REPRESENTATION OF OCCUPATIONAL HYGIENE DATA BY WAY OF A GEOSPATIAL INFORMATION SYSTEM:

INFLUENCE ON OCCUPATIONAL HYGIENE KNOWLEDGE

By

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DECLARATION

I, Hendrik Willem Johannes van der Westhuizen declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Hennie vd Westhuizen

30 August 2018

Signed **Date**

ABSTRACT

Occupational Hygiene is an international professional discipline that is involved in the anticipation, recognition, evaluation and control of conditions (stressors) in the workplace that could cause occupational related illness and disease. In the process risk assessments, technical reports, sampling results and management plans are generated. These documents may be found in various formats e.g. electronic versions and hard copies and may be geographically dispersed within a company.

In order to manage the stressors e.g. chemical, physical, biological and ergonomic the gathered data need to be transformed into information. Retrieval and cross correlation of information could be optimized if the information was consolidated in one site and format.

Geographical Information Systems (GIS) has the ability to capture, consolidate, integrate, interrogate and display large volumes of data. In this research project, the ability of GIS to add value to management data within the paradigm of the knowledge cycle was investigated in terms of an increase of knowledge. Apart from previous work by the author that was done on noise management, no evidence could be found of similar studies combining occupational hygiene, GIS and the knowledge cycle and it appears as if this is the first study of its kind. The process involved a design science approach in the design of a model that could accommodate the Occupational Hygiene (OH) data. The model consisted of a generic framework that was structured in layers to accommodate the spatial data of the various stressors. In addition, a layer was created to deal with nonspatial management data. The model was applied to three industrial plants of two international companies on two continents, after which the opinions of staff members of the individual plants were gathered by way of semi-structured interviews.

It was found that GIS could successfully capture OH data and provided an improved level of information to manage and present OH related data. Value was added in that new perspectives of existing data were created by superimposing the various layers. Despite the differences in products and the geographic distribution, the results of the evaluative feedback interviews proved to be almost identical for all three industrial plants. The results supported an increase of knowledge as interpreted within the paradigm of the elements and sub-elements of the knowledge cycle. In addition to this, a strong spike in the ability of GIS to integrate knowledge and present it in an understandable visual format was reported.

Key words: Occupational Hygiene, Occupational Health, GIS, Knowledge Management**.**

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DEDICATION

To my wife Tryna, who patiently supported me throughout the entire process.

Contents

GLOSSARY

Accessibility	Accessibility means the degree to which web sites, software, or computers provide equivalent information and functionality to a variety of people, including those with disabilities or visual impairment (Esri, n.d.).
AIHA	American Industrial Hygiene Association.
Attribute table	A table in GIS in which the attributes (descriptions) of a specific area of a map are stored. E.g. sampling dates or sampling results.
Base map	A computer-aided drawing or geographic map, used as a base layer onto which additional layers are superimposed.
CAD	Computer aided drawing.
Data	Unorganized facts and observances e.g. random sets of sampling results.
Database	A database is one or more structured sets of persistent data, managed and stored as a unit and generally associated with software to update and query the data. A simple database might be a single file with many records, each of which references the same set of fields. A GIS database includes data about the spatial locations and shapes of geographic features recorded as points, lines, areas, pixels, grid cells, or TINs, as well as their attributes (Esri, n.d.).
Dendrogram	Schutte (2006) defines a dendrogram as a technique designed as a tool to conceptualise the research design and to develop questionnaires.
DSRM	Design Science Research Methodology.
Esri	Environmental Systems Research Institute based in Redlands California.
Essential OH data	Data required to manage OH Stressors.
Geodatabase	A geodatabase is a database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference system, attributes, and behavioural rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others (Esri, n.d.).
Geodesy	The science of accurately measuring the size and shape of the earth and its gravitational and magnetic fields. (Clarke, 2001:329).
GIS Geographic Information System	GIS consists of a special type of computer programme capable of storing, editing, processing, and presenting geographic data and information as maps (Campbell and Shin, 2011:24).

GPS	A global positioning system (GPS) is an operational, U.S. Air Force-funded system of satellites in orbits that allow their use by a receiver to decode time signals and convert the signals form several satellites to a position on the earth's surface (Clarke, 2001:329).
GUI	Graphical User Interface.
ILO	International Labour Organization.
ILO-OSH	International Labour Organization - Occupational Safety and Health system.
Industrial plant	Refers to a production plant of and industry. This term is used interchangeably with the word "plant".
Information	Data plus context (Schulte et al., 2004).
IOHA	International Occupational Hygiene Association.
ISO	International Organization for Standardization.
Knowledge	Information and judgement (Schulte et al., 2004).
Knowledge management	Knowledge management is the process through which an enterprise uses its collective intelligence to accomplish its strategic objectives (Barquin, 2001).
MXD	An abbreviation used in Geographical Information Systems that means "Map Exchange Document".
Nonspatial data	Nonspatial data refers to data that do not pertain to a specific geographic area. E.g. management reports, strategic plans, risk assessments.
Occupational Health	Occupational Health within the context of this dissertation includes the activities of the following professions: Occupational/Industrial Hygiene, Occupational Nursing, Occupational safety and Occupational Medicine.
Occupational Hygiene (OH)	Occupational hygiene is the anticipation, recognition, evaluation and control of conditions arising in or from the workplace, which may cause illness or adverse health effects to persons (South Africa, 1993).
Occupational/Industrial Hygienist	Occupational or Industrial hygienists are professionals who practice occupational hygiene. The terms occupational and industrial hygiene are used interchangeably in this document.
OHSAS 18001	Occupational Health and Safety Assessment Series – 18001. As developed by the International Standards Organization (ISO).
Personal data	OH, data pertaining to an individual in the workplace e.g. dust exposures. This data does not include HIV status, age or other personal information.
Photogrammetry	The Esri support GIS dictionary defines photogrammetry as "the science of making reliable measurements of physical

	objects and the environment by measuring and plotting electromagnetic radiation data from aerial photographs and remote sensing systems against land features identified in ground control surveys, generally in order to produce planimetric, topographic, and contour maps". (Esri, n.d.)
Qualiquantive	A research approach involving qualitative and quantitative methods.
Semantograph	The semantograph may be defined as a graphical presentation, presented as a bar graph, that shows the importance of the main perceptual and evaluative components of a groups' subjective image. In this study the semantic perceptions were projected onto radar graphs where each axis represents as associated semantic clustering of an element of the knowledge cycle as applied to the management of occupational hygiene in the workplace. The magnitude of the responses on each axis portrays the number of responses that corresponded with a specific element. Thus, the concept "semantograph" is associated with a semantic construction, and not only with one of the visual presentations of statistical data (Diaz-Guerrero & Szalay, 1991:27).
Spatial data	Any data that can be mapped for example the sampling points in an industry.
System	A system is group of independent but interrelated elements, such as sampling data, strategic plans, risk assessments, computer programmes and legislation used for managing OH stressors in the workplace (Free Dictionary, 2012).
Tacit knowledge	Indigenous knowledge in the company that has not been written down.
Workplace data	All OH related data pertaining to a workplace.

CHAPTER 1: OVERVIEW OF THE STUDY

1.1 Introduction

This chapter serves as an introduction to the interdisciplinary study, which investigated the improvement of occupational hygiene (OH) management by way of geographical information systems (GIS). It provides a brief background, problem statement and motivation for the study. These introductory paragraphs are followed by several others dealing with the focus of the study and outlay of the chapters.

This thesis is the culmination of data collected during an international study at industrial plants of multinational companies in Belgium and South Africa under the auspices of the Catholic University of Leuven in Belgium and the Cape Peninsula University of Technology.

1.2 Background

Occupational hygienists practice an internationally accepted profession that may be defined as the anticipation, recognition, evaluation and control of conditions arising in or from the workplace, which may cause illness or adverse health effects to persons (South Africa, 1993). Typical actions of the occupational hygienists according to Goelzer (2012) would be to conduct adequate preliminary surveys, sampling, measurements and analysis for hazard evaluation and control purposes, and to recommend control measures and if required, design controls. Industry uses the information in these reports in their occupational health and safety management systems along with other internally or externally generated data, e.g. internal progress reports and audit information. According to Redinger and Orr (2011:1326) the most commonly used management systems used by industry in 2011, were:

1. OSHAS 18001:2005
2. ANSI Z10:2005
3. ILO OHSMS:2001

This project dealt with the control phase of the conditions in the workplace that included the associated hazards and risks to the workforce.

1.3 Problem statement

The management of occupational hygiene (OH) entails the accumulation of volumes of information, such as risk assessments, sampling and biomonitoring results, legislation, company policies and strategic plans. This data are found in various formats (Van der Westhuizen, 2005:29; Kamardeen, 2011:50-64) and because of its nature, may be geographically dispersed within a company.

Seen within the context of knowledge management, the mere availability of data is not sufficient and could easily result in clutter, which could make it challenging to be used in the management process. The US Federal Chief Information Officer Council (2004) cited in Schulte et al., (2004) stated that data is unorganized facts and only when insight and observations are added to data, does it become information. It is information that is required for proper decision-making and data would only be the first step in the process of acquiring of knowledge to manage, i.e. sampling data of stressors needs to be combined with legal parameters to provide information to managers in making decisions.

From this, it is clear that the management of OH stressors found in the working environment, have to be based upon accurate data and information. In the process, vast quantities of data of various descriptions and origins need to be filtered to transfer data into information. This problem is typically not unique to OH, as the need for systems to deal with this problem has been expressed in systems biology (Maier et al., 2011:3).

As mentioned before, data may be found in different formats. For valid and reliable comparisons and predictions to be made, the data needs to be consolidated, a process, which may be time-consuming and costly in the industrial environment.

After gathering and sorting of data, the information needs to be communicated to decision-makers. Fielding (1995:6) suggests that bulky or technical information should preferably be conveyed by way of visual means, e.g. tables, graphs, diagrams, pictograms, maps, flow charts and cartoons. Therefore, the data has to be processed into information before it can be written in reports or communicated during meetings.

Conveying Occupational Health and Safety (OHS) information to management could be problematic as technical information, such as results of noise monitoring, is rarely presented in such a way as to enable the decision-makers to identify potential risks, evaluate trends, to gain a holistic perspective of the situation and/or to develop and implement check controls (Van der Westhuizen, 2004:24).

In summary, the problem was to find a solution to the unification and presentation of OH data in such a way as to provide OH managers with a more holistic input for improved decision-making and management.

Since the advent and use of GIS in various fields, the applications have multiplied and are currently used in many disciplines (see chapter 2). According to Esri (n.d.), GIS "is a framework for gathering, managing and analysing data. Rooted in the science of geography, GIS integrates many types of data. It analyses the spatial location and organizes layers of information into visualizations using maps and 3D scenes. With this unique capability, GIS reveals deeper insights into data, such as patterns, relationships and situations which help users make smarter decisions".

From the above, it may be concluded that GIS could provide an answer to the consolidated storage of data, whilst simultaneously conveying information as the processing of the data (in GIS) specializes in conveying data connected to a specific geographical area in a visual format, enabling the user to form a comprehensive, informative picture of an OH related situation at hand. Therefore, this study aimed at answering the following two questions. As GIS has the ability to store vast amounts of data and could provide a solution to the unification and presentation of data, the question arose as to whether it could (i) successfully integrate and present both spatial and non-spatial data in such a way as (ii) to provide a holistic input for better decision making and management of stressors. Through investigating the afore-mentioned question, a further question was investigated, namely whether there would be any gain in knowledge by presenting OH data based on GIS modelling to a manager and if so, what is the gain? The driver underlying both the questions was whether an increase in knowledge as presented with the help of GIS could be detected in the elements of the knowledge cycle (creation, transfer, utilisation) as applied to OH (Schulte et al., 2004). To achieve this, an OH GIS model was developed and evaluated during a pilot project at a selected industry, after which the implementation of the model was done at branches of another (international) industry. Measurements were done by way of semi-structured interviews in both the pilot and implementation projects.

1.4 Importance of the study

There are several reasons for conducting this study. These reasons are provided below.

1.4.1 Financial reasons

Apart from the moral responsibility for worker protection (Schulte et al., 1986; Gewirth, 1986), there is a financial obligation to reduce expenses related to occupational diseases. Occupational diseases may incur great costs to a company, this point is illustrated by the fact that the 2015/16 financial year medical invoices paid by the compensation commissioner in South Africa, amounted to R2,620,159,000 (South Africa, 2016). Therefore, better management of stressors due to improved data management could contribute toward reducing costs incurred due to occupation-related diseases. This study investigates a possible solution to the better management of data generated in industry towards the creation of better information for decision-making.

1.4.2 International call for improvement in data management

The campaign of the International Labour Organisation (ILO) for the 2017 World Day of Safety at Work focused on the critical need for countries to improve their capacity to collect and utilize reliable occupational health and safety data (ILO, 2017.n.d.). It is argued that GIS provides an electronic database for consolidating, capturing, accessing and interrogating vast amounts of data. Theoretically, this system could be advantageously used for occupational hygiene data.

1.4.3 Data management across disciplines

This system has the potential to combine occupational health, clinical, safety and environmental data and was investigated during a combined European, British and South African project (Delaunay et al., 2015). Thus, removing profession specific data from their silos in the health and safety field and combining the data to be processed into information that provides a holistic perspective on the situation at hand.

The need for communication of information between disciplines is confirmed in an article by Boschman et al., (2016:01). The article states that "The prevention of occupational diseases is limited by a lack of insight into occupational exposure to risk." The authors proceed by stating that they developed a six-staged approach for Occupational Medical Practitioners to improve the diagnosis and reporting of occupational diseases. Steps 3 and 6 of Table 1 of the document calls for occupational hygiene data such as:

1. Exposure data
2. Workplace measurements
3. Reduction of the exposure
4. Personal protective equipment
5. Maintenance of this equipment
6. Control measures e.g. Elimination or reduction of exposure
7. General technical measures
8. Individual, organizational and/or procedural measures
9. Personal protective equipment

1.4.4 Virtual management for international companies

Virtual management became a reality at the turn of the century (Bigelow, 2002). International production companies have plants across the world and health and safety management takes place from a specific country and relies on virtual means for communication and dissemination of information. The system under investigation could prove to be efficient at data management and communication, resulting in better information for decision making, even in a virtual environment as it has the potential to capture the information of each industrial plant of multinational companies, across the world. Thereby permitting access to and interrogation of data, enabling the virtual management of all plants, from a single office anywhere in the world.

1.4.5 Product development

This study aims to serve as a baseline of proof for the development of a marketable product for the management of Occupational Health and Safety data.

1.4.6 International research collaboration

This South African initiated study dovetailed with a study conducted at the University of Grenoble in France that was investigating the use of GIS for the representation of environmental and occupational health data. The South African study investigated the use of GIS indoors in industries while the French study investigated the use of GIS on health-related data emanating into the environment from factories. After the involvement of Belgium and the UK, results of findings were published in the international accredited Oxford journal; Occupational Medicine. (Delaunay et al., 2015)

1.4.7 Exposome

A relatively new branch in epigenetic research deals with the exposome. The phrase exposome was coined by Wild (2005). The National Institute for Safety and Health (NIOSH, n.d.) defines exposome as "…. The measure of all the exposures of an individual in a lifetime and how those exposures relate to health". An individual's exposure begins before birth and includes insults from environmental and occupational sources. It follows on the same page in the same document that the term exposomics refers to the measurement of the exposures mentioned above. This would include exposures such as hazardous chemicals, ionising radiation and hazardous biological agents.

Occupational exposures are amongst the exposures that need to be measured over a lifetime. According to Leu and Wang, (2014) GIS is used for capturing environmental data and it is argued that it may offer a solution for data capturing, as well as the management and storage of occupational exposure data. Thus, providing a solution to the data management of environmental and occupational hygiene data.

1.5 Aim of the study

The aim of this research project was to establish whether the use of GIS in the management of OH could add value to the management of OH data at a company with industrial plants worldwide.

1.6 Goals

The goals of the research were to:

1. Develop an application (model) of GIS for the management of OH data in the workplace.
2. Establish whether this application (model) adds value to the OH management data within the knowledge management paradigm.

1.7 Objectives

To attain the above aim and goals, objectives were set. These objectives are:

1. Development of a generic model for the management of OH data in an Excel spread sheet, using OHSAS 18001 and ILO-OSH 2001 as a point of departure.
2. The initiation of a pilot project at an industrial plant in Belgium. This project involved applying the model by capturing OH data from the company onto the framework.
3. Evaluation of the model during the pilot study. This was done by evaluating the compatibility of OH data and GIS features. After which the effect on the knowledge cycle was evaluated by way of semi-structured interviews with professionals and staff.
4. Implementation of the model at one industrial plant in Europe and one in South Africa by following the same route as above.

1.8 Hypotheses

The following two hypotheses were posed and served as the underlying drivers for the study.

1. It is possible to visually integrate and interrogate spatial and nonspatial OH data on GIS.
2. The implementation of GIS increases the quality of OH knowledge on which decisions are based in industry.

1.9 Study field

This multidisciplinary study cut across and following three combined major fields into one programme. These fields are: (i) Occupational hygiene, (ii) Geographical information systems and (iii) Knowledge management.

1.10 Structure of the dissertation

The dissertation is structured as follows:

1. **Chapter 1:** Overview of the study
2. **Chapter 2:** Literature study
3. **Chapter 3:** Methodology
4. **Chapter 4:** Model development
5. **Chapter 5:** Interviews
6. **Chapter 6:** Analysis and discussion
7. **Chapter 7:** Summary, findings, suggestions, conclusion
8. **References**
9. **Annexures**

1.11 Conclusion

Chapter 1 provided an overview of the need for and rationale behind the study.

In preparation for the chapter on research methodology, the next chapter will provide a literature study on topics contained in the dendrogram.

CHAPTER 2: LITERATURE STUDY

2.1 Introduction

The first chapter focussed on the background and problem statement. This chapter entails a literature study in support of the research.

At the onset of the study, literature was available that combined construction safety and GIS (Manase et al., 2011) and another combining the knowledge cycle and Occupational Hygiene (Schulte et al., 2004). Apart from the publications of Van Der Westhuizen (2004) and (2005) that described the representation of Hearing Conservation data by way of GIS, no other literature could be found that combined Occupational Hygiene management data, GIS and the knowledge cycle. This study is perceived to be the first of its kind that integrates the fields of the knowledge cycle, occupational hygiene and GIS. Sources could not be found in the literature on the linking of the above disciplines or the development of a model that could serve as a management tool for OH data. Therefore, new ways had to be found or designed in the development of the envisaged model and for evaluating the impact thereof on the knowledge cycle.

2.2 Dendrogram

The project was structured by way of a dendrogram. The dendrogram technique is designed as a tool to conceptualise the research design and to develop questionnaires (Schutte, 2006). Mouton and Marais (1988:139) argue that a typology serve as a frame of reference for data gathering and observation guides data gathering and facilitates analysis. Because of this fact and its perceived versatility to arrange the study field into manageable concepts and dimensions, a dendrogram was used in this study to crystallise the logical flow and interrelationships of the main thoughts. The literature review is done in the order of the headings of the dendrogram.

2.3 Improvement of OH knowledge management by way of GIS

The aim of this research project was to establish whether the use of GIS in the management of OH could add value to the management of OH data. This aim as reflected in the first tier of the dendrogram (below), incorporates three concepts namely;

1. occupational hygiene,
2. GIS and the
3. knowledge cycle.

A discussion of each of these items is provided in the following paragraphs. These discussions will be followed by the relevant subsections, as drawn from the underlying theoretic argument in the dendrogram as portrayed in Figure 2.1.

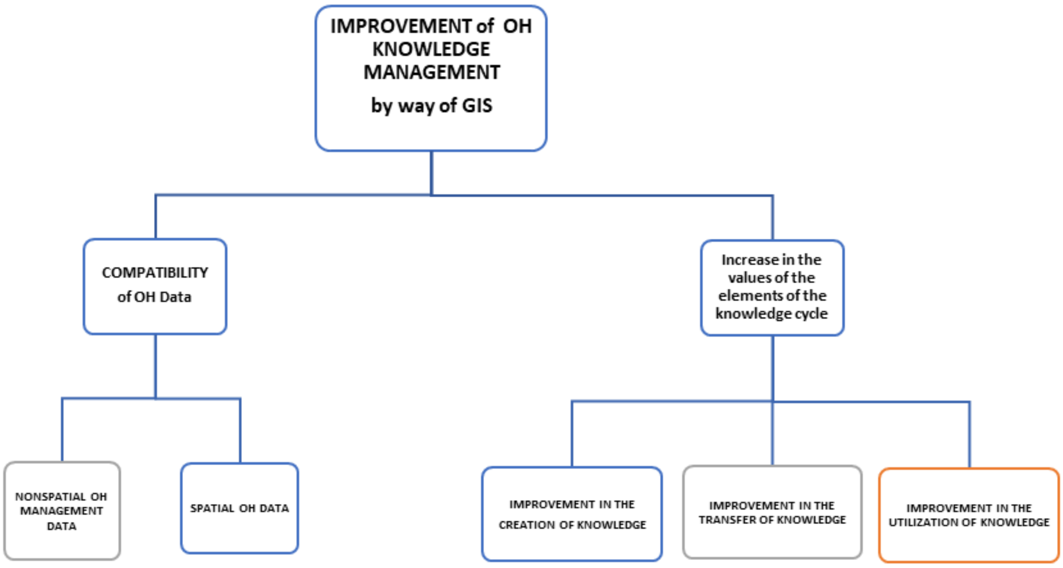


Figure 2.1: First three levels of the dendrogram pertaining to the study

2.3.1 Occupational hygiene

Many definitions may be found for this field, locally as well as internationally such as those of the International Occupational Hygiene Association (IOHA) (2018), the American Industrial Hygiene Association (AIHA), (n.d.) and South African legislation. For this study, the point of departure is that of the South African Occupational Health and Safety Act of 1993 No. 85 of 1993 (South Africa, 1993:5) as it directly reflects the same essential stages as IOHA, AIHA and Guild et al., (2001:6). These stages being anticipation, recognition, evaluation and control. The reason for the choice is that this study cut across international borders and was done at American based international companies in Belgium and South Africa. Therefore, management principles within the paradigm of OH in this study are internationally compatible. The part of the definition of OH that pertains to this study is the control part that applies to the management of stressors in the workplace.

2.3.1.1 Background occupational hygiene

A brief background and perspective on the development of occupational hygiene are provided below. The aim of the profession is to prevent occupational diseases, as aptly captured by the word “hygiene”. The word was derived from the mythological Greek goddess known as Hygeia that was associated with being concerned with the preservation of good health and the prevention of disease (IOHA, 2018; Smith, 1884:383).

Occupational hygiene as a profession developed over time, from the initial awareness and recognition of stressors that could result in occupational disease to the actual evaluation and management of the stressors causing the disease. As early as 460-377 BC, Hippocrates realised that lead might cause colic (Schoeman & Schreuder, 1994:5). The management of stressors has become more formalised since the early days. Government departments were tasked to legislate worker protection. International bodies such as the International Labour Organization (ILO) and IOHA concerned with the promotion of occupational health were formed, and international standards for occupational health and safety standards such as OHSAS 18001 were generated by bodies such as the International Organization for Standardisation (ISO), for the management of OH in industries worldwide. The management systems of the industrial plants at which the research was conducted were based on OHSAS 18001. A new standard has been generated in 2018, namely ISO 45001:2018 (ISO, 2018) which is an improved version of OHSAS 18001.

2.3.1.2 The profession

The practice of occupational hygiene is an established profession and is practised in many countries around the world. Persons who practice this profession are known as occupational/industrial hygienists. This section aims to provide insight into the discipline itself.

As mentioned in section 1.2 occupational hygiene is defined in the South African legislation as the anticipation, recognition, evaluation and control of conditions arising in or from the workplace, which may cause illness or adverse health effects to persons (South Africa, 1993:5; IOHA, 2018; AIHA, n.d.).

The conditions that may give rise to illness or adverse effect that is referred to in the definition are caused by stressors. These stressors are the various agents that workers may be exposed to while conducting their work. Some of the stressors have a singular effect on the body and others have similar effects on the body, and a combination of these stressors could have a combined or even synergistic toxic effect on the body. E.g. both noise and lead (Choi et al., 2012:9) affect the nervous system. The detrimental impact of high noise levels on the nerves on the inner ear of a worker may be exacerbated by simultaneous exposure to lead. It would, therefore, be of importance to a person managing the stressors to know when such exposures occur and where they are to be found. The process of identifying the hazards and assessing the risks are known as a risk assessment.

These stressors are:

1. Chemical stressors: Chemical stressors are chemical agents that may harm the body. Some chemicals have different effects on the body and may be classified as, carcinogens, asphyxiants, teratogens, neurotoxic, toxic to specific organs. Carcinogens are cancer forming. Examples of carcinogens are benzene and chromium[6] (South Africa, 1995:40,42; International Programme on Chemical Safety). (These chemical agents were anticipated to be present on some of the sites where the research was conducted.)
2. Physical stressors: Physical stressors are physical agents such as; ionising radiation that would include alpha, beta and gamma radiation; non-ionising radiation such as lasers, microwaves, ultraviolet radiation, electromagnetic frequencies (EMF); insufficient or oversupply of illumination; thermal exposure against heat and cold; noise. Each of these physical stressors has a unique effect on the body that ranges from physical burns, heatstroke, cancer, blindness, sensorineural deafness and other effects. Kroemer and Grandjean (1997:372) notes that when core temperatures reached around 39ºC during military exercises, it resulted in heatstroke and could lead to death.
3. Ergonomic stressors: Ergonomic stressors deal with humans and their working environments. Schutte and James (2007:299) provides an apt description of the discipline stating that it is a multidisciplinary science with contributions from disciplines such as Engineering, physiology, medicine, psychology, industrial design and occupational hygiene. Typical examples of aspects considered within the field of ergonomics would include, working postures, body movements such as pulling, pushing and lifting, and the actual energy expenditure during a task. In addition it would include environmental factors such as thermal stress, noise, vibration, illumination, air quality and night work (Schutte and James, 2007:299) According to the National Institute for Occupational Safety and Health (NIOSH) (2018.) in the United States of America, the goal of ergonomics is the elimination of injuries and disorders associated with soft tissue injury. NIOSH elaborate by saying that the workplace should be designed to fit the employee's physical capabilities and limitations, a fact echoed by Acutt and Hatting (2011:132). Workplaces are not necessarily ideal depending on when they were built and the information and technology available at the time. Therefore, these stressors need to be managed.

4. Biological stressors: According to Plog (1994:6) biological hazards (stressors) include insects, moulds, fungi and bacterial contamination. These are pathogenic organisms that can cause disease or death. Legionella pneumophila is such an organism. Ulleryd et al. (2017) mentioned that numerous publications had seen the light on community outbreaks of legionnaires disease that was caused by this organism and of which most cases were associated with cooling towers. For effective management of legionnaires disease in the workplace, the possible breeding sites need to be identified, and the associated risks managed. A starting point in the legislative management of legionella and other hazardous biological agents in South Africa is the promulgation of the Regulations for Biohazardous Regulations that list the agents, classify them and prescribe actions to be taken towards controlling the various categories of agents (South Africa, 2001).
5. Psychological stressors: These hazards incorporate psychological aspects affecting workers such as management styles, fatigue, work/rest schedule and boredom (Plog, 1994:3). The Occupational Safety and Health Administration (OSHA, 1998) differs from other authors like Schoeman and Schreuder (1994:9) by not listing psychological stressors. It was concluded from the literature that the inclusion of psychological stressors might not be a universal practise amongst occupational hygienists. Psychological stressors were, therefore excluded from this study.

When managing stressors, the unique effects of each have to be considered, the results need to be recorded, and the stressors managed accordingly. The data pertaining to the measurement or evaluation of stressors that were generated by the occupational hygienist are recorded onto reports, which are then provided to the management systems of the industries for the management of those stressors.

In South Africa, an Occupational Hygienist is a person who is registered as an Occupational Hygienist with a professional occupational hygiene organisation (Southern African Institute for Occupational Hygienists) recognised by the Chief Inspector of the Department of Labour. Such person is a qualified, trained and experienced scientist or engineer who can conduct occupational hygiene monitoring and provide professional advice and recommendations on workplace associated hazards (Department of Labour & SANAS, 2016:6). In South Africa, Occupational Hygienists may be found at academic institutions, the mining sector, the Department of Labour and in the private sector either as consultants or as employees of companies responsible for health and safety or hygiene.

These professionals anticipate, recognise, evaluate and control the stressors in the workplace, as mentioned in paragraph 2.2.2.2 above. The profession draws from various disciplines, e.g. engineering, physics, chemistry and biology, amongst others (Plog, 1994:3). In broad terms, the occupational hygienist would identify hazards in the workplace, confirm suspicions by sampling and then determine the extent of exposure and the risk to workers. The occupational hygienist would then prescribe measures in scientific reports to manage the risk by applying the hierarchy of control, namely (National Institute for Occupational Health, 2015; British Occupational Hygiene Society, 2011):

1. Eliminate the hazard.
2. Substitute the hazard for a less hazardous one.
3. Implement engineering controls, e.g. provision of local exhaust ventilation at points where toxic substances are emitted.
4. Implementation of administrative controls, e.g. training of individuals with regard to the hazards that they will be exposed to and how to reduce the risk of exposure.
5. The provision of personal protective equipment.

All of these actions involve the generation of data that needs to be captured either in hard copy or in electronic format. This data then provide the information for companies on which they base their risk management programmes.

2.3.1.3 Occupational/industrial hygiene as an international profession

Occupational hygiene is practised in many countries across the world. It is an organised profession where societies, institutes or associations are formed by professionals practising the occupation in their specific countries across the world. All of these organisations are dedicated to the discipline and of the inherent principles of occupational hygiene. These bodies are affiliated with an international body, the International Occupational Hygiene Association (IOHA). The mission of IOHA is to: Enhance the international network of occupational hygiene associations that promotes, develops and improves occupational hygiene worldwide, providing a safe and healthy working environment for all (IOHA:2018).

Member organizations are:

1. American Conference of Governmental Industrial Hygienists (ACGIH)
2. American Industrial Hygiene Association AIHA
3. Association of Hygienists of Argentina (AHRA)
4. Australian Institute of Occupational Hygienists AIOH
5. Belgian Society for Occupational Hygiene

6. Brazilian Association of Occupational Hygienists (Associação Brasileira de Higienistas Ocupacionais, ABHO)
7. British Occupational Hygiene Society BOHS
8. Canadian Registration Board of Occupational Hygienists CRBOH (Conseil Canadien d'Agrément des Hygiénistes du Travail, CCAHT)
9. Colombian Association of Occupational Hygiene
10. Dutch Occupational Hygiene Society (Nederlandse Vereniging voor Arbeidshygiëne, NvvA)
11. French Occupational Hygienists Society (Societe Francaise des Hygienites du Travail or French Occupational Hygienists Society)
12. Finnish Occupational Hygiene Society (Suomen Työhygienian Seura, STHS)
13. German Society for Occupational Hygiene (Deutsche Gesellschaft für Arbeitshygiene, DGAH)
14. Hong Kong Institute of Occupational and Environmental Hygiene
15. Indonesian Industrial Hygiene Association (IIHA)
16. Italian Industrial Hygiene Association
17. Japan Occupational Hygiene Association
18. Japan Association for Working Environment Measurement (JAWE)
19. Korean industrial Hygiene Association (KIHA)
20. Macedonian Association of Industrial Hygiene and Occupational Health
21. Malaysian Industrial Hygiene Association
22. Mexican Industrial Hygiene Association (Asociación Mexicana de Higiene Industrial – AMHI)
23. New Zealand Occupational Hygiene Society NZOHS
24. Norwegian Occupational Hygiene Association (Norsk yrkeshygienisk forening, NYF)
25. Occupational & Environmental Health Society of Singapore
26. Occupational Hygiene Society of Ireland OHSI
27. Polish Association of Industrial Hygienists (Polskie Towarzystwo Higienistów Przemys?owych – PTHP)
28. Spanish Association of Industrial Hygiene
29. Southern African Institute for Occupational Hygiene – Certification Board (SAIOH-CB)
30. Swedish Association of Occupational and Environmental Hygiene (Svensk Yrkes- och Miljöhygienisk Förening, SYMF)
31. Swiss Society for Occupational Hygiene (Schweizerischen Gesellschaft für Arbeitshygiene – SGAH, Société Suisse d' Hygiène du Travail – SSHT)
32. Taiwan (Province of China) Occupational Hygiene Association (TOHA)
33. Vietnamese Industrial Hygiene Association (VIHA)

From the paragraphs above it is clear that occupational hygiene is a profession which is internationally practiced and where there is an interaction between countries.

