses might take a considerable amount of time. The first small loss might for instance be a design oversight that eventually leads to disaster at a much later stage of the system's life cycle. Alternatively, one or more localised small losses might occur in quick succession in an otherwise 'perfectly' designed system. Setting the stage for misfortune therefore (normally) plays out over context-specific time duration and will always be a function of the complexity of the system(s) involved.

Meta-reflection on the model proposed in Figure 9 reveals a crucial aspect of losses and wins: the tumbling towards maximum *entropy* and lowest energy states occurs by itself whilst the build-up towards order requires continual input, i.e. addition of *energy*. Any system will degrade naturally over time unless effort is expended to either create order, or alternatively to maintain certain orderly states.

The Twin Stream model of Figure 9 can be turned through 90 degrees so that the line reaching towards the loss situation points straight down and the win-aspiring line is directed upwards. Now imagine a small ball lying on the top 'event layer' that is continuously revolving and changing position. As the ball finds a suitable hole (the occurrence of a particular degrading event or small loss) in the event layer, it falls through it to the next layer – or further down if one or more holes are vertically aligned. When it reaches *ground zero*[34], the chaos/disaster has expended itself and only turmoil, with no residual threat, remains. (Refer to the Discrete Event Disaster Propagation Model, Figure 10).

However, the ball can be kept on any of the event layers and prevented from falling through by 'plugging' the hole, defect or small loss with an appropriate correction or small win. To improve the position of the ball, i.e. to move it away from ground zero, requires effort and energy of some sort to elevate it to the next event layer, where it can only remain if no matching holes exist in that layer. System build-up and decay is therefore a continuous movement up and down this event-layered realm. Degradation is however a natural process whilst improvement or the creation of order requires deliberate intervention and energy influx. The deflation towards disaster by default entails an expenditure of, and reduction in, potential energy of some sort – with a commensurate increase in entropy.

[34] See Section 3.2.4.4, page 65

3.2.4.2 Triggering event

All the disasters investigated had one distinct common attribute: a certain (undesirable) event that had directly caused the physical occurrence of the disaster. Shrivastava et al [38] proclaim that industrial crises are triggered by specific events identifiable according to place, time and agents. They term this crucial event the *triggering event*. Whilst it is not difficult to comprehend what a triggering event constitutes, there may well be different views as to which specific event actually represents the critical stimulus for the disaster. Shrivastava [39] identifies the *leakage of toxic gas* as the triggering event at Bhopal[35] whilst Weick's [37] choice is *the failure to insert a slip blind* into a pipe being cleaned, allowing water to back up and enter a storage tank containing Methyl Isocyanate (MIC), where it catalysed a complex and violent chemical reaction.

To avoid ambiguities and for the purposes of this research project the triggering event will be defined as *the event that directly precipitates the accident and eventual disaster*. It is that specific occurrence that physically sets the destructive powers in motion and gets the clock ticking towards chaos. In the *Discrete Event Disaster Propagation Model*[36] it is the small loss or hole that allows the sphere to fall through the critical event layer. It can therefore be argued that between Weick's [37] *'failure to insert a slip blind'* and Shrivastava's [39] *'leakage of toxic gas'*, another crucial event occurred: the chemical reaction between water and MIC. This chemical reaction – and nothing else – actually set the mechanics of disaster in motion.

Shrivastava et al [38] also proclaim that *'triggering events have a very low probability of occurrence, but there are often warnings of their occurrence'*. Adopting the hypothesis that the triggering event equals the physical decay-initiating event, this statement can also be critically re-evaluated. The point to make here is that the triggering event will naturally occur if allowed to, as in the Bhopal example. As another example, focussing on Weick's [37] *failure to insert a slip blind* may allow a completely different event, e.g. incorrect valve control during normal operation, to also cause the undesirable chemical reaction. The triggering event can therefore be seen as that natural physical response (small loss) that must be prevented at all costs.

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[35] Appendix A: Disaster N° 9

[36] Figure 10, page 66

The triggering event represents the crucial disaster-initiating occurrence and also the turning point or watershed between system decay and physical deflation towards disaster. This is the point where the one component of risk becomes a reality: the probability of an unfortunate event occurring reaches 100% and the previously known or unknown consequences manifest progressively. From a systems perspective this is the point where the failure of 'soft systems' (management systems, decisions, procedures, etc) eventually make way for the natural response of 'hard systems' (structural or mechanical failure, explosions, chemical reactions etc). The significance of this viewpoint lies within the realisation that crisis development has at this point transgressed irrevocably from a position of prevention to one of containment.

Although the triggering event is the critical event that sets the wheels of physical disruption in motion, there should be guarded against attaching too much value to (only) this event. Whilst it is true that preventing the triggering event from happening will prevent an actual disaster from occurring, the same can be said about any of the systemic small losses prior and subsequent to the occurrence of the triggering event.

3.2.4.3 Energy release and disaster

Subsequent to the triggering event's occurrence a release of energy of some sort materialises. The release of energy can be extremely rapid, e.g. the explosion of the Challenger[37] space shuttle (although all energy was only expended when the last piece of wreckage had fallen to earth). It can also be a process that takes time to unravel, e.g. the sinking of the Herald of Free Enterprise barge in the Zeebrugge[38] disaster, or the sinking of the Titanic[39] in the North Atlantic. Here the demise towards the lowest energy state, i.e. the sinking of the vessels and therefore the relinquishing of the potential energy of the floating ship/barge, took some time to unfold. On the other extreme, with a disaster like Chernobyl[40], the radiation energy will take years, if not decades, to finally decay towards an inert state.

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[37] Appendix A: Disaster N° 12
[38] Appendix A: Disaster N° 13
[39] Appendix A: Disaster N° 14
[40] Appendix A: Disaster N° 15

This period of energy release represents the damage or loss creating forces at work. It is the physical unfolding of the disastrous consequences after the occurrence of the triggering event. Nature is striving towards the least orderly states and the system and its direct environment are experiencing a rapid increase in entropy. The 'genie' has been uncorked, natural forces do their unconstrained best to shed energy and the final extent and cost of the incurred disaster is largely unknown, although it can be influenced by the degree of human intervention and the effectiveness of remedial and containment efforts. This liberation of energy will continue until all potential energy is exhausted, potential fuel and energy sources are depleted or the process is halted by an intervention of some sort. A *disaster zone* can therefore be visualised in which the destructive forces and subsequent collateral damage unfold over time.

In the absence of an exact quantitative definition of what a disaster entails the point where energy release becomes disastrous depends largely on the perspective of the stakeholders and/or observers. Whatever this transformation point is, it can be appreciated that the extent of the damage or loss of life during the period of energy release can be contained through effective emergency and response measures.

Within the disaster zone the second constituent of risk, i.e. the severity or consequence of the catastrophic event, has also become a tangible reality. Because disasters normally constitute 'unthinkable' outcomes, chances are that any prior attempts at assessing and addressing the risk involved fell woefully short. In this lies a management practice paradox: if the risk, or rather then the outcome, had been accurately foreseen or predicted, why then was it not properly addressed and prevented?

3.2.4.4 Ground Zero

The term *ground zero* represents the state of lowest energy and maximum entropy. All that is left is absolute chaos and the vivid realisation that something big had gone wrong. At this point in time any containment measures, which may have included search and rescue efforts, change to search and recover and order-restoring efforts. An instinctive human response is the initiation of attempts to quantify the extent of the disaster in terms of human loss of life, financial impact and damage to the environment. This exercise is an elaborate mission in its own right and may in fact never be accurately concluded due to the absolute chaos left in the wake of some disasters. Industrial crises also often create open-ended liabilities for some organisations, thereby making their costs impossible to estimate [38].

3.2.5 Discrete Event Disaster Propagation Model (DEDPM)

The propagation of a disaster can be portrayed as a series of discrete events, represented by a disaster sphere that falls through specific event layers (Figure 10).

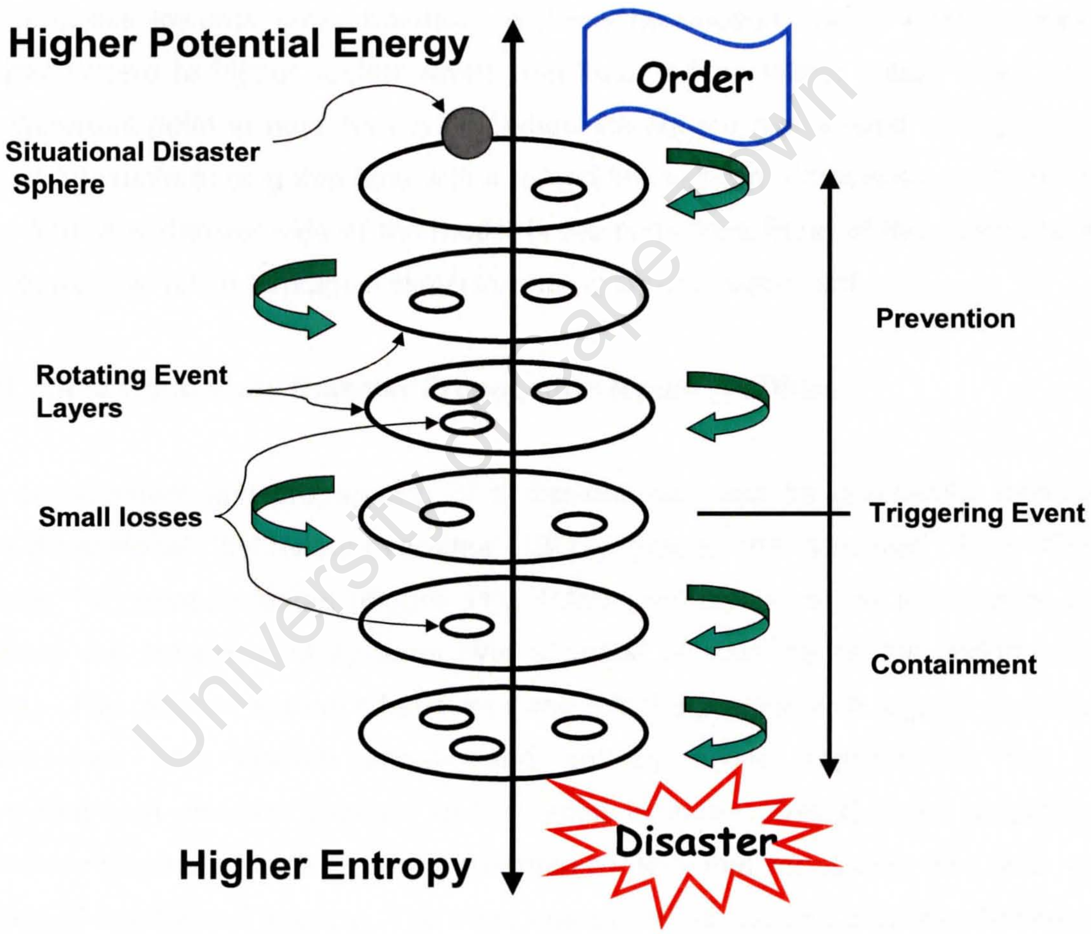

Figure 10: Discrete Event Disaster Propagation Model (DEDPM)

The sphere is allowed to fall through matching holes or small losses on different event layers. The event layers are visualised by rotating discs, which emulate the dynamic nature of systems behaviour within a specific realm. These event layers are riddled with *small loss holes* and represent sub-processes within the overall context-specific disaster scenario. The situational disaster sphere will fall through a matching hole as a result of potential energy stored and can only be restored to its original level, or elevated to a higher level, through the input of energy. Falling through the holes represents a relinquishing of energy and commensurate increase in entropy. A necessary and critical slip, the so-called triggering event, initiates the shedding of physical energy and tilts the sequence from build-up to an undesired event to the containment of disastrous consequences. The triggering event can naturally only occur within one of the last three sub-process layers of the systems engineering process[41].

The progress towards *order* therefore requires continuous energy input to elevate the disaster sphere to higher system levels and keep it from falling trough small loss holes. The important point to note here is that when the sphere has slipped through a layer it is not just adequate to plug that hole with a remedial small win. What is also required to move away from the *disaster* side of the model is the conscious lifting of the sphere to a higher level again – which in turn again requires energy input of some sort.

3.2.6 Time Continuum Disaster Propagation Model (TCDPM)

The development and propagation of a disaster can also be graphically depicted by a three-dimensional 'behaviour-over-time' (BOT) graph, the so-called Time Continuum Disaster Propagation Model (Figure 11). (Managers always strive to visualise and then influence the behaviour of systems over a period of time, hence the importance of this model). The relevant system's behaviour and relative position with regards to a disaster is plotted over time against energy and entropy levels, representing the E2 (i.e. energy/entropy) disaster potential at that point in time. This disaster propagation line represents a specific scenario, within a certain context, that varies over time as a reciprocal function of energy and entropy. The more energy that is invested in a specific situation, the more order (and less entropy) is created. Also, importantly, higher levels of order and hence potential energy mean higher levels of energy available for release. This holds true for both 'hard' and 'soft' systems.

Slipping of system constraints allows energy to be dissipated and leads to an increase in entropy - a natural process. The triggering event represents the threshold event where the

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41 See Section 3.2.3.2 (ii), page 59

accumulation of systemic constraint slips finally cascades into the release of physical energy. From here on the situation may or may not culminate in disaster – depending upon the containment or order-restoring mechanisms/systems active within this domain.

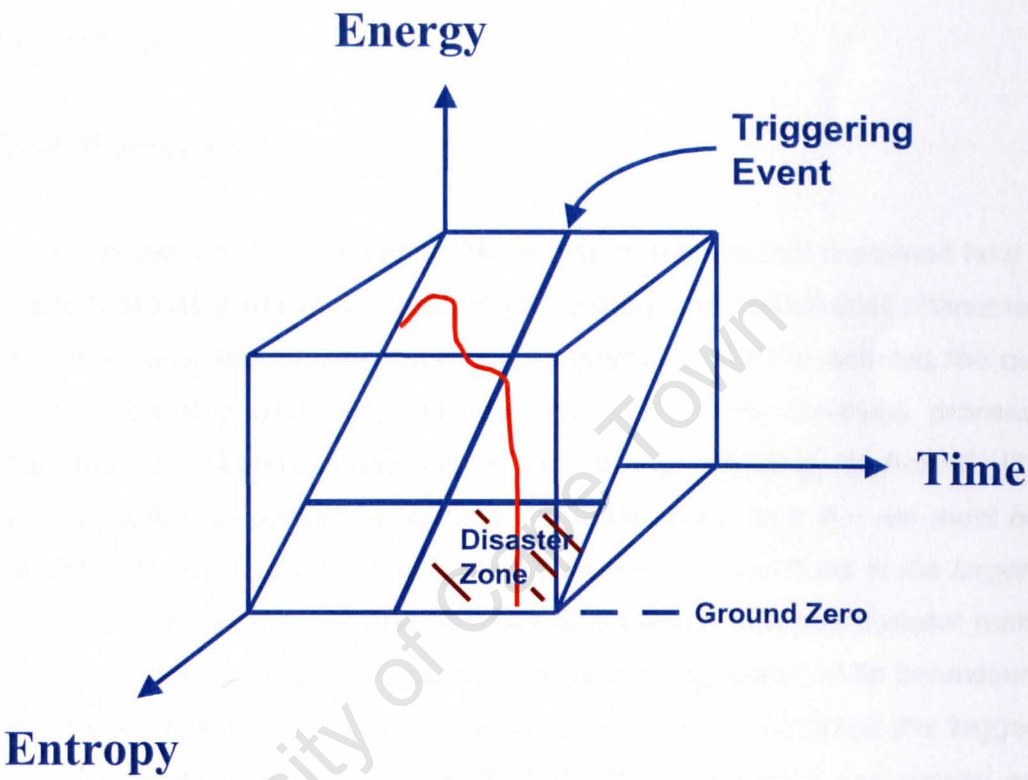

Figure 11: Time Continuum Disaster Propagation Model (TCDPM)

3.2.7 Reflection on Small Win Nº1

Research cycle Nº 1 yielded a conceptual insight into the way that disasters unfold from a physical energy/entropy exchange process perspective. It was discovered that entropy is the ever-present foe that lurks in the background, an energy sink that will always feed on all available energy in a self-expanding fashion. The prevention of disasters, in fact living life itself, is therefore a continuous endeavour of accumulating, applying and storing energy to create order and minimise disorder and chaos. Without this continual energy input, all systems – 'hard' or 'soft', man-made or natural – will (eventually) decay to a state of lowest potential energy and maximum entropy.

The models developed during this research cycle provide an analytical view on the disaster phenomenon. However, from a true systemic perspective, it still needs to be understood why the disaster situation came to be in the first place.

3.3 Research Cycle N°2

3.3.1 Goal of Small Win N°2

Whilst research cycle N°1 yielded plausible end-state models that explained how disasters actually propagate as a function of natural (i.e. orderly and predictable) phenomena, more specifically the interaction between energy and entropy, it did not address the question of *why* disasters develop and occur in the first place. The analysis process yielded knowledge about the disaster phenomenon but not understanding. In Ackoff's [32] words: '*To enable a system to perform effectively we must understand it – we must be able to explain its behaviour – and this requires being aware of its functions in the larger systems of which it is a part'.* In other words: in order to create an effective disaster management paradigm we need to understand disasters, i.e. also being aware of its behaviour and role within larger encompassing systems. In essence it means to embrace the 'bigger picture'. This was achieved through the process of *synthesis* – a disaster was viewed as being a sub-process within a larger environment with the aim of gaining total understanding of the phenomenon.

The synthesis process also involves three steps [32]:

- that what we want to understand is first identified as a part of one or more larger systems
- an effort is made to understand the function of the larger system(s) of which the whole is a part
- the understanding of the larger containing system is then disaggregated to identify the role or function of the system to be understood

Research cycle N°2 therefore built upon the knowledge gained in the first cycle, or small win N°1. Only with the knowledge gained about *how* disasters occur and propagate could attention be outwardly directed to attempt understanding and providing answers to the question(s) of *why* disasters occur. Taking the previous analogy further, this research cycle investigated the reasons for having the 'onion' in your hand in the first place. The generic context within which a disaster occurs was therefore explored.

Research cycle N°2 also had a secondary aim. It was soon realised that the concepts of risk and risk management warranted further exploration and investigation. These concepts were common to all disasters investigated and the attention devoted to it during research cycle N°1 was found to be inadequate. It was therefore deemed necessary to explore these concepts further during research cycle N°2. As it turned out, through properly developing the concepts of risk and risk management, additional, very relevant concepts and variables were distilled that proved to be invaluable in developing the final disaster management theory.

3.3.2 Understanding messes

It was realised very early on in this research project that man-made disasters are complex and systemic by nature. Compare this observation with Ackoff's [32] view on real life problems: *"We are almost never confronted with separable problems but with situations that consist of complex systems of strongly interacting problems. I call such systems of problems **messes**"*. Unravelling the messiness of a disaster, or rather deciphering the dynamics through which disasters develop and culminate, would require solid information about, as well as knowledge and understanding of, the relevant systems involved in the disaster scenario and context.

3.3.3 The nature of systems

As discussed previously the topic of disaster prevention is inherently a systemic issue. Since systems theory had extensively been developed by others it would be futile to attempt the development of new systems theories and/or classification categories. Of more value would be the application of known theories and the use of accepted systems concepts during the development of personal management theory. For this reason the general classification of system types and the key attributes of such system types will be utilised as is. Insights developed during the research project will be evaluated against this known systemic concepts and vocabulary.

Section 3.3.3 (where indicated*) contains a concise summary of the work of Ackoff [32] and Gharajedaghi & Ackoff [40] on systems and models. This summation of important points, and in some instances verbatim quotes, of the said work of others serve as necessary references and a spring board for further, deeper delving into the realm of disaster management.

Ackoff [32] identified 4 types or models through which systems can be conceptualised. The 4 types of systems are:

- *Deterministic* systems (Mechanisms)
- *Animated* systems (Organisms)
- *Social* systems
- *Ecological* systems

i) Deterministic (or mechanistic) systems*

Key attributes, assumptions and examples:

- The system as well as its sub-parts or sub-systems have no purpose, i.e. its behaviour is determined
- The system as well as its sub-parts or sub-systems have functions
- System is reactive and *state-maintaining*, strives to maintain a static equilibrium
- Reaction is not voluntary
- System can function as either an open system, i.e. affected by its environment; or a closed system, i.e. not affected by its environment
- Focus is on input rather than output
- Complete understanding can be achieved through analysis
- Cause-and-effect relationship is sufficient to explain all actions and interactions

Mechanisms include: motor vehicles, buildings, bridges, ships, space vehicles, clocks etc

ii) Animated (or organismic) systems*

Key attributes, assumptions and examples:

- The system (whole) has a purpose but sub-systems (parts) have no purpose
- The parts of the system have functions
- System can exercise choice, sub-parts not
- System is responsive and *goal-seeking*, seeks a dynamic equilibrium
- Response is voluntary
- System is dependent on its environment for inputs (resources) and hence affected by the environment
- Control of outputs rather than inputs
- System adjusts behaviour of its parts to maintain properties of the whole within acceptable limits
- System can accommodate feedback control, which facilitates learning and adaptation
- Although capable of self-control, the system can be influenced by other systems
- Makes the best of a future that is largely out of its control, but predictable

Organisms include: human beings, animals

iii) Social systems*

Key attributes, assumptions and examples:

- The system (whole) as well as the sub-systems (parts) have purpose
- System is active and (completely) *purposeful*
- System and its parts capable of exercising choice
- Performance of system is not the sum of the independent performances of its parts, it is the product of their interactions.
- Management of a social system requires management of the interaction of its parts, not their independent actions
- Non-analytical approach, i.e. synthesis, is required to complement analytical thinking in order to understand the system as a whole.
- Social systems not only learn and adapt, they can create

Examples: corporations, universities, societies, maintenance systems etc

iv) Ecological systems*

Key attributes, assumptions and examples:

- The system (whole) has no purpose but the sub-systems (parts) have purpose
- The system has functions, i.e. to support and serve the purposes of its sub-systems

Examples: Earth, nature

Table 3.1 [32] demonstrates the behaviour of the various systems mentioned above.

Systems and models	Parts	Whole
Deterministic (mechanisms)	Not purposeful	Not purposeful
Animated (organisms)	Not purposeful	Purposeful
Social	Purposeful	Purposeful
Ecological	Purposeful	Not purposeful

Table 3.1: Behaviour of various systems [32]

It is further important to note that Ackoff [32] constantly equates the attribute of purposeful with being able to display or make a choice.

v) Hierachy of systems*

The above-mentioned types of systems form a hierarchy. Animated systems (organisms) have deterministic (mechanisms) systems as their parts. In addition, some animate systems can create and use deterministic systems such as machines but deterministic systems cannot create animate systems. Social systems have animated and mechanistic systems as their parts but animate systems do not have social systems as their parts. Finally, the first three systems are contained in ecological systems, some of whose parts are purposeful but not the whole.

vi) Analysis and synthesis*

Analysis takes a system apart and then tries to explain behaviour of the parts taken separately. An attempt is then made to aggregate understanding of the parts into an understanding of the whole. Analysis, which reveals only the structure of a system, cannot provide understanding of a social system, only knowledge of how it works.

Synthesis sees the system as part of a larger system and then explains the containing system. Understanding of the containing whole is then disaggregated to explain the parts by revealing their role or function in that whole. In social systems thinking synthesis and analysis are considered complimentary; neither can replace the other. Both are necessary to understand a social system.

Figure 12 depicts a schematic representation of the hierarchy of systems and the varying modes of thinking required for making sense of the different systems (own art work).

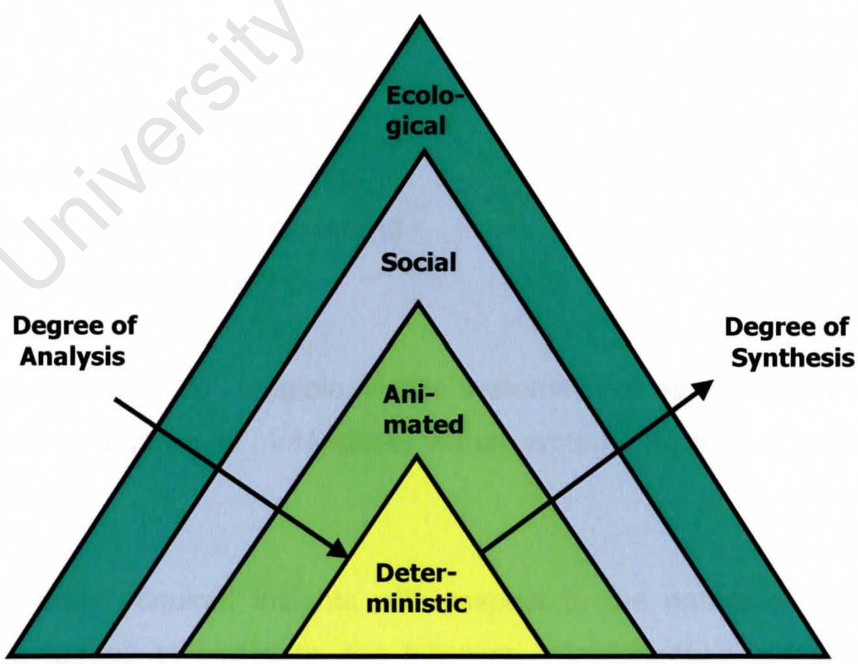

Figure 12: Hierarchy of Systems

3.3.4 Relevance of system models to disaster deciphering

Through the continuous investigation and analysis of the reference disasters an important aspect emerged – one that was previously implicitly assumed/dealt with but then found to warrant classification as a topic of investigation on its own merits. *Human behaviour* was identified as a contributing factor in all the disasters. A fourth dimension that deals with human behaviour is therefore required to complement the array of tenets deemed necessary for complete disaster situational awareness. The three rationality tenets previously proclaimed[42] can now be expanded to include a fourth dimension:

1 - Understanding the basic laws of nature and natural system response
2 - Understanding the functionalities, operational characteristics and failure modes of man-made systems
3 - Understanding the interaction of such man-made systems with other (man-made and natural) systems
4 - *Understanding human behaviour*

More reflection on these awareness requirements yields the following succinct representations:

1 - Understand the environment
2 - Understand the physical system(s)
3 - Understand the conceptual system(s)
4 - Understand human behaviour

(*Physical systems* mean 'hard', tangible, visible systems such as a bridge or motor vehicle. *Conceptual systems* mean 'soft', intangible, virtual systems such as a communication or education system).

Applying the recently acquired insights with respect to the nature of systems and re-arranging the sequence of concepts, the following transformation comes without much effort:

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[42] See Section 3.2.3.2, page 58

- Focusing on the physical system(s) (2) involved requires a *mechanistic* approach
- Focusing on relevant human behaviour (4) requires an *organismic* approach
- Focusing on the conceptual system(s) (3) involved requires a *social systemic* approach
- Focusing on the natural environment requires an *ecological* approach (1)

This result represents a critical resting point in the thinking process whilst developing the disaster prevention paradigm. **In essence it is proclaimed that in order to obtain the 'complete picture' - the total systemic view - of a potential disaster scenario, the situation needs to be viewed from four different perspectives; i.e. a mechanistic, an organismic, a social systemic and an ecological perspective.**

These four perspectives are not mutually exclusive but rather interactively supportive. Conscious and isolated focus on the unique attributes of each system type will compel the researcher to consider all the relevant systemic aspects of the whole mess in question. To quote Ackoff [32]: *"Therefore, problems should be viewed from as many different perspectives as possible before a way of treating them is selected. The best way often involves collaboration of multiple points of view"*. A mechanistic approach is required to fully dissect and analyse the physical system(s) in question. The organismic perspective will ensure that the responsive and goal-seeking behaviour of people within the overall realm are considered. Evaluating a situation from a social systemic view will yield the necessary appreciation and understanding of the active and purposeful behaviour of conceptual systems and interactions with other (conceptual) systems. An ecological perspective will ensure environmental influences and the orderly laws of nature are considered. Figure 13 illustrates this multiple perspective view of a potential disaster.

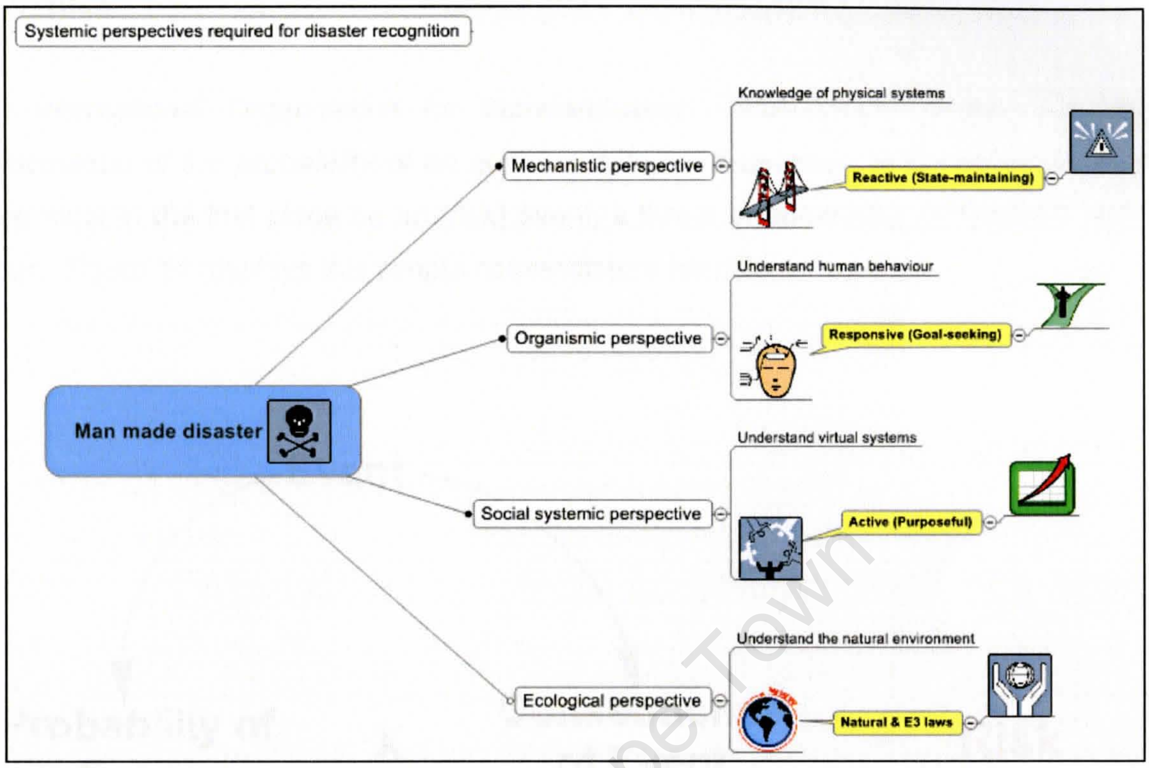

Figure 13: Multiple systemic perspective model for disaster recognition

The major contribution that the aforementioned mental gymnastics will bring to the disaster prevention realm is the following: **(All) negative events that can occur during the build-up and deflation towards disaster are identified. These possible events are in fact the events or threats that are portrayed by the event layers in the Discrete Event Disaster Propagation Model.** Reiterative sweeps of this multiple perspective evaluation of the potential 'mess' will/should improve the comprehensiveness of the evaluation and reveal more and more negative events that can possibly occur. Sound judgement by the researcher will dictate which of these events will eventually make it to the DEDPM as (critical) event layers.

3.3.5 Risk

The International Organisation for Standardisation (ISO) simply defines risk as the *'combination of the probability of an event and its consequence'* [41]. For a risk to exist, there must in the first place be an (risk) event, a threat or something undesirable that may occur. Figure 14 displays this simple nomenclature for risk.

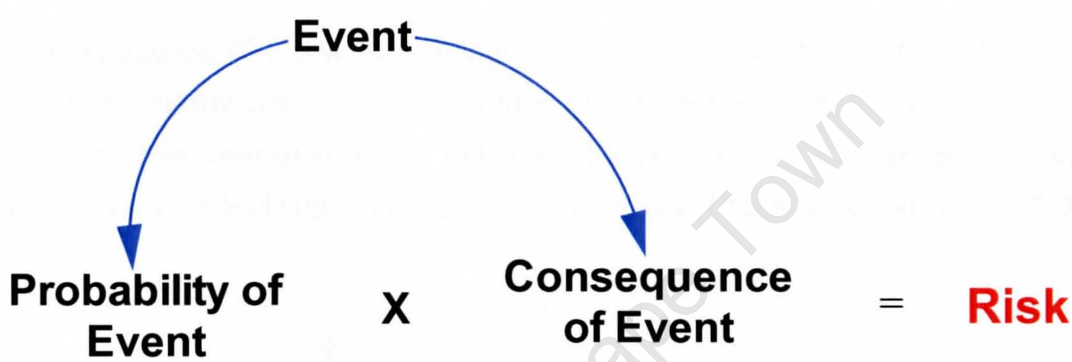

Figure 14: ISO definition of Risk

The identification of the possible detrimental events within the disaster scenario under investigation has been nailed down by the multi-perspective systemic evaluation described in the previous section. We are left with the DEDPM with ***solid*** event layers representing the applicable individual negative events. The probability of a particular event occurring can now be represented by the size of *a hole* (see paragraph below) in the event layer. No hole, or a solid event layer, signifies an impossibility or zero probability of the event actually occurring. A probability between 0 – 100% is represented by a commensurately sized hole. A 100% probability, or certainty, can be represented by a hole with a size exactly equal to that of the 'situational disaster sphere'. At this instance of certainty the sphere drops through the hole and the unwanted event or small loss occurs – the risk materialises. When the sphere drops, energy is released, entropy is gained and the overall situation is one step closer to disaster.

A refinement of the DEDPM is required at this point in time. Probability can only be represented by one hole. Multiple holes of varying sizes on one event layer will negate the model, as it is not possible to have different occurrence probabilities for one event. Furthermore this one hole needs to be located directly in the (fixed) path of the sphere on the rotating event layer. Not having the hole on this fixed path will introduce another probability to the event, i.e. will the ball find the hole? This situation will lower the overall probability of the event occurring as the net probability will be equal to the product of the *hole size* probability and the *ball-hole* positional matching probability.

The consequence of the sphere falling through a 100% probability hole is a loss/shedding of potential energy and a commensurate gain in entropy. It can be represented in the DEDPM by the vertical distance between the specific event layer and the one directly below. Figure 15 indicates how the concept of risk is fully embedded in the DEDPM.

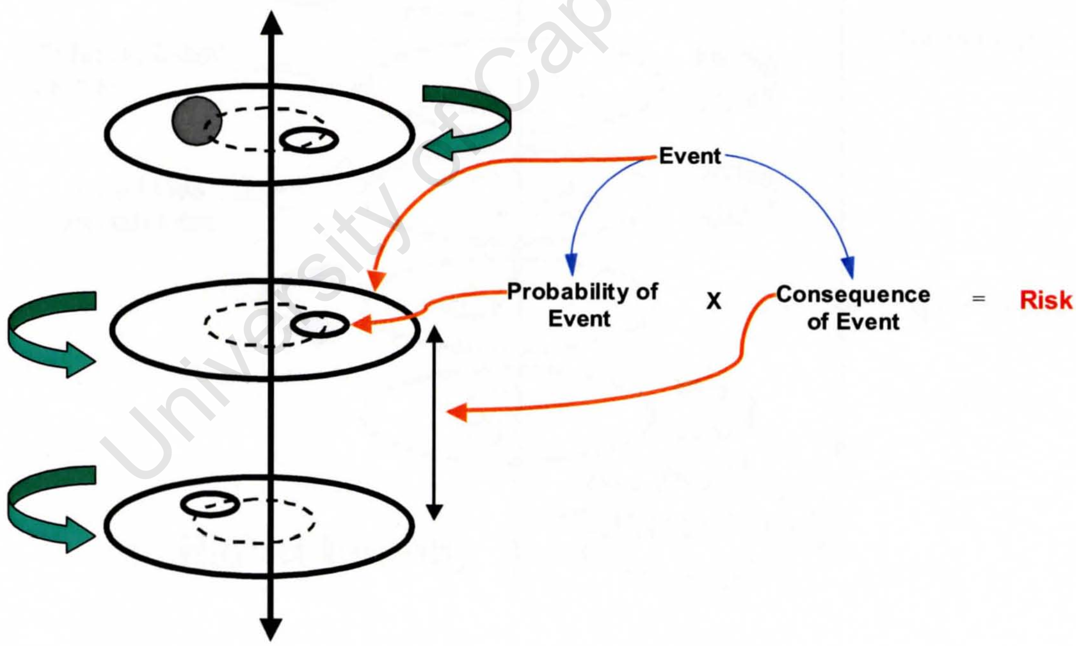

Figure 15: Risk embedded in DEDPM

The final Discrete Event Disaster Propagation Model is shown in Figure 16. This is clearly a risk-based model that, unlike *normal analytical* risk assessment techniques[43], synthesises and portrays the consequences of negative events as the enablers of other subsequent negative events. A disaster scenario is therefore portrayed and thought about as a complex mess with interdependencies between numerous small losses, overall culminating in a disaster.