2.3.1.4 Relationship with other professions

According to the World Health Organization (WHO) Regional Office for Europe, Copenhagen, “Occupational health is primarily a prevention-orientated activity, involved in risk assessment, risk management and pro-active strategies aimed at promoting the health of the working population”. The office elaborates that no single professional group has all of the necessary skills to achieve this goal and so co-operation between professionals is required (WHO, 2001: 27). This need for co-operation in the management of Occupational Health is an echo of an earlier declaration of the Ministerial Conference on Environmental Health where the need for harmonised management approaches that would protect and promote the health of workers and people living in industrial settings and protect the general environment was emphasized. Occupational hygienists work in collaboration with other professions such as safety officers, occupational nurses, occupational medical officers, engineers, towards safety and health in the workplace. The main professions that could be involved in health and safety at an industrial plant are briefly discussed in the paragraphs below. These professions generate related information, and when this information is viewed as a whole, it could contribute towards the more holistic management of the risks in the workplace. It may be noted that the individual functions of the professions below may vary from company to company depending on company structure and policy. The essential factor to bear in mind is that all the data gathered contribute towards the final goal of occupational health.

2.3.1.4.1 Safety officers

Safety officers are mainly concerned with accident prevention and control.

According to Plog (1994:587), the functions may be divided into four major areas, namely:

A. “Identification and appraisal of hazardous conditions and practices and evaluation of the severity of the accident or loss problem.
B. Development of hazard control methods, procedures and programmes.
C. Communication of hazard control information to those directly involved, including the management, planning and motivation necessary to integrate safety considerations into operations.
D. Measurement and evaluation of the effectiveness of the hazard control system and development of the modifications needed to achieve optimum results”.

2.3.1.4.2 Occupational nurses

Occupational nurses are professionals who have a qualification in occupational health and are registered as such. In South Africa, such a person would typically have a qualification in occupational health that is recognised by the South African Nursing Council as referred to in the Nursing Act of 1978 No. 50 of 1978 (South Africa, 1978:13).

Plog (1994:638) describes the functions that may be attributed to an occupational nurse as follows:

- "The responsibility for operating the in-house dispensary, administering first aid to sick or injured employees, determining the severity of accidents and arranging for treatment of employees by a physician when required.
- Developing all relevant information regarding work injuries, circumstances and causal factors; the nurse establishes, maintains and processed detailed and accurate records of all visits to the dispensary and follows up on the status of employees unable to work due to lost-time work injuries.
- Administering preplacement physical examinations and developing of medical histories. The nurse periodically examines or arranges for examinations of employees.
- Maintaining adequate stocks of dispensary supplies, pamphlets and health bulletins and providing first aid supplies when needed.
- Maintaining a nursing policy and procedure manual.
- Maintaining a system of clinical records from which departmental statistical summaries and periodic reports can be developed.
- Participating with the physician in administering health examinations
- Coordinating and managing health education programmes for employees and their families.
- Counselling employees on matters of physical or emotional health and when necessary referring workers to a personal physician, dentist, or community health or welfare agency.
- Serving on facility committees charged with accident prevention, disaster preparedness and first aid training".

2.3.1.4.3 Medical officers

Medical officers are qualified physicians who have a qualification in occupational health and is registered as such. These physicians are called Occupational Medical Practitioners in South Africa. Such a practitioner would typically have a qualification in occupational medicine that is recognised by the South African Medical Dental Council as referred to in the

Medical Dental and Supplementary Health Service Professions Act of 1974 No. 56 of 1974 (South Africa).

Plog (1994:607) summarises the functions of an occupational physician as follows:

- "Appraisal, maintenance, restoration and improvement of the workers' health through application of the principles of preventative medicine, emergency medical care, rehabilitation and environmental medicine.
- Promotion of a productive and fulfilling interaction of the worker and the job, via application of principles of human behavior.
- Active appreciation of the social, economic and administrative needs and responsibilities of both the worker and work community.
- Team approach to health and safety, involving cooperation of the physician with occupational or industrial hygienists, occupational nurses, safety personnel and other specialities".

2.3.2 GIS

Geographical information systems are the technology used in this research, and the following paragraphs provide more information on this technology.

2.3.2.1 Definition

Several definitions for GIS may be found in the literature. Burrough and McDonnell (1998:11) classify the definitions into four groups according to the perspective of the definers. These are; toolbox-based definitions, database definitions and organisation-based definitions. A definition that was put forward by Campbell and Shin (2011:24) was selected. The definition is from a toolbox-based perspective and reads as follows, "GIS consists of a special type of computer programme capable of storing, editing, processing, and presenting geographic data and information as maps". The following authors offer similar definitions: Longley et al., (1999:23), Rob (2003:173) and Huisman and De By (2009:142).

2.3.2.2 History and background

From the definition, it may be seen that mapping is an integral part of GIS. A short discussion on the origin of maps and the relationship between maps and GIS is provided below.

Maps have been used since the earliest of times. The earliest map recorded depicting Babylon is from modern-day Iraq and dates back to the 6th or 7th century BC (Smith, 1996:209-211) This map is of baked clay and contains such features as cities, rivers and a sea. Thereby illustrating the early depiction of geographic areas and the features within. Maps have many uses. Two examples are provided namely: Disease maps for mapping outbreaks were commonly used in the 1830's as an instrument for epidemiological studies

(Koch, 2008) and the other being the management and conservation of the environment at land and sea. Because of the ability of maps to capture and communicate information, this is one of the foremost uses for management as it captures and communicates the extent, geographical range, and ecological characteristics of the resource of interest (Brown et al., 2012:1-13).

Maps have characteristics that should be considered when reproducing, superimposing or manipulation. These characteristics are summarised by McHaffie et al., (2019:91) and are provided below. According to the description, a map is a reduced flattened and abstracted version of selected features on the earth's surfaces and that most maps present features such as roads, buildings and lakes from a point of view directly above those features. The statement provides further clarity that cartographic maps are two-dimensional representations of selected features of the earth's surface, bearing in mind that the earth is three-dimensional. This fact corresponds with Harvey (2008:43), who stated that all maps made up on a flat piece of paper or a flat screen are projected. The characteristics are:

1. A map scale that indicates how much the features on the ground are reduced.
2. A map projection that indicates how much the curvature of the earth is flattened.
3. The cartographic abstraction that determines how features are represented using variables such as colour, shape, size and shading.

There are two types of cartographic maps, namely reference maps and thematic maps (McHaffie et al., 2019:93; Huisman & De By 2009:446). Reference maps, on the one hand, contain as much information as possible (information such as rivers, dams, cities and roads) and are concerned with locations. Thematic maps, on the other hand, focuses on specific themes such as population density in cities. The latter being more concerned about how attributes are distributed in space (Campbell & Shin, 2011:34). It was thematic maps that led cartography towards GIS (Clarke, 2001:9). By superimposing two thematic maps, a new map can be created. The new map contains the features and attributes of both maps (Campbell & Shin, 2011:174). New insights can thus be gleaned from the new map.

By 1950 the technique of map overlay was developed by Tyrwhitt. At this stage, maps were regularly being traced onto transparent overlays for use in land analysis and presentation. This idea evolved during 1962 when two planners at the Massachusetts Institute of Technology added weighting by making the overlays different in their importance with respect to each other (Clarke, 2001:10).

With the development of computers, a new tool became available for mapping. In 1959 Waldo Tobler published a paper outlining a simple model for applying the computer to cartography. His model contained three basic steps: a map input, map manipulation and a map output stage. Clarke (2001:11) states that these steps were the distant origins of the geocoding, data capture, data management and analysis and data display modules now part of every GIS package. The advantage brought about by the computerisation of maps was that once information of any kind is in digital form it is much easier to manipulate, copy, edit and transmit (Longley et al., 1999:3).

The foundations for GIS were laid in the 1960's and had various origins. According to Lemmens (2011:43) as well as Karimi and Akinci (2010), the first country in the world to produce a map of the entire territory by computer, was Canada. This may be attributed to the pioneering work of Dr Rodger Tomlinson. Lemmens continues by stating that the US Buro of the Census developed software for digital mapping in support of the 1970 census. The resulting GIS packages enabled the production of the Census TIGER files (Topologically Integrated Geographic Encoding and Referencing System). This system is perceived to be the forerunners of the modern socio-economic geo-data sets. A third but not inclusive thrust came from the United Kingdom where the experimental cartography unit created software for editing and publishing maps (Goodchild, in Lemmens, 2011:43). The various initiatives were consolidated by 1970 and GIS software packages were available from private vendors such as Esri (Antenucci et al., in Lemmens, 2011:43).
In summary, it may be stated that GIS is a computer-based programme that displays data about a specific geographic area on a computer screen.

2.3.2.3 GIS as a discipline

GIS may be perceived as the confluence of various disciplines. The study of these disciplines supporting GIS is collectively called geographic information science. According to Heywood et al., (2002:13) this science draws from disciplines such as cartography, cognitive science, computer science, engineering, environmental sciences, geodesy, law, photogrammetry, public policy, remote sensing, statistics and surveying. This description of the roots of GIS, provide insight into the various fields of knowledge. However, for better understanding, the description can be narrowed down. Heywood et al., (2002:13) provides an elaborate description, which includes hardware and operating system, software, spatial data, data process and analysis procedures and the people to operate the GIS. Sutton et al., (2009:8) view a GIS as a system consisting of:

1. Digital data. This data is the geographical data and information that will be viewed and analysed using computer hardware and software.

2. Computer hardware. This would entail computers used for storing data, displaying graphics and processing data.
3. Computer software. These are computer programmes that run on the computer hardware and permit the interaction with data.

In summary, it may be said that geographical information systems are computer-based systems that display geographic maps on the screen of a computer. The various features in the map area, such as roads, schools and churches are presented in relation to one another, on the map. The attributes associated with the features, such as type of schools or the size of the congregation in churches is captured in attribute tables that are linked to the applicable features. A point of note is that there is a fundamental difference between viewing a map on paper and viewing one in a GIS. This difference is that GIS can overlay different layers of a map that may be viewed simultaneously, thus producing new insights. Sutton et al., (2009:91) confirms this fact by stating that spatial analysis is the process of manipulating spatial information to extract new information and meaning from the original data. Although GIS was initially designed to deal with spatial data, it can now incorporate nonspatial data as attested by Rob (2003:171).

2.3.2.4 Terminology associated with GIS

A description of specific terminology and its relation to GIS is provided in the following paragraphs.

2.3.2.4.1 Spatial and nonspatial data

Data associated with GIS may be classified into two groups, namely spatial and nonspatial data. Spatial data can be linked to locations in geographic space, typically a feature (Clarke, 2001:338). Nonspatial data are data without inherent spatial qualities, such as attributes (Esri, 2019). For example, one may consider a dam as a feature on a map and the data pertaining to the dam levels through different months of the year would then be attributes describing the feature. The attributes would be tabled in an attribute table and would be linked to the feature portrayed on the map.

2.3.2.4.2 Raster and vector models

For the capturing and presenting of features on a map, using a computer, a decision needs to be made which data model should be used to best present the features. There are two primary data models available to present geographic space (Campbell & Shin, 2011:75; Wieczorek & Delmerico, 2009:167-186). These models are raster or vector models. The choice depends on the nature of the features or data that needs to be represented.

A raster model is made up of equally sized pixels that are interconnected to form a planar surface. These pixels, that are normally square, are used as building blocks for creating points, lines, areas, networks and surfaces Campbell and Shin (2011:77). A typical example of a raster image would be a satellite image of the earth.

Campbell and Shin (2011:85-88) explain the vector data model as an alternative to the raster model along the following lines. Instead of populating map space with pixels as building bricks, the vector data model has three fundamental vector types that exist within the GIS. These are points, lines and polygons. Points are zero-dimensional and have a single coordinate pair. A point would typically denote the location of a feature such as a well within a geographic map. Lines are used to represent linear features such as rivers or roads. Lines, as opposed to points, have the property of length. Polygons or areas are two-dimensional features created by multiple lines that loop back on it to create a feature. Polygons are used to represent features such as city boundaries, buildings, geologic formations, lakes or other features that cannot be presented by a point or line. Polygons are also called areas.

In comparison with the raster data model, vector data models tend to be better representations of reality due to the accuracy and precision of points, lines, and polygons over the regularly spaced grid cells of the raster model. The results from vector data tend to be more aesthetically pleasing than raster data (Campbell & Shin, 2011:93). This fact is augmented by the argument of Clarke (2001:77) stating that vectors have the advantage of accuracy since they can follow features very closely and are effective at storing features. However, vectors would not be as effective as raster data models at displaying topography.

The selection of the correct raster or vector models or a combination of both is of importance as is demonstrated by the following arguments. Huisman and De By (2009:142) argue that all GIS packages have their strengths and weaknesses and that packages that do not handle both models are incomplete. They proceed by listing several packages that contain both. ArcGIS was included in this list. Campbell and Shin (2011:84) on the other hand, cautions that care should be taken in the selection of a raster or vector data model, according to the analytical needs of a project.

2.3.2.4.3 Remote sensing

Remote sensing is the technology that includes the processing, manipulation and analysis of analogue and digital images collected using devices that are not in contact with the earth McHaffie et al., (2019:271). This technology may operate by way of the passive or active sensing of electromagnetic radiation. Passive sensing such as from satellites utilise the reflected light from natural sources. Typically, the energy from the sun would be the source Campbell and Shin (2011:96). Active sensing, on the other hand, is of human origin and involves generating pulses and measuring the reflections. The pulses within the electromagnetic spectrum are generated by radar (microwaves) or LiDAR that generates laser pulses in the visible and infrared spectrum (McHaffie et al., 2019:239).

Images generated by remote sensing, such as satellite images, are in digital format and can be drawn into GIS. These images, however, need to be georeferenced. Georeferencing is the aligning of geographic data to a known coordinate system so it can be viewed, queried and analysed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data (Esri, 2019).

2.3.2.4.4 Global positioning system

A global positioning system (GPS) is an operational, U.S. Air Force-funded system of satellites in orbits that allow their use by a receiver to decode time signals and convert the signals form several satellites to a position on the earth's surface (Clarke, 2001:329), thereby permitting a feature to be georeferenced to specific coordinates.

2.3.2.4.5 Computer aided drawings and GIS

Newell and Sancha (1990:131-135) recognize the fact that there are many similarities and differences between computer aided drawings (CAD) and GIS but identify the main difference between the two disciplines as being the fact that CAD is being used to design new artefacts whereas GIS is used to build a model of the world as it exists. The result is that the data set for GIS would be much larger and more complex than that of CAD. Sipes (2006:48-50) states that, historically, architects and engineers have used CAD as a design tool, whilst GIS has been used primarily as a cartography and spatial analysis tool. Karimi and Akinci (2010) aptly capture the nature of CAD and GIS and illustrate the differences in the following summary:

1. CAD originates from drafting and has great ability to create detailed geometry.
2. GIS has its sources in data management, and its strength is in relating geographic features to databases.
3. CAD drawings are usually single drawing files (e.g., one floor plan) and well suited for design drawings but are not "database information systems."
4. A GIS map often combines multiple feature sets (e.g., streets, buildings, topography) and databases together. GIS also handles many types of data, including photos, videos, and sound clips.
5. CAD is typically applied by a single user.
6. GIS are often multiple users in one dataset (Enterprise Geodatabases).

Due to the individual strengths of both systems, there is logic in combining these systems. A fact supported by the argument of Karimi and Akinci, (2010) who report that there is a growing tendency to integrate CAD and GIS in shared applications. They proceed by listing areas where an integrated approach is needed, such as plan development, visualization, data collection and location-based services and augmented reality.

Important facts to note are that CAD drawings provide accuracy and are detailed to ensure that property lines are laid out accurately, utilities and roads are in the right place and that the corners of houses are square. This accuracy and exactness could be displayed within the points, lines and polygons of a vector system. Most GIS programmes can read popular CAD formats such as DGN, DWG and DXF and because of this fact the simplest method of merging CAD and GIS is by importing a CAD layer into GIS (Sipes, 2006:48-50). The ArcGIS application, ArcMap, of Esri, reads CAD DGN, .DWG, and .DXF files directly and is able to draw CAD in as layer (Karimi & Akinci, 2010).

2.3.2.5 Applications of GIS

Since the advent of GIS, many applications for GIS have emerged. GISGeography (2019) notes 1000 applications divided into 56 categories such as agriculture, engineering, health, ocean, politics, municipalities, humanitarian, and many more. The applications in the health field are categorised as follows:

1. **HealthMap** – Delivering real-time, global disease monitoring.
2. **Centre for Disease Control (CDC)** – Serving county-level maps of heart disease and stroke by race/ethnicity, gender, and age group, along with maps of social and economic factors and health services for the entire United States or a chosen state or territory.
3. **Leukaemia Research –** Investigating leukaemia clusters with proximity to transmission lines.
4. **John Snow –** Forging a whole new field of study (epidemiology) by studying the spatial distribution of cholera cases and identifying the source of the outbreak as the public water pump on Broad Street.
5. **Ebola –** Mapping the change of confirmed and probable cases of Ebola over time.
6. **Distance to Health Care –** Finding the closest doctor is a spatial problem.
7. **Vital Records –** Recording of events, such as births and deaths that are maintained by public health agencies.
8. **Lead Concentrations –** Correlating how children with lead poisoning were found to be closer to an old lead refinery.

9. **Cluster Analysis** – Identifying built environmental patterns using cluster analysis and GIS: relationships with walking, cycling and body mass index.
10. **Euclidean Distance** – Finding the distance to disposal sites during an avian flu outbreak.

    Disease Surveillance – Monitoring West Nile Virus with GIS on handheld devices.
11. **Asthma** – Connecting the dots of asthma and air pollution.
12. **Epidemiology** – Tracking disease and epidemiological information in a spatial database.
13. **UV Exposure –** Exposing the risks of harmful UV rays with birth rates.
14. **Mobile Flu Shots –** Determining an optimal site location for mobile flu shot vehicles to service where demand is needed most with location-allocation.
15. **Geomedicine** –Tracking patients' location history to determine if environmental and industrial hazards put them at risk for certain types of diseases.
16. **Madrid's Air** – Visualization of Madrid´s air (gases, particles, pollen, diseases, etc.) with the aim to make the microscopic and invisible agents visible. (Madrid's Air Map)
17. **Ambulance Response –** Responding to emergencies faster with the quickest geographic route.
18. **Infant Mortality** – Track child immunizations with mortality rates.
19. **Food Trust –** Overlapping factors like poverty and obesity, fresh supermarkets, diet-related disease – space to target for policy-makers.
20. **Public Health Informatics** – Ensuring patients receive the care they need with public health care informatics.
21. **Walgreens Prescription Mapping –** Mapping and analysing influenza based on the prescriptions customers are making to respond to the need of users more efficiently.
22. **Disease Spread Patterns –** Plotting ellipses for a disease outbreak over time to model its spread.
23. **Walkability** – Piecing together walkable neighbourhoods with health diseases like heart disease, hypertension, obesity and even breast cancer.
24. **Anti-Smoking Campaigns** – Targeting anti-smoking campaigns where it's needed most and most visible to target audience.
25. **Cancer Research –** Researching cancer from the sky with the Landsat satellite.
26. **Mosquitoes-borne Illness** – Identifying areas with high indices of mosquito infestation and interpreting the spatial relationship of these areas with potential larval development sites such as garbage piles and large pools of standing water.
27. **HIV/AIDS Database –** Determining the distribution of HIV/AIDS to manage treatment.
28. **Tele-medicine –** Quantifying populations and health care availability when distance separates patients and health care providers.

After conducting a literature review Shaw and McGuire (2017:228-223) found that in health informatics and epidemiology, the main applications of GIS include disease surveillance, health risk analysis, health access and planning and community health profiling. In addition, they found that GIS technologies could significantly improve quality and efficiency in health research, as substantial connections can be made between a population's health and their geographical location.

2.3.2.6 Latest technology in GIS

There is constant growth and development in GIS. A fact supported in the preface of the Encyclopaedia of GIS. The second edition of the Encyclopaedia of GIS accommodates 25 additional fields that were not included in the first edition. The reason being that they were either not included in the first edition or recently emerged as new research topics. These fields include spatial computing infrastructure, spatial optimization, GPS-denied environment, data science for GIS application and 3D modelling and analysis, amongst others (Shekhar et al., 2017: xvi). Though indoor applications were traditionally not a topic of research for the GIS community, professionals such as engineers did work indoors on 3D representations for modelling airflow simulation and smoke modelling. Although research in support of indoor mapping and modelling has been an active field for more than 30 years, the demand for 3D indoor models is increasing. As a result, 3D indoor models seem to be the future direction for further exploration (Zlatanova & Isikdag, 2017:18).

2.3.3 Knowledge management

It was found during the research that data was available in different offices and in various formats (i.e. hard copies and electronic formats) at the industrial plants that were visited. If this data was consolidated in a single database, it could simplify mining for information. In order for a company to attain its strategic objectives, this information or collective intelligence needs to be used, and this process is called knowledge management (Barquin, 2001:128). In this research project, the point of departure for the management of data was the knowledge cycle described by Rich (1991) and adapted by Schulte et al., (2004:1). The adapted cycle is provided below in Figure 2.1.

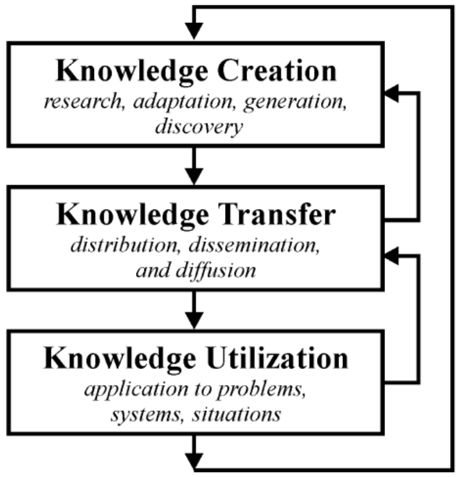


Figure 2.2: Knowledge cycle as adapted by Schulte et al., (2004)

This cycle is based on the premise that knowledge constitutes of three elements, namely:

1. Knowledge creation, which has four sub-elements, namely, research, adaptation, generation and discovery.
2. Knowledge transfer, which has three sub-elements, namely, distribution, dissemination and diffusion.
3. Knowledge utilisation, which has three sub-elements, namely, application to problems, application to systems and application to situations.

These elements were built into the dendrogram as part of the research design. Transcripts of the interviews with the staff members at the individual plants were to be scrutinized for these elements. If during interviews replies were to be found that related to the sub-elements, it would be an indication of knowledge being increased. It would also be possible to ascertain in which of the elements the most significant effect would be.

2.3.4 Application of knowledge cycle to OH

At the onset of the study, literature was available that combined construction safety and GIS (Manase et al., 2011) and another combining the knowledge cycle and Occupational Hygiene (Schulte et al., 2004). Van Der Westhuizen (2004:57) described the representation of Hearing Conservation data by way of GIS. No other literature could be found that combined occupational hygiene management data, GIS and the knowledge cycle. A relationship, therefore, had to be designed. This was done by designing such a relationship and presenting the approach to international experts in the field of OH information and consolidating their opinions by way of consensus. Management activities, as suggested by the ILO-OSH 2001 document (ILO, 2001) were used for the development of the model, as is described in the chapter on methodology.

2.4 Compatibility of data

This branch of the dendrogram describes two criteria that have to be met in order for OH data to be compatible with GIS in terms of the research project. A copy of the dendrogram is provided below in Figure 2.3.

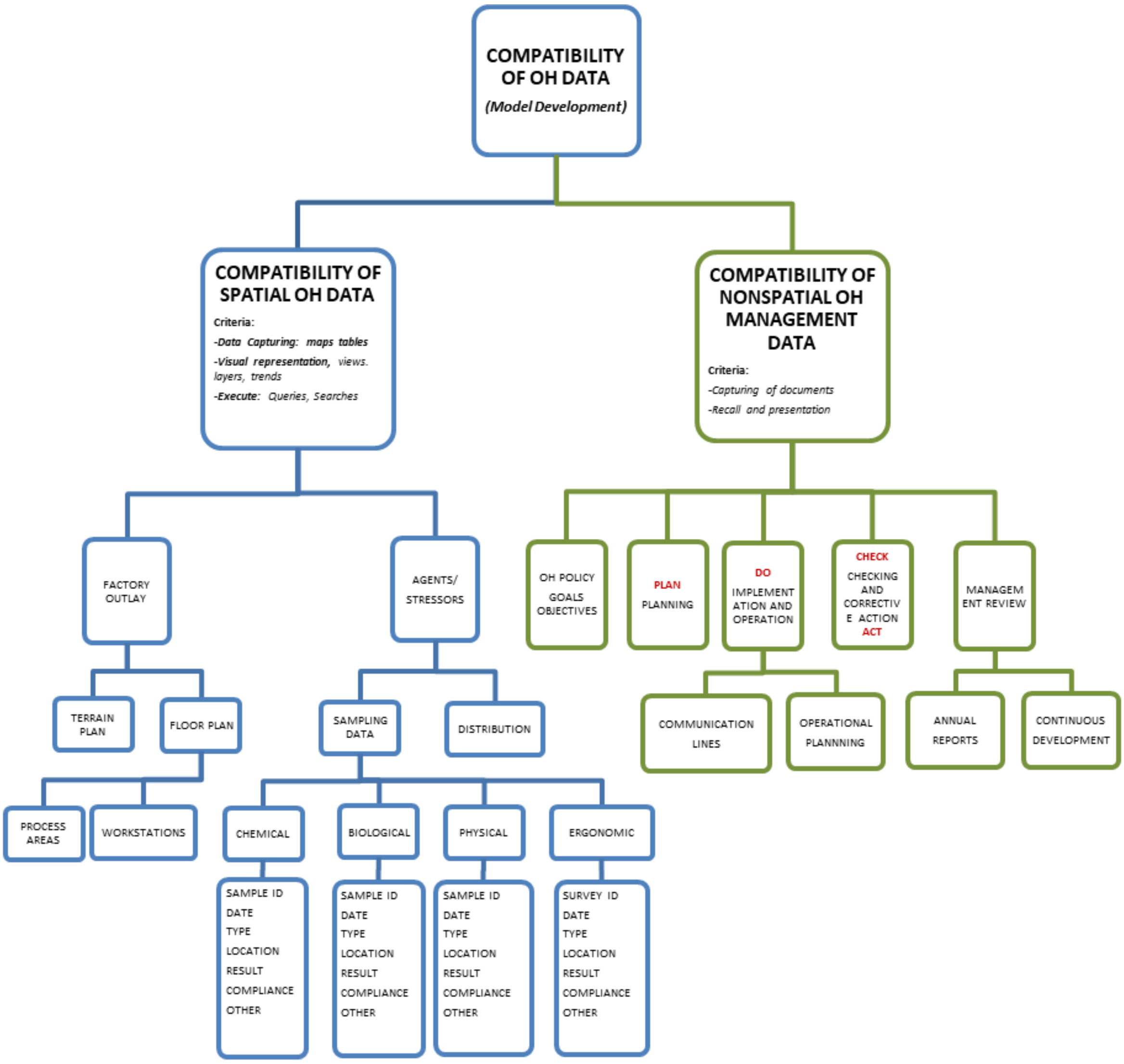


Figure 2.3: Dendrogram compatibility section

2.4.1 Compatibility of spatial OH data

Spatial data are data that have some form of spacial or geographical reference that enables them to be located in two or three-dimensional space (Heywood et al., 2002:289). In the context of this research, spatial data are data that can be allocated to space on a map or a computer-aided drawing of the floor plan. The features on such a floor plan are generally presented as polygons, points or lines. Occupational hygiene features that would be of interest would include aspects such as processes, sampling points and the location of stressors. It is argued that for GIS and OH data to be compatible, compatibility needs to be demonstrated in both the factory outlay and in the stressors present in the plant.

2.4.1.1 Factory outlay

For this research, it should be possible to present the terrain plan as well as the floor plan on the graphic user interface (GUI). A procedure to draw a terrain photo from Google Earth into GIS is described in the notes of the University of California in Los Angeles. No date was provided. Proof of the use of this method is demonstrated by Chang et al., (2009:49) that successfully used Google Earth mapping technologies to create a base for dengue fever surveillance. In addition, Reinhart, and Sanchez, (2012) explain how CAD datasets can be loaded directly into ArcMap. Provide instructions on how to draw CAD drawings into ArcMap, the section of ArcGIS that accommodates maps and drawings. The presentation of process areas and workstations should pose no problem as they could be presented as polygons or points, which is a basic function of the ArcGIS.

In theory, all the requirements pertaining to factory outlay could be met.

2.4.1.2 Agents/Stressors

In order to effectively demonstrate the ability of GIS to handle the data associated with agents and or stressors in the workplace, it was reasoned that both sampling data and the distribution of stressors should be accommodated. Stressors are related to hazards and during risk assessments. According to the Canadian Centre for Occupational Health and Safety (CCOHS), the hazards and location of workstations need to be noted (CCOHS, 2018). In this research project, the spatial element of the data would be the location of the hazards.

Sampling data, as reflected in the dendrogram would entail sampling of the identified hazards, for example, chemical sampling or noise assessment. The actual spatial data would be the locations where the sampling took place, and the attributes would be the actual results that would be stored in data tables that are stored within the model. Legislation demands the keeping of records regarding sampling, e.g. according to the Hazardous Chemical Substances Regulations of 1995 No. 1179 of 1995 (South Africa, 1995:7) an employer must keep records of the results of all assessments, air monitoring and medical surveillance reports. In South Africa, the Department of Labour requires, where practicable, that a report on sampling at an industry include a sketch of the area where sampling was done (South Africa, 2012:8). Thus, a direct request for spatial information. Basing the whole report on a spatial format would automatically comply to and potentially enhance the report to the Department of Labour.

In theory, GIS would be able to capture and display data pertaining to agents/stressors. The ability of GIS to capture, interrogate, process and display data pertaining to the agents or stressors would, however, be investigated in the course of the research.

2.4.2 Compatibility of nonspatial OH management data

The Esri support GIS dictionary (2018) describes nonspatial data as data without spatial qualities, such as attributes. This data is typically stored in data tables (called attribute tables) and could include aspects like names of rivers, the flow rate of a river and recreation types on that river. Nonspatial data in the context of this research has no spatial qualities, as in the definition. Some management documents cannot be stored in data tables due to format, structure and size. Such as company vision about health and safety, risk assessments, technical reports, legislation, organograms, lines of command, operational or strategic planning. To investigate compatibility with GIS, a way had to be found to include this data in the management model on a system that was designed to handle spatial data.

The companies at which the research was conducted, were international companies and their management of health and safety was based on the core of the OHSAS 18001 (ISO, 2007) management system namely: Plan, Do, Check, Act. As these actions form a part of the management system, it was decided to design a comprehensive model that contained all the stages of the OHSAS management system. It included the following stages:

1. OH, policy goals objectives
2. **Plan**ning
3. Implementation and operation (**Do**)
4. **Check**ing and corrective **act**ion
5. Management review

More information on the design and evaluation is to follow in the ensuing chapters.

2.5 Conclusion

This chapter dealt with the underlying theory and conceptualisation of the research as it flows from the dendrogram. Explanations were given of the functions of associated professions in order to demonstrate data needs. It provided the main disciplines and their relationship within this research. The chapter also pointed out uncharted areas where solutions had to be found.

The next chapter deals with the methodology followed in the design of the research.

CHAPTER 3: METHODOLOGY

3.1 Introduction

Chapter 2 provided a background to the literature pertaining to the study, with specific reference to the three major fields that were explored. This chapter describes the research strategy and methodology aimed at achieving the research goals. It presents information on the design, delimitation and development of a model and the execution of the research.

3.2 Delimitation

Tenure of 18 months was spent in Belgium after which the study moved to South Africa. Due to time and cost constraints, this study was limited to three industrial plants of two international companies. Two of which were in Europe and one in South Africa.

Occupational Health and Safety is a broad field in which various disciplines function and integrate data generated from multiple domains, i.e. medical officers, nurses and safety. Although the professions mentioned above were interviewed when present, the focus of this study was on occupational hygiene data and safety, and clinical data were excluded.

This study did not attempt to create a fully functional safety management model but focussed on the integration of the principles concerning data relevant to occupational hygiene management.

Occupational hygienists operate across many sectors, i.e. the educational, industrial, civil service and the mining sectors. This study was limited to three sites in the industrial sector.

As the focus of this study is to develop a model and demonstrate that it can improve the level of integrated decision making of data relevant to occupational hygiene, it was decided to use current data available from the particular industries. The fact that the data provided was old in some cases was considered irrelevant for this study. Whether old or new, the abilities of the application of the management tool to interrogate data were the primary purpose of this study and were considered more important than the actual values. What is important is that real data was used and reflected on.

3.3 Design

As this research deals with the design and testing of an applied information system (artefact), the research design could be classified as a Design Science Research Method (DSRM). Qualiquantive methods were used to verify the credibility of the DSRM.

Although this study was predominantly applied research due to the fact that it was to find a way to improve management of knowledge within the OH paradigm (Huysamen, 1994:34), there may be areas where it overlaps with elements of basic research. Bailey (1978:15-17) stated that this is not an unusual phenomenon.