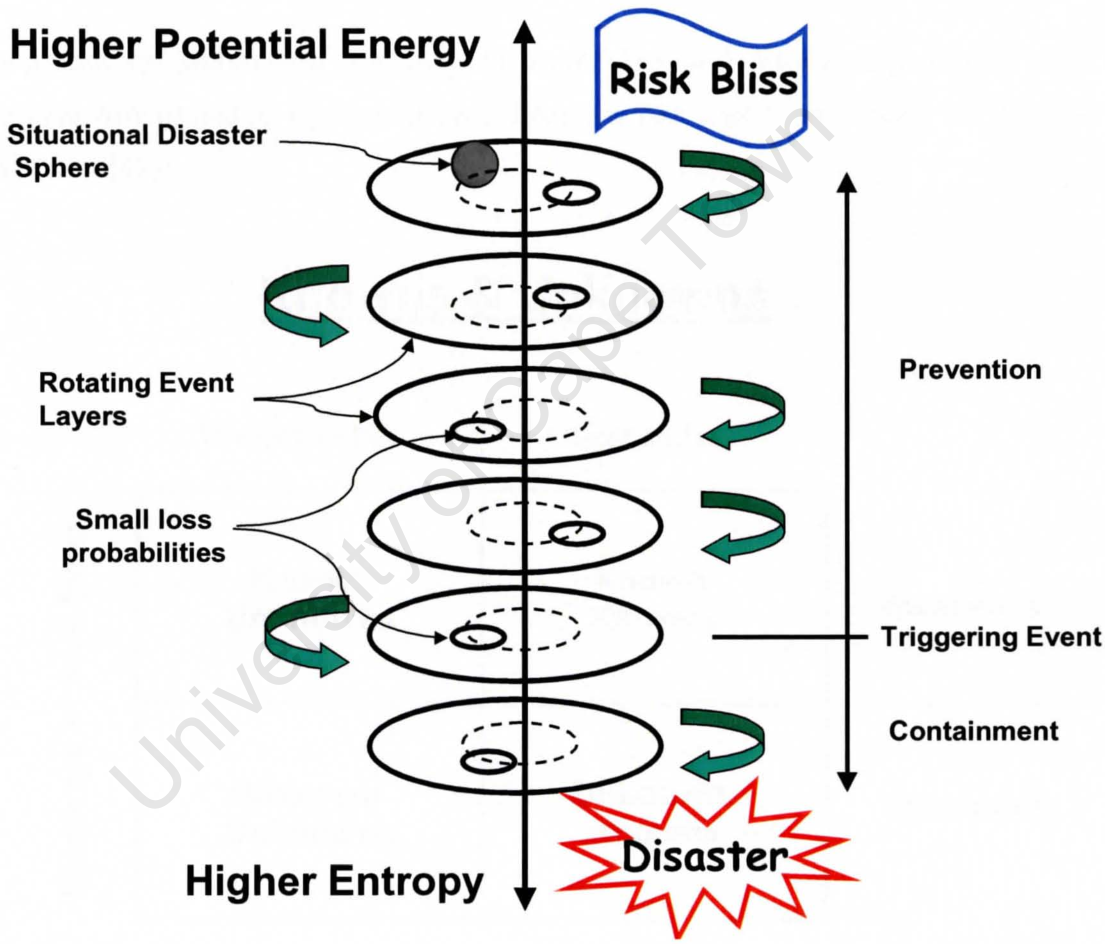

Figure 16: Updated Discrete Event Disaster Propagation Model

[43] Traditional risk assessment techniques usually quantify the consequences of undesirable events in terms of financial repercussions and/or human accident metrics.

3.3.6 Risk Identification

With the tacit explanation of risk provided by Figure 14 in mind it is clear that in order to effectively manage a particular risk one requires

- Knowledge of the event itself
- Knowledge of the probability of the event occurring
- Knowledge and understanding of the consequences of the event occurrence

A useful tool for enhancing the way of identifying and interpreting events and their probabilities are provided by the Known/Unknown risk matrix of Figure 17 (Copied and adapted from [42]):

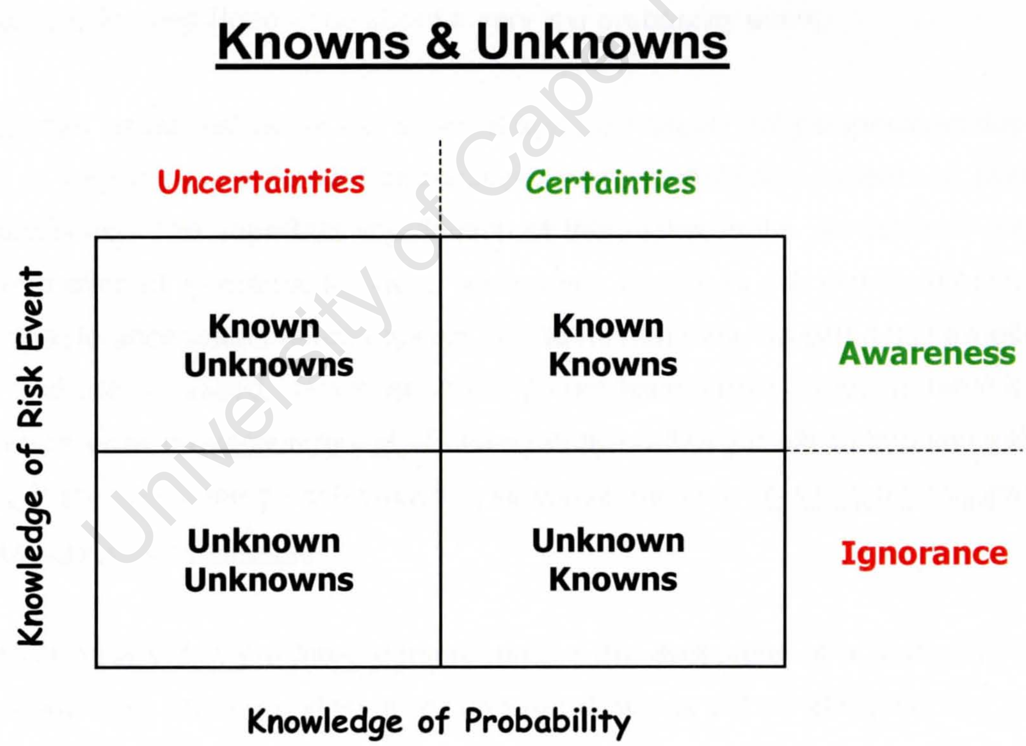

Figure 17: Known/Unknown risk event matrix [42]

The meaning of the different combinations of knowns and unknowns are best explained by means of a practical example:

- *Known knowns*

  There will be rain on a slimes dam in summer. (Awareness of a certainty. Known fact)

- *Unknown knowns*

  Management not aware of weather forecast for heavy rain on a particular date. (Ignorance about an imminent event)

- *Known unknowns*

  There may be heavy rain on a particular date (Awareness about possible problem event).

- *Unknown unknowns*

  Aircraft accidentally plunges into slimes dam wall and causes breach of wall and subsequent flooding (Ignorance about a very low probability event)

This matrix can be utilised within the different systemic situational perspectives depicted in Figure 13 to inspire deeper thought and analysis when identifying possible risk events and their probabilities. The important contribution of this matrix is the provision of a guide to move from a state of ignorance to one of awareness insofar as risk events are concerned. Once a possible undesirable event appears on the mental radar screen it can be effectively analysed and risk assessed. However, if you do not know about a certain event it will not be included in a risk prevention model. Subsequently no thought will go into controlling it or preventing it from happening - or influencing its consequences. In short, an unknown event will not and cannot be managed.

It is fair to conclude that the more comprehensive the evaluation of a particular potential disaster scenario is, the more likely most undesired events will be identified and the more effective the subsequent risk assessment process would be. This would in turn enhance the completeness of the DEDPM for the particular disaster scenario. It also follows logically that the more complete the DEDPM is the higher the level of knowledge of the disaster situation would be.

3.3.7 Risk Perception

People do not all have the same perception of risk, or put differently, different people have different *risk attitudes*. Adams and other academics [43] have concluded that humans perceive risk in four basic ways, as depicted in Figure 18 [43]. (Here the lines represent 'the world' and the balls a 'stable status quo').

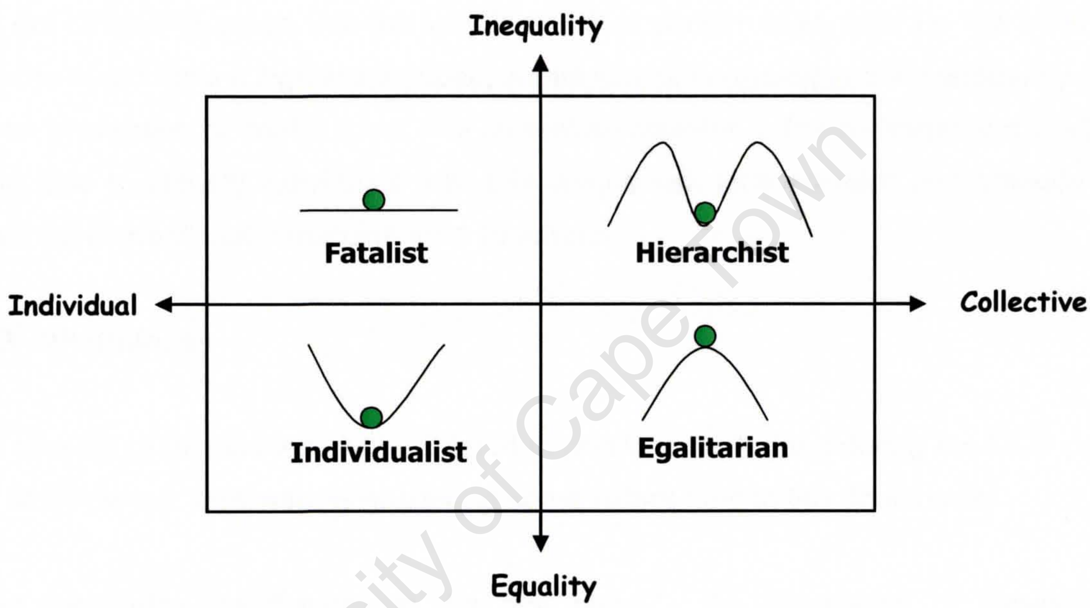

Figure 18: Four ways to comprehend risk [43]

The four ways of comprehending risk are described below (taken verbatim from [43] to not lose content and effect):

Individualists act relatively freely on their own behalf, and to them the world is benign. However violently shaken, the ball always comes safely to rest at the bottom of the basin. *Nature is to be exploited.*

Fatalists see life mostly out of their control. The world is arbitrary, so shaking the system could see the ball land anywhere. *Nature is to be endured and, if it's your lucky day, enjoyed.*

Egalitarians aim to create social equality, presumably on behalf of everyone. The world is a fragile, precarious place. Even minor insults to the system will send the ball spinning downwards towards catastrophe. *Nature is to be obeyed.*

Hierarchists wish for a life where everyone knows his place. The world is seen as robust and forgiving, but not inexhaustible. Shake the system too hard, and the ball could fly over an edge. *Nature is to be managed.*

It is not difficult to grasp that the way in which a person views risk, i.e. his inherent risk attitude, would have a significant impact on his way of analysing and subsequently planning for the prevention or containment of a (potential) disaster. The management challenge is to be able to identify individuals with this unique risk temperament and embody such a person(s) in the disaster management structures.

3.3.8 Mindfulness

The concept of *mindfulness* was explored in previous work done during the MDP portion of this study period. This work is re-used to some extent here in this final thesis.

What constitutes mindfulness in the first place? An abundance of viewpoints and definitions exist in the literature and a powerful and succinct definition is offered by Langer [44], who describes mindfulness as '*the process of novel distinction'.* Gunaratana [45] describes three fundamental activities of mindfulness:

- It reminds us of what we are supposed to be doing
- It sees things as they really are
- It sees the deep nature of all phenomena (even of itself)

Mindfulness however only becomes a useful management tool if it can be applied to bring about intended change. In position paper MDPPP1.2 [46] I postulated a 'mindfulness triangle' (Figure 19) that is analogous to the FIRE triangle well known in fire fighting science [47]:

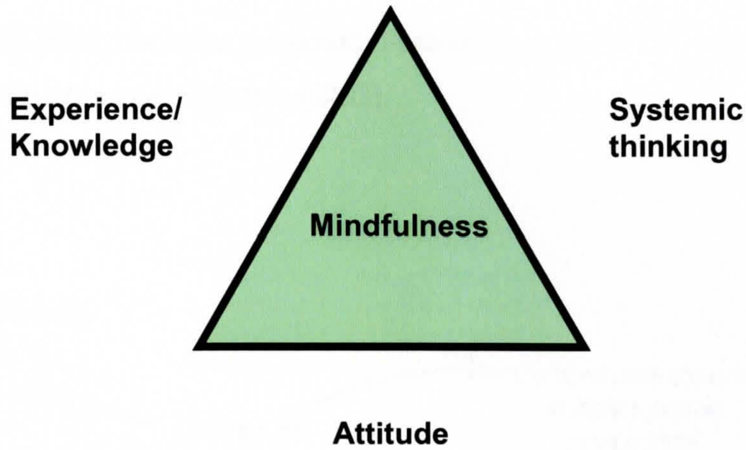

Figure 19: Mindfulness Triangle

A person needs to know his subject well to be able to identify significant issues (technical, social or otherwise). *"How does it work?"* seems to be the appropriate question to be answered. Secondly one must have a certain degree of systemic reasoning ability. *"What causes system malfunction and what will the resultant consequences be?"* mimics this relationship-sensing ability. Finally without the right attitude all the insights and knowledge won't come to much if it isn't stimulated into appropriate action. *"So what needs to be done?"* is the relatively unscientific question that the hierarchist[44] will want to explore and answer. <u>Mindfulness can therefore only exist if all three elements are present in the appropriate amounts</u>. Remove any one element and mindfulness ceases to exist.

Mindfulness, or rather then the lack there-of due to one or more missing constituents, was found to be a common denominator in all the researched case studies. In the final analysis mindfulness provided the closing link that underpinned the new management theory to a high degree.

[44] See Section 3.3.7, page 84

3.3.9 The new management theory

Figure 20 depicts the completed potential disaster recognition and prevention paradigm in the format of a Causal Loop Diagram (CLD).

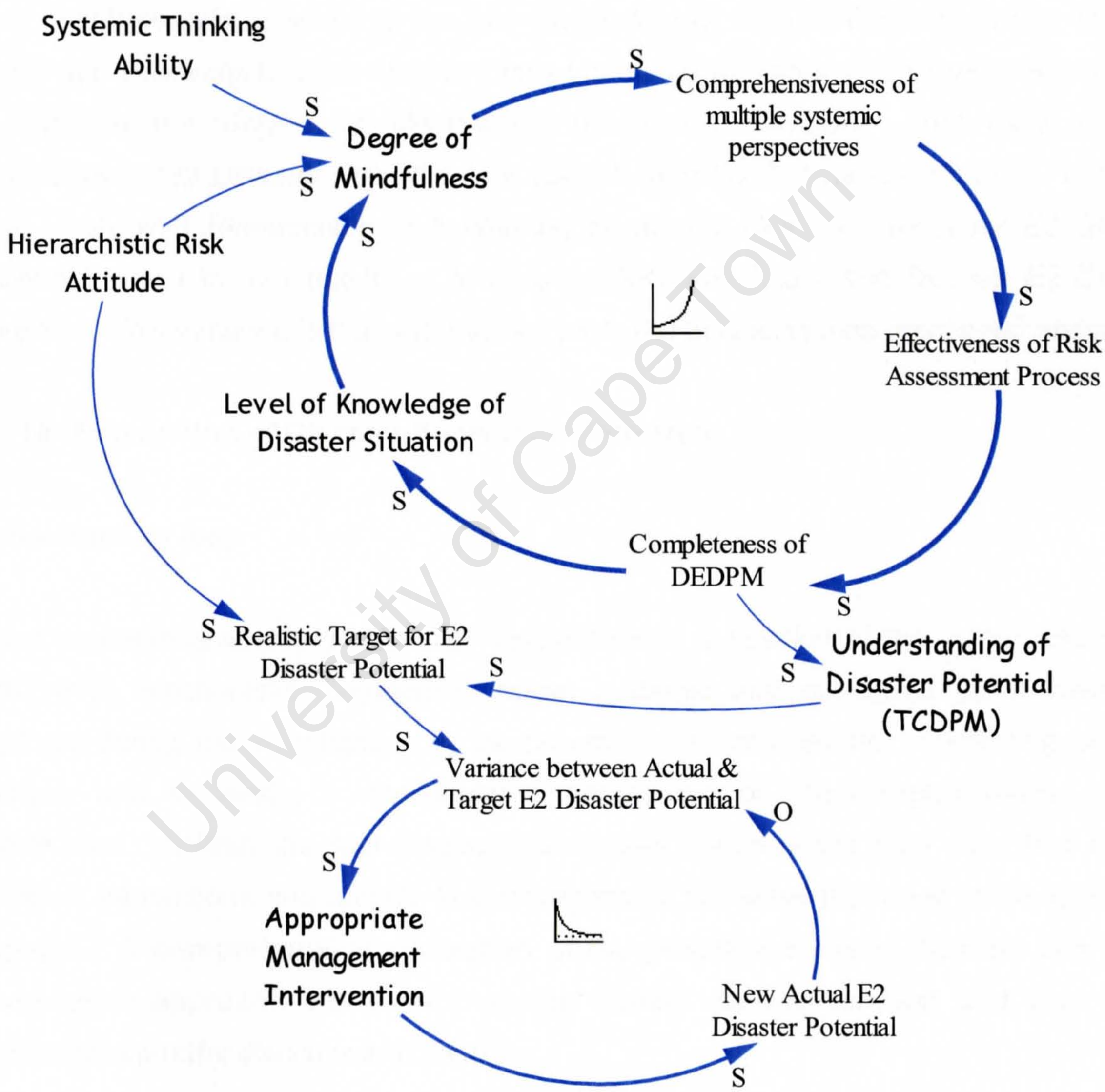

Figure 20: CLD of Disaster Prevention Paradigm

Two causal loops are clearly discernable:

- A reinforcing loop that (can) continuously increase the level of knowledge about a particular disaster or messy scenario.
- A balancing loop that signifies the remedial effect that appropriate management action has on the propensity for disaster within the specific context.