3.4 Dendrogram

At the onset of the study, a dendrogram (Appendix A) was developed to depict the deductive conceptual framework with its underlying theoretical rationale. Interrelated criteria were arranged into a cascading hierarchy within the dendrogram with concepts related to the same repeated question "… is determined by …". This process provided the needed nexus (golden thread) between concepts applied during the phase of model building. Each heading serving as a criterion that had to be met to achieve the goals of the research. The point of departure is that subheadings contribute towards the demarcated validity of headings of the layer above, throughout the dendrogram. A discussion on the flow of the concepts within the dendrogram and the influence thereof on the research design are given in the paragraph following Figure 3.1.

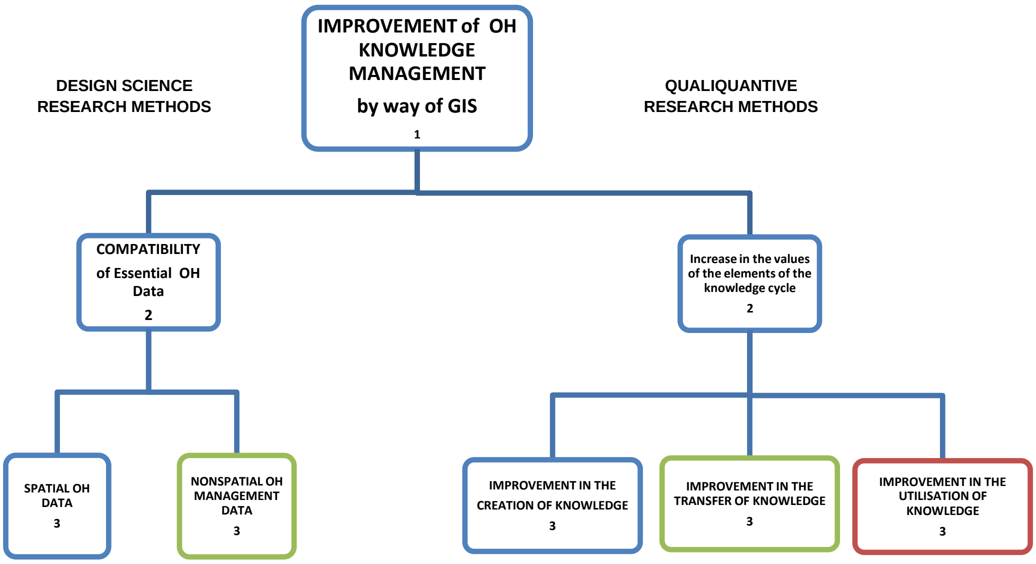


Figure 3.1: The first three tiers of the dendrogram

The dendrogram technique as a tool to develop questionnaires may serve as a deductive or inductive approach to research design (Schutte, 2006).. In this research, the dendrogram provides a deductive approach as the headings in each tier are determined by the headings in the tier below which in turn are determined by the headings in the tier below them and so forth.

From Figure 3.1 it can be seen that the improvement of OH knowledge management (tier 1) is determined by the compatibility of OH data from tier 2 on one hand and on the other, an increase in the values of the elements of the knowledge cycle from tier 2, as well.

At tier 2, the compatibility of OH data is determined by the compatibility of nonspatial data as well as the compatibility of spatial data from tier 3. On the right-hand side of the dendrogram the increase in the values of the elements of the knowledge cycle in tier 2, is determined by an increase in an improvement in the creation of knowledge, as well as the improvement in the transfer of knowledge and the improvement in the utilisation of knowledge from tier 3. This principle perpetuates down into the lowest levels of the dendrogram. The bottom row of the dendrogram contains aspects that cannot be broken down into contributing factors.

As illustrated in the dendrogram, improvement of OH knowledge management is determined by the compatibility of OH data and an increase in the values of the elements of the knowledge cycle. Each of these two branches of the dendrogram represented a research question. Namely whether:

1. Workplace and personal OH data could be represented by way of GIS.
2. The use of GIS could improve the management of OH data.

Due to the nature of the research questions, each necessitated an individual procedure for analysis, and each required a unique research procedure to ensure the compatibility of data and the increase in the elements of the knowledge cycle.

1. Compatibility of data. The Design Science Research Methodology (DSRM) was used. To evaluate the compatibility of OH data, a case study was used as a research procedure. The development of a model for the capturing of and interaction with data within the GIS programme was the technique used. A generic model (artefact) was developed for this purpose. To prove the universality of the generic model, it was applied to each of three uniquely different plants by populating the database with data of that individual plant. The ability of the models was evaluated against set criteria on the prerequisites of the lower tiers as defined in the dendrogram, as well as the main abilities of GIS to store, display, query, conduct searches and interrogate data. Although the generic models were the same, the individual models for each factory differed in content as each plant had its unique processes and associated hazards. Observations made during the development of the models were noted for cross-referencing and triangulation with the results from the subsequent open-ended interviews. A detailed breakdown of the procedure is provided in Chapter 4.

2. Increase in the value of the elements of the knowledge cycle**.** The survey procedure was used to generate the information used in this study. The open-ended question techniques were used to obtain feedback from staff regarding the abilities of the model. Being explorative in nature, the open-ended question technique was preferred as it provided some control over the respondent's frame of reference during the interview, but at the same time gave the respondent some freedom to open his/her frame of reference beyond the possible anticipated answers used during the typical categorized response options of the closed question technique. Therefore, although open-ended, these questions were designed to address aspects of the knowledge cycle as presented in the dendrogram. This technique can be described as qualitative as the information generated was, in essence, qualitative, but by way of coding the information received was grouped into categories and quantified to observe and compare the profiles in semantographs.

3.5 Strategy

The strategy was developed from the dendrogram and involved the testing of a GIS-based model of OH data by way of case studies, which was followed by semi-structured interviews of staff perceptions of the model, to determine whether knowledge was gained in terms of the knowledge cycle.

Interviewees of this study that had to voice opinions on the effectivity of the theoretical model included plant managers and staff involved in Health and Safety management as well as medical practitioners. Being a qualiquantive study, the validity of the information depended mostly on the interviewing situation to produce free, honest and complete responses on the open-ended questions. These questions were proposed to the respondents with specific reference to the Design Science Research Methodology (DSRM) approach of artefact development and testing (Kuechler & Vaishnavi, 2012:397) and the steps that were followed was according to the route as identified by Peffers et al., (2007:7) namely;

1. identification of the problem to which a solution is required,
2. defining the objectives of a solution,
3. design and development of a prototype to solve the issues identified,
4. demonstration of the abilities of the prototype to deal with actual problems in the field,
5. evaluation of the artefact in terms of the design objectives and
6. communication of findings.

These factors were incorporated into the dendrogram from which the final design emerged.

3.6 Methodology

The research was conducted in various stages, starting with the development of an artefact, hereafter called the model.

3.6.1 Stage 1: Development of model

Phase 1 entailed the development of a model for OH data within GIS to determine the compatibility of OH data with GIS. During this phase, planning was done to consolidate spatial and nonspatial data onto a geographical information system. The following steps were taken.

Step 1: A generic conceptual framework was developed for the incorporation of data into a geographical information system. Spatial and nonspatial data that needed to be incorporated in the model were identified from the dendrogram.

Step 2: From the dendrogram, a conceptual design for attribute tables was done in Excel format. This design served as a basic framework for capturing data from industries. Attribute tables were created for each of the stressors, such as noise and chemical exposures.

Step 3: Data layers for the conceptual model and GUI were created with features and attributes. These layers determined how the data were to be loaded into the model, as demonstrated in Table 3.1.

Step 4: Decisions were made as to how data was to be presented and how layers of data should be interconnected.

Step 5: As data such as policies and management plans pertaining to the whole plant could not be pinned to one specific point, a base layer based on Figure 1 of the OHSAS 18001 (ISO, 2007:vi) system was created. This layer was imported into GIS under the heading called “management”.

Table 3.1 below illustrates the design of the generic model. It contains the base layers onto which the features are superimposed by way of shapefiles, point, line or polygon. In the column on the far right are the attributes that were captured in Excel and then imported into the model.

Table 3.1: Conceptual layers of the model

	BASE LAYERS	FEATURES	SHAPEFILE	ATTRIBUTES
1	Arial site map displaying orientation	Managerial aspects	Polygon and Point (Label & map tips)	• Physical address (Label & map tips) • MD (Label & Mt) • OH/S manager • Physical address • Contact details
2	Management template (OHSAS 18001, 2007:vi)	Layers indicating progress with: • Strategic plans • Operational plans • Training schedules • Legal documents	Polygons	Hyperlinks to the following: • Strategic plan • Operational plans • Training schedules • Legal documents • Stressor controls
		Management template	Polygon	• Organogram link • OH policy • Mission Vision Goals Objectives • Strategic plans, training, engineering controls, administrative controls • Management reviews
3	Floor plan of industry	Work areas	Polygons/ Points	• Hazards, e.g. chromium[6], noise, organic vapours etc.
		• Sampling results	Points	• Sampling and monitoring data
		• Exposures	Polygons and points	• Exposures indicated

3.6.2 Stage 2: Development of semi-structured Interview

At the onset of the research, no literature could be traced to the representation of occupational hygiene data within a GIS and the influence on the knowledge cycle. Interview questions, therefore, had to be generated. Questions for the semi-structured interviews were developed in terms of the knowledge cycle. These questions were based on the lowest tier of the dendrogram that fed into elements of the knowledge cycle. The questions were developed from the management principles that were captured within a publication of the International Labour Office that is titled "Guidelines on Occupational Safety and Health Management Systems ILO-OSH 2001" (ILO, 2001).

To ensure credibility to the process, the Delphi technique (McKenna, 1994 in Hasson et al., 2004:1010) of finding consensus was applied to develop the interview questions. An international panel of 11 experts in OH, from Belgium, UK and South Africa were approached to assist in refining the aspects of OH management that pertained to the elements of the knowledge cycle as depicted in the lowest row of the dendrogram in Figure 3.2 below. A list of perceived aspects was sent to the panel. After receiving their replies, the answers were collated and an alternative document generated. This document was then sent to the panel and the process repeated until sufficient consensus was achieved on the OH management aspects. These aspects were incorporated into the dendrogram. See Table 3.2 after Figure 3.2 below. The interview questions were then developed from the dendrogram.

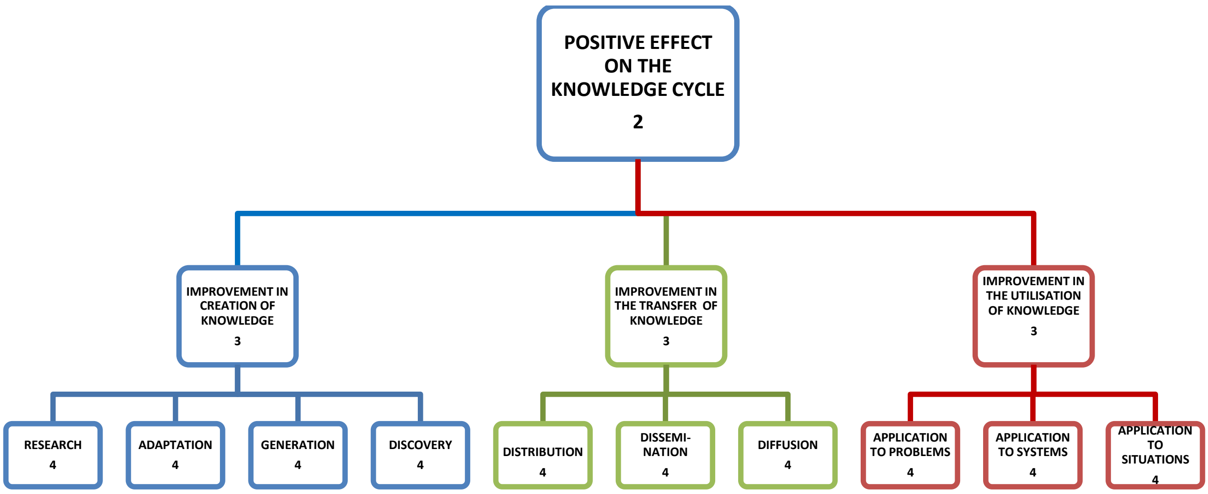


Figure 3.2: Knowledge cycle sub-elements that had to be matched with OH requirements

Table 3.2: Sub elements of the knowledge cycle that were matched with aspects of OH requirements by way of the Delphi consensus technique

	KNOWLEDGE CYCLE: MAIN ELEMENTS	KNOWLEDGE CYCLE: SUB ELEMENTS	LOWER TIER OF DENDROGRAM RELATING TO KNOWLEDGE CYCLE AS DEVELOPED VIA DELPHI TECHNIQUE
1	CREATION OF KNOWLEDGE	**1. Research**	Contains an integrated database suitable for problem solving
2			Contribute towards formal research by way of consistent data
3		**2. Adaptation** Solving new problems from existing information.	Provide a clear view of worker exposures to multiple stressors
4			Prompt alternative control measures in the working environment
5			Reflect the actual site of workplaces that require priority attention
6		**3. Generation** Creating information from data	Allow for better recording of indigenous company (tacit) knowledge
7			Ensure sustainability in the Occupational Hygiene knowledge of the industry by providing an integrated database
8			Provide information on the sampling results in relation to the actual sampling positions
9		**4. Discovery Relationships**	Display trends which enable predictions to be made from existing data
10			Link legislation to stressors in the workplace
11			Link policy documents with management systems
12	TRANSFER OF KNOWLEDGE	**5. Distribution** Through the organization	
13			Relate training schedules to stressors
14			Clearly, indicate risk profiles
15		**6. Dissemination Of data**	Save time seeking for information by having data freely accessible
16			Present OH knowledge in an understandable format
17			Ensure the sustainability of knowledge during changes in staff
18		**7. Diffusion** Benefit to others	Provide planning information for other sections in the industry. Such as HR. OH Medical practitioner
19	UTILISATION OF KNOWLEDGE	**8. Problems**	Assist in prioritising risks
20			Show progress with continual improvement
21			Indicate in which areas Occupational Hygiene training is required
22		**9. Situations**	Provide information on progress with strategic plans
23			Facilitate preparations for audits
24			Demonstrate exposure trends
25		**10. Systems**	Assist with the strategic planning for the management of stressors
26			Demonstrate progress with strategic plans
27			Provide information on progress with Occupational Hygiene training

It was not necessary to cover all aspects by way of questions, as some would be demonstrated by the model. Table 3.3 is provided below to indicate which questions were set and where they impacted on the knowledge cycle and the dendrogram. The cells that were marked with the word "model" were to be evaluated by the researcher during the creation of the model. The final aim was to compare the findings from two sources, i.e. the creation of the model with the results of the interviews to enhance the credibility of the study by way of triangulation (Burns & Grove, 2005:225).

Table 3.3: Displaying questions for semi-structured interviews

	KNOWLEDGE CYCLE	ATTRIBUTES	DESCRIPTION	QUESTIONS/PROOF
1	CREATION OF KNOWLEDGE	**1. Research**	Contains an integrated database suitable for problem solving	Model
2			Contribute towards formal research by way of consistent data	Model
3		**2. Adaptation** *Solving new problems from existing information.*	Provide a clear view of worker exposures to multiple stressors	Model
4			Prompt alternative control measures in the working environment	Model
5			Reflect the actual site of workplaces that require priority attention	Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?
6		**3. Generation** *Creating information from data*	Allow for better recording of indigenous company (tacit) knowledge	Model
7			Ensure sustainability in the Occupational Hygiene knowledge of the industry by providing an extensive database	Model
8			Provide information on the sampling results in relation to the actual sampling positions	Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?
9			Display trends which enable	Model

		4. Discovery *Relationships*	predictions to be made from existing data	
10			Link legislation to stressors in the workplace	Model
11			Link policy documents with management systems	Model
12	TRANSFER OF KNOWLEDGE	**5. Distribution** *Through the organization*	Relate training schedules to stressors	Model
13			Clearly, indicate risk profiles	What problems do you experience with observing the distribution of hazards in the workplace?
14		**6. Dissemination** *Of data*	Save time seeking for information by having data freely accessible	Model
15			Presents OH knowledge in an understandable format	Express your views on the ease of access to data
16			Ensure the sustainability of knowledge during changes in staff	Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?
17		**7. Diffusion** *Benefit to others*	Provide planning information for other sections in the industry. Such as HR. OH Medical practitioner	Express your views on the possible use of such a system to professions other than occupational hygienists? For example medical practitioners, engineers, H&S staff, HR etc.
18	UTILISATION OF KNOWLEDGE	**8. Problems**	Assist in prioritising risks	Model
19			Show progress with continual improvement	Model
20			Indicate in which areas Occupational Hygiene training is required	Model
21		**9. Situations**	Provide information on progress with strategic plans	Model
22			Facilitates preparations for audits	What do you think would the value of this system be in preparing for audits?
23			Demonstrate exposure trends	Model
24		**10. Systems**	Assist with the strategic planning for the management of stressors	What would you think would the value of this system (if any) be in your planning during OH management?
25			Demonstrate progress with strategic plans	Model
26 27			Provide information on progress with Occupational Hygiene training	Model
28				Express your views on the practical application of the system in identifying weaknesses in your overall OH

				management programme?

Not all questions pertained to the dendrogram as some were designed to check internal reliability such as questions one, two and thirteen. Should similar responses be received for these questions, it would indicate consistency in the replies of the interviewees.

3.6.3 Stage 3: Prototyping

In preparation for the pilot study, the prototype of the model was demonstrated and discussed with an experienced Occupational Hygienist at IDEWE in Belgium. The questionnaire for the semi-structured interview was discussed with the South African promoter who is experienced in qualitative research.

3.6.4 Stage 4: Pilot study

A pilot study to test the prototype of the model was done at the manufacturing plant of a large aluminium smelter in Europe. If necessary, adjustments would be made to the model or interview questions after the pilot study. Using the theoretical point of departure for a generic model, the pilot study involved creating a model specifically for that plant, by populating the generic model framework that was created, with data from that specific plant. After that, the opinions of health and safety staff were collected during semi-structured face-to-face interviews.

3.6.4.1 Pilot of the GIS model

The following procedures were followed during the pilot study:

1. A meeting was convened with the management to discuss the data that would be required and to demonstrate how the project would be done.
2. Permission was obtained to conduct the study.
3. A confidentiality contract was signed between all parties involved in the research. I.e. The Catholic University of Leuven, Company no. 1, where the pilot study was to be conducted, The Cape Peninsula University of Technology and the researcher.
4. Once the documentation was in place, computer aided drawings (CAD) of the industrial plant were obtained.
5. Spatial data, as indicated in the dendrogram, was then obtained from the company, i.e. sampling data.
6. Nonspatial data such as strategic plans, risk assessments were obtained and hyperlinked to polygons on a base layer that was created for this purpose.
7. A Map Exchange Document (MXD) was created for the specific plant.

8. An aerial view was created by importing a georeferenced Google aerial view into the model to demonstrate the external layout of the plant.
9. Polygon and point shapefiles were created as layers (overlays) on the aerial view and data were linked to these layers using attribute tables.
10. A CAD drawing was imported into the GIS programme as a base layer.
11. Once again, polygon and point shapefiles were created for data layers to be linked to attribute tables containing the data.
12. The nonspatial management system framework that was designed and based on OHSAS 18001 was imported into the model as a picture.
13. Polygons were created as layers on this management system. These polygons were connected to strategic documents via hyperlinks.
14. Excel data tables were populated with spatial information from the plant and connected to the specific layers where the information applied.

3.6.4.2 Pilot of the interview

The face-to-face interviews were conducted after completion of the model and were done in the following stages:

1. The completed model was demonstrated and discussed at a meeting convened with the Health and Safety department.
2. A day later, the staff members were interviewed one at a time after demonstrating the model to them once again.
3. Interviewees were informed of their right not to participate and that they would be free to withdraw at any time before or during the interview.
4. Interviews were conducted in a collegial manner and questions rephrased when necessary to ensure that the interviewees understood the questions.
5. Permission was obtained from each individual, and the semi-structured interviews were recorded.
6. Transcripts were typed.
7. Each audio recording was listened to and compared to the transcript by the researcher. Edits were done where required. Great care was taken with responses that were in Flemish.
8. Transcripts were coded according to the principles of the knowledge cycle as captured in the dendrogram.

From the data generated from the pilot study, it was clear that only minor changes to the verbal presentation and the sensitivity to the body language of the interviewee were needed. Reflection techniques were used to determine whether the interviewee interpreted the questions within the frame of reference determined by the researcher.

Some interviewees could not relate to the questions, and after initial prompting, they were not able to respond within the needed frame of reference. This was probably due to the respondent's unrelated work environment to the purpose of the study.

Because of the minor changes that transpired from the pilot study, it was decided to include the pilot study site as a third industrial site into the main study to broaden the information base.

3.6.5 Implementation at other industries

This stage involved implementing the improved OH model for GIS (artefact) at Company number 2, which was an international United States based company with 85 plants across the world at that time.

An agreement with an American based automotive components company was made to implement the model in one plant in Belgium and one in South Africa. The same methodology was followed as with the pilot study with regard to the creation of the models for the two plants and the conducting of interviews.

3.7 Population

The entire management staff involved in OH management at the selected industrial plants of Gent in Belgium and South Africa were targeted. There were two withdrawals, one from each plant in Europe due to personal reasons, which they did not wish to disclose to the researcher. Interviews were conducted according to the identified questions. The questions were open-ended, and discussion was prompted. In order to accommodate the international nature and possible differences and similarities of the company, interviews were held on premises in both Belgium and SA.

3.8 Variables

3.8.1 Independent variable

The theoretical base of the system supporting the knowledge management acted as an independent variable for this study.

3.8.2 Dependent variable

By implementing a geographic information system, the improvement, decline or the status quo of knowledge acted as the dependent variable (qualitative content analysis of the interviewing data).

3.9 Measuring instruments

Measurement at all phases took place by way of critical evaluation of the constructed model of the OH application in GIS and the effect of the model on knowledge management by means of semi-structured interviews as depicted in the following Figure 3.3.

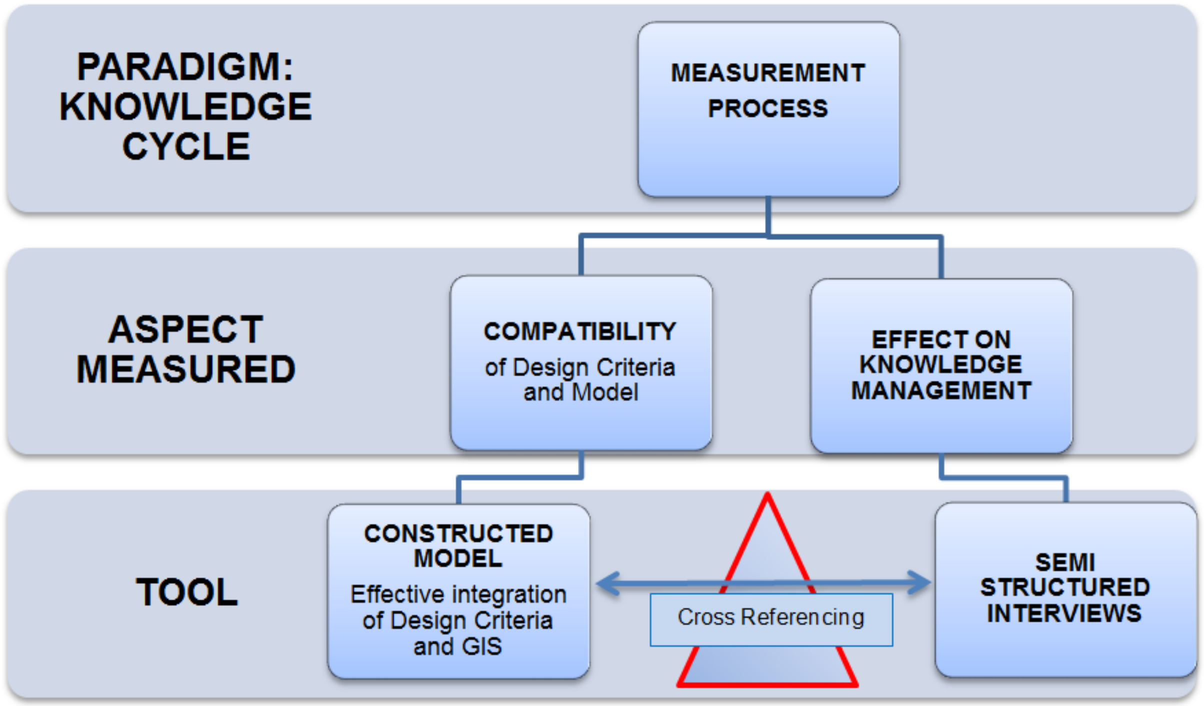


Figure 3.3: Measurement process

This process took place as follows:

1. During the development of the OH application, an evaluation was done of the compatibility of industrial OH data with the features and structure of GIS. The programme itself demonstrates whether specific actions could be carried out and to what extent this was possible. Detailed notes were taken during interviews and related to the knowledge cycle.
2. Evaluation of the system design criteria during the semi-structured interview.
3. Evaluation of the extent to which the model and GUI influence the data management in terms of the knowledge cycle will also take place during the semi-structured interviews.

3.10 Gathering of information

As the application to GIS was developed (base layers, shapefiles and attribute tables), the abilities of the programme were evaluated. Feedback was received from the model on the loading of data in specific formats. These obstacles and compatibilities were recorded meticulously.

3.11 Data collection and processing

As mentioned, the opinions of respondents were captured by way of semi-structured questionnaires. The reason for semi-structured questionnaires as opposed to structured questionnaires being that the interviews are intended to be conversational to elicit possible information that might be beyond the current frame of thinking for this study and that conversational interviews often lead to more consistent question interpretations (Conrad & Schober, 1999).

3.12 Interpretation in a qualitative context

The approach in qualitative research differs from quantitative research, and an explanation of the related terminology and the application of this study follow in the paragraphs below. These paragraphs deal with the results of the semi-structured interview. The model itself was not discussed in this paragraph, as it was evaluated by the researcher. Credibility was, however tested by cross-referencing the findings of the researcher with the results obtained from the interviews.

3.13 Trustworthiness

Trustworthiness is the term used in qualitative research as opposed to validity in quantitative research. In this research, the criteria for trustworthiness are listed below with the quantitative nomenclature provided in brackets after the headings.

3.13.1 Credibility (Internal Validity)

According to Denscombe (2007:306), credibility may be perceived as the extent to which qualitative researchers can demonstrate that their data is accurate and appropriate.

To increase credibility in this research, four of the five techniques of Lincoln and Guba (1985:306-314) were applied. The 5th did not have a direct bearing on the research.

1. Activities that increase credibility: The intent was to increase credibility by way of comparison of data that was gathered by way of direct feedback from the GIS application, transcripts and audiotapes from the interviews. Prolonged and persistent observation took place during data collection. The outcomes of each of these different formats and methods were compared and analysed for consistencies and incompatibilities. Comparison also took place between the results at the industrial plants in Belgium and South Africa as well as the pilot study as each industrial plant differs from the other with respect to management culture, design and end products. Similar results would point towards accuracy in the methodology.
2. Peer debriefing: Opinions were gained from knowledgeable peers on aspects such as the classification of questions according to the knowledge cycle and the selection and

arrangement of data on GIS application. The supervisor, a specialist in qualitative research, provided constant guidance to the researcher throughout the study.

3. Member check: During the interviews, answers were rephrased, and the respondents were requested to reply on whether it was what they meant. The purpose is to avoid that any information was misinterpreted.
4. Negative case analysis: Refining the hypothesis until it accounts for all known cases without exception was an integral part of modelling the decision-making phenomena.

3.13.2 Transferability (External Validity)

Mabuza et al., (2014:3) describe transferability as the measure to which study conclusions may be applied to other similar settings.

In order to ensure transferability, a sufficient and well-explained background is provided to enable readers to determine whether the findings may be applied to other industrial plants. The fact that the sites on which the pilot study and the implementation studies took place at industrial plants with different production outcomes as well as being in different countries should contribute towards illustrating transferability.

3.13.3 Dependability (Reliability)

In accordance with Denscombe, (2007:307) the ability of other researchers to replicate the research will be enhanced by providing detailed descriptions of procedures and decisions. Decisions and conclusions alongside with the associated reasoning was therefore carefully noted during the creation of layers, attribute tables and construction of the semi-structured interview.

3.13.4 Confirmability (Objectivity)

Confirmability is primarily achieved by audit trails (Lincoln & Guba, 1985:319). In this case, scrutiny will take place via the supervisors of the research project. Both supervisors have extensive experience, one in qualitative and one in quantitative research.

Denscombe (2007:10) warns against ignoring information that does not fit the analysis or rival explanations. Care was, therefore taken to be on the lookout for the presence of these phenomena. These phenomena occurred and were individually scrutinised and coded as "other". When encountered, these phenomena were individually scrutinized, evaluated and documented.

3.14 Analysis

Similar to the approach of Polit and Beck (2012:725), the analysis was aimed at condensing and crystallizing the mass of data collected to a point where logical conclusions can be made.

For the analysis of data, the systematic five-stage framework developed by Pope et al., (2000) was selected. The following paragraphs name the phases and explain how they apply to the analysis of the semi-structured interview:

1. Familiarization: The researcher immersed himself in the raw data, by listening to an audio recording of the semi-structured interview, reading transcripts, studying notes taken during the interview and identifying key ideas and recurring themes within and outside the framework of the interview.
2. Identifying a thematic framework: The idea, in this case, was to identify and create a framework of themes in the data that is related to the aims and objectives of this study. The elements of the knowledge cycle that was explored during the interview formed part of the framework as well as categorized feedback from the respondents that do not fall within the predetermined categories.
3. Indexing: During this phase, all data was matched to the thematic framework and numerical codes, and short text descriptors were assigned to the themes (coded). Cross-referencing was done, and in cases where more than one theme emerged from the interview, it was noted as the same incident.
4. Charting: By way of abstraction and synthesis, data was sorted into the themes of the framework to form semantographs for each theme identified previously. The charts will be a step beyond a conglomerate of data allocated into a category. It would then be a collection of carefully evaluated and sorted data.
5. Mapping and interpretation**:** The semantograph was used to define concepts, map the range and nature of phenomena, create perceptual clusters and find associations between themes to provide explanations for the findings. Thus, producing a distillate of objectives and outcomes that were presented on semantographs.

These theoretical guidelines were used as a general guide for the analysis of the raw data from this study, which consisted of transcripts from audio recordings of semi-structured interviews of participants.

3.15 Ethical and legal aspects

Participants were well informed regarding the purpose of the study. Strict confidentiality was maintained both in South Africa and in Belgium. Individual information was not distributed to a third party and will not be traceable to the individual.

The project was approved by the ethics committee of the Cape Peninsula University of Technology (ref number: 10/2014).

Three types of data were collected during the study:

1. Data from respondents**.** Respondents were each served with a consent form that they had to sign before the commencement of the interview. In order to prevent traceability, the individual transcripts were named in numerical order. I.e. Interview No.1, etc.
2. Existing sampling data. Data pertaining to the area and personal sampling was drawn from company records. In this case sampling was done by the company to determine worker exposure to contaminants in order to control the exposure of their workers to contaminants. Although the sampling results do not represent personal medical conditions but reflect workplace conditions, the information was presented in such a way as not to identify individual workers. It is to be noted that personal sampling refers to a sampling technique (instrument carried by the respondent) and not the interviewing of, or drawing of, biological samples from individuals. Where necessary logos or traceability to the individual companies were removed or shaded.
3. OH, management data**.** The management goals and objectives of the companies were drawn into the geographical information system. In this case confidentiality contracts were signed with the management of the respective companies to ensure that no data is made public via articles and conference papers, inter alia, without the consent of the company.

It needs to be mentioned that one of the objectives of this study was to find ways that could assist industry in managing their existing data in order to ensure a safer working environment and to ensure legal compliance with regard to OH. Therefore, no new data was created, but the operational data of the company was utilised and rearranged in the new proposed format.

3.16 Conclusion

This chapter dealt with the methodology used in the research. The research concepts were unpacked in a dendrogram, which served as a map for conducting the research. The methods, strategy, methodology, processes and techniques were developed from the dendrogram.

This project materialised as mixed, applied research with two legs, namely design science research methods (DSRM) on the one leg of the dendrogram and qualiquantive methods on the other. A model was built and evaluated by the researcher in the creation and operational stage. The procedures used were case studies and survey procedures. A semi-structured interview for establishing opinions of staff on the model was used as a research survey procedure. Results of the model and the qualiquantive methods were cross-referenced to establish reliability.

The next chapter deals with model development.

CHAPTER 4: MODEL DEVELOPMENT

4.1 Introduction

Whereas the previous chapter dealt with the research methodology followed, this chapter deals with the development of a model for OH within GIS. It describes the evaluation criteria and the steps taken and the reasons for doing so. Demonstrations of the results by way of figures are provided as well as discussions of the process.

A framework for the capturing of data was developed. The design of the framework aimed to create a generic framework within the GIS programme that could accommodate the data of all the industries that were to be investigated. The framework was designed to facilitate spatial and nonspatial data and provide space for the different types of data, though it might be unique to each industry. During the development, it was indeed found that the data types differed, but in spite of the diversity, it was able to capture the data efficiently.

Because the research was conducted at multinational companies and legal limit values vary, the legislation used by each plant was used to indicate legal compliance. However, it is to be remembered that the point of departure was not to develop a perfect product, but rather to test whether knowledge improvement for proper decision-making was attainable, in a specific environment.

4.2 Background

Managing stressors such as chemical stressors, heat, radiation and noise require accurate positioning of the sources. This holds true in indoor environments, especially when planning safe distances or when modelling is done of the emission of hazardous chemicals. Global Positioning Systems (GPS) have limitations in this regard. According to Kjærgaard et al., (2010:39), the structure of buildings affects the accuracy of GPS. In the case of wooden structures, the accuracy was given as less than five meters, and in mortar and brick buildings the accuracy was less than ten meters. To ensure more accurate placement of the stressors (features), it was decided to use CAD as base maps within a vector-based programme. The reason for the use of vectors being the advantage of accuracy, in that features are followed closely and are effectively stored (Clarke, 2001:77).

The model was designed to contain the elements of the dendrogram in Figure 4.1 below.

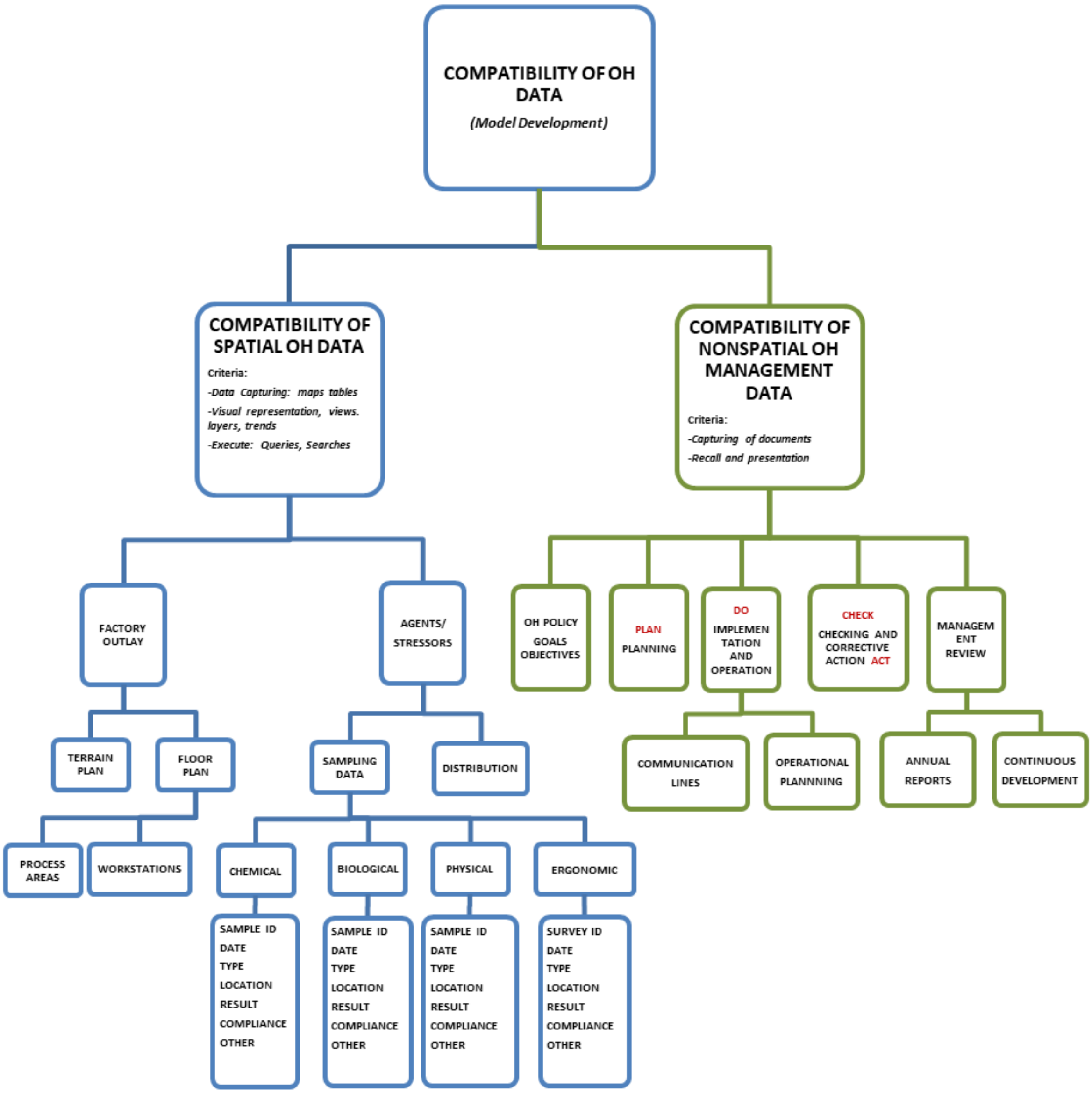


Figure 4.1: Dendrogram indicating elements to be included in the model and criteria that had to be met

4.3 Strategy

The final model was developed to satisfy the requirement that the compatibility of spatial and nonspatial data determines the compatibility of OH data (dendrogram). A generic model was therefore built to test the compatibility of each of these components.

The visuals of each industry would differ, but the design of the index to the programme would remain the same.

4.4 Techniques used for the construction of the model

To test the compatibility of occupational hygiene data a map exchange document (MXD) was created for each industrial plant that formed part of the project. These files were named according to the industrial plants, and a set pattern was followed in the design of the views and the capturing of data. Although the plant outlay and processes differed the presentation of data on the GUI were similar. The reason is to create consistency in use and to simplify comparisons between the different projects. Within each MXD file, views were created by importing or creating base layers. Polygon or point shapefiles were then created onto each base layer. ArcGis10.1 automatically created attribute tables associated with each layer. The attribute tables were in turn populated by either entering occupational hygiene-related data or by way of joins with data tables from Excel.

The software programme ArcGIS 10.1 was used for the development of the model. The reason being that ArcGIS 10 tutorials are easy to access on the Internet. Esri offers a student version of ArcGIS 10.1 to universities at a reduced rate, and a licenced copy was purchased from the company by the Cape Peninsula University of Technology.

A basic framework was designed with three main base layers and four headings, as may be seen in Table 3.1. This framework served as a template according to which the unique data of each plant would be populated. By doing this, it was ensured that all respondents viewed the same outlay of data as portrayed in Figure 4.2. Thereby reducing the possibility of including unique individual responses from the various plants, that are less important in the decision making process. This view consists of three base maps, namely: Floor plan, Management and Arial view. The heading named "Operational" is a group layer.

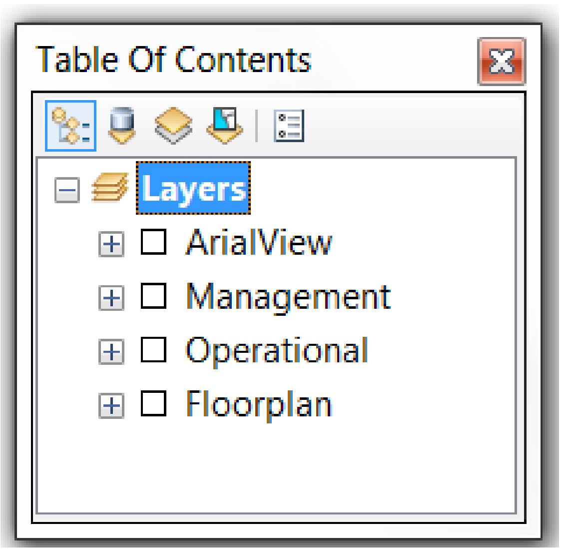


Figure 4.2: Generic table of contents as presented to all plants

Expansion of the layers in the initial view then led to the specific layers as may be seen below in Figure 4.3.

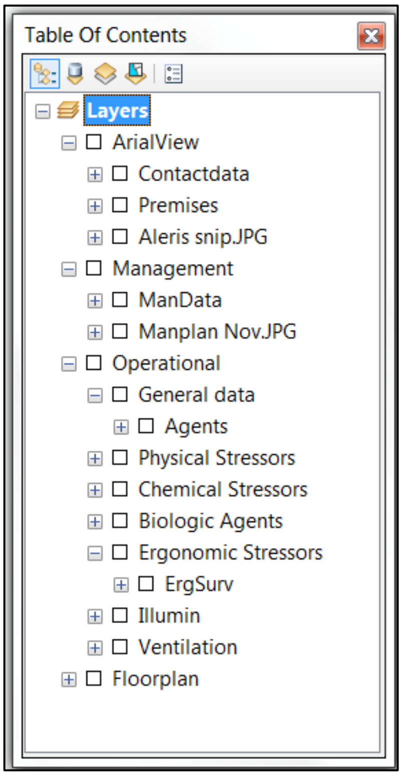


Figure 4.3: Comprehensive view of the data table containing base maps, group layers and sub layers

It was deemed necessary to provide future researchers with information as to the exact methodology used to create the model so that if necessary, the study could be replicated. A discussion will follow on the relationship of the model to the dendrogram that is based on the information provided in the paragraphs below.

A summary of the steps followed is provided below.

4.5 Compatibility of spatial OH data

According to the dendrogram, the compatibility of OH data is determined by the compatibility of spatial OH data and the compatibility of nonspatial OH management data. In turn, the compatibility of spatial data is determined by the ability of the model to accommodate the factory outlay and data pertaining to agents/stressors. Therefore, this section dealt with the compatibility of spatial OH data, which is determined by the terrain plan and the floor plan.

4.5.1 Factory outlay

All the plants had indoor and outdoor operations. To map the stressors and work areas, maps had to be available for the outdoor and indoor areas. Therefore, terrain plans as well as floor plans.

4.5.1.1 Terrain plan

During the design of the model, a terrain plan was necessary to be able to identify that plant from other similar plants in the world. It could also serve as a reference to determine the possibility of contaminants entering the plant from companies in the proximity depending on the wind direction. Alternatively, it could assist with planning for disaster management in the event of the release of water or airborne chemicals. By way of GIS modelling or merely by observing the topography or prevailing winds, arbitrary estimates of consequences could be made. To achieve this objective, an aerial view of the plant and the surroundings were drawn from Google Earth. The photo was drawn into the model and set as a base layer. After which it was georeferenced, meaning that it was given the correct geographical coordinates and orientation that it would have on a map of the earth. Layers were then created as polygons and point sources. The attribute tables were consequently populated with data relevant to that industry. The attribute table was then populated with data (attributes) describing that specific point or polygon. By way of the "map tips" function, specific data would be activated and automatically pop up whenever the cursor on the computer screen (GUI) would hover over a specific area.   Figure 4.4 illustrates the aerial view that was created of Industry Number 1, as well as the layers that were created. The opaque area is a polygon layer that was created over the base layer and distinguished the plant from surrounding industries. The green triangle indicates a point layer that was created and overlaid on the base layer. It identifies the admin block whenever the cursor hovers above that area.

Figure 4.4: An aerial view of the plant

Observations for the importation of terrain plans, as was found at all plants:

1. The screenshot from Google earth was successfully integrated as a base layer in the MXD file that was created for each industry.
2. The aerial photograph was successfully georeferenced. Thereby having the correct geographic coordinates and orientation.
3. The attribute table accepted the data and effectively displayed information when prompted by the cursor.
4. When a layer was activated, the programme responded by providing the requested view of the layer.
5. When the information icon was prompted, the programme provided a summary of the data on the screen at a specific identified point.

4.5.1.2 Floor plan

The compatibility of the floor plan is determined by the ability of the programme to successfully demonstrate the process areas and be able to zoom into the workstations (dendrogram).

To visually demonstrate where in the workplace, hazards may be found or where sampling was done, a point of reference is required. In GIS this would typically be a map. CAD drawings, when up to date, provide an accurate presentation of the interior of industrial plants. It was decided to make use of CAD drawings for the model. The latest available CAD drawings were drawn into the models and set at the bottom of the Table of Contents as a base layer. Layers were created that indicated the different process areas in the plant. This was achieved by obtaining the process areas of each plant and creating polygon shapefiles by drawing the polygons along the borders of each area.

An advantage of CAD is that a person can zoom in to any workstation provided that it is included in the original drawing. Figures 4.5 and 4.6 demonstrate the successful incorporation

into the GIS model of the CAD as well as the creation of a layer containing process areas. The ability to zoom into a workstation is illustrated in Figure 4.7

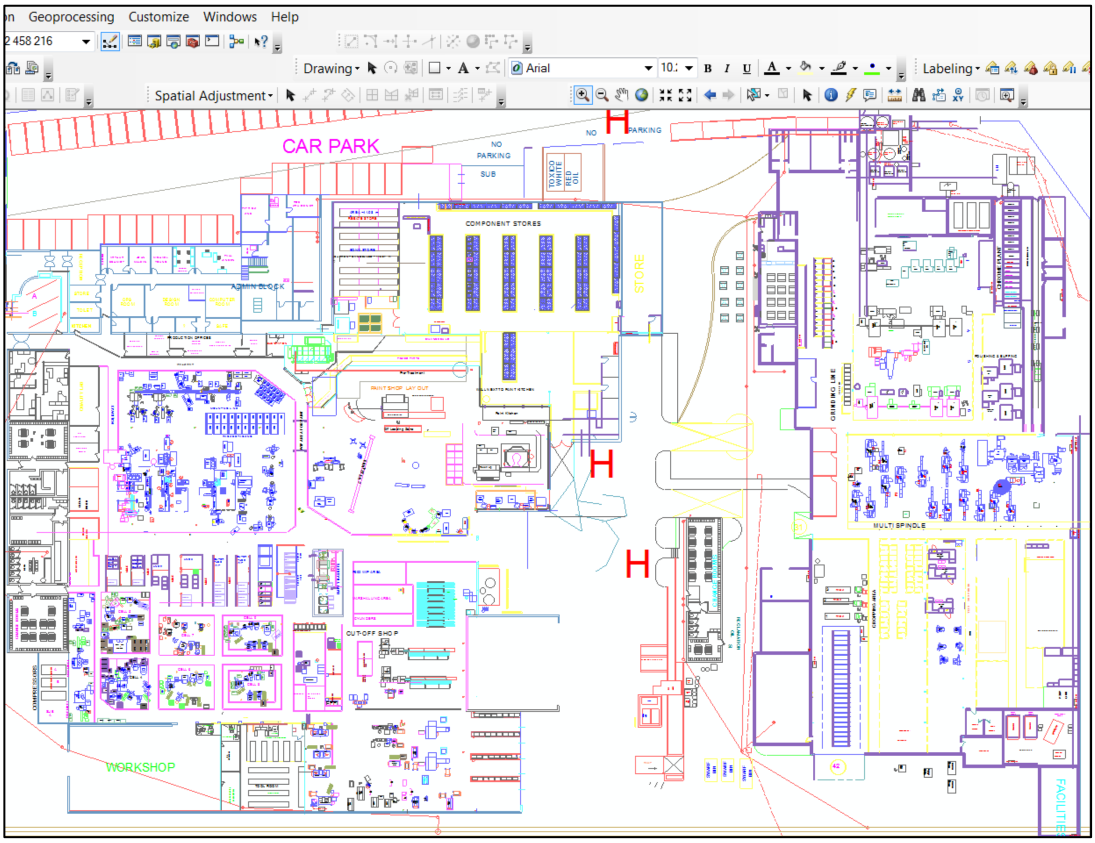


Figure 4.5: CAD successfully drawn into the model

In Figure 4.6 the names of the process areas pop up when the cursor hovers over them. As demonstrated at the Paint Shop below the red arrow.

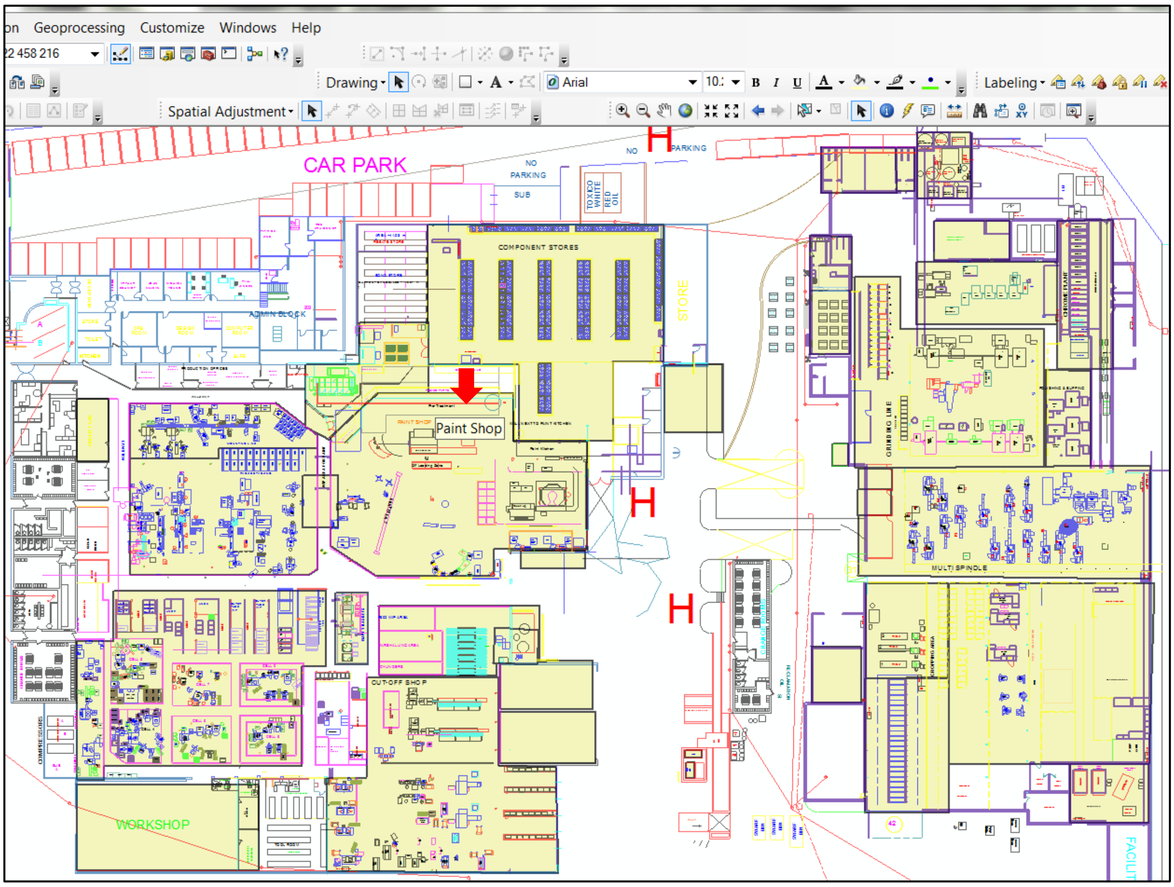


Figure 4.6: CAD with an overlay to demonstrate different process areas

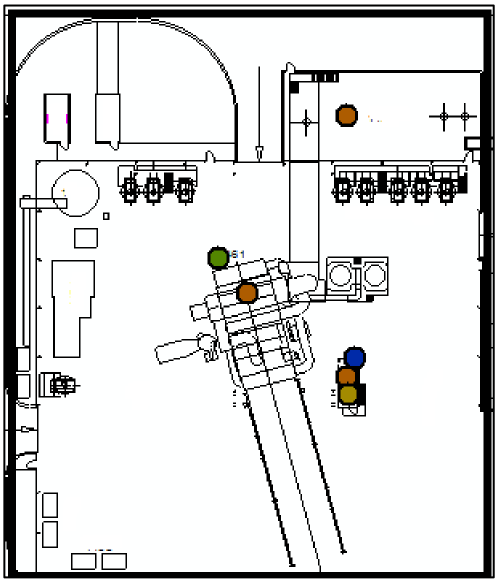


Figure 4.7: Zoom in to workplace with illustrating work areas and sampling positions

Floor plan observations:

1. The CAD floor plan was imported into the model and set as a base layer.
2. A layer consisting of polygons signifying the various work areas was created in each of the industries.
3. It was possible to zoom right into a workplace of a specific area and view the apparatus.

4.5.2 Agents, stressors

As mentioned earlier, the factory outlay and the OH agents/stressors determine the compatibility of spatial data. In turn, the compatibility of **agent or stressor data** is determined by the compatibility of **sampling data** and the **distribution of stressors**. The presentation of the distribution of stressors will be dealt with first.

4.5.2.1 Distribution of stressors/hazards

Section 8 {paragraph (2)(d) and (2)(I)} of the Occupational Health and Safety act of 1993 No. 85 of 1993 (South Africa, 1993:8) states that every employer should determine the hazards in the workplace and provide information, instruction, training and supervision to the workforce regarding these hazards. Section 13 of the same act elaborates on the “right to know” of employees of hazards in the workplace. Presenting the stressors or hazards associated with the stressors as a layer on a floor plan should theoretically assist with communicating the nature and location of stressors in the workplace. Layers consisting of points, rectangles or polygons that could be superimposed on the floor plan were created for each stressor. The collective name for this section was “Agents”. This part of the model building placed a very high tax on time.

Layers could be switched on and off to be viewed individually. As some areas contained more than one stressor, the transparency and legend of the various layers were set in such a way that all the stressors could be seen simultaneously. In Figure 4.8 the various agents may be seen as separate layers. From the presentation on the GUI, it may be seen that some areas have more than one stressor (agents) present, therefore theoretically increasing the risk to workers.

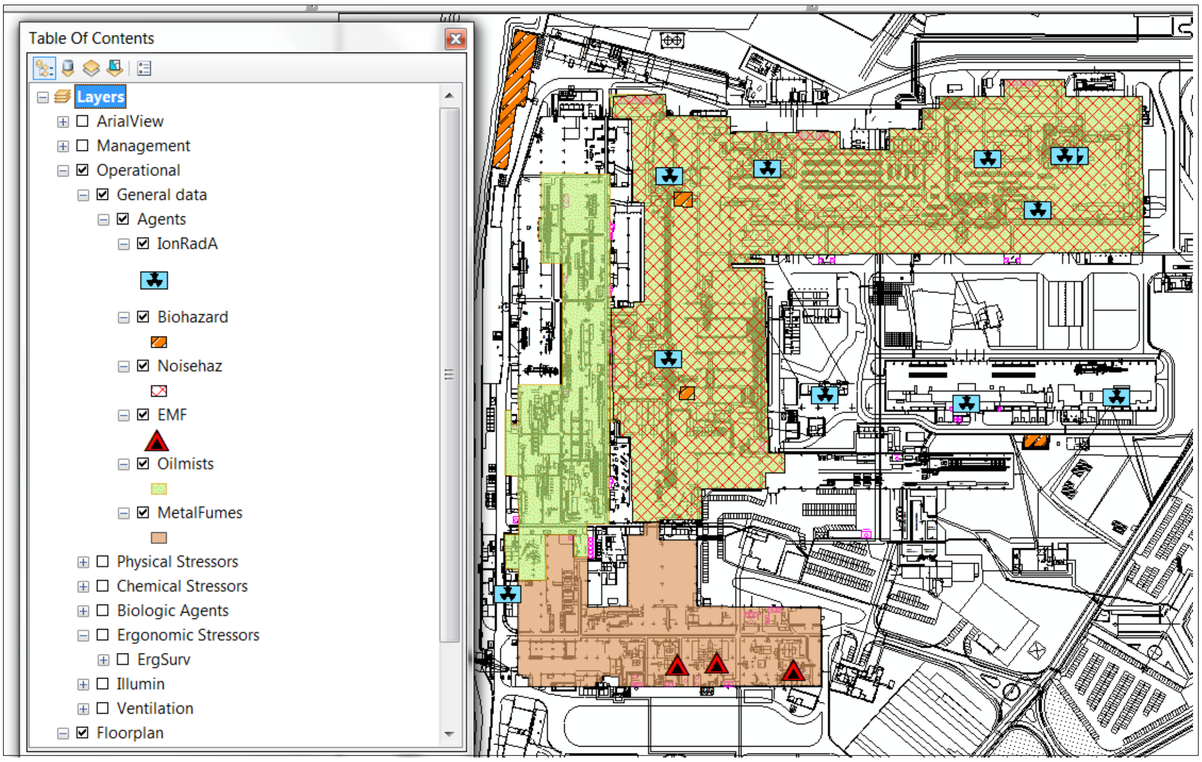


Figure 4.8: A screenshot of the various agents as superimposed layers

4.5.2.2 Sampling data

In South Africa, approved inspection authorities must keep a record of samples taken at an industry and indicate by way of a sketch at which areas samples were taken (South Africa, 2012:8). These sketches are incorporated into the reports. Reports from consultants differ in format, which could make it difficult at times to compare results, establish trends or make predictions.

A layer was created for each stressor for the easy recognition and access to a specific agent, for example, a chemical stressor. Under this heading layers were created to indicate specific locations of chemicals being used. Specific data concerning the hazards associated with the chemicals were entered into the attribute tables. Any person wishing to gain the information on the particular chemicals simply had to click on the desired location and have the information at hand. This was done by creating shapefiles, and in these cases, they were point files.

Unique icons in the legend distinguished the various agents that were sampled for, from others. An extra field was added to the attribute table to distinguish whether samples complied with legislation or not. Samples that did not comply with legislation were presented in red on the screen.

Figures 4.9 – 4.17 illustrate the outcomes of the models after being populated with data from the individual industries.

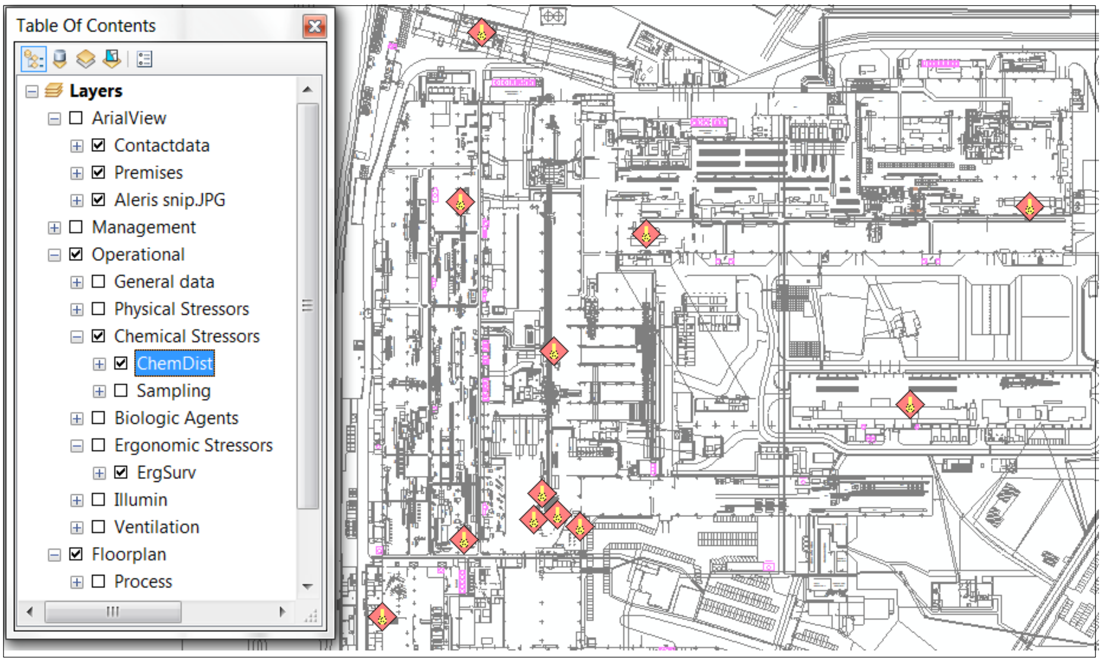


Figure 4.9: Screenshot indicating the location of specific chemicals

ChemDist

FID	Shape *	Substance1	Risk1	ToxEff1	Carcinog	Mutagen	Teratoge	TargetOrg1	Note1
0	Point	Tolueen	<Null>	Irritant, terratogen	n	n	y	Eye, CNS, reproductive system	No pregnant women
1	Point	Dichloromethane, Methylene chloride	<Null>	Iritant, CNS, converted to CO in bood. Confirmed animal carcinogen,	y	y	y	Blood, Heart, Kidneys, liver, lungs, pancreas	<Null>
2	Point	Perchloroethylene	<Null>	Irritatant, Narcotic, dermatitis	n	n	n	Liver, Kindneys, eyes, Upper Resp syst, CNS	No pregnant women
3	Point	Polyoxyetheylene Dioleate	<Null>	No Data	<Null>	<Null>	<Null>	<Null>	<Null>
4	Point	Organic mixture	<Null>	Resp Irritant, CNS depressant	n	n	n	Kidneys, Liver, CNS	<Null>
5	Point	Sulphuric Acid	<Null>	Corrosive, Genotoxic	n	n	n	skin, eyes	<Null>
6	Point	Sulphuric Acid	<Null>	Corrosive, Genotoxic	n	n	n	skin, eyes	<Null>
7	Point	HF	<Null>	Highly corrosive	n	n	n	Body	<Null>
8	Point	MEK	<Null>	Irritant	n	n	n	Eyes, skin	<Null>
9	Point	2,2,butoxyetoxy,ethanol	<Null>	Low toxicity	n	n	n	<Null>	Add no nitrites or nitrogenating compounds. Su
10	Point	Nitrogen	<Null>	Simple asphyxiant	n	n	n	<Null>	<Null>
11	Point	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>

Figure 4.10: A screenshot of a section of an attribute table populated with data related to chemical stressors

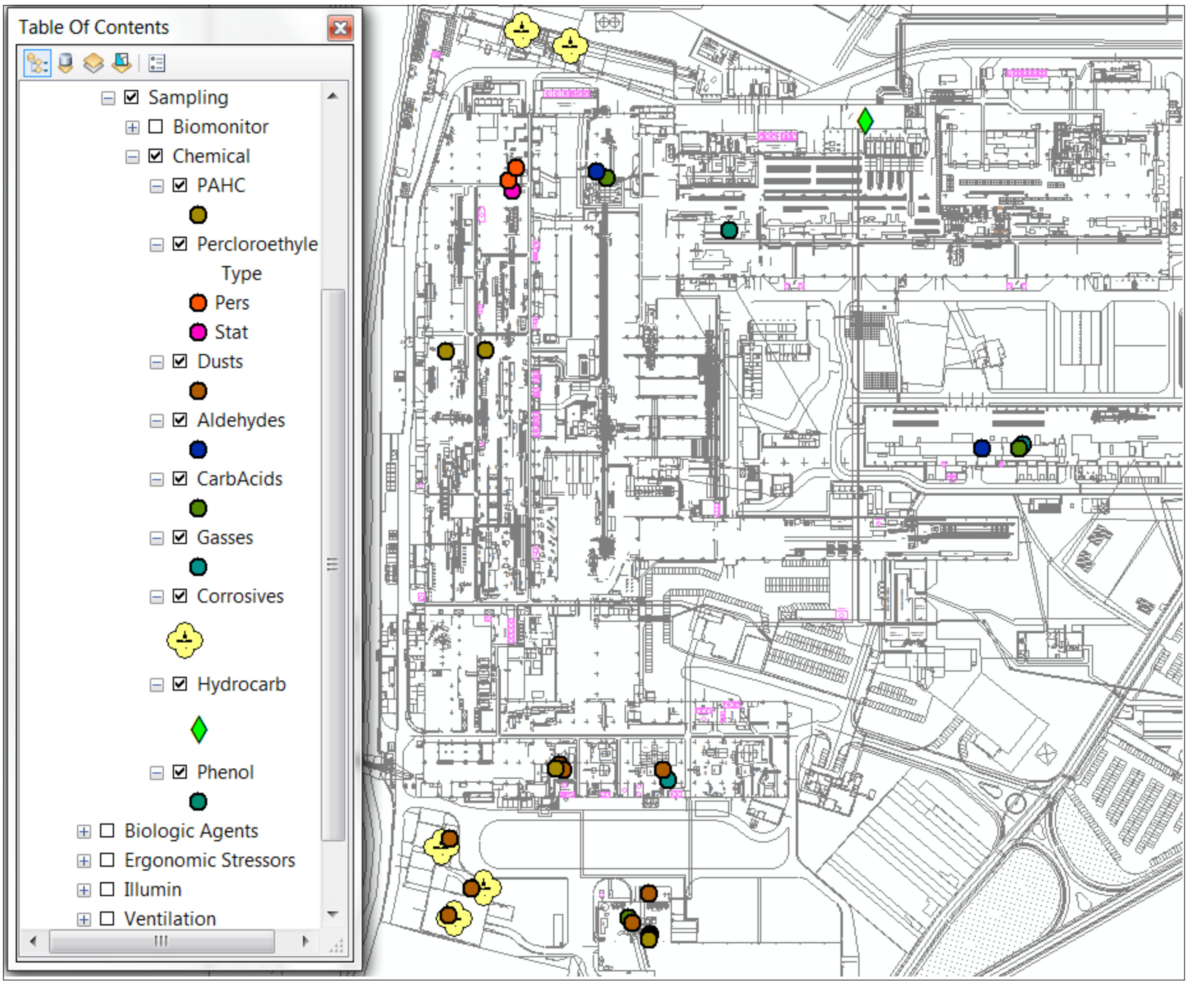


Figure 4.11: Screenshot showing locations of all chemical sampling

Information pertaining to a specific site may be obtained by clicking with the mouse on the information icon and then on the area of which information is required. In this case, the site where the noise levels exceeded 85dB(A) was interrogated. The management of the noise problem is summarized in the last line of the popup on the right as may be seen in Figure 4.12.