Four variables exist external to the two causal loops. The first two, *Systemic Thinking Ability* and *Hierarchistic Risk Attitude* jointly contribute (together with *Level of Knowledge*) to enhance the *Degree of Mindfulness* (about the disaster). The third variable, *Understanding of Disaster Potential*, is a spin-off from the first reinforcing loop. It directly (and jointly with *Hierarchistic Risk Attitude*) dictates a *Realistic Target for E2 Disaster Potential*, which in turn results in a *Variance between Actual and Desired E2 Disaster Potential*. This variance is the systemic entry into the balancing loop mentioned above.

3.3.10 Explanation of Disaster Prevention Paradigm

i) Reinforcing loop

The *Comprehensiveness of Multiple Perspectives* is a function of the vigour and insight with which mechanistic, organismic, social systemic and ecological perspectives are explored during the investigation of the potential disaster scenario. Oscillating between analysis and synthesis, a representative perspective on the complex reality can be constructed. (Within the four perspectives further causal loops may exist that explain systemic interactions and identify key management variables that need to be taken into account). **A comprehensive evaluation of the potential disaster through this quad-perspective approach will inform on the threats (or risk events) that may occur within the specific disaster scenario.**

Risk assessment by definition requires knowledge of the possible detrimental events that can occur, before attempting to gauge the probability of such events actually occurring and finally combining these two aspects to determine the resultant risk. An *Effective Risk Assessment Process* will enhance the *Completeness* of the *Discrete Event Disaster Propagation Model (DEDPM).* In this model the possible threatening events are represented by the event layers and the risks associated with the actual occurrences are portrayed by the sizes of the 'small loss' holes in the event layers.

The more complete the DEDPM with respect to the possible mess under scrutiny, the higher the *Level of Knowledge of the Disaster Situation*. Knowledge about a specific situation is one of the three requirements of overall mindfulness about a situation. In conjunction with Systemic Thinking Ability and also a Hierarchistic Risk Attitude (or approach towards risk), the *Degree of Mindfulness* with regards to the possible disaster is elevated. This heightened mindfulness serves as a stimulant for sweeping in ever more detailed perspectives within the mechanistic, organismic, social systemic and ecological spheres, thereby completing the first reinforcing loop.

This reinforcing loop will be a *virtuous cycle* when positive things happen and the overall evaluation process, and hence awareness of possible disaster, is continuously enhanced. It is not difficult to comprehend that this would require a continuous input of (management) energy. Alternatively, when no energy is imparted to the loop and natural decay takes its course, or sloppiness leads to an ineffective evaluation process, this loop quickly becomes a nasty *vicious cycle*, eroding overall awareness of a possible imminent disaster.

ii) Linking the Loops

A crucial link exists between the knowledge enhancing/reinforcing loop described above and the disaster potential limiting/balancing loop described below. Understanding **WHY** - at a specific point in time and within a certain context - disaster can be imminent, of no significant threat or somewhere in between, is the catalyst for appropriate management action. The *Completeness of the Discrete Event Disaster Propagation Model (DEDPM)*, which is continuously refined with every sweep of the reinforcing loop, facilitates *Understanding of the Disaster Potential* profile at the relevant point in time, as displayed on the Time Continuum Disaster Propagation Model (TCDPM). This vivid, graphical representation of a developing mess on a behaviour-over-time (BOT) graph will enable a *Realistic Target for E2 Disaster Potential* to be set. As alluded to earlier, a *Hierarchistic Risk Attitude* pre-supposes a strive towards some safer, lower entropy state or acceptable E2 Potential Level. *Understanding the Disaster Potential* through the TCDPM enables calibration of this desire in terms of a realistic, measurable and achievable target. It sets the goal posts for improvement - away from a potential mess.

iii) Balancing Loop

Acceptance of the *Realistic Target for E2 Disaster Potential* will (normally) result in a V*ariance between the Actual and Target E2 Disaster Potential.* This variance signifies the degree of misalignment between the actual and desired states of disaster prevention preparedness and will create a tension that can only be minimised by closing the gap. This tension will initiate *Appropriate Management Intervention* that in turn will result in a new *Actual E2 Disaster Potential* point on the TCDPM. This new actual potential point will be closer to the desired state thereby closing the gap and reducing the V*ariance between the Actual and Target E2 Disaster Potential.* This dynamic closes the balancing loop. Every iteration of the cycle will bring the actual state closer to the desired target state.

iv) 'Assess and Action' Nature of the Disaster Prevention Model

This final disaster prevention mental model firstly assesses the disaster potential for a particular scenario and then enables this information to be transformed into actionable knowledge. A sensing and doing loop therefore exists within the same model. Rightly so, as only knowing about a potential disaster will contribute nothing towards its prevention. The paradigm loosely proclaims that more and more information about, and understanding of, a possible disaster scenario should enable effective management intervention and ultimately disaster prevention.

3.3.11 Reflection on Small Win N° 2

The disaster management paradigm developed during this research cycle emerged from the data and categories distilled from the numerous case studies and relevant literature references. It can therefore be viewed as a *grounded theory* seeing that it is firmly grounded in the data analysed.

The concept of *mindfulness* manifested as the core variable in this new theory. Without mindfulness, which in turn is comprised of three necessary components, very little else will happen in terms of identifying possible disaster scenarios, conducting proper risk assessments and actioning unhealthy or undesirable conditions.

There is however an aspect of mindfulness that warrants further reflection. Although any (reasonable) person can gain extensive experience and knowledge on specific subject matter, not everybody possesses a systemic, relationship-sensing capability. This personal characteristic trait can be viewed as a function of a person's personality, which largely dictates the way that an individual (normally) operates or prefers to function. One of many personality assessment tools is known as the Meyers Briggs (Personality) Type Indicator, the so-called MBTI. This well-known psychological assessment tool classifies a person's temperament or personality into four different functionalities, each in turn having two possibilities, resulting in a total of 16 different basic personality types. The second of these functionalities deals with the perceiving function and indicates how a person prefers to receive data from the environment around him [48], either through sensing or intuition. Sensing (S) persons usually focus on direct stimuli from data received to draw inferences and make decisions. Intuitive (N) people have the natural talent for detecting or seeking inter-relationships or patterns in data analysed. Attributes assigned to 'intuitives' include amongst others [49]:

- To bring up new possibilities
- To supply ingenuity on problems
- To read the signs of coming change
- To see how to prepare for the future
- To watch for new essentials

It is claimed that certain of the N-type personalities *'have insight into the big picture'* [49]. It can therefore be argued that N-type personalities will probably be more alert to inter-dependencies and inter-relationships between data and occurrences within a disaster context. In turn it may be argued that one's risk attitude is (may be?) influenced by your data processing preference. After all, if one does not see the dangers lurking in inter-relationships and close coupling of events, how can you be concerned about them? For disaster management purposes an argument may therefore be made that a person with the appropriate personality type, in conjunction with experience and knowledge, should be appointed in the 'disaster scenario analyst' role.

Another implicit reality is also derived from the disaster management paradigm. Many disasters have happened because dangers that had been foreseen by knowledgeable persons were not taken cognisance of in the management decision-making process – with fatal results. For instance, the Challenger[45] space shuttle disaster occurred despite engineers' warnings and predictions of equipment malfunction – these warnings were however disregarded by managers in the final launch decision. Therefore, to ensure that preventive action is indeed taken when a potential for possible disaster is recognised, the hierarchistic 'disaster manager' needs to be appointed in a position with executive responsibilities, i.e. he/she should have the full power to intervene in any management process where a potential disaster is recognised. The line of decision-making should go through this position and not past it.

3.4 Research Cycle N° 3

3.4.1 Goal of Small Win N° 3

At the conclusion of Research Cycle N°2 the end-state mental model for disaster prevention was only a theory, a hypothesis. Although thoughtful and systemic effort was expended in its creation the validity and practical usefulness for its intended purposes remained unproven and needed to be determined. Without robust verification of the principles and logic embedded in the model it would but remain another theoretical, mental flight of fancy.

Relevant questions at this stage of the research project were:

- If satisfied with the end-state models and theory, what methodology can be applied to 'stress-test' or validate the paradigm?
- Does the currently available theory/paradigm present a plausible explanation for identifying and dealing with possible disasters, i.e. is it a useful tool for disaster prevention?

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45 Appendix A - Disaster N°12

The challenge at this stage of the research project was therefore to devise a measurement or evaluation tool that could prove, disprove or partially validate this new theory developed through the grounded theory methodology. Some objectivity had to be injected into the evaluation of the theory at least, seeing that the theory was inherently a subjective tool. Only through appropriate 'stress-testing' of the model could its validity and a potential usefulness as a management tool be evaluated.

3.4.2 Unique challenges with theory verification

A peculiarity with respect to the validation of this theory and models was the fact that it is largely based on risk management, which by definition deals with the prevention of identified risks from materialising. The prevention of its occurrence and by implication the prevention of a possible disaster can therefore never be fully attributed to the application of this model or any other technique simply because risk and its assessment will always be subjective by nature and remain an abstract concept. (The intangible portion of it was introduced by the notion of 'probability', as delineated in Section 3.3.5).

This abstract nature of risk and hence the disaster prevention model is in stark contrast to a physical intervention model where the correctness of the hypothesis and the resultant performance of the model can easily be verified against improved performance of the targeted physical system, e.g. better fuel consumption as a result of improved engine management. The closest that the disaster prevention paradigm can come to being **concretely** measured for appropriateness and subsequently performance, is through a reduction in the E2 disaster potential, which yet again is a subjective indicator at best.

Criticism against this sort of predictive or forward-looking model would typically maintain that the non-occurrence of an event is often difficult to attribute to preceding preventive measures, especially within complex, closely-coupled systems – simply because there is no physical evidence to analyse, just the non-occurrence of risk events and the blissful non-manifestation of an anticipated calamity[46]. The irony is that the non-suitability and consequently the non-performance of this model would be easier to prove when there is physical evidence of things gone wrong and the resultant consequences - which by deduction profess the failure of the disaster prevention model in the first place!

[46] Also see '*The paradox of prevention*', Sect 1.3.3, page 28

3.4.3 Validation of proposed disaster prevention paradigm

After serious reflection it seemed that the only reasonable way of evaluating the disaster prevention paradigm was by applying the new theory to past disasters where facts and actual occurrences are known and then evaluating the 'degree of fit' of the theory to history. Sequential occurrences of 'small losses' can be traced, critical events and event layers can be re-constructed and, with the benefit of hindsight, the exact causes and deficiencies in management and other systems are known or can be determined. It can be reasoned that if the newly constructed models and theories can be super-imposed on a number of known disaster situations with a reasonable degree of fit, that it is in fact a valid representation of events and circumstances that culminated in the eventual disaster.

Perhaps the acid test then is the following: If the events had transpired as represented by the various components of the disaster prevention theory, could the disaster have been prevented in the first place by appropriate management intervention as proposed by the paradigm? In other words, if any of the detrimental physical events had been prevented, would the disaster have been averted? By implication and as reflected in the disaster prevention theory CLD, certain management interventions and actions would have been required in order to identify, pre-empt and prevent specific 'small losses' from occurring in the first place. The pivotal realisation remains that the prevention of only one of many small losses would/should have been sufficient to prevent the eventual disaster from occurring altogether. If the thought experiment therefore revealed that by 'mind-walking' a known past disaster situation through the model it is found that most, or all of the theory constituents are applicable to the disaster situation and that certain actions as prescribed by the CLD and models would have prevented the disaster, it would be reasonable to infer that the disaster prevention model sufficiently explains the specific disaster. From this foundation it could then be argued that the paradigm is in fact a useful tool that can be applied to identify and prevent future possible disasters from occurring.

3.4.4 Stress testing of paradigm against known past disasters

The disaster prevention model was benchmarked against all the disasters referenced during the research process. Appendix A contains the list of referenced disasters and comprises the following disasters:

1. Vaal Reefs 2# 1995
2. Coalbrook
3. Kinross
4. Merriespruit
5. Westdene
6. Stava
7. Vaal Reefs 2# 1980
8. Saulspoort
9. Bhopal
10. Hawk's Nest
11. Mann Gulch
12. Challenger
13. Herald of Free Enterprise
14. Titanic
15. Chernobyl
16. Westray[47]

Seven of these disasters (Nº's 1, 2, 3, 4, 6, 7 & 16) occurred within the mining industry and therefore 'close to home' from my working perspective. The other nine occurred within various other technical spheres of modern life, i.e. public transportation (2), the chemical industry, tunnel construction, fire fighting, space exploration, sea-faring (2) and nuclear power generation. This widely diverse sample of past disasters provided a good basis against which to confirm or disprove the generic nature of the disaster prevention models and theory.

The most practical way to evaluate the various constituents of the disaster prevention CLD against the sixteen reference disasters was by means of a comparative matrix. The model components were listed on one axis of the matrix and the disasters on the other, with the intersecting points on the matrix indicating the results of the theory component vs disaster comparison/evaluation.

Two aspects of the model components were evaluated:

[47] Appendix A: Disaster Nº 16

i) Relevance - Is the specific component of the model in fact relevant to the disaster in question, and if so to what degree? The degree of relevance was gauged as High, Partially or Nil.

ii) Enactment – Was the model component in fact applied by any of the role players during the course of the disaster, and if so to what extent? The degree of enactment was evaluated as either Fully, Partially or No.

Furthermore the answers were recorded in a coloured block format in the matrix for ease of reading. Table 3.2 indicates the legend followed:

Relevance	Enactment	Colour
High	Fully	
Partial	Partial	
Nil	No	

Table 3.2: Legend used in theory evaluation

The completed evaluation matrix is displayed in Table 3.3 and is self-explanatory to a large degree. It is important to note that as indicated in the disaster prevention CLD;

- *Systemic Thinking Ability*, *Hierarchistic Risk Attitude* & *Level of Knowledge of Disaster Situation* jointly determine the *Degree of Mindfulness*
- *Hierarchistic Risk Attitude* & *Understand Disaster Potential* combine to determine *Realistic Target for Disaster Potential*

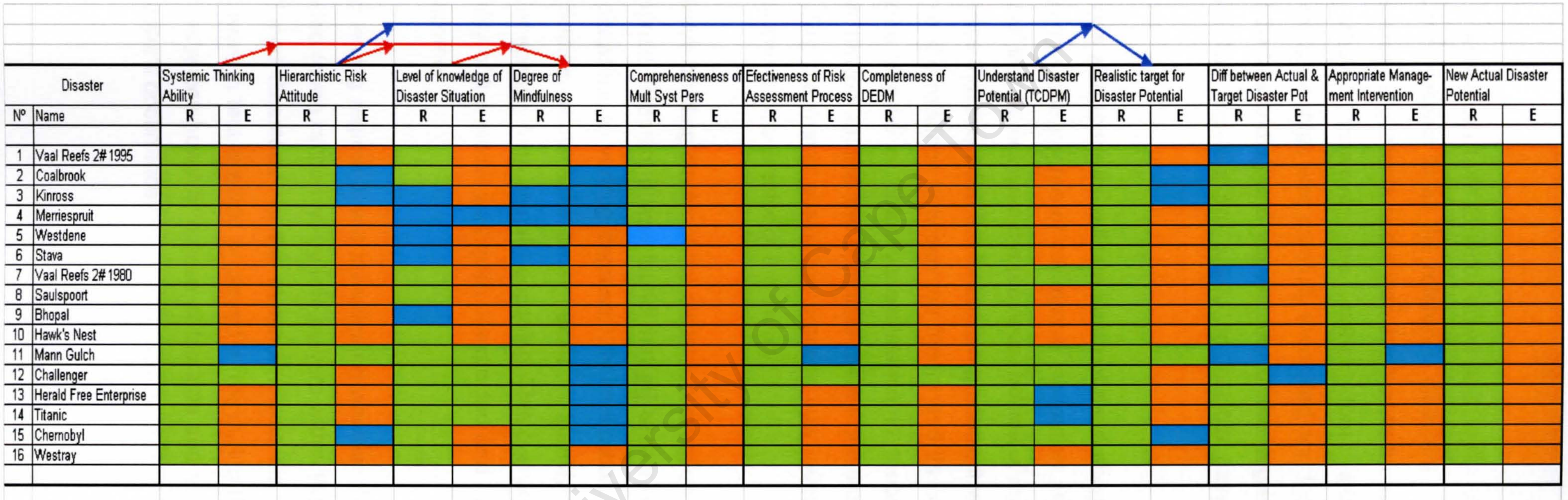

Table 3.3: Theory evaluation against past disasters

It would be a mammoth task to write down and argue the assessment of all the model components with respect to all the reference disasters. The process would require 384 (12*2*16) separate arguments and it was deemed to be outside the scope of this research thesis. It should however be noted that each of the 384 individual combinations/relationships was carefully evaluated and the colour coded outcome reflects my personal understanding and assessment of the degree of applicability of the specific combination. The answers are based on insights gained during the overall research process.

An attempt was also made to validate some of the findings by obtaining second opinions, thereby instilling some degree of alternative evaluation and/or verification. However, for the 'uninvolved' that do not have the (obvious) benefit of insight into the analysis and theory creation process that preceded the evaluation process, it was problematic to give educated opinions as to the relations between the theory and its concepts and then actual historic events. Some degree of objective assistance in theory evaluation will only become possible after having studied the complete theory creation process recorded earlier on in this thesis. So, the matrix evaluation process was indeed largely a subjective exercise conducted by myself, the creator of the theory.