Figure 4.12: Retrieval of all information pertaining to a specific location

4.6 Conforming to criteria

The main aim of uploading occupational hygiene data onto the MXD files of each project was to establish compatibility between the mentioned data and the capabilities of a GIS. The primary data handling features of ArcGis10 were to be used on the data and the results were evaluated to determine the compatibility of the GIS and occupational hygiene data. These criteria, as it was determined by the dendrogram, were as follows; data capturing, visual representation and execution of searches. The findings of these aspects are discussed below.

4.6.1 Data capturing

The model was able to capture data, maps and photographs of each plant within each separate model. If this did not happen, then the visual representation in ArcMap would not be possible. Effective capturing of chemical data in an attribute table is visible in Figure 4.9. The attribute tables were able to effectively capture different types of data. E.g. the data for the risk assessment in ergonomics differed from chemical data captured.

4.6.2 Visual representation

Data captured were visible as views and layers. GIS was able to generate charts to illustrate trends of samples that were taken over time as well as indicating compliance, as seen in Figure 4.13.

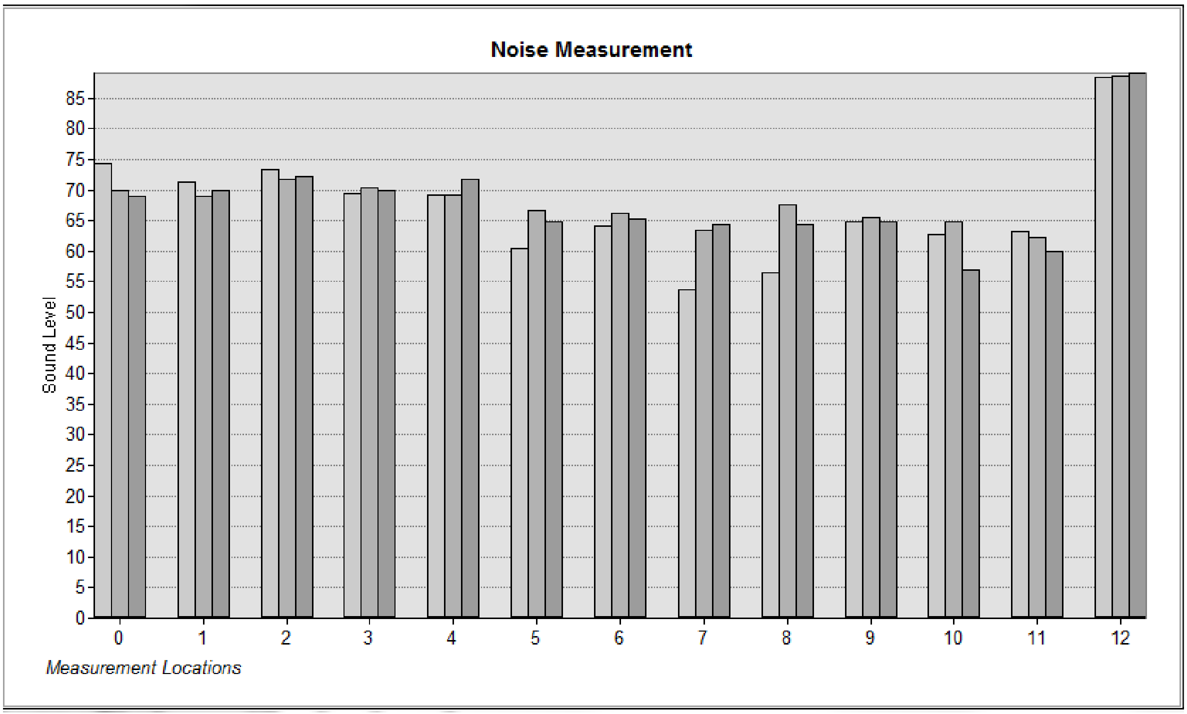


Figure 4.13: The chart generated by GIS to show results of noise monitoring at set positions in the plant, over time

The following illustration depicts the results of three consecutive surveys of noise levels. Non-conformances were indicated in red, thereby visually distinguishing areas that required priority attention. In the case of colour-blind managers, the programme offers an opportunity to launch a query. By launching a query "Indicate where noise levels exceed 85dB(A)", the programme will find the specific area and highlight it on the screen and in the attribute table. The result of such a query is shown in Figure 4.14 below.

Figure 4.14: Results of noise survey showing one point of noncompliance (red) that needs to be managed

.

The model illustrated the varying ergonomic risks of the assessment that was conducted. Figure 4.15. Thereby demonstrating its ability to present varying data and evaluations, whether it be the results of chemical sampling or an ergonomic survey. The screenshot indicates areas of high risk, medium and low risk as well as areas where no assessment was done. The transparency of the base map layer has been set to 50% so that the image is softer on the eye.

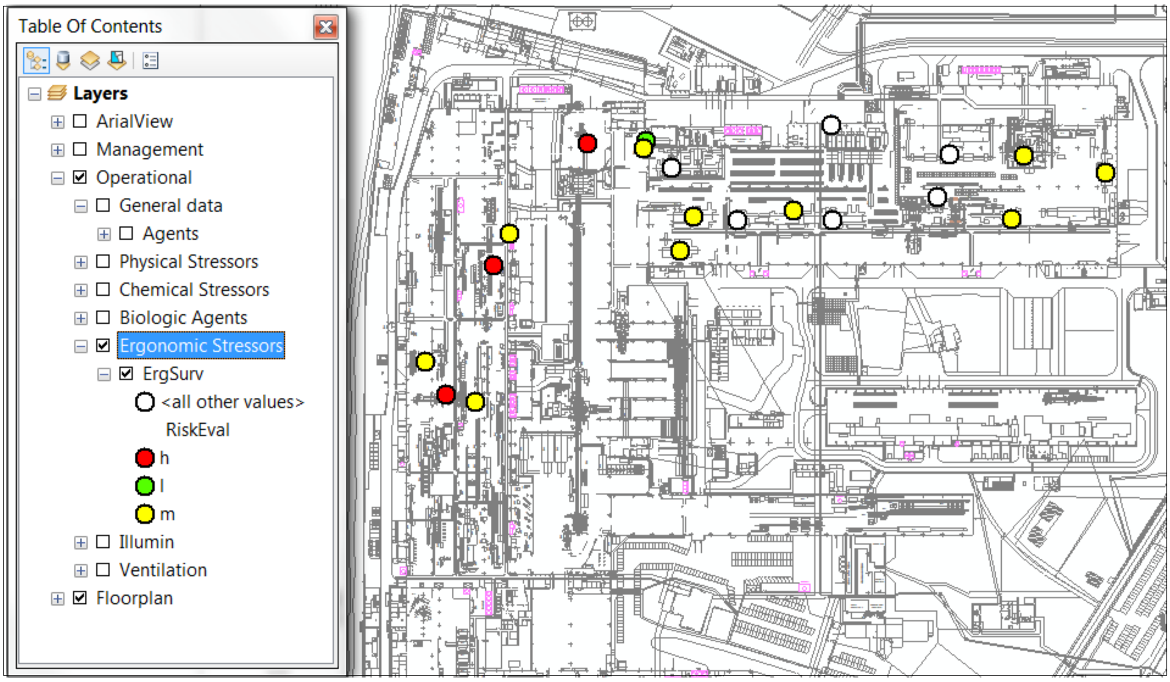


Figure 4.15: Screenshot demonstrating the layer that was created for ergonomic risk assessments

Figure 4.16 below illustrates the results of an illumination survey. The illumination bands are demonstrated by way of colour coding.

Figure 4.16: Results of an Illumination survey

4.6.3 Execution of searches

OH data was successfully interrogated by the model to indicate searches for specific attributes, i.e. searches for teratogens. The version of GIS used indicates the result of the search by flashing the particular position. An important fact to note is that by clicking with the information key on the identified location, all the captured OH data pertaining to that spot will appear in a window. In Figure 4.17 below, the search for teratogens is illustrated. Two locations were identified. The green dot flashed when selecting the top line of the two options provided in the window.

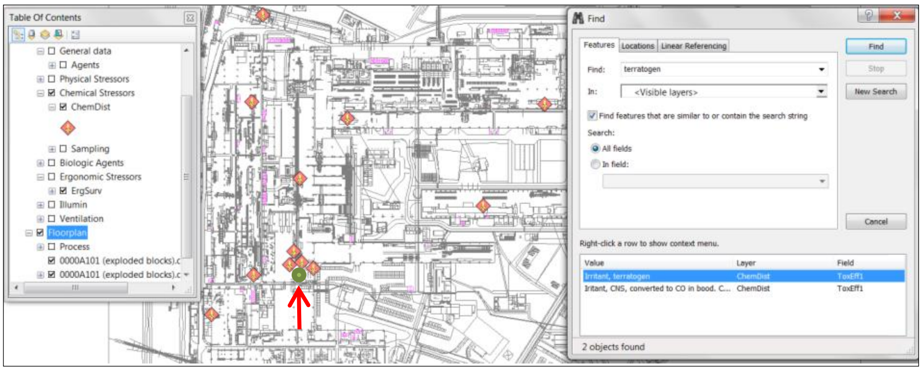


Figure 4.17: Result of a search for a teratogen

4.6.4 Data not captured

It needs to be noted that only the available data from the industrial plants were captured. The data, therefore, was not necessarily comprehensive. A point in case would be data associated with personal sampling. However, the programme can capture data related to personal sampling. This may be achieved by simply creating a layer indicating workstations or workers within an area. The associated attribute table would then be created to contain columns with identification names or codes of workers on whom personal samplers were fitted. Another adjacent column in the attribute table could be populated with the corresponding laboratory results, dates, limit values, etc.

Short Term Exposure Limit (STEL) values and full-shift exposure may be accommodated by creating shapefiles (point) in ArcMap and then connecting the shapefile to a column in the attribute tables that have been created for STEL values and full-shift exposures. Alongside the actual exposures for STEL's and full-shift exposures, columns need to be created for the legislated limit values of the various agents. This action enables a search to be done on the data, i.e. "indicate where the short-term exposure limits were exceeded in the current sampling". The programme will then indicate the positions of nonconforming values on the GUI. In turn, this information could enable the prioritisation of actions to be taken.

4.7 Nonspatial management data

As was mentioned in the dendrogram, the compatibility of spatial OH data and the compatibility of nonspatial OH management data determine the compatibility of OH data.
Linking nonspatial management data such as the strategic planning of a company to a single area on CAD base map may isolate the data and may not be as efficient as linking it to a location that contains all the management data. A layer to which all the management data were linked would enable a manager to have access to all management data in one location. Both companies under study made use of the Plan-Do-Check-Act (PDCA) methodology to manage OH. This methodology is an integral part of BS OHSAS 18001 (2007:iv). To dovetail with their existing systems, it could prove beneficial to incorporate this standard and embedded methodology within the layer. Since the onset of the research, a draft of a new international management system for OH was circulated in 2016. This standard ISO 45001 was published in 2018 (International Standards Organization, 2018). This document included the PDCA methodology and augmented the validity of including the PDCA in the management model.

The challenge in creating the model was to create a base map layer to which the relevant nonspatial data could be linked. This was achieved by creating a framework of the main headings of the OHSAS 18001 management system namely; policy, planning, implementation and action, operation, checking and corrective action and management review, that could be saved as a Word document. Subheadings pertaining to the headings were then created as a sub-layer flowing from the main one. A screenshot of this outlay was taken and imported as a photograph into the MXD file that was created for each plant. These outlays were slotted under the layer named "Management" in the Table of Contents of each in each of their files. For the sake of the programme, each management layer had to be provided with a unique name. Suffixes identifying each plant were then added to the management layer, for example, Management RC. Polygons were then superimposed as a layer onto the last column of "click boxes" to permit the programme to identify the separate sections on the photograph. After which hyperlinks were created that linked each demarcated area to documents pertaining to that heading. A manager wishing to peruse the communication chain at a specific plant could activate the "Management" layer by clicking on the tick box. Then activate the hyperlinks by clicking the hyperlink icon in the toolbar. Once the hyperlinks are activated, a manager could proceed to one of the highlighted boxes and click on the box containing the required data. The hyperlink would then navigate directly to the information. During the design, links were not created to all documents — the reason being to test and illustrate the principle rather than creating a working model. Links were successfully created to Word, Excel documents and screenshots. For the sake of the study, individual files were built to accommodate the documents that were to be recalled via the hyperlinks. The reasons being that the preparation for demonstrations would be hampered and (more important) that direct links to company data could be guarded by firewalls. Negotiating these would be time-consuming and could be against company policies.

In Figure 4.18 below, the main stages of the BS OHSAS 18001 can be seen. The rectangles with the highlighted borders are those with the hyperlinks, and by clicking on these links, the requested documentation would be produced. The dendrogram indicates that documents such as policy, planning, implementation, checking and corrective action and management reviews should be retrievable. The OHSAS 18001 management stages incorporating Plan-do-check-act components are marked.

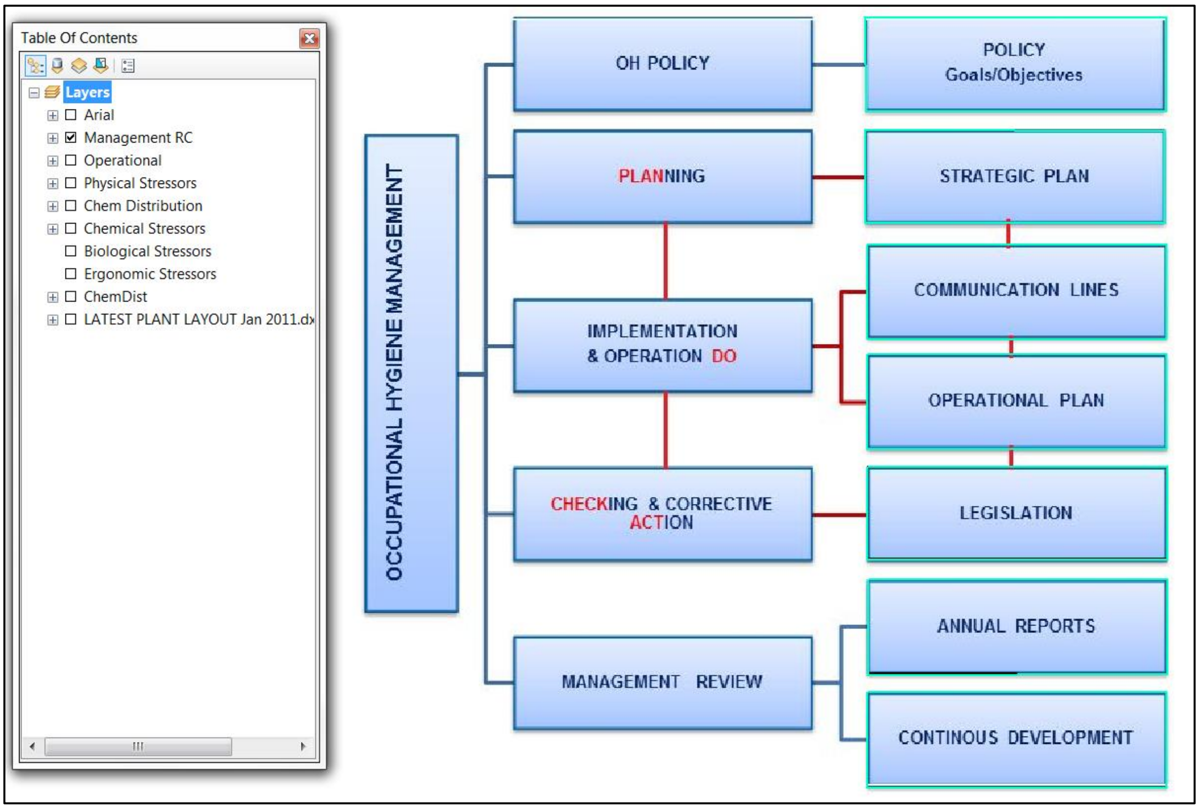
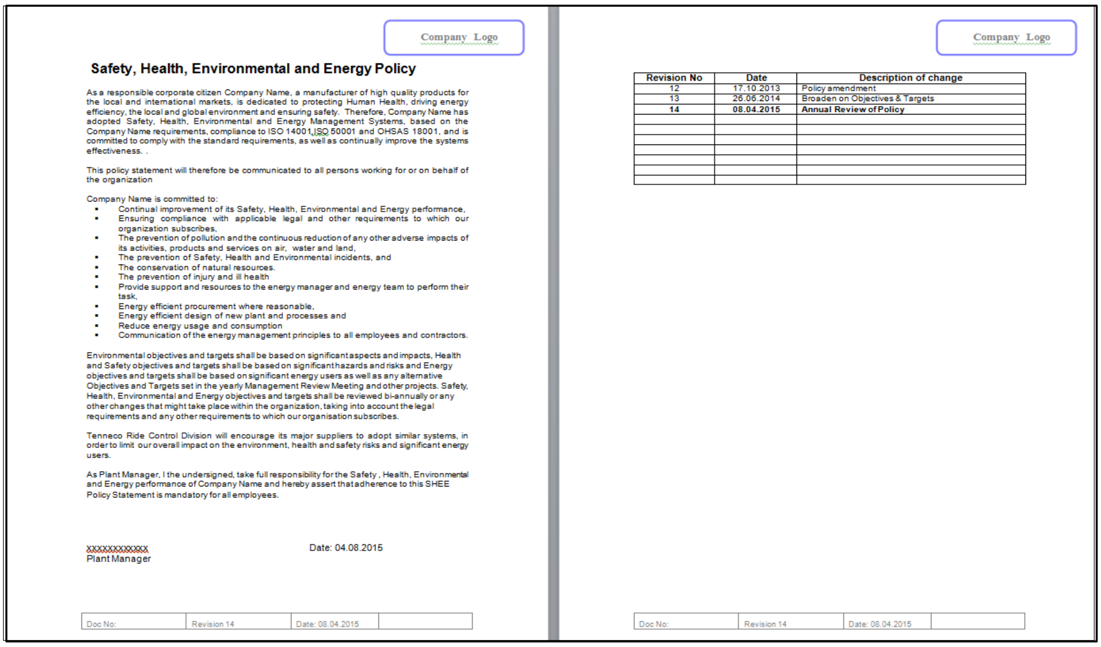


Figure 4.18: Representation of nonspatial data

4.7.1 OH policy goals objectives

In terms of the OHSAS 18001 (ISO, 2007:5) top management should define and authorise a policy. The purpose of the research in this regard was not to evaluate the policy of the company but rather to gain access to the company policy in relation to Health and Safety. Consequently, the policies were obtained and stored in a file and access was gained by clicking on the hyperlinks created. Figure 4.19 illustrates the successful retrieval of a document containing the safety policy.



Company Logo

Safety, Health, Environmental and Energy Policy

As a responsible corporate citizen Company Name, a manufacturer of high quality products for the local and international markets, is dedicated to protecting Human Health, driving energy efficiency, the local and global environment and ensuring safety. Therefore, Company Name has adopted Safety, Health, Environmental and Energy Management Systems, based on the Company Name requirements, compliance to ISO 14001,ISO 50001 and OHSAS 18001, and is committed to comply with the standard requirements, as well as continually improve the systems effectiveness. .

This policy statement will therefore be communicated to all persons working for or on behalf of the organization

Company Name is committed to:

- Continual improvement of its Safety, Health, Environmental and Energy performance,
- Ensuring compliance with applicable legal and other requirements to which our organization subscribes,
- The prevention of pollution and the continuous reduction of any other adverse impacts of its activities, products and services on air, water and land,
- The prevention of Safety, Health and Environmental incidents, and
- The conservation of natural resources.
- The prevention of injury and ill health
- Provide support and resources to the energy manager and energy team to perform their task,
- Energy efficient procurement where reasonable,
- Energy efficient design of new plant and processes and
- Reduce energy usage and consumption
- Communication of the energy management principles to all employees and contractors.

Environmental objectives and targets shall be based on significant aspects and impacts, Health and Safety objectives and targets shall be based on significant hazards and risks and Energy objectives and targets shall be based on significant energy users as well as any alternative Objectives and Targets set in the yearly Management Review Meeting and other projects. Safety, Health, Environmental and Energy objectives and targets shall be reviewed bi-annually or any other changes that might take place within the organization, taking into account the legal requirements and any other requirements to which our organisation subscribes.

Tenneco Ride Control Division will encourage its major suppliers to adopt similar systems, in order to limit our overall impact on the environment, health and safety risks and significant energy users.

As Plant Manager, I the undersigned, take full responsibility for the Safety , Health, Environmental and Energy performance of Company Name and hereby assert that adherence to this SHEE Policy Statement is mandatory for all employees.

xxxxxxxxxxxx
Plant Manager

Date: 04.08.2015

Doc No: | Revision 14 | Date: 08.04.2015

Company Logo

Revision No	Date	Description of change
12	17.10.2013	Policy amendment
13	26.06.2014	Broaden on Objectives & Targets
14	**08.04.2015**	**Annual Review of Policy**

Doc No: | Revision 14 | Date: 08.04.2015

Figure 4.19: Retrieval of Word document containing OH policy

4.7.2 Strategic plan

The retrieval of the strategic plan is illustrated in Figure 4.20.

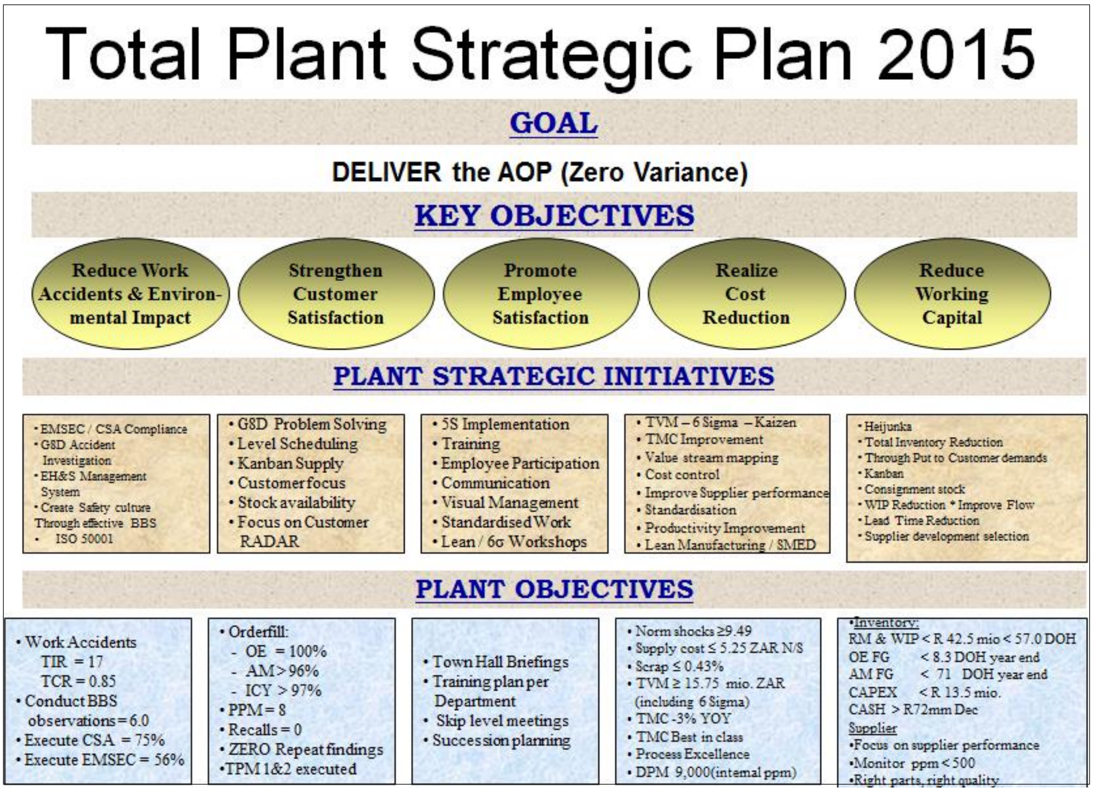


Figure 4.20: Retrieval of the strategic plan

4.7.3 Communication lines

Figure 4.21 illustrates the successful retrieval of staff hierarchy and communication lines.

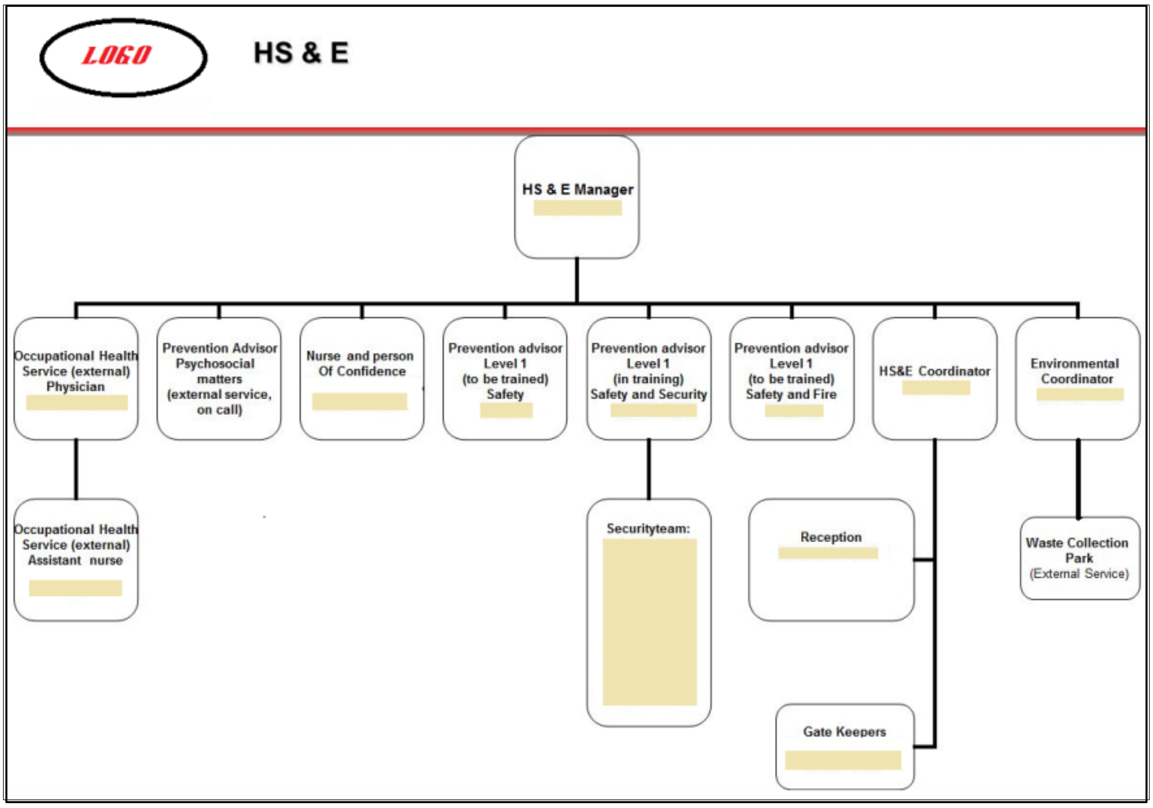


Figure 4.21: Retrieval of staff hierarchy and communication lines

4.7.4 Operational plan

Planning in the OH context involves the recognition, evaluation and control of the stressors in the workplace. Figure 4.22 below shows an operational plan set in a matrix. It was specially designed to demonstrate progress and incorporated training as part of the management process. Figures 4.23 and 4.24 illustrate other variations of the operational plans.

Red - Outstanding
Blue - Complete

EHS TASK MATRIX RC

2014

NO.	EHS INFORMATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
	DAILY												
1	Stormwater water drain checks (Mondays)												
2	External/Internal Communication Log												
	MONTHLY												
3	Cooling Towers (beginning and end of month readings)												
4	Chrome baths (beginning and end of month readings)												
5	Capturing waste disposal slips												
6	Environmental Graphs												
7	PPI (Plant pollution index)												
8	Check and write latest Oilkol collection date on seperator												
9	Spill kit checks												
10	Organizational training matrix												
11	Internal Audits												
12	Close out can pan's												
13	Surveys / Tests												
14	File legal register of Dr. Lapere												
	BI-ANNUALY												
15	Aspects & Impacts Register												
16	Objectives and Targets												
17	Check Permits / Licenses												
18	Emergency Contact / Team List												
	ANNUALLY												
19	EEHS Management Review												
20	Legal Compliance Audit												
21	Surveillance / Certification audit												
22	EHS Policy & Evacuation Plan Update												
23	Emergency Evacutation Drill												
24	Spill Drill												
25	Building checks												
26	Chemical Risk Assessment												
27	Licence to store petroleum												
28	Effluent Permit	2018											
29	Certificate for Spray booth	Jun-15											

EHS SURVEYS	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
MONTHLY												
Ventalation									2014			
Ground water								2014				
Storm water						2014						
Legionella	2014											
Drinking water				2014				2014				2014
Effluent				2014				2014				2014
HCS (Chemicals)							2014					
Stack Emissions									2014			
Ambient Dust								2014				
Microbiological Tests												
Asbestos (personal monitoring)							2014					
Asbestos Inventory							2014					
Illumination				2014								
Environmental Noise						2014						
Noise					2014							

Figure 4.22: Retrieval of an operational plan during the planning stage

GLOBAAL PREVENTIEPLAN 2010-2014 20/01/2010

EHS-BELEID

	Actiepunt	Verantw	2010	2011	2012	2013	2014
1	VEILIGHEIDSMANAGEMENTSYSTEEM: behalen van OHSAS18001	EHS		X			
2	Verantwoordelijkheid van de Hierarchische Lijn: opleiding voorzien voor ganse HL	EHS	X	X			
3	BEHAVIOUR BASED SAFETY: Opleiding van alle werknemers voor het herkennen van risico's en het aanspreken van, of aangesproken worden door, collega's.	HL	X	X			
4	MANAGEMENT-overleg EHS: systemathiek opzetten zodat het beleid uitgewerkt wordt zoals voorzien in het KB Beleid en eisen volgens OHSAS.	EHS	X				
5	INFOSESSIES voor personeel: elk kwartaal een infosessie geven aan personeel	HL	X	X	X	X	X
6	SENSIBILISERINGSCAMPAGNES: minimaal 2 campagnes per jaar organiseren	EHS	X	X	X	X	X
7	AUDITS: auditprogramma opzetten ter controle van het veilig gedrag (BBS, LOTO, 2min risk, basisveiligheidsregels)	HL	X	X	X	X	X
8	REGISTRATIESYSTEEM INCIDENTEN: Opzetten van een overkoepelend registratiesysteem voor alle incidenten (AO, AW, EHBO, BRAND, OEF, SECURITY, MILIEU)	EHS	X				
9	BASISOPLEIDING VEILIGHEID: organiseren voor elke nieuweling	EHS	X	X	X	X	X

ARBEIDSVEILIGHEID

	Actiepunt	Verantw	2010	2011	2012	2013	2014
1	RISICOANALYSES op niveau site, afdeling, functie: TA van alle werkposten opstellen	HL	X	X	X	X	X
2	MACHINEVEILIGHEIDSDOSSIER: in orde brengen van de wettelijk verplichte documenten in het veiligheidsdossier in de afdeling en het machineklassement van EHS	HL	X	X	X		
3	VEILIGE WEGEN: alle zwakke weggebruikers scheiden van het intern transport	HL	X	X	X	X	X
4	LOTO: in beslag name van alle installaties aanpassen naar de LOTO-systhematiek	HL	X				
5	SAFE MODE: elk jaar een installatie aanpassen naar SAFE MODE	HL	X	X	X	X	X
6	PERIODIEKE KEURINGEN: alle keuringen onderbrengen in één database	HL	X	X			
7	EXPLOSIEVEILIGHEID: Zoneringsplan opmaken en explosieveiligheidsdocumenten aanmaken	HL	X	X			

ARBEIDSHYGIENE

	Actiepunt	Verantw	2010	2011	2012	2013	2014
1	RISICOANALYSE van alle werkposten volgens standard HSE005	HL	X	X	X		
2	GELUID/LAWAAI: Reductie geluid voor één werkpost per jaar	HL	X	X	X	X	X
3	CHEMICALIEN: invoering GHS-systeem	EHS	X	X			
4	LUCHT: acties opzetten om de luchtkwaliteit te verbeteren	HL	X	X	X	X	X
5	KLIMAAT: acties opzetten om het klimaat in de fabriek te verbeteren	HL	X	X	X	X	X
6	TRILLINGEN: Reductie van de probleempunten	HL		X	X	X	X
7	NIET-IONISERENDE STRALING: Inventariseren en checken t.o.v. bestaande wetgeving	EHS		X	X	X	X

Figure 4.23: Retrieval of long-term planning in Excel format

ANNUAL ACTION PLANNING 2012

	CATEGORY	AREA	STRESSORS	ACTION	RESP. PERSON	PERFORMANCE INDICATOR	DUE DATE/S	COMPLETION DATE	STATUS 15 JUNE	STATUS 15 DECEMBER	COMMENTS
1	POLICY										
2	RISK ASSESSMENT	Productie ism PA afd	All	Risocoanalyse uitvoern voor productie ism PA afd (Conformiteit met HSE005) (inclusief assessment betreffende trillingen en ergonomie) Aanpak analoog taakanalyses productie	BESUVA/ DI,KDH				Opgestart, trial pers 5000		
3	SAMPLING/MONITORI										
	- Chemical										
	- Physical										
	- Ergonomic										
	- Biological										
	- Biomonitoring			Biomonitoringsstrategie bijstellen op basis van resultaten van HSE005	CRA						
4.1	MANAGEMENT OF STRESSORS		Chemicals	Chemicaliën: database updaten volgens CLP/GHS	PVD				Inventarisatie is klaar. 2e fase is lopende herbekijken MSDS en geven van artikenummer voor produkte zonder		
4.2			Noise	LAWAAI-punt : volgens prioriteitenlijst punt aanpakken met de grootste impact. 2011: 5000 blokkenzaag. Rest afhankelijk van prioriteiten, resources	KDH						
4.3			Noise	Acties naar dragen van PBM's met betrekking naar blootstelling aan lawaai met sensibilisatiecampagne door de arbeidsgeneesheer betreffende het dragen van gehoorbescherming	ALI				Afgewerkt aan koudwals		
4.4			All	Testen PBM's in functie van Europese standardisatie	DI/WO				Fase 1: Testen helm, veiligheidsbril, gehoorbescherming afgerond. Beslissing genomen. Fase 2: Voorbereidende vergadering ifv Europese standaardisatie van handschoenen uitgesteld tot september 2012.		
4.5			Ergonomics	Aanpak werkpost: volgens prioriteitstelling en aanbeveling arbeidsgeneesheer	BES / CRA				Ergonomie aan de techint is bekeken (stellen van scharen). Actieplan te implementeren op basis van de gegeven adviezen.		
4.6			Ergonomics	Ergonomie opnemen in taakanalyse bij review TA en in nieuwe projecten	PA Afd						
5.1	TRAINING		Ergonomics	Rugschool voor medewerkers onderhoud	BB						
5.2			Psychological	Opleiding leidinggevenden: herkennen van symptomen, hoe omgaan met medewerkers met stressklachten volgens advies van CRA.	BB				Feedback CPBW 1/11/2011: Behandelen op CSC alvorens hiermee te starten.		
6	ENGINEERING										
7	REVIEW										

Figure 4.24: Retrieval of the planning for OH stressors in Excel format

4.7.5 Legislation

The model provides a link to legislation as well as associated documentation. Figure 4.25 demonstrates the successful retrieval of a working document on legislation. This is a working document, therefore the use of more than one colour by the company.

COMPANY NAME Pty Ltd
LEGAL AND OTHER REQUIREMENTS

Methodology
This register is compiled at the hand of:
1. The existing legal and other requirements register at Company Name Pty Ltd.
2. An updated review of the current environmental, health & safety legislation.
3. A review of Company Name Pty Ltd occupational hazards and environment aspects during site inspections.
4. The energy management requirements at Company Name Pty Ltd.

Current format
1. Changes resulting in requirements no longer being applicable are indicated in ~~red strike-through~~ text.
2. Additions are indicated in red.
3. Where current procedures ensure legal compliance, these procedures have been documented in the 'application' column.
4. Energy-related specific legislation is listed in the 'ENERGY' chapter, listed last in this register. References are highlighted in green headers and documented in bold and underlined font.

Updates
1. Updates will be supplied monthly have been reverted to ordinary black text.
2. New changes in legal and other requirements will be highlighted as above and an introductory discussion and explanation of the application of these amendments (entitled UPDATE) is placed below as pre-amble to the update.
3. **The impact of a statutory amendment is highlighted in red.**
4. The proposed action by the SHE coordinator is ***highlighted in red, placed in italic and underlined.***
5. Updates are mailed monthly to the SHE coordinator and replace the entire previous file.

Updated items for September 2015
There are no relevant Occupational Health and Safety or Environmental Legal amendments

Updated items for October 2015
Correction Notice: National Code of Practice for the Training Providers of Lifting Machine Operators read with the Driven Machine Regulations, 2015 issued on 2/10/2015.

Figure 4.25: Successful retrieval of communication regarding legislation

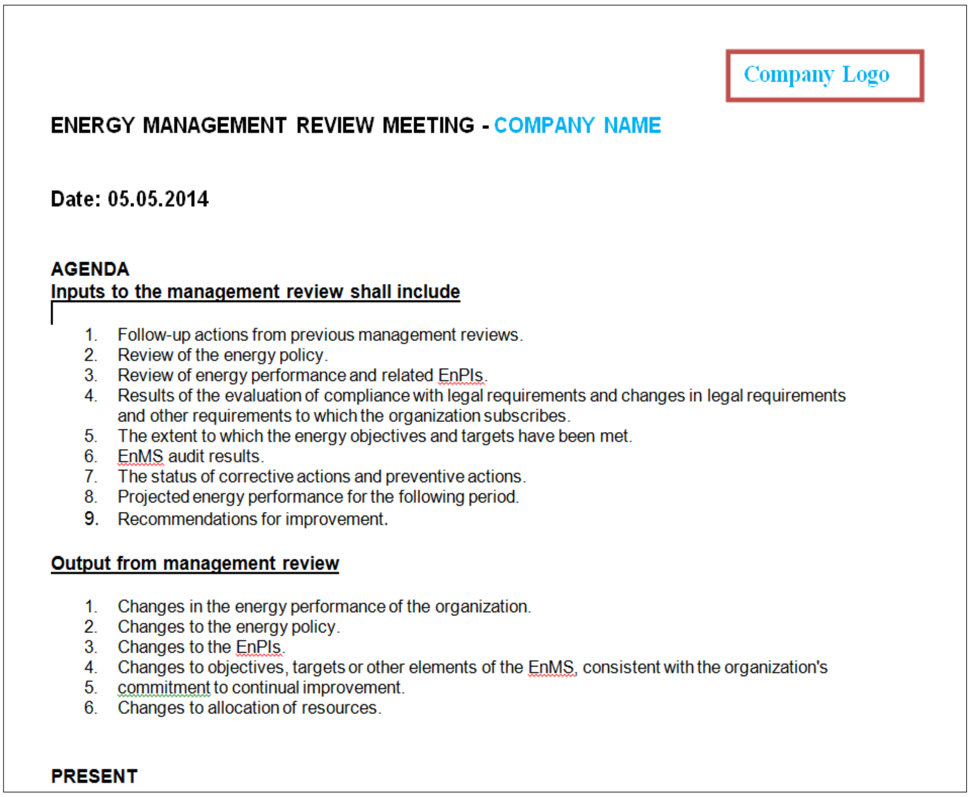
4.7.6 Annual reports

In practice, annual reports may in some cases be presented verbally. Figure 4.26 is the first slide of a yearly report that was orally presented using PowerPoint.

Figure 4.26: Retrieval of PowerPoint presentation of an annual report

4.7.7 Continuous development

Management reviews serve to gauge progress and to plan. During the management of OH, it becomes necessary at times to review these documents to determine whether operations are in line with management decisions. Figure 4.27 below illustrates the successful retrieval of a management review meeting.


Company Logo

ENERGY MANAGEMENT REVIEW MEETING - COMPANY NAME

Date: 05.05.2014

AGENDA

Inputs to the management review shall include

1. Follow-up actions from previous management reviews.
2. Review of the energy policy.
3. Review of energy performance and related EnPIs.
4. Results of the evaluation of compliance with legal requirements and changes in legal requirements and other requirements to which the organization subscribes.
5. The extent to which the energy objectives and targets have been met.
6. EnMS audit results.
7. The status of corrective actions and preventive actions.
8. Projected energy performance for the following period.
9. Recommendations for improvement.

Output from management review

1. Changes in the energy performance of the organization.
2. Changes to the energy policy.
3. Changes to the EnPIs.
4. Changes to objectives, targets or other elements of the EnMS, consistent with the organization's
5. commitment to continual improvement.
6. Changes to allocation of resources.

PRESENT

Figure 4.27: Records of management review meeting retrieved

As argued and depicted in Figure 4.1, the dendrogram, compatibility of nonspatial data is determined by the compatibility of documents pertaining to the main elements of the OHSAS 18001 management system. The criteria set for compatibility was that the documents should be captured on the system and are retrievable. As a result, the function to lodge the documents within the model was included in the model. However, it was deemed more functional and less time-consuming to retrieve the documents via hyperlinks as it would be time-consuming to access the document for day-to-day uses or alterations once the document was lodged in the system. The following observations were made during the construction of the layer for nonspatial data:

1. The importation of a screenshot of the management model that was developed according to the OHSA 18001 management system into the MXD file was achieved by using the “Add data” function.
2. The creation of a layer consisting of polygons was achieved by following the standard procedure for creating new shapefiles.
3. The required files were retrieved via the hyperlinks.
4. The hyperlinks were able to retrieve the files regardless of the format. I.e. Excel, Word or PowerPoint

4.8 Conclusion

This chapter dealt with the development of a GIS-based model for the management of OH data in three plants of multinational companies. An MXD file was created for each of the plants. The data pertaining to each of these plants were captured in these electronic files in attribute tables and layers in ArcGIS. The data were classified into two main categories, namely nonspatial and spatial data. Layers were created for each of the categories in the MXD files. It was possible to display the results on the GUI (screen) and noted by the researcher. Detailed discussions are to follow in Chapter 6.

The next chapter deals with the development, application and analysis of the semi-structured interviews that were held with staff from the three plants.

CHAPTER 5: INTERVIEWS

5.1 Introduction

Chapter four dealt with the development of a GIS model for the management of OH data. This chapter deals with aspects of the design of the semi-structured interview in which staff members were interviewed on their perceptions of the GIS model, as well as the processing of the results from the interviews. The purpose of the interviews was twofold, namely:

1. To establish whether GIS improved OH management knowledge in terms of the knowledge cycle.
2. To cross-reference opinions on the model with those based upon theory and the interpretation of the researcher in order to establish a level of credibility in applying the suggested GIS technology.

5.2 Semi-structured Interviews

This section flows form the section on the design of the semi-structured interviews in chapter three (Par. 3.7.2). In order to ensure continuity in the flow of information, there is a further elaboration of statements in chapter three.

Using the dendrogram (Figure 5.1) as a point of departure, the focus was on the knowledge management branch of the dendrogram, which depicts the qualiquantive part of the research. The same demarcation approach as that of the compatibility of spatial and nonspatial data was dictated by the dendrogram. Therefore, the improvement of knowledge management is in terms of the knowledge cycle determined by the improvement in knowledge creation, the improvement in the transfer of knowledge and the improvement in the utilisation of knowledge. In turn, it is argued that the improvement in knowledge creation is determined by the improvement in research, adaptation, generation and discovery. The improvement in the transfer of knowledge is determined by the improvement of the distribution, dissemination and diffusion of knowledge. The improvement in the utilisation of knowledge is determined by the application to problems, the application to systems and the application to situations as may be seen in Figure 5.1 below. A semi-structured interview instrument was developed to determine the perceived effect of a GIS management model on each of the elements identified above.

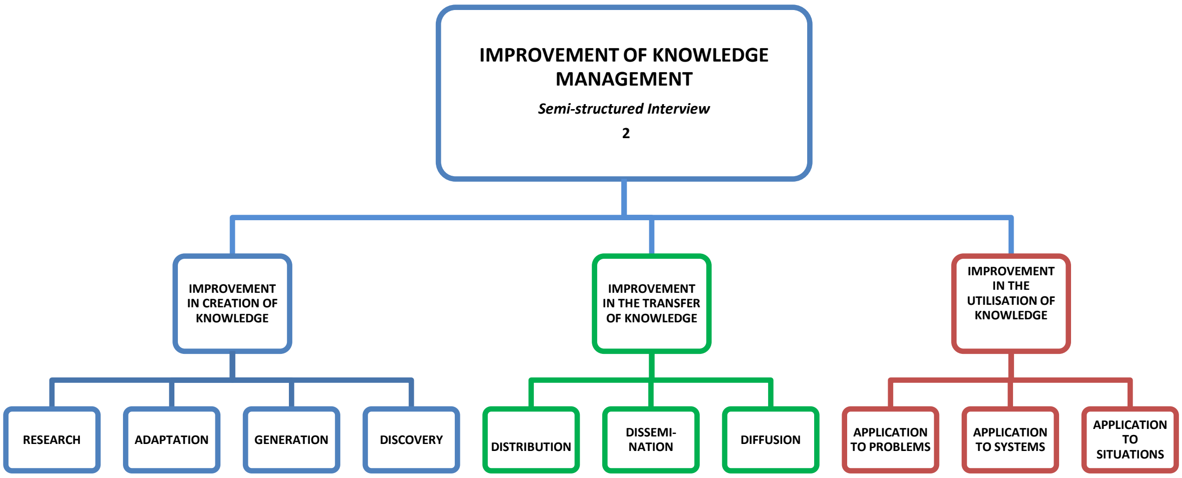


Figure 5.1: The section of the dendrogram about the knowledge cycle and the semi-structured interview that illustrates the theoretical framework into which the questions of the semi-structured interviews had to dovetail

5.2.1 Development of interview questions

In order to set a framework for interview questions, the relationship between the knowledge cycle and OH management data had to be put in place. This framework was informed by the principles gleaned from the same international documents that were used in the construction of the layer for the nonspatial management data, in the section of the dendrogram dealing with the compatibility of data as reflected in the guidelines on occupational health and safety management systems (ILO-OSH & OHSAS 18001). These management aspects were identified and incorporated in the deductive argument and are reflected as the last tier of the dendrogram is illustrated in Figure 5.2 below. Note that this section of the dendrogram was presented vertically (and not horizontally) to accommodate the added management aspects.

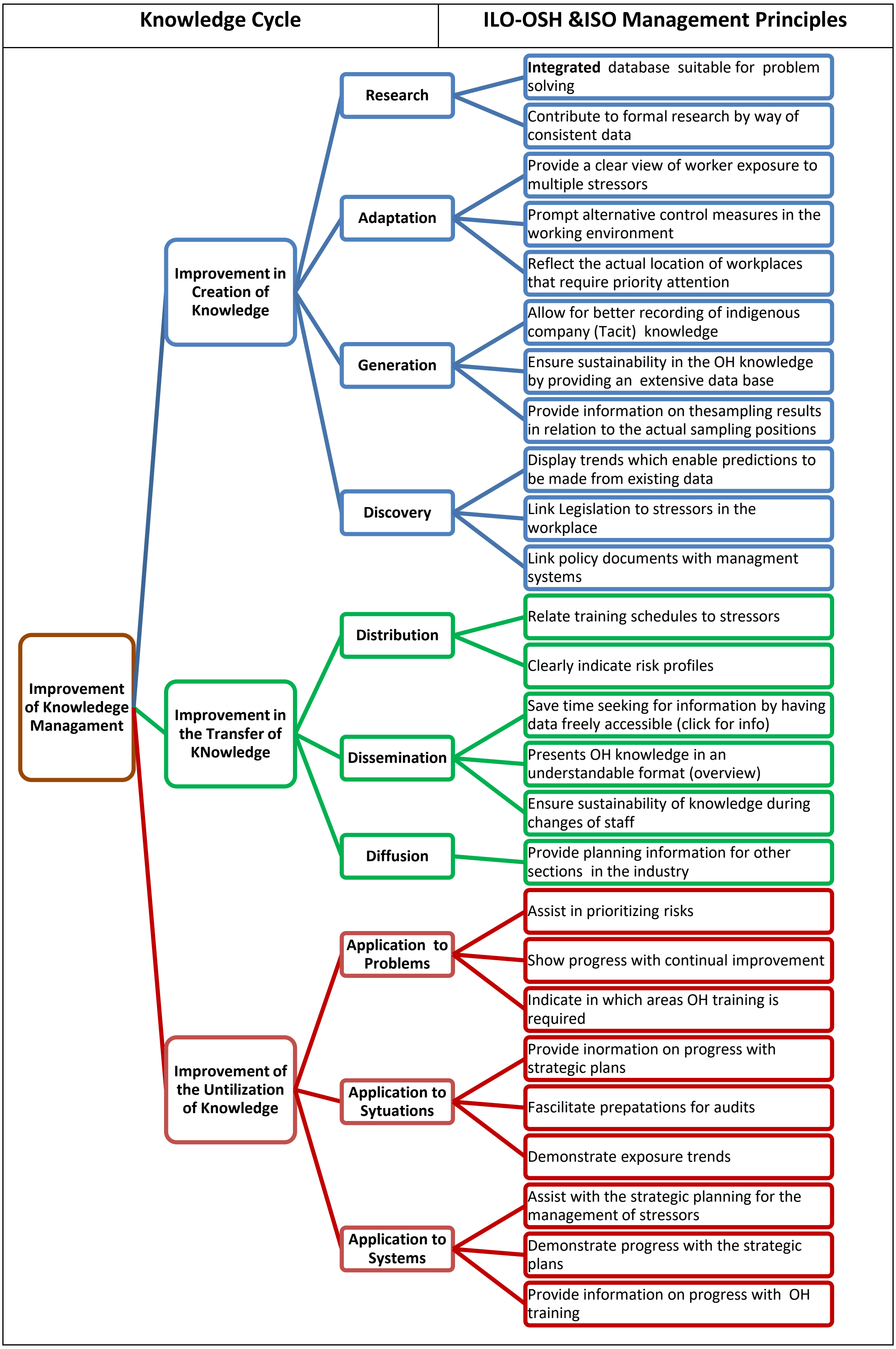


Figure 5.2: Branch of the dendrogram illustrating the relationship between the knowledge cycle and OH management data

In order to allow the respondent, the needed freedom of expression for the purposes of extracting perceptions based upon first time exposure to the technology, a set of open-ended questions pertaining to each of the aspects on the lowest level of the dendrogram depicted in Figure 5.2 were developed. It is also argued that the use of open-ended questions would solicit opinions more freely while it would encourage discussion on the aspects listed in the last tier of this section of the dendrogram. In order to combat bias and the risk of misinterpretation of questions, the questions were evaluated by parties other than the researcher. This was achieved by way of the Delphi system in finding consensus in a nominal group (Jones & Hunter, 1995:377). Ideally, a nominal group would consist of 9-11 members who are specialists in their field. Consequently, a group was formed by contacting OH specialists from Belgium, UK and South Africa to forward their opinions on the questions. These participants were selected on the strength of their leadership and involvement in the profession as academics, scientists and consultants. The aim with this strategy was to gain and consolidate an as broad as possible spectrum of opinions in order to reach a point where the questions were internationally applicable, as well as being relevant to OH and the knowledge cycle. A list of the 11 professionals is attached (Appendix B). The Delphi process of evaluation and consolidation by way of a modified nominal (virtual) group, as described by Jones and Hunter (1995:377) was followed until optimal consensus was found. The stages may be summarised as follows:

1. Definition of problem

   Questions were formulated from the dendrogram for the semi-structured interviews by the researcher. These questions required evaluation and refinement in terms of OH.

2. Selection of experts

   Academics, professionals and scientists from the worldwide OH fraternity were approached and involved. Each member was sent a letter requesting their assistance. The concept questions, their relationship to the knowledge cycle and the ILO-OSH 2001 principles were subsequently sent to them. They were free to comment on any aspect.

3. The first round of nominal questions

   The interview questions, their relationship to the knowledge cycle and ILO-OSH principles were presented for evaluation and comments to the selected professionals. As convening a meeting in one location would not be cost-effective, the process was conducted via email. Responses were ordered and laid out on a table (Long table technique) to give a clear picture and avoid confusion (Appendix C).

4. The second round of nominal questions

The proposed set of questions was edited according to the responses received in the first round of evaluation. The edited version was sent back to the experts for the second round of evaluation and comments.

5. Results examined for consensus using predefined rules

Responses from the second round were set in the table to identify possible voids. Final edits were made to the questions. The third round of comments was not deemed necessary as the questions were open-ended and were designed to stimulate and focus discussion and no suggestions for changes to the actual elements of the lowest tier of the dendrogram were received.

After completion of the Delphi process, it was established that several questions could directly be answered by the researcher by merely evaluating the model in the construction phase. It was decided to omit these questions from the interview in order to reduce the number of questions put to the interviewees. The reason being that the interviewees were in management positions and had limited time to spend on this exercise. It was argued that if they were unnecessarily delayed, they might become irritated, which may in turn affect the quality of the replies received as explained by Johnson in Bell (1999:141). However, the design of the open-ended questions and the technique of indexing and coding of the replies did provide for the recording of replies pertaining to expected relevant areas, as well as for responses that could be relevant, but not foreseen. Provision was made for unforeseen but relevant replies, under the heading “Other”.

5.2.2 Procedures at interviews

During the development of the model, the interviewees were constantly involved during the data collection process. Thereby, familiarizing them with the type of data required they would witness their data being visualized at a later stage and be in a better position to forward an informed opinion. During this time, the researcher became acquainted with most of the staff that were to be interviewed and relationships were established where the interviewees would not be intimidated during the interviews.

According to Bell (1999:141), venues and times should be booked when there are no disturbances. This ideal was not attainable in industrial plants where the input of managers is continuously in demand. However, specific attempts were made to reduce disturbances. Interviews were therefore held in the offices of the respondents, and office doors were closed during interviews. Dates of interviews were decided upon in collaboration with plant management, and all participants were notified of the dates. It was perceived as an advantage that interviews were held in their office environment in which the interviewees felt comfortable.

As standard procedure at the onset of each interview, interviewees were put at ease stating that there were no right or wrong answers. They were informed that the interview will be recorded and that they were free to withdraw at any stage, as suggested by Hart and Bond in their ethical guidelines (1995:198-201). Other aspects brought to their attention were as follows (Appendix D):

1. Questions with regard to clarity were welcome at any time.
2. They were requested not to discuss questions with colleagues until all interviews were done.
3. Requests for questions to be repeated at any time were welcomed.
4. Flemish words would be welcome if interviewees could express themselves better in Flemish. The researcher understood Flemish and would be able to do an accurate translation.
5. Interviewees were informed that questions were to be presented in a specific order and manner but that they were welcome to return to questions at any time.

Each interviewee was requested to sign a consent form permitting the interview (Appendix E)

Interviewees were presented with the questions in printed format when required, in order to enable reading and hearing of questions, thereby enhancing understanding and consequently stimulating relevant replies. This system also permitted interviewees to move back to a previous question if and when required.

After the conclusion of the interviews, the interviewees were thanked for their participation.

5.3 Transcripts

All the recordings of the interviews were typed. The researcher listened to all recordings and checked the transcripts for accuracy. Where the transcribers could not correctly reproduce the meaning of the Flemish words, the necessary translation and editing were done. At one or two occasions parts of the replies were inaudible in which case these were recorded as such and not coded. Each transcript was set to indicate line numbers. The purpose being to be able to trace or revisit responses during revision or discussion of the coding with a peer.

After editing, the transcripts (Annexure F) were carefully coded on a Microsoft Excel spread sheet (Annexure G). The process used was as follows:

Coding took place against the elements of the lowest layer of the knowledge cycle branch of the dendrogram. It is important to note that although some questions were removed from the interview coding, every question of each interview was coded for all the elements as indicated in the last tier of Figure 5.2. The responses were then grouped under the headings of the knowledge cycle, as indicated in the second and third tier in Figure 5.2.

Initial results of the coding were noted per plant in a comprehensive excel table that contained all the questions. To avoid confusion, the questions were set in the table and the replies for that question captured in the following columns. The line numbers where each response could be found were added in brackets to ensure traceability back to the transcript. Each interview was done in a different colour in order to avoid confusion or repetitions and is demonstrated in Table 5.1 below.

Table 5.1: A section of the coding sheet per industrial plant showing the questions and the coding of the interviews in different colours. The line numbers were noted in brackets at the end of each note.

	CODING SHEET			**PLANT 2**
NO	**QUESTION**	**INTERVIEW 1**	**INTERVIEW 2**	**INTERVIEW 3**
1	What comes to mind if you think of this system?	**Visual** (3)	Overview (9)	Provides structure for data (4)
		Shows **non-compliances** (3)	Biggest risk (9)	Easy access (7)
		More than one discipline / **comprehensive** (4)	Prompts alternative control (9)	Visual (8)
		Good **visual Management** system (4)	Contrast biggest problem (19)	Identify and localize problem areas. (11)
2	If you had to improve such a system, what would you do?	Extended comprehensive system (8)	X	X
		Easier to use (9)		
		Compliances and non-**compliances** (12)		

The replies for each industrial plant were then placed in the following categories:

1. Research
2. Adaptation
3. Generation
4. Discovery
5. Distribution
6. Dissemination

7. Diffusion
8. Problems
9. Situations
10. Systems
11. Other

Each category was quantified by calculating the total of each set of responses in that category. Each interview was done in a different colour in order to avoid repetitions Semantographs (See Chapter 6) were generated from the data gained. Provision for uncategorized comments was made under the heading “Other” as may be seen in Table 5.2.

Table 5.2 Clustering of responses of an industrial plant according to the elements of the knowledge cycle

Interview 1								
Interview 2								
Interview 3								
Interview 4								
Interview 5								
Interview 6								
Knowledge Cycle	**Plant 1 Cluster Q1**	**Total N**	**Total %**					
Creation of Knowledge	**Research**	2	10		Lot of information (3)	Easier to contain data (7)		
	Adaptation	2	10		Visualisation of all hazards and risks (4)	**Locations** (6)		
	Generation	3	14		Comprehensive (4)	Complex system (3)	Excessive (4)	
	Discovery	0	0					
Knowledge Transfer	**Distribution**	0	0					
	Dissemination	10	48		Overview (3)	Overview (5)	Easy to understand (7)	Overall view (4)
	Diffusion	0	0					
Utilisation of Knowledge	**Problems**	0	0					
	Situations	0	0					
	Systems	0	0					
	Other	4	19		Lot of work (**effort**) (6)	Difficulty getting correct data (11)	Time-consuming initially (8)	Demand lot of input (5)
		21	100					

Whereas the preceding section noted the number of responses in each category per question, the total number of responses for all the questions needed to be captured. This was done by populating all the results per plant as may be seen in Tables 5.3 – 5.5 below.

Table 5.3: Total responses of Plant 1, Clustered into the third tier of the dendrogram

PLANT 1																	
Combined: Clusters	**Grand Total**	**%**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Views**	**Q Resp**
Research	13	8%	2	0	0	4	3	1	0	1	0	1	1	0	0	0	0
Adaptation	21	12%	2	0	0	1	2	7	2	0	0	2	2	2	1	0	0
Generation	30	17%	3	4	2	4	2	2	0	0	6	1	0	3	1	2	0
Discovery	3	2%	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Distribution	0	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissemination	58	34%	10	1	2	8	5	4	2	7	7	1	3	2	5	0	1
Diffusion	5	3%	0	1	1	0	0	0	0	0	0	3	0	0	0	0	0
Problems	5	3%	0	0	0	0	1	1	0	0	0	0	2	1	0	0	0
Situations	4	2%	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0
Systems	13	8%	0	1	0	0	0	1	1	0	0	1	2	7	0	0	0
Other	21	12%	4	1	3	0	0	3	0	2	1	0	0	0	4	2	1
Total	173	100%															

Table 5.4: Total responses of Plant 2, Clustered into the third tier of the dendrogram

PLANT 2																	
Combined: Clusters	**Grand Total**	**%**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Views**	**Q Resp**
Research	15	9%	3	0	0	1	1	5	1	1	0	0	1	1	0	1	0
Adaptation	24	14%	2	0	0	3	4	3	2	1	1	2	1	1	3	1	0
Generation	21	12%	3	1	1	2	2	0	0	0	4	3	2	0	1	2	0
Discovery	8	5%	1	1	0	2	1	0	0	0	1	1	0	0	1	0	0
Distribution	3	2%	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Dissemination	61	35%	6	1	1	5	7	5	2	6	6	4	6	4	5	2	1
Diffusion	10	6%	2	0	0	0	0	0	0	0	3	5	0	0	0	0	0
Problems	7	4%	2	0	0	1	1	0	0	0	0	0	0	2	1	0	0
Situations	6	3%	2	0	0	0	0	0	0	0	0	1	3	0	0	0	0
Systems	10	6%	1	0	0	0	0	0	0	0	1	0	3	4	1	0	0
Other	8	5%	1	1	3	0	0	0	1	0	0	0	0	0	0	2	0
Total	173	100%															

Table 5.5: Total responses of Plant 3, Clustered into the third tier of the dendrogram

PLANT 3																	
Combined: Clusters	**Grand Total**	**%**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Views**	**Q Resp**
Research	**11**	**7%**	1	0	0	1	1	3	2	0	1	0	1	0	1	0	0
Adaptation	**17**	**11%**	0	1	0	0	3	3	1	0	3	0	3	0	3	0	0
Generation	**22**	**14%**	3	3	0	2	0	2	0	2	1	1	6	1	0	0	1
Discovery	**4**	**2%**	0	0	0	0	0	0	0	0	0	1	2	0	1	0	0
Distribution	**3**	**2%**	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
Dissemination	**62**	**39%**	4	2	2	6	8	7	0	8	5	5	3	6	2	4	0
Diffusion	**8**	**5%**	0	0	0	0	1	0	0	0	0	6	0	0	0	1	0
Problems	**4**	**2%**	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0
Situations	**9**	**6%**	2	0	0	1	0	0	1	0	0	0	4	1	0	0	0
Systems	**14**	**9%**	1	0	0	0	1	3	0	0	0	0	1	5	3	0	0
Other	**7**	**4%**	0	2	3	0	0	0	0	0	1	0	0	0	0	1	0
Total	**161**	**100%**															

From these tables, the data from the three plants were projected onto a semantograph. This represented the profile of responses with regard to the criteria at the base of the dendrogram.

The data was further refined by clustering each of the elements into the three main elements of the knowledge cycle and generating a semantograph graph that represented each of the plants. These elements being:

1. Creation of knowledge.
2. Knowledge transfer.
3. Utilisation of knowledge.

5.4 Conclusion

This chapter provided additional information on the development of the semi-structured interview as a technique to establish the effect of OH management data on the knowledge cycle. It covered the development of questions for the interviews and the capturing of the data collected.

Chapter six will be a discussion and comparison of the results of chapters four and five.

CHAPTER 6: ANALYSIS AND DISCUSSION

6.1 Introduction

The research project was based on the two main branches (arguments) of the dendrogram as dealt with in chapters 4 and 5. Chapter four dealt with the development and implementation of the model and the assessment of the compatibility of OH data with the GIS programme along with set criteria. In turn, chapter 5 dealt with the knowledge management branch of the dendrogram and was aimed at determining whether the use of GIS for OH data caused a knowledge improvement in the industrial plant. This chapter deals with the analysis and discussion of results as captured in chapters 4 and 5. The discussion is opened with a general discussion of the compatibility of OH data, followed by a general discussion of the interview responses regarding the elements of the knowledge cycle. After that, a joint discussion on the compatibility and outcomes of the interviews follows. Attention was also given to replies, which were not within the pre-set categories of the knowledge cycle.

6.2 Compatibility data

The compatibility of OH data to a GIS database is one of two primary criteria for the increase of knowledge. Incompatibility would simply mean that the model could only be partially constructed, or not be constructed at all, resulting in the ending of the project. Though the format of the input data was found to be mostly compatible, several modifications and adjustments had to be made to effectively accommodate OH data. In this case, the salient question was the extent of compatibility between GIS and OH data. This question will be discussed in terms of the argument as depicted in the dendrogram (Figure 4.1) using the criteria incorporated into this framework that directed the information obtained from the respondents.

6.2.1 Spatial data

The term spatial data within the context of this research refers to data that pertains to a specific point on a two-dimensional map of the earth or a workplace as represented on a scale drawing of an industrial plant. This section deals with the compatibility of the data pertaining to the plant outlay that formed part of this research as well as sampling data related to agents/stressors.

6.2.1.1 Factory Outlay

Following the argument depicted in the dendrogram, the compatibility of spatial data associated with the factory is determined by the successful assimilation, processing and recall of OH data into the terrain plan and the floor plan. These aspects are discussed below:

Terrain plan: The terrain plan and the predetermined associated data such as company details were successfully captured, georeferenced and integrated into the model. When tested, it displayed the requested data in the required format.