When the twelve building blocks of the disaster prevention CLD were evaluated against the sixteen reference disasters it was found that **all** twelve components were relevant within the sixteen disasters, to varying degrees. By implication, knowledge of or work in any of these components would have been helpful in identifying and perhaps preventing the disaster under scrutiny form actually occurring. This overwhelmingly positive confirmation of the applicability of the model was quite unexpected and re-assessed a number of times to verify the outcome.

As a second testing regime it was investigated whether the twelve CLD components were applied/enacted (even randomly) by role players within the various tragedies that unfolded in the mentioned disasters. In this instance it was discovered that some of the model constituents were in fact enacted or played a role during the unfolding of certain disasters. It was in all instances however a case of too little and too dislocated effort to prevent the eventual disaster's occurrence.

3.4.5 Reflection on Small Win N°3

The matrix evaluation process would have highlighted any components of the disaster prevention paradigm that was non-congruent with actual events during physical occurrences of disasters. None were identified and the newly developed model was found to be very relative and appropriate when compared to actual past man-made disasters. When systematically applied to specific disasters it was clear that had the model in fact been meticulously followed, the specific disaster could probably have been prevented. It was further found that very few of the actions proposed by the model were in fact employed by role players during the various disasters.

It is therefore not too imaginative to project that the newly developed model does have a practical usefulness and with the appropriate application can in fact be utilised as a framework for identifying and (hopefully) preventing future disaster scenarios. A very important realisation is the fact that the model is generic enough by nature to accommodate situations in different industries, organisations and environments. This confirms the original suspicion that there are common factors in action during the propagation of man-made disasters, irrespective of the sphere of life involved.

The method of evaluating the new, grounded disaster management theory against past disasters may attract some criticism for not being comprehensive or scientific enough. Judicious application of the models and theory against past disasters has however revealed striking resemblances and relationships with historic events. This 'data comparison packs' so generated during the evaluation process in fact bring the research full cycle: the data substantiate the new theory thereby confirming that the theory is conversely *grounded* in the data.

The very detailed modelling of a past disaster by applying the new models and theory would call for considerable effort that falls outside the scope of this thesis.

3.5 Reflection on new management theory

Chapter 3 developed an organisational and industry insensitive management theory or paradigm by utilising the research processes and grounded theory methodology introduced in Chapter 2. The theory itself contains some new management models and is represented by a Causal Loop Diagram (Section 3.9) and exhaustively explained in Section 3.10. As part of the theory (and therefore Answer) development, the new paradigm was evaluated in the only way deemed appropriate – by applying it to past man-made disasters to verify its correctness and fit. This new management theory therefore presents a very detailed Answer to the Question 'How can man-made disasters be managed?' It does however not claim to be the one and only answer and as with any other management practice theory, different researchers may come up with different answers and then theories. A fair amount of work has however been done to at least attempt validation of this theory, albeit from a one-person perspective.

The fact that a generic disaster management paradigm could be developed points to a satisfactory address of the original three-fold research Concern. Herein lies the true worth then of a new management theory: to provide a management tool that can confidently be applied across the discipline of general management practice. Indications are that this new paradigm can also be applied to other human endeavours where 'disastrous' results can ensue if the situation under scrutiny is not properly 'managed' – even in areas where the clinical result areas of *people*, *profit* and *planet* are not at risk. For instance, by applying the theory and its models to the specific realm of personal relationships, which has its own set of 'soft' rules and complexities, it may not be too far-fetched to argue that the 'disastrous' collapse of a relationship may be prevented by 'managing' it in line with this new theory. Typically, the concepts of energy, entropy, multiple perspectives, risk management and mindfulness would also be applicable and would require consideration during the relationship 'management' process. The application of the new theory in this context would however require a lateral mind shift from the world of industry and physics to the world of feelings and emotions. However, if the rules of engagement and the 'mechanics' of relationships are understood, the same management principles as postulated by this new paradigm apply. It stands to reason then that if the context specific management models are correctly created and the theory suitably applied, the 'disastrous' collapse of a relationship could be predicted and possibly prevented.

4. LITERATURE REVIEW

4.1 Introduction

The *Concern* regarding the occurrence of man-made disasters; the *Question* as to how these disasters are to be managed; and the *Answer* provided by the new management paradigm constitute the essence of the research project. The detailed Answer was developed in Chapter 3 and the role of Chapter 4 is to now locate this established Answer, i.e. the disaster management paradigm or theory, within the wider literature. The aim of a literature study generally is to explore the appropriate literature in order to either i) steer the research efforts, or alternatively, ii) verify/evaluate completed research work against relevant and available literature. As alluded to in Section 1.4.5 of this thesis it was decided to conduct a literature study in line with the latter purpose, i.e. as a reflective or confirming exercise, rather than a guiding or informative one. Also, in line with the SCQARE reporting format, a reconfirming or answer locating exercise can only be done after the actual research work had been completed and a satisfactory answer developed. Hence the positioning of the literature review here in Chapter 4, after the theory creation work had been executed.

The literature review was conducted on 3 levels:

- Firstly within the wider context or parent discipline, in this case disaster management in general. Here two existing management frameworks were investigated and the research work related thereto. This review actually led to an improvement in the newly developed management paradigm as some obvious shortcomings were identified when compared to the well-established management frameworks.

- The mid-level review focused on the theory implementation level where the predictive value of a properly constructed management model was confirmed. During this part of the review two well-known management models that are/were extensively used were explored and similarities drawn with the models developed as part of the new management theory.

- In the third level review some of the key components or building blocks of the new management theory were reviewed through comparison with the literature. It was attempted to re-confirm and validate the importance and correctness of these specific theory components within the overall management paradigm.

4.2 Review of well-known management frameworks/models

Two familiar and widely used management frameworks were closely examined in order to gain understanding of what attributes acceptable and successful management paradigms possess. The management frameworks that were reviewed during this literature review included:

- *The Project Management Framework* as described by the Guide to the Project Management Body of Knowledge (PMBoK) [50].
- *Prince2*, acronym for **PR**ojects **IN** **C**ontrolled **E**nvironments, the de facto standard for project management in the United Kingdom.

4.2.1 The PMBoK Project Management framework

The PMBoK Guide [50] is a comprehensive document that contains the collated knowledge regarding the science of (generic) project management. This publication has in fact been certified as an American National Standard [51]. It is an official guideline or standard for project management and is administered and published by the Project Management Institute (PMI), *'the world's leading not-for profit professional association for project management'* [52]. The PMI's two primary goals are [52]:

- Professional development and certification of project managers
- Advocating the profession of project management

Some verbatim quotes from the PMBoK Guide [50] illustrate its focus and intent:

- The PMBoK is the sum of knowledge within the profession of project management.

- It provides and promotes a common lexicon for discussing, writing and applying project management.
- The PMI uses this document as a foundational, but not the sole, project management reference for its professional development programs.
- This standard provides a foundational reference for anyone interested in the profession of project management.

The PMBoK Guide prescribes a specific framework for managing projects in general, in any sphere of modern life. The framework can be seen as a 'soft systems' tool applicable to the generic world of (project) management and its relevance to disaster management will be discussed later in the thesis. Inherent to this framework are certain very specific processes and process groups, as well as knowledge areas. Furthermore various models and techniques exist within the knowledge areas. The following process areas, each containing several sub-processes, are defined in the PMBoK Guide [50]:

- Initiating processes
- Planning processes
- Executing processes
- Monitoring and controlling processes
- Closing processes

Figure 21 displays the PMBoK's project management process model, applicable to all projects [50].

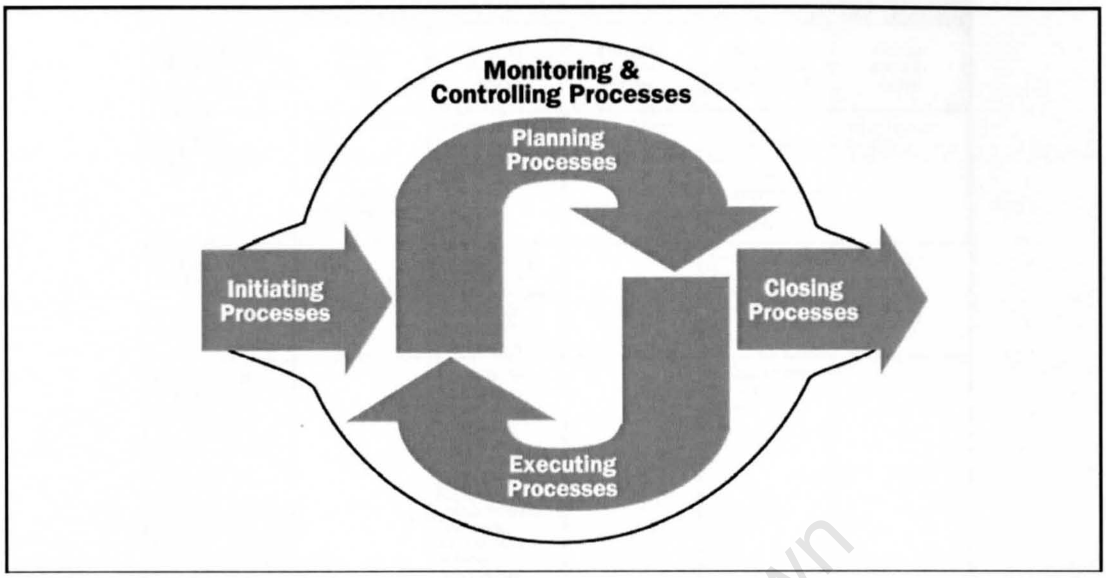

Figure 21: PMBoK Project Management Process Group Model [50]

The following nine knowledge areas are also defined in the PMBoK Guide [50]:

- Project Integration management
- Scope management
- Time management
- Cost management
- Quality management
- Human Resources management
- Communications management
- Risk management
- Procurement management

By implication a thorough understanding of the above knowledge areas is required as a basis for effective project management.

Table 4.1 maps the *project management processes* to the *process groups* and *knowledge areas* and provides an integrated overview on project management the PMBoK way [50].

Knowledge Area Processes	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Management Integration	Develop Project Charter 3.2.1.1 (4.1) Develop Preliminary Project Scope Statement 3.2.1.2 (4.2)	Develop Project Management Plan 3.2.2.1 (4.3)	Direct and Manage Project Execution 3.2.3.1 (4.4)	Monitor and Control Project Work 3.2.4.1 (4.5) Integrated Change Control 3.2.4.2 (4.6)	Close Project 3.2.5.1 (4.7)
5. Project Scope Management		Scope Planning 3.2.2.2 (5.1) Scope Definition 3.2.2.3 (5.2) Create WBS 3.2.2.4 (5.3)		Scope Verification 3.2.4.3 (5.4) Scope Control 3.2.4.4 (5.5)	
6. Project Time Management		Activity Definition 3.2.2.5 (6.1) Activity Sequencing 3.2.2.6 (6.2) Activity Resource Estimating 3.2.2.7 (6.3) Activity Duration Estimating 3.2.2.8 (6.4) Schedule Development 3.2.2.9 (6.5)		Schedule Control 3.2.4.5 (6.6)	
7. Project Cost Management		Cost Estimating 3.2.2.10 (7.1) Cost Budgeting 3.2.2.11 (7.2)		Cost Control 3.2.4.6 (7.3)	
8. Project Quality Management		Quality Planning 3.2.2.12 (8.1)	Perform Quality Assurance 3.2.3.2 (8.2)	Perform Quality Control 3.2.4.7 (8.3)	
9. Project Human Resource Management		Human Resource Planning 3.2.2.13 (9.1)	Acquire Project Team 3.2.3.3 (9.2) Develop Project Team 3.2.3.4 (9.3)	Manage Project Team 3.2.4.8 (9.4)	
10. Project Communications Management		Communications Planning 3.2.2.14 (10.1)	Information Distribution 3.2.3.5 (10.2)	Performance Reporting 3.2.4.9 (10.3) Manage Stakeholders 3.2.4.10 (10.4)	
11. Project Risk Management		Risk Management Planning 3.2.2.15 (11.1) Risk Identification 3.2.2.16 (11.2) Qualitative Risk Analysis 3.2.2.17 (11.3) Quantative Risk Analysis 3.2.2.18 (11.4) Risk Response Planning 3.2.2.19 (11.5)		Risk Monitoring and Control 3.2.4.11 (11.6)	
12. Project Procurement Management		Plan Purchases and Acquisitions 3.2.2.20 (12.1) Plan Contracting 3.2.2.21 (12.2)	Request Seller Responses 3.2.3.6 (12.3) Select Sellers 3.2.3.7 (12.4)	Contract Administration 3.2.4.12 (12.5)	Contract Closure 3.2.5.2 (12.6)

Table 4.1: Matrix of Project Management processes, process groups & knowledge areas [50]

This matrix at a glance provides a very useful and condensed overview of the PMBoK and the extent of the effort involved in the effective management of a project.

4.2.2 Prince2 Project Management framework

Prince2 is also a process-based method for effective project management [53]. Its aim therefore is the same as that of the PMBoK, but with a different approach and methodology. In the UK and Europe, Prince2 is the project management methodology of choice and is required by the UK government for all projects it commissions [54]. Prince was established and launched in 1989 by the Office of Government Commerce (OGC) in the UK. After contributions from some 150 European organisations, Prince2 was published in 1996 [53].

Prince2 therefore provides another process-based framework for managing projects. It has its own unique processes and process model defined, the processes being the following:

- Starting up a project
- Directing a project
- Initiating a project
- Planning
- Controlling a stage
- Managing product delivery
- Managing stage boundaries
- Closing a project

Figure 22 displays the Prince2 process model for project execution [54]:

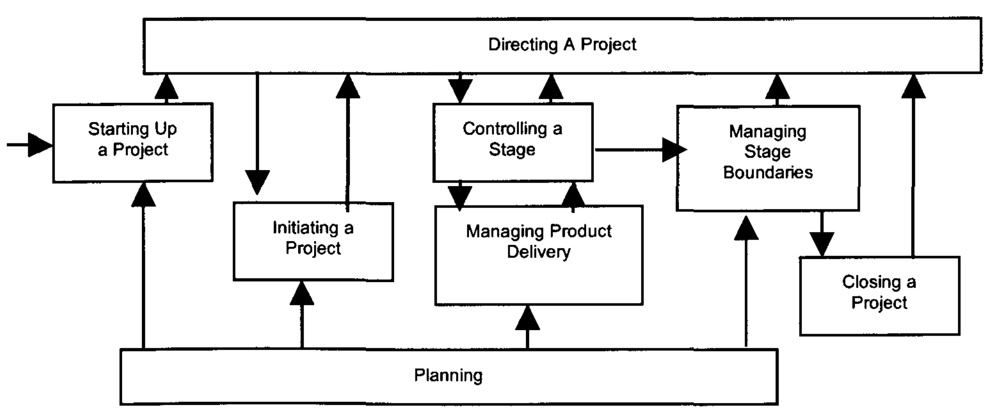

Fig 22: Prince2 process model [54]

Similar to the PMBoK, Prince2 is also a structured methodology that highlights how eight particular components (the equivalent of the knowledge areas in the PMBoK), when understood and effectively addressed, can reduce risks in all types of projects [54]. The eight components are:

- Business case
- Organisation
- Plans
- Controls
- Management of risk
- Quality in a project environment
- Configuration management
- Change control

4.2.3 Relevance of PM frameworks to disaster management paradigm

Whilst evaluating the two well established project management frameworks described above, and comparing it to the newly developed disaster management framework, some valuable insights became apparent.

The first realisation was that the project management (PM) frameworks are also 'forward-looking' management tools that aim to produce a given result at some point in an uncertain future. In comparison, the disaster management paradigm is also very definitely 'forward-looking', its aim being to prevent some situation, or a number of derivatives there-of, in a very uncertain future. The only practical way of attempting a look into the future is through risk management, the forward-looking effort being represented by the notion of probability[48]. Risk management is also a common denominator in both project management frameworks reviewed. Hence, and as was clearly illustrated during the development of the disaster management paradigm, risk management constitutes an irrefutable component of any (forward-looking) management framework, theory or model. To disregard risk in any managerial paradigm is to short-sightedly accept that we live life forward in an ignorant way, whilst understanding it backwards [17], sometimes in a very disillusioned way. The two widely accepted project management frameworks therefore re-

[48] See Section 3.3.5, page 78

confirm the absolute necessity of embracing risk in the newly developed disaster management paradigm.

Secondly, the more profound insight gained through the review of these project management frameworks was the realisation that the new disaster management framework still needs some refinement and development before it can actually be acknowledged as a proper management framework. The crucial insight was that the new framework does not have topic specific knowledge areas and clear processes defined. The causal loop diagram (CLD) indicates a continuum of effects, the 'results' of certain 'causes', but the specific processes necessary for motivation and initiation of these 'results' are ominous in their absence. The CLD, which was seen as the essence or representative summary of the new theory actually only paints a picture of the results obtainable through executing certain actions, which in turn cause the effects or results reflected in the CLD. For example the *'degree of mindfulness'* has a similar/direct effect on the *'comprehensiveness of multiple systemic perspectives'* and so on. How these enhanced states-of-being are actually achieved is not revealed. Going full circle with the research effort it can now be seen that the CLD actually provides answers to why certain things happen as they do, i.e. it facilitates understanding of the disaster phenomenon. What is lacking in the paradigm is the guidance as to what must be done and how it must be done to achieve the desired results. In short, what is still required is to define the knowledge areas and process groups for the overall disaster management framework, similar in fashion to those of the two project management frameworks explored in this review.

By meta-reflecting on the theory in its current state and focussing on the content of the CLD, the following processes, or then process groups, were distilled:

- Identifying possible disaster scenario
- Evaluating current disaster potential
- Planning management intervention
- Executing management intervention
- Monitoring & controlling intervention
- Providing feedback on new disaster potential

Similar to the other project management frameworks, a process model for disaster management was conceived. Figure 23 shows this newly created disaster management process group model.