Floor plan: The CAD floor plan was successfully drawn into the model as a base layer. Once the layer was set, the user could zoom in on any workstation by simply clicking on the zoom function in the toolbar. No problems were experienced with creating and displaying layers for the various process areas. The advantage of being able to zoom into a workstation is that it enables the manager to envisage the stressors associated with that specific workplace. It provides a wider perspective on stressors in the environment, which could have a cumulative or synergistic effect on the workers.

6.2.1.2 Agents/Stressors

It was argued that the compatibility of agents or stressors with the spatial data is determined by the effective demonstration of the distribution of hazards and the effective capturing, processing and representation of sampling data. The model effectively displayed the distribution of physical, biological, chemical and ergonomic stressors/hazards. The layers could be switched on as desired to either display a single stressor or demonstrate multiple exposures.

Sampling and survey data on the stressors/hazards mentioned above were successfully captured in the attribute tables, processed and visually represented by the model.

Sampling reports from various sources contained similar information, namely the levels of the stressors/agents, compliance to legislation and recommendations regarding the control of the stressors as the reports are done according to set guidelines set by individual governments or institutes/societies as applicable (BOHS, 2011; Department of Labour, 2012). During the creation of the database for the model, it was found that although the different reports had similar data, the format of presentation varied in the individual reports. It was observed that sampling practice did not necessarily occur in the same positions or proximity to the previous sampling. This could have a negative effect on the reliability of comparisons during the evaluation of improvements or the effectiveness of management programmes in the same workplace under investigation. It was also found that the various sets of sampling results were not necessarily consolidated into a single electronic database.

In order for sampling results to be utilized in this model as an indicator for establishing the effectiveness of management programmes, the data had to be captured in a single location and in a consistent format. This consistency is a sound scientific practice that should play an essential role in ensuring management effectiveness. However, to overcome this burden, Excel tables were created for this purpose and uniquely designed to accommodate the attributes of each stressor. The Excel tables were imported into the model and GIS was able to extract and process the data and demonstrate the results.

6.2.2 Nonspatial data

After creating a model of the OHSAS management plan in an MS Word document, it was successfully drawn into the model as a base layer. Shapefiles were created and superimposed as layers onto this base layer. By applying the linking tools in GIS, hyperlinks were created to PDF, Word and Excel documents in their respective folders. By activating the links with the click of a mouse, a manager could gain immediate access to policy documents, operational documents or legislation pertaining to a specific plant.

The methods of linking nonspatial management data to a management model, as was done in this section, also hold for linking documents to workplaces, i.e. standard safety procedures for working with the chemicals of a specific workplace could effectively be linked to any site on the floor plan of the plant.

6.2.3 Summary of findings

Figure 6.1 below provides a summary of the compatibility of OH data and the model as evaluated in terms of the theoretical argument depicted in the dendrogram.

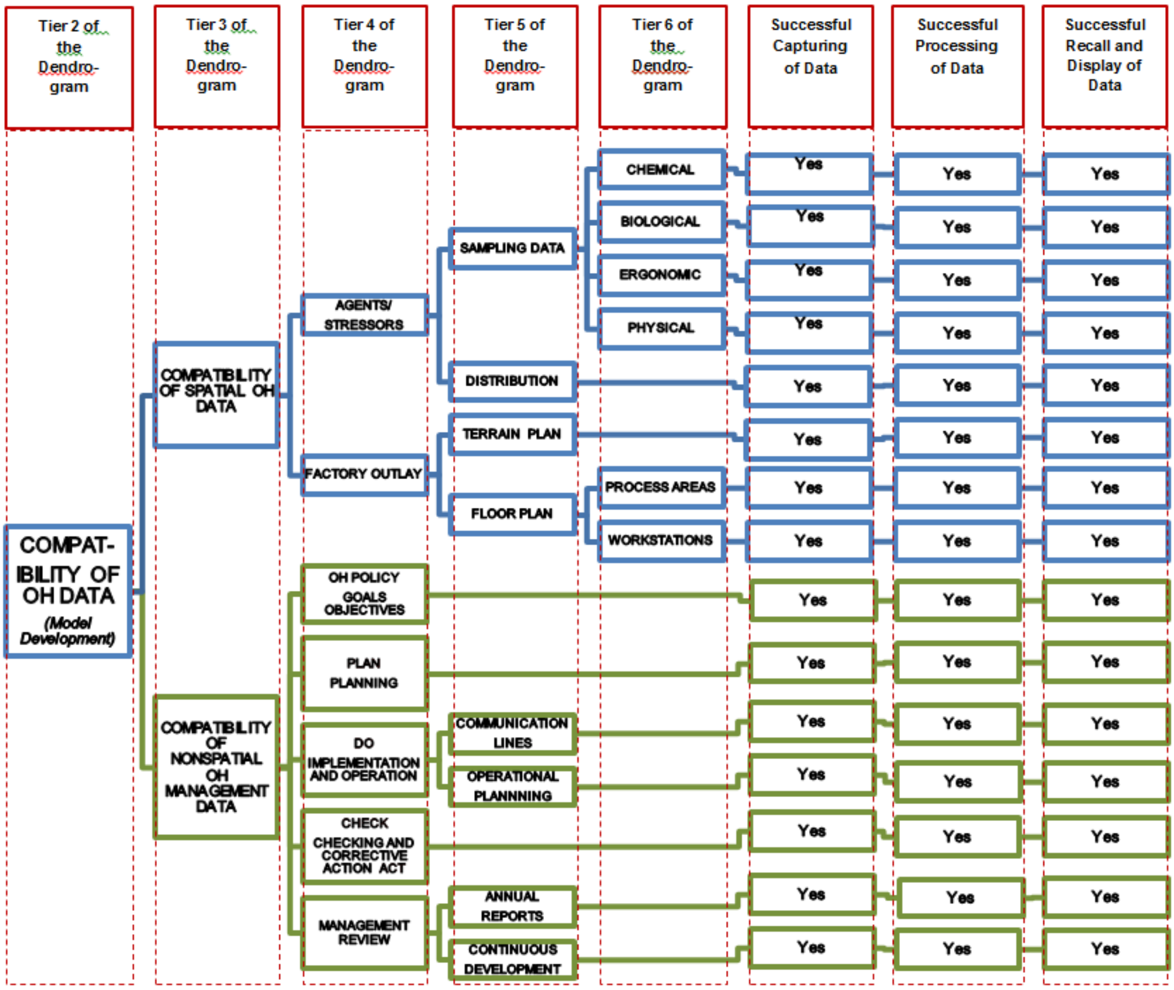


Figure 6.1: Summary of the integration of OH data and the GIS model

6.3 Knowledge cycle, interviews

In the preceding sections of this chapter, the compatibility of OH data and the findings with regard to the model and its relationship to the knowledge cycle were discussed. This section focuses on the perceptions of the interviewees regarding the abilities of the model in terms of the knowledge cycle and the possible acceptance of the model as part of standard practice. Due to the explorative nature of this study and the small number of respondents, the qualitative data collection technique was used to elicit information for this purpose. The responses were qualitatively conceptualised to correspond with the categories as in terms of the knowledge cycle as discussed and presented in the dendrogram. After which the responses were quantitatively projected onto a series of semantographs. The latter produced a visual reflection of the responses. Results of the interviews were compared and triangulated with the findings on the compatibility of OH data and the model. The semantographs depict the distribution of the cluster of responses to the main and subcategories of the knowledge cycle.

In order to reduce bias and to triangulate the consistency of the clustering (done by the researcher), an Occupational Hygienist with international experience was approached to conduct random checks on the coding of the transcripts of each of the three plants. A meeting was scheduled where the rationale, point of departure and the methodology of the coding system was explained. After the meeting, all the transcripts and the coding thereof were emailed to him for random selection, scrutiny and coding. The rationale for this process is that the scrutiny takes place away from the influence of the first coding process. The Occupational Hygienist randomly drew one interview from each plant and fully concurred with the coding as it was done.

The following paragraphs elaborate on the preparation and interpretation of data.

6.3.1 Results and data preparation

After coding of the transcripts, the responses were classified according to the headings in tier 3 and 4 of the dendrogram in Figure 6.2, pertaining to the knowledge cycle and captured on excel sheets.

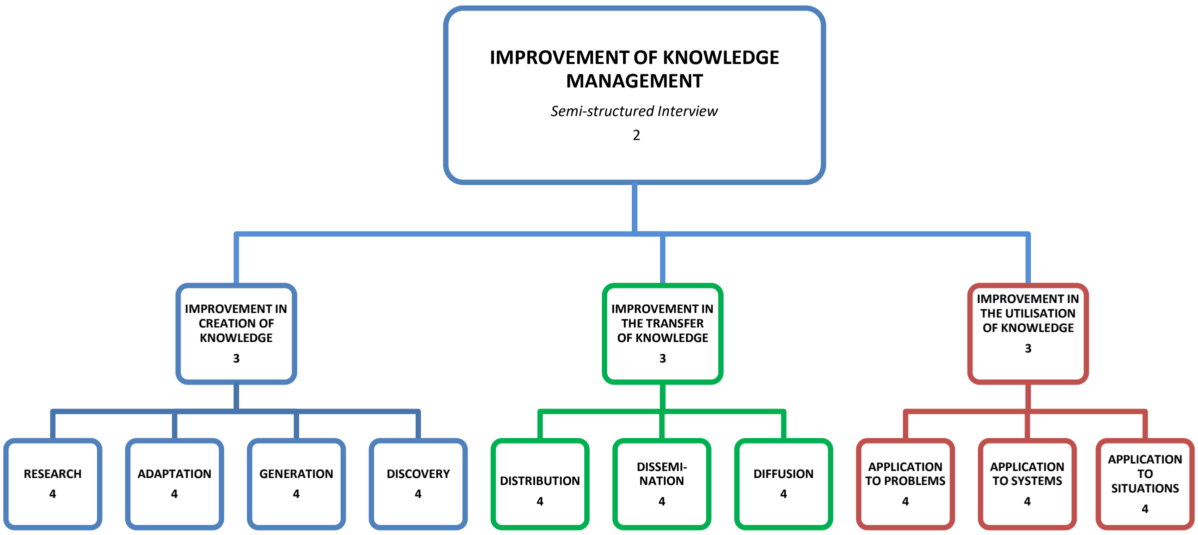


Figure 6.2: Knowledge cycle as portrayed in the dendrogram

The total number of responses of each plant differed from the other plants, and in order to compare the profiles on an equal base, the actual number of responses was converted into percentages. The responses were classified according to the headings as pre-dictated in tier 4 of the dendrogram. However, an additional “other” category was created to accommodate comments that could not be classified under the headings above. The reason being to accommodate responses that did not resort under the identified pre-determined categories. These responses are discussed separately. This category of reactions was not taken into consideration when the subgroups of tier 4 were condensed into the main categories of the knowledge cycle as was portrayed in tier 3. The reason is that the responses referred to elements that were not directly classifiable into the predetermined elements of the knowledge cycle.

The final data tables depict the classified responses as well as the percentage responses and may be seen in Tables 6.1 and 6.2. The semantographs were generated form these tables. This information visually conceptualises the effect of the responses on the tiers of the knowledge cycle. The mentioned semantographs depict the percentage distribution of the responses on the various tiers of the knowledge cycle. For the sake of comparison, the semantographs of the three plants were superimposed. It was deemed necessary to depict the responses on semantographs for both the sub (tier 4) and the major elements (tier 3) of the knowledge cycle, as a consistent outlier (Dissemination) was observed in all the sub-elements. This phenomenon will be discussed in the next section. The semantographs (Figure 6.3 and 6.4) is presented below the tables.

Table 6.1: Clustering of responses per plant of the sub-elements of the knowledge cycle

Combined: Clusters	Plant 1	P1%	Plant 2	P2%	Plant 3	P3%
Research	13	8	15	9	11	7
Adaptation	21	12	24	14	17	11
Generation	30	17	21	12	22	14
Discovery	3	2	8	5	4	2
Distribution	0	0	3	2	3	2
Dissemination	58	34	61	35	62	39
Diffusion	5	3	10	6	8	5
Problems	5	3	7	4	4	2
Situations	4	2	6	3	9	6
Systems	13	8	10	6	14	9
Other	21	12	8	5	7	4
Total Responses Identified and coded	173	100	173	100	161	100

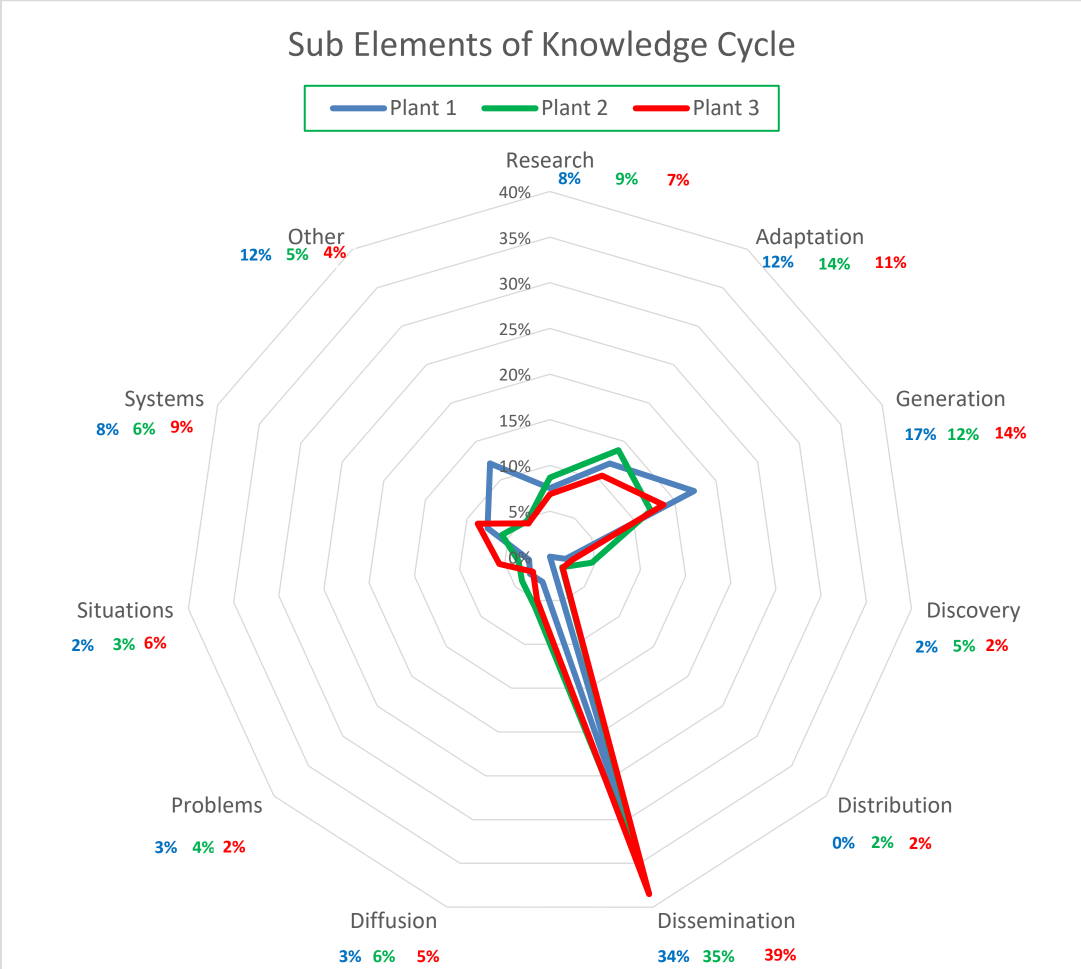


Figure 6.3: Superimposed profiles of the responses from the three plants

Table 6.2: % Responses Knowledge Cycle

Knowledge Cycle	Plant 1 %	Plant 2 %	Plant 3 %
Creation of Knowledge	44	41	40
Knowledge Transfer	41	45	44
Utilisation of Knowledge	15	15	15
Total	100	100	100

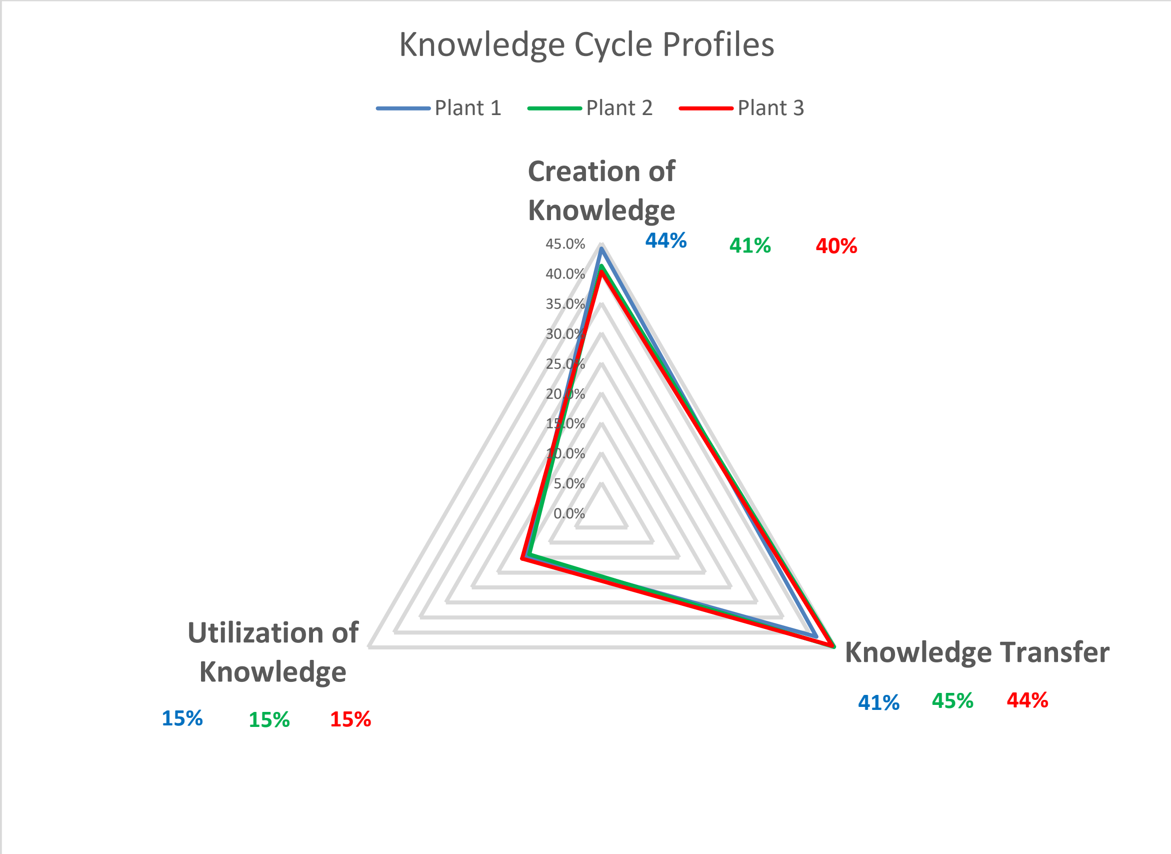


Figure 6.4: Superimposed profile of responses from the three plants, in terms of the knowledge cycle

6.3.2 Interpretation of data

Herewith a discussion on the observation and interpretation of the results from the interviews. It is to be noted that the interpretation of the semantographs was based on the premise that if no responses were recorded in a specific category, a value of zero would be allocated. If, however, responses were recorded in a specific category, it would be indicative of the fact that an increase in knowledge was affected in that specific category of the knowledge cycle. The higher values allocated in some categories where due to the number of responses in that category that supported it. These higher values, therefore, are an indication of the strength of the evidence and are not an indication of the magnitude of the growth that took place.

6.3.2.1 General observations

Considerable differences in variables such as geographic location, nationality of interviewees, processes used and different end products produced, could produce divergent results. It may be seen that the total number of coded responses are very similar in each of the three plants. This argument holds for Figures 6.3 and 6.4.

During scrutiny of the two semantographs depicted in Figure 6.3 and Figure 6.4, the following aspects were noted:

1. Scrutiny of the results as summarised in the tables and presented indicated by way of the similarity and closeness of the profiles, that there was consistency in the interpretation and coding of responses as well as in the responses of the interviewees across all three plants. It may also be interpreted as consistent coding, pointing to internal reliability.
2. The profiles of the three semantographs were similar, with slight variations in the individual plants.
3. The distribution of the responses of the three plants produced similar profiles on the semantographs. Once again pointing towards similar perceptions and reliability of the technique used.
4. All three plants demonstrated a prominent peak of almost the same magnitude in the dissemination of knowledge indicating that respondents from all three plants felt strongly that the model, assisted with the dissemination of knowledge. This consensus may be attributed to the fact that the strength of the visual dissemination of information was recognised by all the respondents.
5. Smaller peaks were observed under the following elements of the knowledge cycle, namely:
    1. Research.
    2. Generation of knowledge. All three plants had a higher proportion of responses coded in this area than in the other areas, except for the dissemination of knowledge.
    3. Adaptation of knowledge.
    4. Systems.
6. The distribution of knowledge did not get as much support as expected.
7. The semantograph depicting the three plants spread across Africa and Europe were almost the same in magnitude. Indicating a similar perception of growth at all the plants. The semantograph is skewed towards the creation and transfer of knowledge. The utilisation of knowledge has weaker support than the other two main elements of the knowledge cycle. It is argued that this phenomenon may be attributed to the fact that the functions at which the interview questions were directed, were not within the scope of work of the respondents.

The noted aspects will be discussed in more detail in the following section, where the evaluation of the model is discussed and compared to the results from the interviews.

6.4 Model and knowledge cycle

In this section, the interpretation of the ability of the model to add value in terms of the knowledge cycle is discussed in terms of the elements allocated in the lowest tier of the section of the dendrogram pertaining to the knowledge cycle (Figure 6.2). The following discussions are based on actual findings and associated reasoning by the researcher during the development and operation of the model.

The gist of the responses from the interviews pertaining to the knowledge cycle will be added and compared to the findings stated in the above paragraph. When the profile of the responses from the various plants was viewed, similar trends were observed. Responses from all the plants were therefore noted.

When comparing responses, it was found that the profiles were almost similar. Because of the similarity of the total reactions as documented, the coding of interviews is to be compared to the findings as documented from the development of the model.

Each of the classifications of Research, Adaptation, Generation, Discovery, Distribution, Dissemination, Diffusion, Problem solving, Situations and Systems are discussed below.

6.4.1 Research

This section addresses research as an element of the knowledge cycle and focuses on the ability of the model to (1) To provide an integrated database suitable for problem solving (6.3.1.1), (2) Contribute to formal research by way of consistent data (6.3.1.2).

6.4.1.1 Integrated database suitable for problem solving

Model: The model contains and integrates an extensive database showing (i) all hazards, (ii) where they occur, (iii) sampling results and the (iv) associated management data. It contains the history of the problems as well as the current planning to manage them. If needed for management purposes, all of these could be viewed at once. By examining all this information within a new (more complex) context, may permit new insights into existing problems and provide new perspectives for problem solving. I.e. the new compound perspectives allow for the investigation of pathologic synergies of stressors or compounding factors. A case in point would be the model clearly demonstrating in Plant 1 (Figure 4.8) that workers in one area could theoretically be exposed to chemical agents (oil mists) and biological agents (Legionella pneumoniae). Both the chemical and biological agents are positively associated with possible lung conditions (NIOSH pocket guide, 2016). It is logically possible that without the visual display illustrating the next level of exposures, the combined effect would not have been detected. Therefore, the new combined visual display creates a new integrated perspective on the extent of the problems at hand, thereby alerting the OH viewer to search for possible combined or synergistic effects, of the agents. In the same vein layers containing ototoxic chemicals such as toluene, which is classified as such by the Instituto Sindical de Trabajo, Ambiente y Salud (istas) (2006) in their risctox document, may be superimposed onto the level in the same factory that shows the areas of high noise, thereby indicating an increased risk for sensory neural hearing loss. If such effects are found, the OH viewer could be prompted by the new integrated insight to develop a different strategy to solve the problem or to manage the agents/stressors. In addition, the model demonstrated the ability to illustrate more than one synergy.

Interviews: Responses during the interviews supported the fact that the model accommodated an integrated database suitable for problem solving (analysis). Respondents in all three plants recognised the ability of the model to produce information beyond the traditional that may be applied for solving problems such as assessing risks. Responses in support included statements such as:

1. "To have an overview on which lines do we have most accidents or the biggest risk and then to put some actions against them." (Put controls in place). (Plant 2, Interview 2, Line 8)
2. "It can also be production, or for analysing purposes." (Plant 2, Interview 4, Line 6)
3. "Yes, it can be handy in use and stimulate your thinking on risks and risks analysis." (Plant 1, Interview 6, Line 37)
4. "all-encompassing system where it can actually be cascaded to various other things." (Plant 3, Interview 5, Line 28)

6.4.1.2 Contribute to formal research by way of consistent data

Model: A primary requirement for using the model is that data should be organized in a prescribed way before capture. This requirement serves as a regulator for the consistency in the sorting of data. Therefore, data from various consultants should be arranged in a predetermined format within the attribute tables and allocated to unique workplaces (Figure 4.10). Such a standard database ensures that all data is entered in the same format to enable comparisons, establishing trends and permitting possible OH related risk projections.

It happens in an industry that floor plans or processes change, or that sampling is done at new sites. For these purposes, GIS makes provision for the creation of new layers or the addition of new data sets containing sampling results. Once follow up samples are taken, the results will be added to the existing samples, and the new sets of data enable the interrogation of existing data anew. Data that existed before the changes that were mentioned above took place will not be lost and will remain in this layer. The question may arise as to whether the data on the initial data layer would remain relevant once a new layer is created. In such a case, the continuity of the data would be affected, especially if the stressors or positions of stressors have changed. The data would, however, remain relevant in the context of providing a representation of the data up to a specific point in time. It is to be expected that the old and new data sets would not be compatible or comparable. The two datasets need to be dealt with as separate data sets. The new layer would contain new data sets from which comparisons may be made, and conclusions may be drawn in respect of hazards and risks.

Apart from the fact that a new layer was created the need for data on the older data layer remains. The Hazardous Chemical Substances Regulations of 1995 No. 1179 of 1995 (South Africa, 1995:7) demands the keeping of records regarding sampling for at least 30 years. An additional but not less important reason would be the need for accurate data in the case of claims or civil suits that may arise years after the exposure of a worker.

Having organised data in the database of lifetime exposures of the workforce may prove useful in research on the aetiology of occupational diseases. Reliability of research findings would strongly depend on consistent sampling and capture of data through the years. This model provides for both these requirements and pinpoints the exact locations where samples took place on proper evidence-based scientific principles. The ILO announced in a press release regarding the world health and safety day, the critical need for countries to improve their capacity to collect and utilise reliable occupational safety and health (OSH) data (2017).

Interviews: No responses were noted that could be linked to this category. It is argued that the reason for the lack of responses may be contributed to the fact that the respondents are particularly production and safety orientated and not research orientated.

6.4.2 Adaptation

This section addresses adaptation as an element of the knowledge cycle and focus on the ability of the model to (i) provide a clear view of worker exposure to multiple stressors (6.3.2.1), (ii) prompt alternative control measures in the working environment (6.3.2.2) and (iii) reflect the actual location of workplaces that require priority attention (6.3.2.3).

6.4.2.1 Provide a clear view of worker exposure to multiple stressors

Model: The model clearly expressed the distribution of all stressors and the degree of exposure in every workplace (Figure 4.8). The exposure of workers in a workplace, adjacent to it, or passing through the area is clearly portrayed.

Interviews: Responses during the interviews supported the fact that the model provides a clear view of worker exposure to multiple stressors. Responses in support included statements such as:

1. “It is a value for combined exposures to determine where the combined exposures could be found.” (Plant 1, Interview 6, Line 84)
2. "recognise the areas, and you see immediately the hazards." (Plant 2, Interview 1, Line 86)
3. “The hazards and risks that are there.” (Plant 3, Interview 2, Line 208)

6.4.2.2 Prompt alternative control measures in the working environment

Model: The model also indicates to noncompliance to legal or internal limits, thereby identifying weaknesses in the management system. OH, management is prompted into seeking the root cause or health risks and devise alternative control measures in order to ensure compliance and consistency in identifying weaknesses through proper sampling techniques lies at the root of any OH management system. As an example, it may be seen in Plant 3, as indicated in Figure 6.5, that all the chemical samples and all the chromium samples but one, were found compliant. In order to address the problem, OH management is therefore timeously alerted to the problem and prompted to resolve it. By inspecting and critically evaluating the sampling positions in relation to the processes and associated stressors, the occupational hygienist could become aware of areas that were overseen during the initial risk assessment.

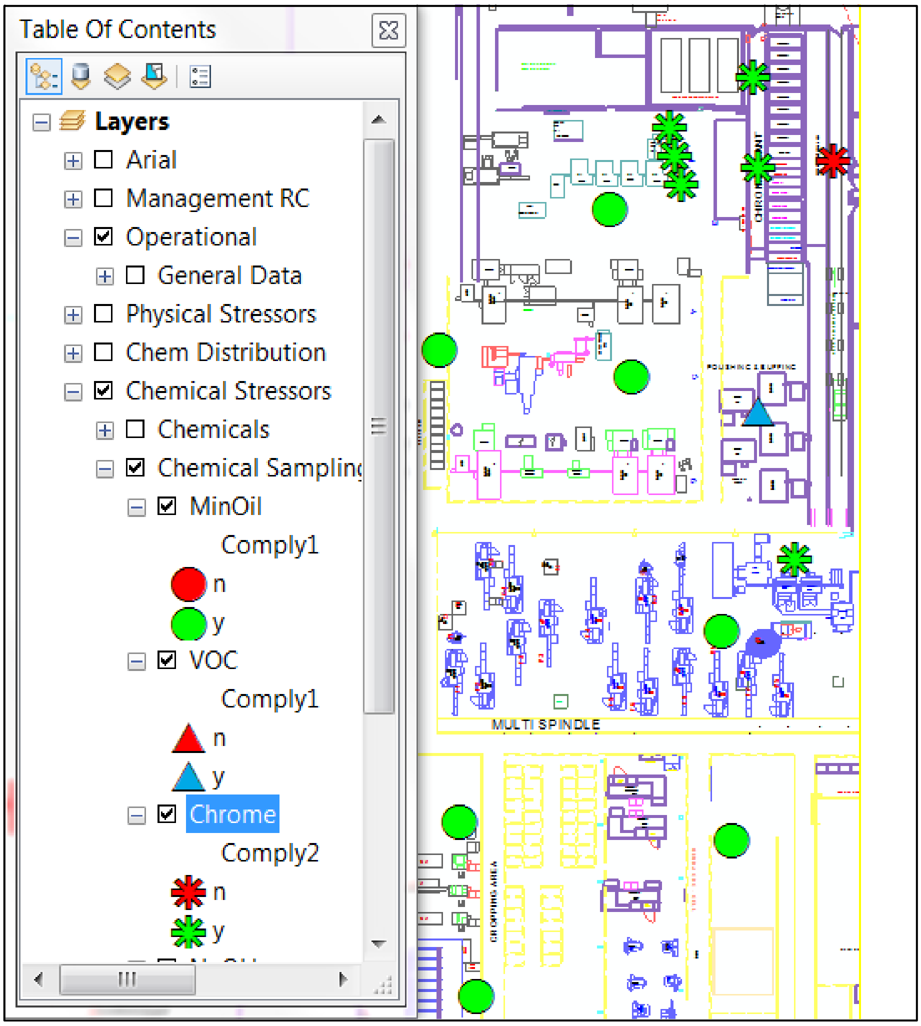


Figure 6.5: Noncompliant chrome sample indicated by an asterisk

Interviews: Responses during the interviews supported the fact that the model prompt alternative control measures in the working environment. Responses in support included statements such as:

1. "In the end, it is about having measures and taking new measures." (Plant 1, Interview 2, Line 175)
2. "Help identify weaknesses." (Plant 1, Interview 4, Line 167)
3. "Start working on an action plan for the non-conformities." (Plant 2, Interview 4, Line 129)

6.4.2.3 Reflect the actual location of workplaces that require priority attention

Model: Sampling results that did not meet the prescribed limits are colour coded (Figure 6.5 above), thereby signalling which areas require sampling priority attention. Red is not the only colour used as varying degrees of risk may be indicated using other colours. A legend at each layer can provide the key to the different colours used.

Interviews: Responses during the interviews supported the fact that the model reflects the actual location of workplaces that require priority attention. Responses in support included statements such as:

1. "… identify areas that need to be rectified." (Plant 1, Interview 1, Line 51)
2. "You can see easily where you need to work." (Plant 2, Interview 5, Line 133)
3. "… recognize the areas, and you see immediately the hazards." (Plant 2, Interview 1, Line 86)

6.4.3 Generation

This section addresses generation as an element of the knowledge cycle and focus on the ability of the model to: (i) Allow for better recording of indigenous company (Tacit) knowledge (6.3.3.1), (ii) Ensure sustainability in the OH knowledge by providing an extensive database (6.3.3.2), (iii) Provide information on the sampling results in relation to the actual sampling positions (6.3.3.3).