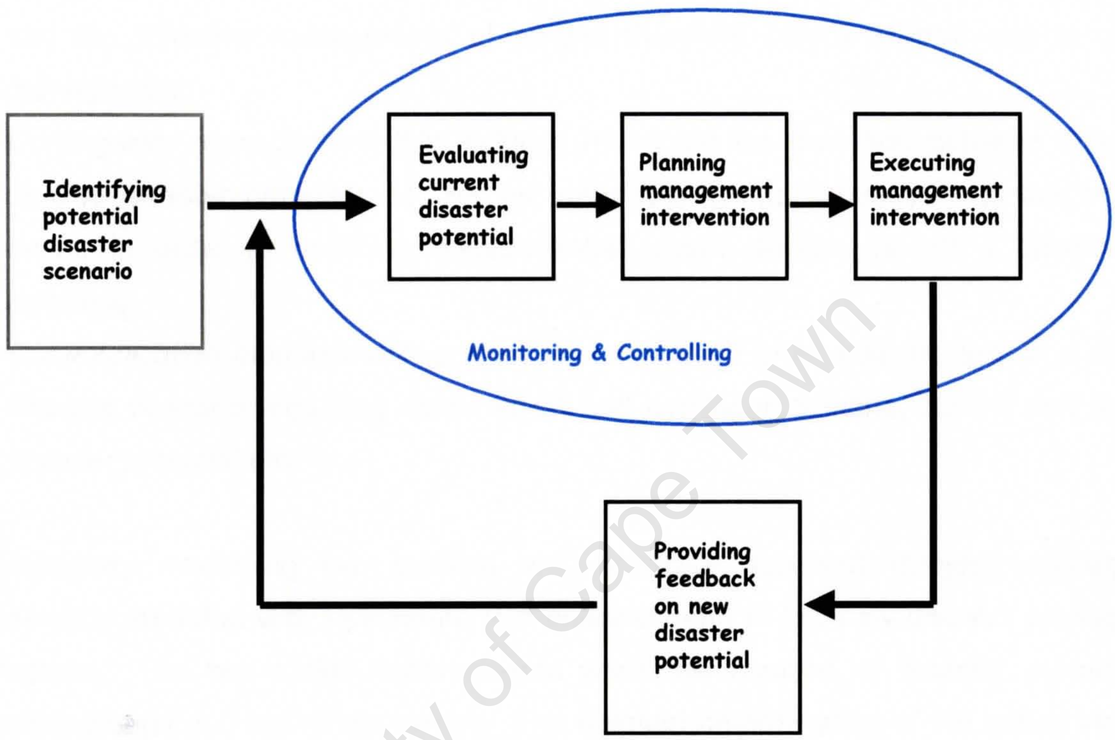

Figure 23: Disaster Management process group model

An interesting point to note here is that the process model contains an overall reiterative loop, in contrast to the project management process models that clearly indicate termination of the overall process at project closure. Where-as *'a project is a temporary endeavour undertaken to create a unique product, service or result'* [50], a non-disaster is the result of a reiterative endeavour to minimise disaster potential.

Further reflection and contemplation revealed the following six knowledge areas:

- *Mindfulness*; as defined by the triangle of Figure 19. The three constituents need to be closely understood and all present throughout the disaster management process.

- *Systems theory*; the science encompassing systems engineering and general systems theory as discussed in Chapter 3.
- *Risk management*; a crucial component of disaster management and the only mechanism for 'seeing into the future'.
- *Human resources management*; man-made disasters are after all caused by humans and the effective management of people therefore play a pivotal role in disaster management
- *Contingency management*; this includes managing the deviation between actual and desired disaster potential, as well as managing events subsequent to the triggering event, in order to minimise consequential losses and/or prevent a disaster from unfolding.
- *Communication management*; proper communication to all stakeholders in a potential disaster scenario regarding risks, action and contingency plans, current and targeted disaster potential etc.

In summary, reviewing two existing and generally accepted (project) management frameworks assisted with refinement and enhancement of the new disaster management paradigm. The two major improvements were the creation of disaster management process groups and knowledge areas. The detailed determination of the actual individual processes embedded in the various process groups, and relative to the knowledge areas (similar to the matrix in Table 4.1), was deemed to fall outside of the scope of this research project and could perhaps be investigated in continued research on this disaster management topic.

4.3 Review of theory implementation models

During this part of the literature review *scenario planning and analysis,* a technique utilised as a forward-looking tool that facilitates good (management) decision-making, was investigated due to obvious synergies with the newly developed management theory and models. An exploration of the Periodic Table of chemical elements was also undertaken, for reasons that will become apparent later in this chapter.

4.3.1 Scenario planning and analysis

Scenario planning is the *'process of visualising i) what future conditions or events are probable; ii) what their consequences or effects would be like; and iii) how to respond to, or benefit from them* [55]. It is not about predicting the future. It is about exploring the future [56]; and in a sense, 'learning' from the future. If you are aware of what could happen, you are better able to prepare for what will happen [56]. Or in the case of this disaster management theory, better able to prevent that what could very well happen.

Although scenario planning is normally seen as a strategic thinking and planning tool [57], closer investigation of this technique reveals striking resemblances with the attempts of the new disaster paradigm to identify potential future disaster situations, or then scenarios. For one, scenario planning is grounded in risk assessment and risk management. Doing scenario planning equates to asking the great *'What if?'* It's about identifying risk [56]. Secondly, scenario planning has a fairly straightforward methodology and also a clearly defined process model as operating platform. Ilbury & Sunter [58] describe the scenario planning process as a continuous and fluent exercise, oscillating between certainty and uncertainty, control and lack of control. It fundamentally revolves around what you know - and more importantly what you don't know - and realising what you can and cannot control. The process is represented by the model or matrix shown in Figure 24 [58].

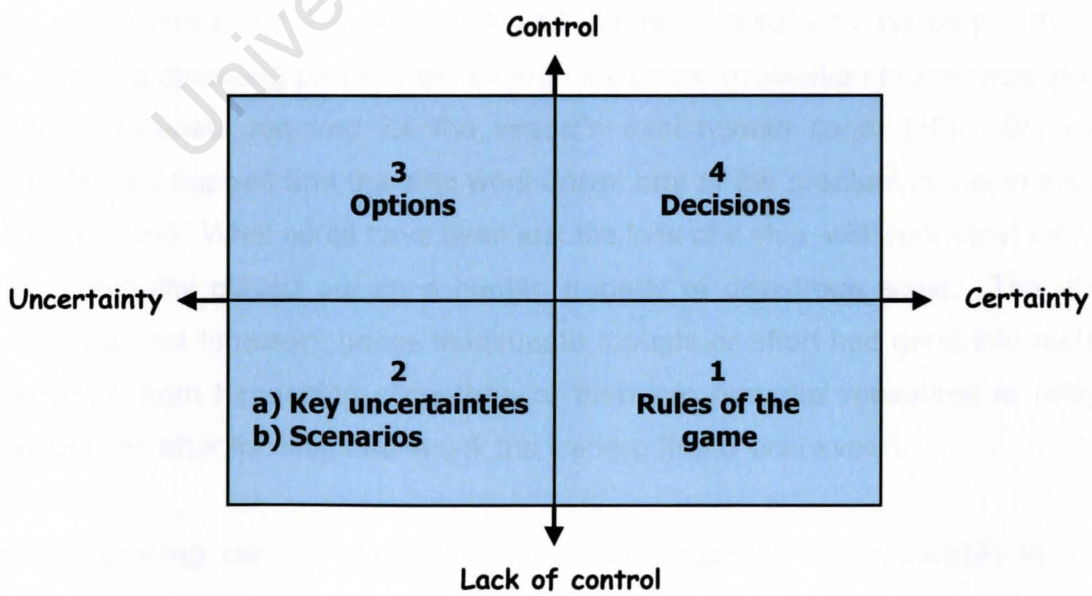

Figure 24: Scenario planning matrix [58]

The scenario planning matrix has four quadrants:

1. *Rules of the game* – establishing the 'givens' for a particular situation under scrutiny
2. *Key uncertainties* – evaluating the probabilities and uncertainties regarding the occurrence of a (risk) event

   Scenarios – visualising the results of an event occurring, completing the risk evaluation process
3. Options – generating plausible options that would prevent the undesired event from occurring or ameliorate the results there-of
4. Decisions – taking positive action and selecting a route to follow, making management decisions

A key attribute of scenario planning and analysis is – as the name implies – the creation of <u>vivid scenarios</u> of possible future realities. This calls for some degree of (visionary) imagination to conjure up events or outcomes that would normally, during the day-to-day busyness of life, remain 'unseen'. An accusing example of this 'reality blindness' is provided by the official report of the 9/11 Commission in Washington that stated 'the principal reason for the intelligence agencies failing to detect the plot[49] beforehand was a *failure of imagination*' [59]. As a further example, the Titanic[50] disaster (and many others) provides grim evidence of what the outcome can be like when the 'unthinkable' is not contemplated. Nobody had foreseen the 'impossible' event of the ship's sinking and the vessel was deemed 'unsinkable' by all and sunder. Resultantly no proper thought had gone into safe operating procedures, emergency plans, evacuation procedures or even the amount of lifeboats required for the vessel's total human cargo [58]. So, when the unthinkable did happen and the ship went down, one of the greatest maritime disasters of all times ensued. What could have been just the loss of a ship, with (perhaps) minimal loss of life, eventually played out as a human tragedy of disastrous scale. The disastrous scenario was not foreseen, hence inadequate thought or effort had gone into methods for preventing it from happening altogether, or then into remedial measures to mitigate the consequences after the ship had struck the iceberg (the critical event).

Scenario planning can therefore be seen as an important tool applicable to the new disaster management paradigm. As a matter of fact, it was pondered at some stage

[49] See Section 1.2.1, page 15, paragraph 1
[50] Appendix A - Disaster N° 14

whether scenario planning should not be a knowledge area within the new management framework. It was however soon realised that the technique is but a tool, one of many available to the mindful manager responsible for disaster prevention. Scenario planning would therefore typically feature as a process under the process group *'Identifying potential disaster scenario'* and within the knowledge area *'Risk management'.* It can greatly assist to widen the risk identification focus and prevent tunnel vision associated with the detailed analyses of localised risk events.

Once a possible disaster scenario is visualised the techniques and models of the disaster management framework can be applied to create a model of the calamitous future scenario that needs to be avoided at all costs. Detailed analysis and 'reverse thinking' will then reveal the disaster potential, event layers, possible critical events and eventually the management interventions required for elimination or reduction of the probability of the disaster scenario materialising. And in this lies the ultimate purpose of the new disaster prevention paradigm: *to prevent a possibility from becoming a probability and to prevent a probability from becoming a reality* [58].

4.3.2 The Periodic Table of chemical elements

During the literature review an interesting and relevant bit of history was serendipitously stumbled upon – that of the development of the Periodic Table of chemical elements. Although this table or model clearly resides within the 'hard' world of physical science, there are aspects that are also relevant to the models of the 'softer' world of management practice. The following two paragraphs* provide a concise overview of the development of the Periodic Table and is a summary of information and quotations obtained from two sources [60], [61].

* Dmitri Mendeleev (1834-1907) is often regarded as the father of the Periodic Table and he himself called his table, or matrix, the Periodic System. When Mendeleev became a professor of general chemistry at the University of Petersburg, he was unable to find an appropriate textbook and thus began writing his own. That textbook was written between 1868 and 1870 and would provide a framework for modern chemical and physical theory. In the process of writing his book, *The Principles of Chemistry*, Mendeleev created a table or chart that listed the known (at that time) chemical elements according to increasing

atomic weights. Mendeleev had written the properties of elements on pieces of card and tradition has it that after organising the cards while playing patience he suddenly realised that by arranging the element cards in order of increasing atomic weight that certain types of elements regularly occurred. When he organised his table into horisontal rows, a pattern became apparent – but only if he left blank spaces in the table. If he did so, elements with similar chemical properties appeared at regular intervals – periodically – in vertical columns of the table. In his own words: *"I began to look about and write down the elements with their atomic weights and typical properties, analogous elements and like atomic weights on separate cards, and this soon convinced me that the properties of elements are in periodic dependence upon their atomic weights'* [62].

* Mendeleev was bold enough to suggest that new elements not yet discovered would be found to fill the blank spaces on his table and even went so far as to predict the properties of five of the yet-to-be-discovered elements. What makes this forward-looking framework and initiative so astounding is the fact that there were two main problems about establishing a pattern for the elements. First only 60 elements had been discovered (we now know of over 100) and second some of the information about the 60 was wrong. It was if Mendeleev was doing a jigsaw puzzle with one third of the pieces missing, and other pieces bent! Although many scientists greeted Mendeleev's first periodic table with scepticism, its predictive value soon became clear. Three of these missing elements were discovered by other scientists within 15 years (i.e. within his lifetime). These discoveries established the acceptance of the Russian's table, although the two other elements whose properties were predicted were not discovered for 50 years. The current day Periodic Table is arranged in order of atomic number, i.e. the number of electrons each atom carries - and not relative atomic weight - but in most cases the two tables result in the same order of elements. An element, atomic number 101, has been named after Mendeleev in recognition of his visionary work during the early days of modern chemistry.

4.3.3 Relevance of investigated models to management theory

But what relevance does a physical model such as the periodic table of chemical elements have in management practice? Just this: if a correctly configured 'model' of some phenomena or future reality is constructed, it can actually function as a guiding tool or template to i) verify that the required components are present to achieve the desired future end-state and ii) inform on elements or links that are absent and would consequently hinder or prevent the attainment of the desired situation. Admittedly the context is more fluid and less exact in the 'soft' world of management practice than in the 'hard' physical world. For instance, when considering project management as a management discipline and remembering Section 4.2.1 & 4.2.2 above, it would be imprudent to declare the PMBoK framework as the exact, definitive and only model for managing projects. However, project management professionals by now know that if some the components prescribed by the framework are absent during the execution of a project, problems can definitely be expected with project delivery. If the scope, schedule and budget (to name a few of the necessary components requiring management focus) of a project are not well defined upfront and diligently managed throughout the execution of a project, an unsuccessful project is not a vague probability anymore but rather becomes a stark reality, visible for all (or the informed at least) to recognise well in advance.

Similarly the new disaster management paradigm with its CLD, process model and knowledge areas sketch an array of required components or entities that should be present in any disaster management endeavour. If the 'rhythm' or periodicity or common denominators in man-disasters are effectively isolated and combined in this management framework, the potential to identify and prevent possible future disasters becomes an attainable achievement. As an example, the less obvious but very necessary component of a *hierarchistic risk attitude* is indicated by the new paradigm as a pre-requisite for disaster aversion. If this component is therefore not present in the management systems and structures involved in potential disaster environments, red lights should flicker and efforts towards instilling this 'correct' attitude should be pursued.

It is clear from the above that the sensible application of a properly constructed model of reality, a *paradigm* through which to view the world, can have far-reaching benefits – both in the 'hard' physical world of physics and chemistry, as well as in the 'soft' world of management practice.

4.4 Review of some key theory components

4.4.1 Risk attitude

The traditional approach towards risk attitude of different people maintains that a person is either [63]:

- Risk-averse, i.e. individuals who are afraid of, or sensitive to, risk. Purchasing insurance is an example of risk-averse behaviour.
- Risk-seeking, i.e. individuals who are not afraid to take on risk. An individual that plays the state lottery exhibits risk-seeking behaviour.
- Risk-neutral, i.e. individuals that do not care about risk and can completely ignore risk aspects in the alternative that he or she faces.

Clemen [63] has postulated the notion of a utility function, or then a utility curve that, when plotted against financial gain or wealth, indicates the three behaviours mentioned above. Figure 25 indicates the three different shapes for utility functions [63].

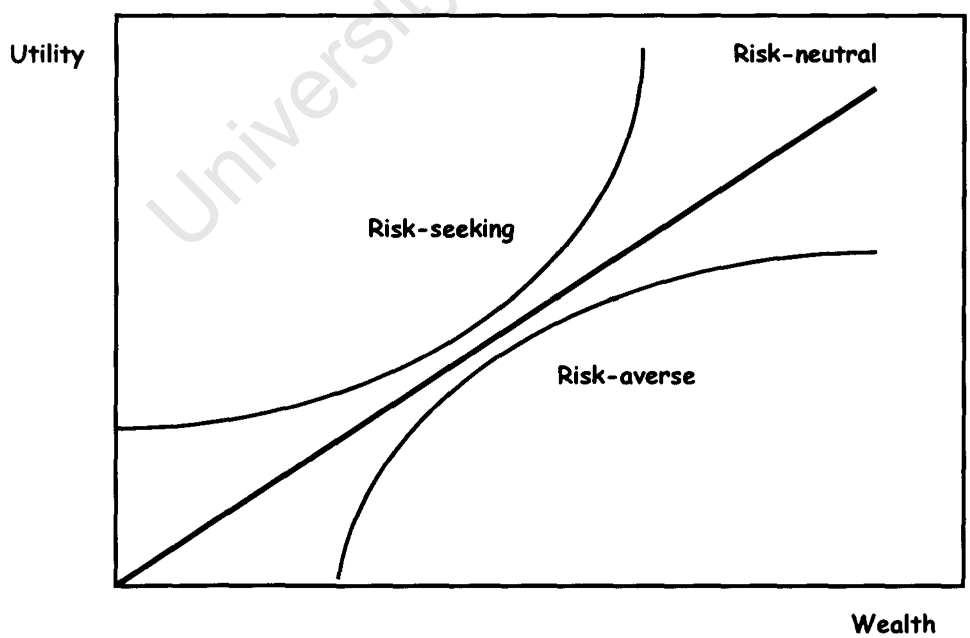

Figure 25: Utility functions indicating risk attitude [63]

Admittedly this categorisation of risk perspectives is purely from a financial perspective, i.e. how much risk, or consideration towards risk, an individual is willing to endure under different economic conditions. Clearly, when adopting a systemic view of the world as required by this research project, risk preferences towards injury, death, the environment and then also financial aspects of business and life warrant consideration. When managing the triple bottom line[51], peoples' risk attitudes in relation to this all-encompassing whole need to be examined.

The four basic risk attitudes or perceptions [43] of people as described in Section 3.3.7 presented a novel and fresh approach on the way that humans perceive risk in the bigger scheme of things. Some careful reflection revealed that there is a correlation between the risk attitude descriptions of Section 3.3.7 and the three risk appetites or utility functions described by Clemen [63] and indicated above:

- *Individualists* are individuals that will seek out risk
- *Fatalists* are individuals that can approach risk indifferently
- *Egalitarians* are individuals that are risk averse

The model of Section 3.3.7 however also describes an additional, fourth way of perceiving risk, that of the *hierarchist*. This type of person seems to encompass the best of the other three attitudes and then adapts his or her risk attitude as a function of prevailing circumstances. In other words, the hierarchist considers risk and makes informed and balanced decisions by viewing a possible risk situation systemically and adopting multiple perspectives on the risk situation. He/she manages risk.

During the literature review it was discovered that this four-way risk perception/attitude classification bears striking resemblance to the way that Sherwood [64] maps planning methods to different personal styles and beliefs. His book on systems thinking, *'Seeing the forest for the trees'* [64], describes four types of planning mentalities:

- *Gods*; those who believe they can predict and control the future. They have enormous self-confidence and 'know' all the answers.

[51] See Section 1.2.3, page 17

- *Gamblers*; those who have less confidence in their ability to predict the future. They know that they will not win on every bet so they like to know the odds.
- *Grinders*; those who prefer a style of empowerment but believe they can predict the future. They are always searching for the 'right' answer.
- *Guides*; individuals that know that the future cannot be predicted and seek to guide their organisation wisely through uncertainty. They find *scenario planning*[52] (!) to be a very powerful aid.

Comparison of the risk perception and planning mentality models indicated a good match between the four attitudes and profiles. *Idividualists* could be referred to as *Gods; Fatalists* could be referred to as *Gamblers; Egalitarians* would be seen as *Grinders* and *Hierarchists* would be represented as *Guides.* There is thus affirmation for a four-quadrant way of classifying people's attitudes towards uncertainty in general. From a disaster management perspective it is therefore clear that the attributes required of a mindful manager are that of a *hierarchistic* risk approach and a *guiding* affinity towards the unknown. This is typically the type of person that Ilbury & Sunter [58] would describe as a *fox*. The challenge is to identify and select individuals with these unique character traits for deployment in disaster management structures.

Whilst it falls outside the scope of this research project to comprehensively investigate the knowledge domain of risk attitude and more specifically the methodologies available for determining a person's risk attitude, some closing comments on the topic are appropriate. Weber et al [65] are of the opinion that the existing measures available for measuring risk attitude in individuals (in 2002) had proven unsatisfactory. They subsequently developed a scale for assessment of risk attitudes in individuals and claim that their scale improves on the shortcomings of earlier assessment tools in two ways [65]:

- Their scale distinguishes between two psychological variables (risk perception and attitude towards perceived risk) that have been confounded in previous risk-attitude indices and instruments implicitly or explicitly grounded in expected utility theory
- The scale examines risk-taking and its determinants in several distinct content areas

The psychometric scale that they developed assesses risk taking in five content domains, i.e. financial, health/safety, recreational, ethical, and social context. This assessment

[52] See Section 4.3.1, page 110

methodology seems to be more in line with the type of evaluation tool required for screening and selecting people with the 'right' attitude for deployment on risk management teams.

4.4.2 Mindfulness

The concept of mindfulness was identified as the key variable in the new disaster management theory, i.e. as the most important aspect that can have the highest impact on any disaster prevention initiative. Further investigation of this attribute in the literature review was thus warranted.

The term mindfulness may conjure up (only) images of mediation, deep reflection and acute awareness. Carlson [66] for instance describes mindfulness as having *'the effect of making us far more aware of what's really going on around us. ...It's the experience of becoming alive, fully aware of the moment, as it really is'.* From a disaster management perspective it however implies also doing something with or about the insights and knowledge fostered through experience and systemic analysis, i.e. having the appropriate attitude towards the situation under scrutiny. In a sense one can define two states of mindfulness, i.e. passive and active mindfulness, the latter being the only mental state that can influence the success of any disaster management endeavour. This is also the 'type' of mindfulness as proposed by the mindfulness triangle[53] postulated earlier.

Nowhere is this distinction between 'passive' and 'active' mindfulness more vividly illustrated than with the disaster resulting from hurricane Katrina, that devastated large parts of the South Eastern United States in August 2005. (The Katrina disaster is an example of a hybrid disaster, i.e. partly natural and partly man-made). The hurricane, a known and natural occurrence, coupled to the 'well-engineered' man-made system of allowing people to live below sea level with civil structures protecting against flooding, resulted in a grave disaster when the city of New Orleans was flooded. The disaster was many years in the making and had been foreseen for a very long time. It required only a hurricane of appropriate magnitude – like Katrina – to set the rapid decay to chaos and maximum entropy in motion. TIME Magazine [67] stated *'The hurricane was the least of the surprises'* and asked the question *'why a natural disaster became a man-made*

[53] See Figure 19, page 85

debacle?' A further damning observation is then offered: *'Hindsight is 20/20. But once in a rare while, foresight is too. For years, researchers have described exactly what would happen if a mega hurricane hit New Orleans and the surrounding Gulf region. They predicted that the city levees would not hold. Their elaborate computer models showed that tens of thousands would be left behind. They described rooftop rescues, 80% of New Orleans underwater and "toxic gumbo" purling through the streets. If experts had prophesied a terrorist attack with that kind of accuracy, they would be under suspicion for treason'.*

Another article in the same TIME Magazine edition calls the reason for the catastrophe by its name [68]: *'After 9/11, whatever the evidence of intelligence failures, many people still saw that attack as almost unimaginable, so brutal and brazen an assault. But Katrina was in the cards, forewarned, foreseen and yet still dismissed until it was too late. That so many officials were caught so unprepared was a failure less of imagination than will, a realization all the more frightening in light of what lies ahead'.* The crucial missing link was the lack of attitude/will to do something with the vast knowledge and experience that was backed up by impressive systemic thinking abilities. This shortfall crippled mindfulness and culminated in a grave disaster.

Weick et al state the following characteristics of mindfulness (within organistional context) in their book 'Managing the Unexpected' [69]:

- Pre-occupation with failure, i.e. learning from previous errors with the aim of improving future conduct and avoiding repetitive mistakes
- Reluctance to simplify interpretations, i.e. to see things as they really are and not perceiving details as being trivial 'noise'
- Sensitivity to operations, i.e. knowing what's happening at the moment within the organisation and its operating environment
- Commitment to resilience, i.e. the focus is not on zero error but rather on the more realistic goal of error containment
- Deference to expertise, i.e. decision-making is not hierarchically reserved for 'managers', but influenced by people with the required knowledge and skills. Decisions migrate down and up the chain-of-command.

It goes without saying that these attributes should also be present when 'managing the expected.'

Mindfulness to the manager in practice therefore centres on acquiring, or then nurturing, the appropriate triad of attributes for appropriate decision-making - and action - where it counts: in the arena of disaster management. A mindful manager also realises that even mindful processes unravel pretty fast and that uncertain technologies and environments warrant nothing less than ongoing effort [69], i.e. a continuous input of management energy[54], to prevent a disaster.

4.4.3 Luck factor

It was previously mentioned that the theory and models created during this research project constitute plausible explanations and a sound framework for understanding disasters. The Discrete Event Disaster Propagation Model (DEDPM) introduced a model where an overall disaster situation is portrayed as a series of events that continuously cause fluctuations in energy and entropy levels. One peculiar aspect of disasters and potential disasters however remains unexplained, even by this model: Why do certain risk events result in disasters and chaos whilst other events, sometimes under very similar or even the same circumstances, result in no harm?

For instance, the locomotive that fell down the Vaal Reefs N°2 Shaft[55] resulted in a tragic disaster with huge loss of life and tremendous financial repercussions. This was however not the first loco to fall down a shaft, as a matter of fact equipment and material falling down mine shafts is not that rare an occurrence. But not all items falling down mine shafts result in disasters. More often than not there is only equipment and infrastructure damage and perhaps temporary business interruption. Why? In terms of the model, why does a specific event, located in say event layer 0, initiate energy release (and entropy increase) and then result in a disaster, or sometimes not? When no injuries or deaths or major loss materialise does it mean that the/some critical event, probably located in the next lower event layer (layer –1), did not occur, i.e. the probability gap on this layer was 'closed' thereby preventing the further decay towards chaos? Or does it mean that the layer through which the situational sphere had just slipped (layer 0), is/was in fact the (potential)

[54] See Section 3.2.5, page 67, par 2
[55] Appendix A: Disaster N° 1

critical event, but that some other phenomenon intervened and prevented injury, death and/or financial or environmental loss? Is there some unidentified and unmanageable factor at work here, or does entropy 'change its mind'?

The answer to this conundrum was discovered during the literature review. McKinnon [70] postulated the existence of the so-called *luck factor*, an intangible entity that resides in the world of safety and loss control management. The term implies that some things are totally outside of the control of any manager, even the most mindful one with the best intentions towards preventing a disaster. 'Luck' implies a chance event, a totally unpredictable, random and unmanageable occurrence. Three luck factors were in fact identified [70]:

- *Luck factor 1* determines whether contact with energy occurs after energy release, i.e. is anybody/anything in the way of the energy being dissipated? Contact with this energy is what injures, kills, damages, interrupts business processes or pollutes.
- *Luck factor 2* dictates what type of consequence or loss results from contact with energy, i.e. impact on people (injuries/fatalities), profit (damage/interruption) or planet (damage/pollution)[56].
- *Luck factor 3* determines the severity of the consequence, i.e. severity of injuries/ number of deaths, amount of financial loss, extent of environmental damage etc

Between every event layer of the DEDPM these three luck factors thus exist and determine eventual outcomes of energy releasing occurrences in a totally random way. Heinrich et al [71] compiled ten axioms of industrial safety, the fourth being '*perhaps the most significant statement in the safety management profession*' [70]. This axiom professes that the severity of an accident (having progressed through luck factor 1 and 2) is largely fortuitous (luck factor 3) but that the occurrence of the accident/event that results in harm or loss is largely preventable.

The 'foxy' manager will therefore estimate the Maximum Probable Loss[57], i.e. the worst case scenario for the particular energy dissipating event, realise and accept his lack of influence in determining the final consequence - and then move his attention to an area where he can in fact have influence, even achieve control. This area of possible control lies

56 See The Triple Bottom Line, Section 1.2.3, page 17
57 See Section 1.2.3, page 17

in influencing the probability of occurrence of the undesired (critical) event – and the probabilities of all preceding events for that matter.

The final observation concurs with Heinrich's [71] fourth axiom: to prevent the critical event from occurring altogether is obviously better than relying on remedial measures to curtail disaster, or in terms of the DEDPM, prevention is better than containment. But then even the most reckless have always known that 'prevention is better than cure'.

5. EVALUATION OF RESEARCH PROJECT

5.1 Introduction

This final chapter of the thesis provides a backward glance and evaluative scrutiny on the research effort as a whole. An attempt is made to gauge the level of contribution of this research thesis to the existing knowledge regarding disaster management. A qualitative assessment is then conducted to assess the extent to which the research intent was met, through determining to what degree the various components of the thesis explained and complemented each other, when viewed from the S**CQA**RE[58] format perspective. Also very importantly, having earlier firmly established and explored the *Concern* (occurrence of man-made disasters) - *Question* (how to manage these disasters) - *Answer* (new management paradigm) triad, the purpose of this chapter is to explore and conclude on the wider value, possible contribution and significance of the Answer arrived at during the research process and project.

Finally a forward glimpse on possible future research work that may validate and/or further develop this first-attempt management theory is provided.

5.2 Contribution of research project

The research intent was the development of a paradigm for systemic disaster management. In the following sections of this final chapter it will be clearly demonstrated that this intent was indeed met and that the results and thesis comply with the requirements for relevance, validity, utility and ethics. But what practical contribution does this work bring to the disaster management realm?

It would be fair to claim that this research work and thesis contributed towards the existing body of knowledge regarding disaster management and prevention. The new paradigm provides a novel and systemic view on the disaster phenomenon and the overall framework represents a useful, practical tool for determining whether the components required for effective disaster management are in fact present. But similar to money, knowledge has more value when it is spread around and more people come into contact with it. The ideas

[58] See Sect 1.4.1, page 30

and models developed here in this thesis can and should be further expanded upon by other researchers and refined to a best practice framework for disaster prevention. If nothing else, a good guiding foundation was laid for further research on the topic.

On a personal level the yearning to comprehend and understand the disaster phenomenon has been satisfied to a large extent. Although there is still a lot to learn about the subject, it is satisfying to have gained some insight into a field that has intrigued me for a long time. More rewarding and encouraging still is the fact that since getting involved with this research project, I have started to think about and analise difficult and potential tumultuous situations in terms of the models created during the research project. A number of examples exist where I had viewed situations in terms of the Discrete Event Disaster Propagation Model and visualised situations where constraint slips had taken place and only one or two more small losses could have resulted in energy shedding events and possible accidents or even disasters. Realising that the stage was set for (possible) mayhem and being able to identify tell tale pre-cursors to a critical small loss that may have set the forces of destruction in motion, allowed me to intervene and eliminate the possibility of a calamity altogether. Obviously these were incidents only I knew of or viewed in this light, nothing might have happened anyway and nobody would have been the wiser. The *paradox of prevention*, as explained in Section 1.3.3, is clearly illustrated here; when incidents are prevented it remains somewhat illogical to explain or claim that anything undesirable would have happened in the first place. The true reward for effective disaster management therefore lies in never having to explain a disaster that had in fact occurred.

Another significant personal insight that manifested from the theory development process is the notion of mindfulness and what role it plays in the management of disasters. Irrespective of the amount of experience and technical knowledge a person or body may have, if the 'right' (caring) attitude is not present and manifested through appropriate action, mindfulness is absent and the degree of understanding and influencing of a possible disaster situation is diminished. Furthermore the centre of mindfulness must reside in a person or body with actual influencing or executive powers with respect to the situation at hand. In short, managers, who have clout, need to be mindful themselves, or alternatively appoint the appropriate mindful personnel that are in line with the decision-making process and not parallel to it.

5.3 Relevance

This portion of the evaluative process investigates whether the *Concern* as described in Section 1.3.1 is/was actually relevant in the *Situation,* which in turn was comprehensively articulated in Section 1.2 of this thesis.

The situation considered in this research project was the dynamic and high-stakes world of man-made disasters and the impact there-of on its result bearers, i.e. on people, profits and the environment. Although the project started out as a research effort within the mining industry it was expanded to industry and life in general. This expansion ensued largely as a result of the realisation that the same factors are at work during any man-made disaster, irrespective of the context or environment in which it occurs. It was argued that the occurrence of man-made disasters in fact constitutes management failure and hence challenges for modern day management practice.

A three-fold concern was highlighted:

- Disasters seem to occur randomly across all spheres of life and within all types of organisations
- Similar disasters occur repeatedly
- The same organisations repeatedly cause disasters

A fairly simplistic but sensible way of establishing relevance between the concern and situation is to evaluate whether the occurrences (man-made disasters) as described in the situational narrative directly resulted from the issues identified in the section delineating the concern. Here it was clearly the case – had the negative aspects identified in the concern not existed, the situation under scrutiny, i.e. the occurrence of disasters, would not have materialised.

It is worthwhile to note that the term 'concern' implies some human emotional or intellectual process; in the context of this thesis a 'correct' attitude to actually be concerned about the occurrence of disasters. A more clinical evaluation would perhaps be to view the actual facts contained in the *Concern* as exactly that – facts that are/were the pre-cursors to the negative events described in the *Situation*. Whether it is of concern to somebody or not then becomes irrelevant, what remains clear to the impartial observer is that these clinical facts are totally related, and hence relevant, to the situation under scrutiny.

It is therefore fair to conclude that a relevant *Concern* was identified during the analysis of the *Situation* under review. This is a very important aspect for the research project as a whole because if the concern had been incorrectly identified and engaged, the rest of the research work would not have been sensibly and relevantly aligned with the situation under investigation and hence the research topic.

5.4 Utility

Establishing utility entails ascertaining whether the *Answer* arrived at during the research project adequately answers the *Question* and deals with the *Concern* identified at the onset of the research. In other words, would the management theory derived during this research project adequately address the undesirable aspects associated with the occurrence of man-made disasters? Would the application of the theory assist managers in identifying disaster situations and ultimately preventing a potential disaster from actually occurring?

It would be difficult to ascribe a definite confirmation to this question. Having developed a theory and framework for disaster management does not necessarily mean that the desired results will be achieved. As with all management frameworks, the theory that was developed and presented in the form of a Causal Loop Diagram presents a perceived model of reality. Effective application if this model would be required to achieve the desired results.

What would be fair to claim is that a plausible theory and associated models were derived, i.e. a management framework that seems to present an acceptable explanation for the man-made disaster phenomenon. The stress-testing or verification of the theory and models that was conducted in Section 3.4.4 of this thesis demonstrated adequate utility and verified the ‘fit’ of the model to a variety of past disasters. It stands to reason then that the models and theory should be suitable for analysing and managing future potential disasters and true utility would be demonstrated by the use there-of in actually evaluating potential disaster situations.

This new management theory does not claim to be the ultimate and complete solution to the disaster dilemma. It merely presents a plausible framework that, if properly followed and/or implemented, should yield a considerable chance of effectively managing potential disasters. Similarly, the project management models explored in Chapter 4 present frameworks from which to manage any project and by diligently employing any of these frameworks, the probability of project success is greatly enhanced. Appropriate management effort is however required to convert these theories and models into actionable knowledge and eventual project success - and disaster prevention. In summary, the new disaster prevention paradigm can be utilised by management as a tool for getting to grips with the elusive but dangerous phenomenon of man-made disasters.

5.5 Validity/Trustworthiness

In determining the validity of the work done and theory developed in this thesis, it needs to be evaluated whether the *Rationale* adequately explains the *Answer*. In other words, was a logical and acceptable process employed to arrive at the answer? In this case, is the final theory a logical result of the theory development process? In qualitative research the concept of *trustworthiness* is deemed more appropriate than validity, which finds more suitable application in quantitative research. The basic question addressed by the notion of trustworthiness is: *'How can an inquirer persuade his or her audiences that the research findings of an enquiry are worth paying attention to?'* [72]. A set of four criteria is employed to judge and evaluate qualitative work [72]:

5.5.1 Credibility

'Credibility depends less on sample size than on the richness of the information gathered and on the analytical abilities of the researcher' [72]. Richness of information is adequately demonstrated through the investigation into 16 different disasters. Furthermore, topics such as mindfulness, risk and risk management, multiple perspectives and systemic considerations are all acceptable and well-known academic subjects on which a lot of knowledge is available and generally acceptable. As is evident from the final theory Causal Loop Diagram, many of the theory components are widely accepted managerial concepts and can therefore be viewed as credible, enriching constituents of the theory. Other building blocks of the CLD comprise concepts and models that were derived as part of the

research and analysis effort. The disaster propagation models are based on fundamental and widely accepted laws of physics that are yet to be disproved. The combination of the concepts of energy and entropy into the disaster models was found to explain all disasters it was applied to during the validation effort. Furthermore the concepts of hierarchistic risk attitude, disaster potential and appropriate management intervention also stem from deeper, well-known concepts and theories.

The final management theory is the result of one long analysis, synthesis and integration process. The process employed triangulation of data and of existing and well-known theoretical concepts, as well as concepts and models developed through the theory creation process itself. The applicability of the models and the overall new theory - and hence the credibility of the thought processes employed - was then comprehensively confirmed through the stress-testing exercise conducted towards the end of Chapter 3. It can therefore be proclaimed that the research effort and final product conforms to the requirements for credibility.

5.5.2 Transferability

'In the naturalistic (or qualitative) paradigm of research the transferability of a working hypothesis to other situations depends upon the degree of similarity between the original situation and the situation to which it is transferred' [72]. Again the self-evaluating process of stress-testing the new management paradigm against past disasters provides the gauge for transferability. It would not be too far-fetched to argue that a tool/theory/paradigm that adequately explains past occurrences of a phenomenon will also be suitable as a predictive or forward looking tool when dealing with the same phenomenon. It is therefore believed that the new disaster management paradigm adequately meets the requirements for transferability to other contexts within the overall man-made disaster realm.

5.5.3 Dependability

An evaluation of dependability needs to review both the *process* and the *product* of the research effort for consistency. Insofar as the process is concerned, the specific process followed during this research effort to derive the research answer, as depicted by Figure 6, needs to be scrutinised. When described in a linear fashion, the research process entailed one of analysis, synthesis, validation and then integration, with continuous feedback loops to all other sub-processes to ensure overall dependability. It does seem to constitute a logical and defendable method of enquiry to firstly analyse a phenomenon in detail; then synthesise the 'now understood' phenomenon into the bigger picture; and then to subsequently validate the results through a method of stress testing against known occurrences. The integration process, which culminated in the compilation of this research thesis, is the final action and only logical way to conclude the research effort and present findings for review and further exploration. A consistent method of enquiry, with constant feedback to rectify developed hypotheses as the process progressed and matured, was therefore followed. From a dependability point of view the research process therefore seems to be acceptable.

The product of the research project comprise two components, i) this thesis itself and ii) the theory and models developed during the research process. Insofar as the thesis document is concerned close guidelines regarding the layout and format of the final document were followed. The five-chapter layout proposed by Perry [16] was largely adhered to and the SCQARE reporting format was also incorporated. The core of the thesis is the *Concern – Question – Answer* trilogy and this entity was comprehensively addressed and illustrated throughout the thesis. It would be fair to conclude that the thesis itself adheres to the (pre-scribed) requirements for consistent reporting of a postgraduate research project.

Insofar as the actual research findings and results, i.e. the new theory and all its constituent parts, are concerned, it can be argued that the new paradigm does indeed bear close resemblance to some other widely known management frameworks, as illustriously explored in Chapter 4. An overall disaster management process model and knowledge areas were distilled and in addition the management theory underpinning the new framework was clearly demonstrated by means of a Causal Loop Diagram. Inherent to the new theory then were also a number of models that explain certain key components of the theory. So as far as a dependable theoretic structure was developed during the research project, consistency with some other related theories, and hence dependability, can be proclaimed. It is only the subject matter, which by nature represents an individual effort resulting from the one-man research effort, that remain open to external scrutiny and evaluation for dependability.

5.5.4 Confirmability

'Qualitative research, which relies on interpretations and is admittedly value-bound, is considered to be subjective' [72]. On the other hand quantitative research, which relies on numerical methods, can be considered objective. *'To avoid futile debates about subjectivity versus objectivity the (qualitative) researcher should seek 'emphatic neutrality'. Empathy is a stance towards the people one encounters, while neutrality is a stance towards the findings'* [72]. Confirmability therefore reflects the degree to which the researcher can demonstrate the neutrality of his research interpretations, when subjected to a confirmability audit [72]. In other words the researcher should leave an audit trail available for scrutiny by reviewers. This audit trail typically includes research information such as data and data sources, own notes and evidence of analysis as well as adequate developmental information that show how claims are arrived at. (Although in general the claims made in the thesis are substantiated within the thesis itself). The thesis obviously only contains the systematic write-up of the research effort and results and the documents necessary to confirm due process would be made available when and if needed. Also due to the process of rigorous referencing, it should be clear to the reviewer which interpretations are the author's and which are those of others. The reasoning process should therefore be clearly confirmable within the thesis itself.

5.6 Ethics

An evaluation of this project thesis from an ethical point of view needs to determine whether the *Answer* arrived at during the research work is indeed the 'right' thing to do given the original *Situation* (or research field). A management practice research project has the potential to uncover certain motives and behaviour of individuals or groups and it might not always be ethical towards these people to reveal this behaviour in the research results. Additionally, actions or theories proposed in the *Answer* to the research problem may have ethical implications.

Ethics can be defined quite simply as *'the science of morals in human conduct'* [1]. It refers to the standards of behaviour that prescribe how humans ought to act in the many situations in which they find themselves in as citizens, friends, parents, managers and so forth [73]. It is helpful to look at what ethics is NOT [73]:

- Ethics is not the same as feelings
- Ethics is not religion
- Ethics is not following the law
- Ethics is not following culturally accepted norms
- Ethics is not science

Ethics therefore do not lie in the eye of the beholder, with his or her individual background, values and moral convictions. It refers to some set of generic, context-insensitive guidelines for the 'right' human behaviour. Many frameworks for ethical thinking and/or decision-making exist. *'The Ethical Framework'* [74] for instance, is a compilation of simple, easy-to-understand, ethical and moral principles which focus on taking into account the common good and considering the interests of other individuals as well as one's own. This framework aims to be *'a foundation on which to build daily behaviour'* and proposes the following broad principles [74]:

- Be **for** people rather than **against** people; i.e. consider others, consider the common good
- Treat people with concern and strive for harmony; i.e. build caring, trusting relationships
- Respect the wonder of life; i.e. life is precious and sacred
- Accept responsibility to people collectively and to society as a whole; i.e. as members of society, all have responsibilities. Specifically *'the environment, the earth, space beyond the earth's atmosphere and all natural resources deserve care, concern, preservation and conservation'*.
- Accept one's own share of society's responsibilities; i.e. support society's obligation to provide every person access to a decent quality of life

Other formal ethical frameworks or sources of ethical standards include [73]:

- The Utilitarian Approach; i.e. which option will produce the most good and do the least harm?
- The Rights Approach; i.e. which option best respects the rights of all stakeholders?

- The Justice Approach; i.e. which option treats people equally or proportionately?
- The Common Good Approach; i.e. which option best serves the community as a whole, not just some members?
- The Virtue Approach; i.e. which option leads me to act as the sort of person I want to be?

In summary all ethical frameworks or standards revolve around one principle: taking care.

It is therefore clear that there is no single framework on which managers can exclusively draw to assist with their decision-making. Some attempts have however been made to integrate the various considerations prescribed by the different ethical approaches into one all-encompassing approach. Velasquez [75] suggests the following four questions to enquire systematically into the utility, rights, justice and caring involved in any particular moral judgement [76] (these questions will also be utilised to evaluate the ethical implications of this research thesis):

1. Does the action, as far a possible, maximise social benefits and minimise social injuries?

   The final management theory and its required actions do exactly this. Any attempt at understanding the unfolding of disasters with the aim of preventing the re-occurrence there-of, or the occurrence of other man-made disasters, is of noble and ethical intent. It would rather be socially and ethically unacceptable to do nothing about the occurrence of man-made disasters and allow these 'preventable' disasters to keep on claiming the lives of scores of people, cause harm to the environment and waste fortunes in remedial costs.

2. Is the action consistent with the moral rights of those whom it will affect?

   Indeed so. Every human being has the right to live, work and enjoy life without the risk of injuries, accidental death or health threats caused by human error and deficient management decision-making that may result in man-made disasters. Although this moral right of people to live free form harm are often recognised and protected through law and company policies and procedures, ignorance about the occurrence of man-made disasters may inadvertently lead to violation of this right. The new disaster prevention paradigm, through attempting to prevent such disasters, particularly strives to protect the moral right of safety and health of 'innocent' bystanders, employees, tourists and people from all walks of life. The paradigm can serve to enhance understanding and prevention of disastrous events and hence serve to protect people and thus their moral right to safety and heath.

3. Will the action lead to a just distribution of benefits and burdens?

The actions proposed by the disaster management theory will rather prevent or minimise the negative implications or liabilities resulting from man-made disasters. It may be argued that not incurring any liabilities is a benefit in itself. The fact remains that the research project revolved around the prevention of some undesirable social phenomenon, rather than the creation or promotion of some desirable phenomenon. The benefits associated with this initiative are therefore related to the decreased risks of incurring harm as a result of man-made disasters.

Insofar as burdens are concerned, it would be appropriate to argue that the 'burdens' imposed on management by the actions stemming from the application of the new disaster prevention theory are in fact justified and ethically sound. It does remain a management responsibility to prevent disasters in the first place and any tool to facilitate this endeavour can actually be construed as a 'benefit' to managers.

4. Does the action exhibit appropriate care for the well being of those who are closely related to or dependent on oneself?

The newly constructed disaster management paradigm most definitely exhibits appropriate care for people involved in potential disasters situations. If correctly applied it can serve to guide timely identification of potential disaster situations and aid greatly in the prevention of the misfortune from actually occurring. There is nothing unethical about this purpose and any attempt to prevent such misfortune from actually occurring does have the best interests of, and care for, all stakeholders as a primary objective.

Reflection on the above 4 questions and their answers therefore confirms that the research results and the implied actions stemming there from indeed constitute ethical endeavours. There are no negative ethical implications evident – the purpose and intent of this theory only project positive results and possibilities for all stakeholders.

5.7 The way forward in Disaster Management research

The final consideration regarding this research project provides a future glance on possible work that might extend, enhance or capitalise on the work done here.

Firstly additional research can be directed towards distilling all the processes applicable to disaster management and populating a 'knowledge area' vs 'process group' matrix, as delineated by the Project Management example of Table 4.1, and hinted towards in the closing paragraph of Section 4.2.3.

Secondly, to take the theory and its inherent models, assumptions and logic to the next level, a specific disaster situation needs to be analysed by means of this theory and models. This would entail creating the Discrete Element Disaster Propagation Model with all the relevant systemic constraints or event layers in detail and relating this model to the Time Continuum Disaster Propagation Model, yielding a commensurate disaster potential. This creation and population of the models will constitute a significant task, if done properly and for a fairly complex situation, and falls outside the scope of this research thesis. The completeness of these models will be a direct function of the open-minded consideration of all possible systemic considerations, as prescribed by the Causal Loop Diagram. The exercise could be done on a past disaster, to foster understanding of what went wrong, and on an identified potential disaster situation to gain understanding and a basis for intervention. As previously mentioned, the true utility of the model will only be revealed once the paradigm is actively employed in a real life disaster situation.

Thirdly and finally, the question arises whether like-minded professionals should not contemplate the creation/development of a formal Disaster Management Body of Knowledge (DMBoK), akin to the Project Management Body of Knowledge (PMBoK) explored in Chapter 4? This body of knowledge should contain the knowledge areas and processes necessary for sound disaster management (as mentioned above) and would serve as the normative standard for generic, man-made disaster management. The creation and managing of an authoritative document or entity such as this would require the inputs of numerous intellectuals worldwide (as with the PMBoK) and also the establishment of a governing body (similar to the Project Management Institute). This governing body would be responsible for the administration of the DMBoK and provide guidance and training in disaster management to practicing managers worldwide.

Disaster management could, or should, become one of the specialist disciplines within general management practice.

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APPENDIX A

LIST OF REFERENCE DISASTERS

Disaster N°1: **May 10, 1995; Vaal Reefs N° 2 Shaft, Orkney, South Africa:** 104 Miners plummeted to their death when a runaway locomotive fell down the shaft and on top of the moving conveyance they were travelling in, severing the rope attachment.

Disaster N°2: **January 21, 1960; Coalbrook, South Africa:** 437 Miners died after an underground explosion that resulted in a massive cave-in of large parts of the mine. Most of the victims were buried alive whilst all initially trapped survivors perished because no rescue efforts could reach them in time.

Disaster N°3: **September 16, 1986; Kinross, Evander, South Africa:** The use of an acetylene torch to cut a rail resulted in an underground fire that claimed the lives of 177 mineworkers. Polyurethane insulation sprayed onto the side and hanging walls to seal off water seepage ignited and generated toxic fumes that killed the workers.

Disaster N°4: **February 22, 1994; Merriespruit, Virginia, South Africa:** A tailings dam collapsed after heavy rains and obliterated a mining village located nearby and downhill of the dam. 17 people lost their lives and large-scale environmental damage was caused.

Disaster N°5: **March 27, 1985; Westdene, Johannesburg, South Africa:** A school bus laden with children on their way home from Hoërskool Vorentoe plunged into the Westdene dam when the driver lost control of the bus. 42 children could not escape or be rescued from the bus and drowned.

Disaster N°6: **July 19, 1985; Stava, Trento, Italy:** A fluorite tailings dam, consisting of two basins built on a slope, collapsed, engulfing two downstream villages in a tidal wave of sludge. 286 people lost their lives and environmental damage of an unprecedented scale ensued.

Disaster N°7: **March 27, 1980; Vaal Reefs N° 2 Shaft, Orkney, South Africa:** A descending conveyance got stuck in the shaft and the hoisting rope was still paid out. The slack rope coiled on top of the stranded conveyance. The obstruction in the shaft suddenly gave way and the conveyance fell abruptly. When it reached the end of the slack the force ripped the transom off the cage, sending 31 people to their deaths at shaft bottom.

Disaster N° 8: **May 1, 2003; Saulspoort, Free State, South Africa:** Fifty-one municipal workers, on their way to a Workers' Day rally in Qwa Qwa, died in the early hours of May 1, 2003, when their bus plunged into the Saulspoort Dam on the outskirts of Bethlehem in the eastern Free State. The bus driver had become disorientated in the unfamiliar surroundings in the dark and drove down an unrestricted road that led straight down to a jetty and into the dam. Technical deficiencies with the bus' braking systems and emergency escape exits were later cited as causes contributing to the disaster.

Disaster N° 9: **December 2, 1984; Bhopal, India:** At the Union Carbide Pesticide plant a faulty pipe washing operation resulted in water entering a storage tank containing Methyl Isocyanate. A violent chemical reaction ensued and large quantities of poisonous gas were released into the atmosphere until the reaction ended without intervention at about 2 am. More than 2500 people died shortly after being exposed to the poisonous chemical and more than 200 000 were injured. Large animal losses occurred and standing crops were devastated. Independent agencies estimate that the number of disaster-related deaths is currently between 15,000 and 20,000. This accident is widely recognised as the worst industrial accident in history.

Disaster N° 10: **1930-1931; Hawk's Nest, Fayette County, West Virginia, USA:** Hundreds of workers (some figures quote +/- 760) died during construction of the Hawk's Nest tunnel as part of a project to provide hydro-generated electricity to the Electro Metallurgical Company, a subsidiary of the Union Carbide Corporation. The tunnel was drilled through pure silica and the workers contracted silicosis as a result of inhaling fine silica dust generated by the dry drilling techniques that were enforced by the company for economic reasons. No respiratory protective equipment was supplied to the contract workers in the tunnel - only to inspectors and company men. This disaster is viewed as the worst industrial disaster in the history of the USA.

Disaster N° 11: **August 5, 1949; Mann Gulch, Montana, USA:** A 15 man smoke jumper platoon parachuted down to fight a forest fire that was started by lightning. They were joined on the ground by a forest guard. Whilst on their way down the gulch towards the Missouri river the fire jumped the gulch and blocked their path. As the fire burned towards them the fire fighters desperately tried to outrun the fire up the steep slopes of the gulch. They were overwhelmed by the quicker moving fire and thirteen men perished.

Disaster N° 12: **January 28, 1986; Space shuttle Challenger:** Just more than a minute after take-off the Challenger exploded, killing all 7 crew members instantly. The launch took place at a very low temperature and the subsequent explosion was caused by a failure of a seal on the right side solid rocket booster. Replacement cost of a shuttle was estimated at more than $2 billion and the space shuttle programme was severely compromised and delayed.

Disaster N° 13: **March 6, 1987; Herald of Free Enterprise; Zeebrugge, Belgium:** Whilst busy with a routine channel crossing the passenger and freight ferry (HFE) left the Zeebrugge harbour with its bow doors still open. The vessel took in water, capsized and came to rest on a sand bank. 193 passengers and crew members lost their lives.

Disaster N° 14: **April 14, 1912; Titanic; North Atlantic Ocean:** More than 1500 people lost their lives when the luxury cruise ship hit an iceberg and sank during its maiden voyage from Southampton, England en route to New York, USA. Its creators had heralded the ship as 'unsinkable'.

Disaster N° 15: **April 26, 1986; Chernobyl Nuclear Power Plant, Ukraine, (former USSR):** Whilst testing reactor N° 4 numerous safety procedures were disregarded and the reactor became unstable. The chain reaction in the reactor raged out of control, causing explosions that ripped off the reactor's steel and concrete lid. High levels of radioactivity were spewed into the atmosphere. The final death toll, financial implications and environmental repercussions will never be accurately known.

Disaster No 16: **May 9, 1992; Westray Coal Mine Disaster, Novia Scotia, Canada:** An explosion in the Westray Coal Mine killed all 26 miners underground at the time of the explosion. The cause of the explosion has been attributed to a combination of methane gas and coal dust build-up within the mine whilst the actual event that triggered the blast has never been identified.