6.4.3.1 Allow for better recording of indigenous company (Tacit) knowledge

Model: Indigenous company knowledge was not defined as such within the companies visited. However, indigenous knowledge may be found in various operating procedures. The model effectively captured and linked such documents as these to specific worksites. For the example, a standard operating procedure (SOP) pertaining to the filling or operation of a chrome tank could therefore effectively be linked to the floor plan at the location of the chrome tanks. Selecting the area in the GIS model and the specific link via the attribute table to the SOP would then produce the SOP from where it was stored in the system.

Interviews: Responses during the interviews supported the fact that the model allows for better recording of indigenous company (Tacit) knowledge. Responses in support included statements such as:

1. "… advantages for staff turnover... for the simple reason all the filing will remain the same, the database will be the same, and the retrieval will be the same, unlike what we got now." (Plant 3, Interview 5, Line 101)
2. "… it will organise your service." (Plant 1, Interview 6, Line 99)
3. "Of course, because the data is uniformised, so of course it is very good." (Plant 2, Interview 4, Line 124)

6.4.3.2 Ensure sustainability in the OH knowledge by providing a comprehensive database

Model: The GIS model proved to be successful in capturing spatial and nonspatial data within the comprehensive database. Datasets contained (i) stressors, (ii) policies, (iii) strategic planning, (iv) lines of command, (v) applicable legislation, (vi) compliances and (vii) trends. It successfully demonstrated the ability to capture standard operating procedures and other OHS related data. Sustainability of knowledge lies in the fact that data has effectively and systematically been captured over time and may be processed or recalled when required.

Sustainability of OH knowledge is perpetuated by the fact that information remains on the comprehensive system. New data could be captured in the same format and consequently, be processed and compared with existing data providing a consistent data profile over time.

Interviews: Responses during the interviews supported the fact that the model ensures sustainability in the OH knowledge by providing a comprehensive/extensive database. Responses in support included statements such as:

1. "If the position changes from person A to person B, it will be rather easy for him to get an overview." (Plant 1, Interview 2, Line 114)
2. “Will assist in communicating and passing information on to the next person.” (Plant 1, Interview 1, Line 37)
3. “Things that are in the system cannot be forgotten.” (Plant 1, Interview 5, Line 157)

6.4.3.3 Provide information on the sampling results in relation to the actual sampling positions

Model: By providing the actual locations of the problematic spots, information was successfully generated. I.e. data is connected to a location, and it also provides perspectives on multiple exposures at a glance. See Figures 4.11 and 4.7.

Interviews: No responses emanating from the interviews supported the fact that the model provides information on the sampling results in relation to the actual sampling positions. The reason for the absence of support for this point cannot be explained. It is speculated that other aspects of the model came stronger to the fore, blinding the insight of the interviewees. It may, however, be mentioned that the model clearly demonstrated the ability to link sampling results with sampling positions.

6.4.4 Discovery

This section addresses discovery as an element of the knowledge cycle and focus on the ability of the model to: (1) Display trends which enable predictions to be made from existing data (6.3.4.1), (2) Link legislation to stressors in the workplace (6.3.4.2), Link policy documents with management systems (6.3.4.3).

6.4.4.1 Display trends which enable predictions to be made from existing data

Model: The programme successfully integrated the capture of repetitive data sets and enabled trends to be generated from the data tables. (Figure 4.13)

Interviews: One response supported the fact that the model displays trends that enable predictions to be made from existing data. The response in support included the statement:

1. "… problems are 20% higher than the rest of the factory." (Plant 2, Interview 4, Line 50)

6.4.4.2 Link legislation to stressors in the workplace

Model: The model succeeded in linking legislation to stressors and provides an evaluation of compliance by way of colour coding the sampling results (Figure 4.15). Hyperlinks can provide direct access to applicable legislation.

Interviews: Responses during the interviews supported the fact that the model links legislation to stressors in the workplace. Responses in support included statements such as:

1. "… some job's legal compliance, which is not OK." (Plant 1, Interview 2, Line 129)
2. "… also, when you will see the non-compliances, you need to click on it." (Plant 2, Interview 1, Line 12)
3. "… have some job's legal compliance, which is not OK." (Plant 1, Interview 2, Line 129)

6.4.4.3 Link policy documents with management systems

Model: The model permits the uploading of all documents in Word, Excel, PowerPoint as well as photographs. These documents were linked to a management framework model that permits instant access within a predetermined perspective, such as policy or planning documents (Figure 4.19).

Interviews: No responses supported the fact that the model links policy documents with management systems. The model, however, clearly demonstrates the ability to link documents with the management framework.

6.4.5 Distribution

This section addresses distribution as an element of the knowledge cycle and focuses on the ability of the model to: (1) Relate training schedules to stressors (6.3.5.1), (2) Clearly indicate risk profiles (6.3.5.2).

6.4.5.1 Relate training schedules to stressors

Model: As mentioned in 6.3.111, the model was able to link documents to a location on the floor plan, whether it be, stressor or management plans. In the model, an example may be found of action plans relating to stressors and training (Figures 4.20 & 4.22).

Interviews: No Responses supported the fact that the model relates training schedules to stressors. This lack in response may be attributed to the fact that training was more of a management function, whereas the respondents focussed on risk and safety management.

6.4.5.2 Clearly indicate risk profiles

Model: Apart from the fact that the location of hazards or risks could be presented in the GUI, the use of colour coding illustrated the magnitude of the hazards and risks present in a specific workplace (Figure 4.8). Thus, clearly indicating the risk profiles. Alternatively, the risks may be accessed via hyperlinks from the management system.

Interviews: Responses during the interviews supported the fact that the model clearly indicates risk profiles. Responses in support included statements such as:

1. “To have an overview on which lines do we have most accidents or the biggest risk.” (Plant 2, Interview 2, Line 8)
2. “it is going to highlight our risk.” (Plant 3, Interview 4, Line 45)
3. “I mean straightaway you can hone into the areas where there is risk – simple!” (Pant 3, Interview 4, Line 149)

6.4.6 Dissemination

This section addresses dissemination as an element of the knowledge cycle and focus on the ability of the model to (1) Save time seeking for information by having data freely accessible (click for information) (6.3.6.1), (2) Present OH knowledge in an understandable format (overview) (6.3.6.2), Ensure sustainability of knowledge during changes of staff (6.3.6.3). This section received the highest number of positive responses in all three plants. Thus, indicating that in all three of the plants, the respondents felt strongly about the abilities of the model with regard to time saving, visual dissemination of information and sustainability of knowledge.

6.4.6.1 Save time seeking for information by having data freely accessible (click for info)

Model: As all relevant OH data was consolidated within one model and in most cases in a single geographical position, it was found that by the click of a mouse within a geographic position or within the attribute tables, the required data was displayed. Thus, saving the OH Manager time in perusing various documents in different locations and formats. Hyperlinks ensured further time to save by providing immediate access to relevant legislation, strategic planning or policy documents.

Interviews: Responses during the interviews supported the fact that the model saves time seeking information by having data freely accessible. Responses in support included statements such as:

1. “I think you will gain or win time.” (Plant 1, Interview 5, Line 12)
2. “very quick analysis.” (Plant 2, Interview 4, Line 42)
3. “beautiful to see immediately.” (Plant 2, Interview 1, line 44)

6.4.6.2 Presents OH knowledge in an understandable format. (overview)

Model: Dewan (2015:2) argues on the grounds of her research that visual communication with the inclusion of graphic elements is more effective than text-driven communication. Logically this argument should also hold for the presentation of OH knowledge. As this fact was also the point of departure for this research, judgment by the researcher on this aspect could contain an element of bias. Therefore, the results of the effect of this question rested on the responses of the interviewees rather than the opinion of the researcher. Their responses are discussed in section 6.4.

Interviews: Responses during the interviews supported the fact that the model presents OH knowledge in an understandable format. The point of departure was that understandable included easy access to date. Responses in support included statements such as:

1. "For me, it is a visualisation programme, of all hazards and risks in the complete factory. It gives an overview of the hazards and risks." (Plant 1, Interview 2, Line 4)
2. "… easy tool to access." (Plant 2, Interview 3, Line 7)
3. "… overview of the current system." (Plant 3, Interview 1, Line 10)

6.4.6.3 Ensure sustainability of knowledge during changes in staff

Model: Sustainability of knowledge in the model is supported by the permanency and systematic capture of information on the comprehensive database. Information may be communicated to new staff members by drawing information from the system or by training members to draw information on their specific needs, from the model.

As an example, it may be mentioned that should an employer wish to make a new employee conversant with the hazards in the workplace in terms of section 13 of the South African Occupational Health and Safety Act, which reads as follows:

"Without derogating from any specific duty imposed on an employer by this Act, every employer shall- as far as is reasonably practicable, cause every employee to be made conversant with the hazards to his health and safety attached to any work which he has to perform, any article or substance which he has to produce, process, use, handle, store or transport and any plant or machinery which he is required or permitted to use, as well as with the precautionary measures which should be taken and observed with respect to those hazards."

It is postulated that the information regarding the hazards, risks and precautionary measures at a specific worksite could be accessed via the model and presented to new staff.

Interviews: Responses during the interviews supported the fact that the model ensures sustainability of knowledge during changes of staff. Responses in support included statements such as:

1. "Because of the fact that you can visualise it, it will be much easier for other people to understand it." (Plant 1, Interview 2, Line 7)
2. "Communicate and pass information through to newcomers." (Plant 1, Interview 3, Line 60)
3. "… with new people coming in to make them aware we have a very good robust induction training system in the company, and this could explain the hazards and the potential hazards there in the work environment." (Plant 3, Interview 3, Line 91)

6.4.7 Diffusion

This section addresses diffusion as an element of the knowledge cycle and focuses on the ability of the model to (1) Provide planning information for other sections in the industry (6.3.7.1).

6.4.7.1 Provide planning information for other sections in the industry

Model: Information captured in the database could provide information towards the planning of other sections of the industry. As medical practitioners, nurses and safety offices work in different disciplines towards the health and safety of the worker, it is perceived that sections of data could serve each of these professions.

New perspectives could provide better information to persons such as the occupational medical practitioner. Knowledge from professional silos may be shared amongst professions and assist to plan for or modify planning. I.E. A medical practitioner could access the model and find all related information pertaining to a specific workplace. By accessing the model, a medical practitioner may ascertain which agents workers are exposed to in a specific workplace and the degree of risk the workers are exposed to. It is argued that by comparing hazards, risks, sampling data and trends (the occupational hygiene data) from the model with the prevalence of occupational disease and injuries (clinical data) an occupational medical officer would gain a more comprehensive view of the situation at hand. This new perspective could assist the medical officer in the **early recognition of occupational diseases** and provide information for the planning, treatment and management of possible occupational diseases.

Interviews: Responses during the interviews supported the fact that the model provides planning information for other sections in the industry. Responses in support included statements such as:

1. "It does not matter which department it is; this information can be used as beneficial." (Plant 3, Interview 1, Line 105)
2. "Yes, to everybody. No, not only the clinic sister, production – especially the production manager." (Plant 3, Interview 2, Line 177)
3. "… but for engineers and especially for my profession, like machine safety, it can be very, very helpful." (Plant 2, Interview 1, Line 104)

6.4.8 Application to problems

This section addresses application to problems as an element of the knowledge cycle and focus on the ability of the model to: (1) Assist in prioritizing risks (6.3.8.1), (2) Show progress with continual improvement (6.3.8.2), Indicate in which areas OH training is required (6.3.8.3). The most replies were received in the section on the assistance with prioritizing of risks. This reaction may be attributed to the fact that the interviewees were primarily involved with risk assessment. It is argued that the respondents were sensitised for risk assessment by their daily functioning; thus, the higher number of reactions.

6.4.8.1 Assist in prioritising risks

Model: The model was able to effectively captured risk assessment and planning documents. Problem areas were visually demonstrated by highlighting and grading risks and sampling results. The model also demonstrated in which areas more than one stressor were present. It is argued that viewing the existing planning and actual status of a workplace in one document could assist OH management in re-evaluating and prioritizing risks. An alternative argument would be that the possibility exists that information could be omitted during the prioritizing of risks, if the required documentation were in different formats and locations, as may be found in other management models.

Interviews: Responses during the interviews supported the fact that the model assists in prioritizing risks. Responses in support included statements such as:

1. "To have an overview on which lines do we have most accidents or the biggest risk." (Plant 2, Interview 2, Line 8)
2. "… easily spot where you have ergonomic issues." (Plant 2, Interview 3, Line 11)
3. "People are working here, and lots of people are not aware of the risks we have here. And having a system like this could help to make them more visual." (Plant 1, Interview 2, Line 160)

6.4.8.2 Show progress with continual improvement

Model: The model proved that strategic plans with target dates, progress and responsible staff members were available by way of clicking on the hyperlinks. In addition to these documents, trends in sampling results could be generated, which could serve as indicators of the actual improvement in managing stressors.

Interviews: Responses during the interviews supported the fact that the model show progress with continual improvement. Responses in support included statements such as:

1. "It gives you a good overview, and you can track the progress." (Plant 3, Interview 1, Line 37)
2. "... you can use this tool to look up those checks, those controls."
3. "… but also for evaluation." (Plant 2, Interview 3, Line 191)

6.4.8.3 Indicate in which areas OH training is required

Model: It is argued that by viewing strategic plans of a plant on GIS or by viewing progress with the management of stressors or the lack thereof, management would be able to identify possible training or re-training needs.

Interviews: Responses during the interviews supported the fact that the model indicates in which areas OH training is required. Responses in support included statements such as:

1. "… you train newcomers etc." (Interview 1, Plant 2, Line 269). The incorporation of training in the model is implied in this case.
2. "… persons personal development and also for appraisal setting." (Plant 3, Interview 5, Line 165).

6.4.9 Application to situations

This section addresses application to situations as an element of the knowledge cycle and focuses on the ability of the model to (1) Provide information on progress with strategic plans (6.3.9.1), (2) Facilitate preparation for audits (6.3.9.2), (3) Demonstrate exposure trends (6.3.9.3). The most responses were recorded for audits. It is argued that all respondents are exposed to audits in their work and that the responses are therefore higher.

6.4.9.1 Provide information on progress with continual improvement

Model: The management framework of the model allowed for instant access to the strategic plans where the progress with the planning and progress may be viewed.

Interviews: Responses during the interviews supported the fact that the model provides information on progress with strategic plans. Responses in support included statements such as:

1. "… what do we do to improve it." (Plant 1, Interview 2, Line 50)
2. "… want the management overview for the health status." (Pant 3, Interview 5, Line 30)

6.4.9.2 Facilitate preparation for audits

Model: One of the major aspects in the preparation for audits is to produce documentary or other evidence of the actions taken and achievement of goals and objectives of a specific plant. The model successful linked the relevant documents and demonstrated progress with matters. Documents and views of information drawn from the model can be printed. It I s therefore argued that the model as a central source of information could facilitate in the preparation for audits.

Interviews: Responses during the interviews supported the fact that the model facilitates preparation for audits. Responses in support included statements such as:

1. "… it is perfect for every form of audit." (Plant 1, Interview 2, Line 265)
2. "Of course, you can use it to prepare for audits." (Plant 2, Interview 1, Line 132)
3. "I think it would be an excellent tool for audits." (Plant 3, Interview 4, Line 94)

6.4.9.3 Demonstrate exposure trends

Model: As mentioned before the model demonstrated the ability to demonstrate exposure trends.

Interviews: Responses during the interviews supported the fact that the model demonstrates exposure trends. Responses in support included statements such as:

1. "This system could trend it for us." (Plant 3, Interview 5, Line 77)
2. "You can see immediately if you have a problem somewhere, but with the exposure since." (Plant 2, Interview 1, Line 119)

6.4.10 Application to systems

This section addresses application to systems as an element of the knowledge cycle and focus on the ability of the model to (1) Assist with the strategic planning for the management of stressors (6.4.10.1), (2) Provide information on progress with OH training (6.4.10.2), (3) Demonstrate progress with strategic plans (6.4.10.3).

6.4.10.1 Assist with the strategic planning for the management of stressors

Model: Risks, stressors, priorities flowing from previous strategic planning, progress and the success of the management of stressors were all successfully demonstrated by the model. It is argued that the consolidation of OH data in one model could assist with the overall strategic planning for the management of stressors as all relevant information is at hand and that new perspectives and insights may surface due to the added visual perspective.

Interviews: Responses during the interviews supported the fact that the model assists with the strategic planning for the management of stressors. Responses in support included statements such as:

1. “You can see easily where you need to work.” (Plant 2, Interview 5, Line 133)
2. “… it directs your attention immediately to where there is a problem and you can have a very quick overview if the health of your plant is good or bad and where to focus.” (Plant 3, Interview 1, Line 44)
3. “It helps you to keep in mind which steps you are going to develop, to monitor and to survey their health.” (Plant 1, Interview 6, Line 75)

6.4.10.2 Provide information on progress with OH training

Model: Training concerning OH was captured in the strategic planning of Plant 1. By clicking on the hyperlink, the document could be recalled, and the progress with the OH training be evaluated by perusing the target dates and progress. (Figure 4.22)

Interviews: Responses during the interviews supported the fact that the model provides information on progress with OH training. Responses in support included statements such as:

1. “So, I have my hazards, I have my measures. Then can be safety instruction, I have training and I have supervision.” (Plant 1, Interview 2, Line 86)

6.4.10.3 Demonstrate progress with strategic plans

Model: As mentioned earlier, the model showed the ability to capture any spatial or nonspatial data. This fact holds for the capturing of strategic plans and progress thereof.

Interviews: Responses during the interviews supported the fact that the model demonstrates progress with strategic plans. Responses in support included statements such as:

1. “… it gives an overview of the current system with all the different audits how you doing, you can track exactly how you are improving.” (Plant 3, Interview 1, Line 10)
2. “… you can see the old data, the new data as well, so you can immediately see it.” (Plant 2, Interview 1, Line 121)
3. “Could illustrate to the auditor that systems are in place.” (Plant 1, Interview 5, Line 149)

6.5 Other opinions

During the interviews, specific replies were recorded that could not be classified within the defined context of the knowledge cycle. However, these remarks do warrant discussion and are discussed below for the sake of completeness.

6.5.1 Updating the system

The statement "I would not like to be the one and only that is responsible for furnishing and nourishing all the data that it needs", (Plant 1, Interview 6, Line 171) was aimed at the large size of the database of the model. The interviewee was not familiar with the programme and expressed concern for the updating of the data. Updating is not such a concern. Once the Excel sheets containing data has been designed to register data in a standardised format, updating simply involves adding the new data set to the existing data set. The person doing the update will, however, have to undergo basic training to operate the GIS. Depending on the level of competence, it is perceived that one day of training should be sufficient.

6.5.2 Complimentary to systems

A statement was made that the system was complementary to their systems (Plant 1, Interview 6, Line 177). "I think it is very complementary to the conventional ways of working". The model has been designed to accommodate data from industry, and this statement is construed as a confirmation of the compatibility between the model and the occupational hygiene data from industry.

6.5.3 Provides structure

During interview no 3, of Plant 2, (Line 219) the interviewee expresses the need for such a model to create a structure for their industry. The argument was based on the fact that the model would combine all their data into one structured model. This, once again, is perceived as to stress the compatibility between the model and the occupational hygiene data from industry. It needs to be noted that this interview was conducted in a totally different industry as the previous one.

6.5.4 Not for a small plant

One respondent mentioned that the system would not be ideal for a small plant. He said that "I think it is a very good system but not for a small plant" (Plant 2, Interview 4, Line 200). His argument then follows that for a small plant such as theirs with one type of machine and nine copies of the machine, it would not be necessary. It is argued that there is truth in the statement, especially for the staff in that plant. However, if seen from multiple exposures and an international management perspective, it enables regional managers to view and compare the management of stressors at all the plants. This specific company has managers for the United States branches, Europe, India, Africa and South America. This model will enable the managers to view information from all the regions in their offices and should theoretically cut back on some travelling time and expenses.

6.5.5 Winner

One respondent reacted by stating that this model is a winner for the management of occupational hygiene data. His words were, "For the purposes of what you want to do, for your purposes, I think it is a winner. It is definitely a winner" (Plant 3, Interview 5, Line 185). Thereby endorsing that the model could serve a management system for spatial and nonspatial data.

6.6 Conclusion

This chapter dealt with the analysis and interpretation of the results of the research. It started with a discussion on the compatibility of the model and OH data. This was followed by a discussion on the interview responses. After which the findings of the model in terms of the knowledge cycle were compared to the results of the interviews. It was found that:

1. Compatibility: Spatial and nonspatial OH data is compatible with GIS
2. Effect on the knowledge cycle: The model causes an increase in knowledge in terms of the elements of the knowledge cycle. This fact is supported by the results of the semi-structured interviews that were based on the elements of the knowledge cycle.

The next chapter will provide a complete summary of the research done towards establishing whether GIS causes an increase in knowledge.

CHAPTER 7: SUMMARY

7.1 Introduction

This chapter provides an overview of the research by way of a summary, which will be followed by deliberations on the possible impact and value of the research and a conclusion.

7.2 Summary

This section provides a review of the research project and revisits the purpose, research questions, strategy, methodology and results of the research.

7.2.1 Aim of the study

The purpose of this study was to establish whether the use of GIS in the management of OH data could add value to the management of OH data at a company with industrial plants worldwide. Underlying and driving this purpose where the two hypotheses, namely:

1. It is possible to visually integrate and interrogate spatial and nonspatial OH data on GIS.
2. The implementation of GIS increases the quality of OH knowledge on which decisions are based in industry.

7.2.2 Strategy

The strategy was theoretically based, conceptualised and structured in the dendrogram and involved the development and testing of a GIS-based model for the capturing and management of OH data by way of case studies at industrial plants in Europe and South Africa. Examination of the model took place in two ways, and the results of these techniques were compared as a means of triangulation. The testing of the model involved:

1. Noting the observations of the performance of the model during construction development and
2. Gathering the perceptions of staff working at the industrial plants by way of semi-structured interviews with staff.

The questions put forward during the interviews were designed to prompt discussion in terms of the knowledge cycle.

To answer the questions above a strategy was developed from a basic deductive conceptual framework (Dendrogram) with its underlying theoretical rationale, (Appendix A). The dendrogram contained the research concepts, which served as a blueprint for conducting the research and from which flowed the strategy, methodology, processes and techniques best suited to answer the research questions. The theoretical approach depicted in the dendrogram consists of two branches. One branch involved design science research methods and focussed on the development and testing of a GIS-based model for the management of OH data in the workplace. The other branch included a qualiquantive research approach based on assessing a possible increase in knowledge according to the elements of the knowledge cycle, as depicted in Figure 7.1.

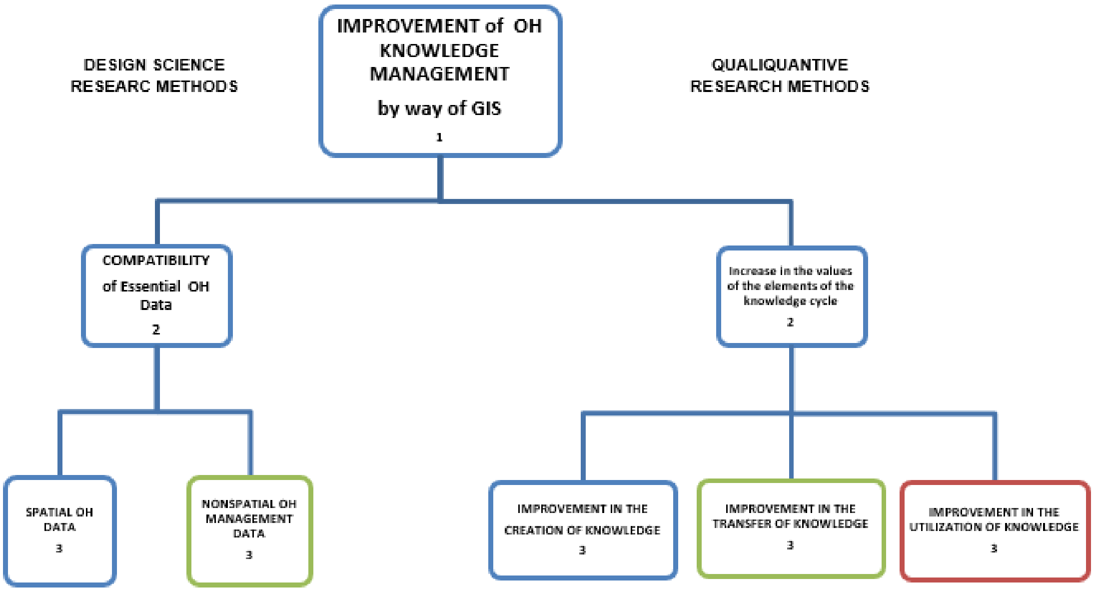


Figure 7. 1: First three levels of the dendrogram

7.2.3 Methodology

According to the argument in tier 2 of the dendrogram, one of the requirements for the improvement of knowledge management is that OH data should be compatible with the GIS features. A generic GIS model, based on the requirements of OHSAS 18001 and ILO-OSH 2001, was developed following accepted scientific research methods. Before implementation, the model was demonstrated and discussed with an occupational hygienist in Belgium, after which the model was tested during a pilot study that was done at a plant in Europe where spatial and nonspatial OH data from that company was integrated into the generic framework. During the development phase, the model was evaluated in terms of the compatibility of typical OH data and the GIS features.

The other requirement that had to be met according to the research design (see the dendrogram) was that an increase in knowledge had to take place in terms of the elements of the knowledge cycle. This was achieved by way of qualiquantive research techniques. Semi-structured interviews were developed involving knowledgeable international occupational hygienists in refining the elements to be evaluated by way of the Delphi technique. Once the model had been completed, it was demonstrated to staff involved in health and safety. Individual semi-structured interviews were then held to obtain the views of the staff about the model in terms of the knowledge cycle. This action concluded the pilot study. From the pilot study, it transpired that minor changes were required to the interview questions. These changes were not considered to have an impact on the face validity of the information. As a result, it was decided to include the data collected from the plant where the pilot study was conducted as a third industrial site. The data from this site was incorporated into the main body of research to broaden the information base.

The procedures described in the previous paragraphs were followed when the project was moved to two other plants, one in Belgium and one in South Africa.

Interviews were recorded, transcribed, coded according to the elements of the knowledge cycle. The results for each plant were portrayed in a unique colour on a semantograph for evaluation and triangulation with the other plants.

7.2.4 Trustworthiness

The steps followed towards achieving trustworthiness are provided below under the headings in a qualitative context.

7.2.4.1 Credibility

The following activities were conducted to increase credibility.

1. The capability of the model was triangulated with the results of the interviews as well as internally between plants. The interviews supported the findings on the model and the semantographs of the different plants were generally similar in profile. These similarities pointed towards the accuracy and consistency in the methodology applied.
2. Opinions of professionals from the UK, Europe and South Africa were gained on the development of elements of the knowledge cycle pertaining to occupational hygiene. The Delphi approach was used until a suitable consensus was reached.
3. Before implementation of the model at the first plant in Europe, the model was demonstrated and discussed with an occupational hygienist in Belgium to establish whether the model was doing what it was designed for.
4. During the interviews, questions were rephrased where necessary, to ascertain that the replies were more representative of the respondent’s opinion.

7.2.4.2 Transferability

In order to ensure that the model could be applied to other industrial plants, the purposefully selected plants differed in management styles, geographic locations, end products and size and ethnicity of the staff components. Similar results were obtained for all three plants indicating that the model could be applied at all of the selected plants irrespective of the variables mentioned.

7.2.4.3 Dependability

Other researchers would be able to replicate this research on the grounds of the clarity of the model and the notation of procedures followed in developing the study. The dendrogram captured and demonstrates a clear pathway for the reasoning behind and the execution of the research so that other researchers could follow.

7.2.4.4 Confirmability

All information was considered during analysis and clustering process of information retrieved from the interviews. Information that was not classifiable as to have a bearing on the predetermined elements of the knowledge cycle were listed as "other" and discussed. The process to interpret the information was scrutinised and evaluated by the research supervisors.

7.2.5 Analysis

The aim of the analysis of the semi-structured interviews, was to condense the data obtained to a point to which logical conclusions could be made. The process was initiated by the researcher immersing himself into the audio records of the interviews and identifying recurring themes in terms of the pre-set elements of the knowledge cycle. A framework of themes was then created in terms of the objectives of this research. (Appendix B, Table 2). Transcripts of the interviews were then coded and indexed. By way of abstraction and synthesis, data was sorted into the themes of the framework and projected onto semantographs. The semantograph was used to condense the information gathered into a visible tool for comparing results and provide possible explanations for the findings.

7.2.6 Ethics

Strict confidentiality was maintained. Before the onset of the research, confidentiality agreements were signed by all parties involved in each project. Data was captured and presented in such a way that it could not be traced to an individual or a company. Besides, sampling data reflected workplace conditions, and not the personal health of individuals.

Companies could not be identified by way of documents that contained logos and were drawn into the model, as logos were removed from the documents.

Before the onset of each interview, the interviewees had to sign a consent form to grant permission for the interview to take place (Annexure. D). They were informed that they could withdraw at any stage.

7.3 Findings

This research answered the question as to whether GIS could add value to the management of OH data in terms of the knowledge cycle. By doing so, it put forward an additional and optional tool that after refining and further research could be used for the management of occupational hygiene data in multinational companies.

A summary of the findings of this research and a brief discussion of the potential applications thereof for the OH management environment follows below.

1. The first hypothesis that it is possible to visually present and interrogates spatial and nonspatial OH data on GIS was confirmed (Figure 6.1) by the model that was created. Not only did it accommodate spatial and nonspatial data, but also illustrated compatibility between OH data and GIS. The ability to represent information in an understandable format and to provide insight and save time was further recognised by the interviewees of the semi-structured interview. This sector showed a strong positive reaction amongst participants in all the three plants, as was indicated on the semantographs (Figure 6.4).
2. The second hypothesis stating that the implementation of GIS increases the quality of OH knowledge on which decisions are based in the industry was confirmed in Chapter 6. It is clear from the data that the hypotheses set in both first-level branches of the dendrogram were met. The opinions of the health and safety staff concurred with the findings of the researcher when he evaluated the model. It can, hence, be concluded that the GIS-based model increased the OH knowledge in the participating industries.
3. The aim of this research project was to establish whether the use of GIS in the management of OH could add value to the management of OH data at a company with industrial plants worldwide. It is argued that this aim was met and the proof lies in the fact that the model that was created answered to the requirements as was set in the dendrogram that integrated both the compatibility and the knowledge cycle in the theorem. Triangulation with the responses from the interviewees of the semi-structured interviews as portrayed in the semantographs supported the notion that value was added to the management of OH data in terms of the knowledge cycle.
4. This model permitted the virtual management of multinational companies. It opened up the possibility that a person could manage multiple plants across the world by opening the model for a specific plant and having all the information available at the click of a mouse, i.e. compliances and non-compliances, risk assessments, planning, and other OH related information.

5. The main impact of the model is its ability to create a higher level of new integrated insights into OH risk management. It needs to be noted that the vertical integration of information as layers are added, changes the manageable contents of each preceding layer, up to the first layer. I.e. the concept of the first layer which is the factory layout is enriched with manageable information of an additional individual layer (2) which is further enriched by layer three which exposure to noise, in example, an identified lead exposure layer superimposed with noise exposure, increased risk for noise induced hearing loss. Therefore, Manageable risk information of an individual standing in that position on the first layer is exponentially increased with the vertical integration of information into the original first layer.
6. The health and safety departments of companies typically comprise of different professions working together within the department, each of the professions working with its own separate data sets. This research has shown that it is possible to permeate these silos of knowledge in practice, and thereby providing the information needed for an integrated approach.
7. By using the model developed in this research as a template, companies could standardise the data received from consultants, thus enabling the evaluation of trends.
8. As was mentioned, the model can inform across and serve more than one discipline. The medical officer may for instance be alerted by monitoring results indicating noise levels above 85 dB(A) in a workplace and be on the lookout for a decline in the hearing ability of workers from that area. Thus, assisting with the early recognition and diagnosis of potential occupational disease.
9. This model could serve to prevent occupation-related consequences. I.e. by conducting a search (via the search function on the toolbar) for teratogens (monster forming agents), one would be able to identify such area in the workplace. The risk of female staff bearing deformed babies could be managed by preventing woman of childbearing age to work in that area or with that specific substance. The research proved that OH data was effectively captured and can be stored within the database. It is also possible to store lifelong exposure data in the model.

7.4 Potential Applications

Once fully functional, the model has the potential for further applications as provided below.

1. Because occupational hygiene exposure data can be effectively captured, searched, manipulated and displayed in GIS, as well as the fact that GIS is being utilised for environmental data (Delaunay et al., 2015), the model offers the opportunity for combining the data in different layers of GIS. The capturing of lifelong exposure data

of occupational and environmental exposures is one of the objectives of the exposome. This objective, combined with the ability of GIS to store vast amounts of data, opens the possibility of using a GIS as a database for the capturing of OH exposomic data for the exposome. A point in case is captured in the mentioned article by Delaunay et al., (2015) in which the researcher was a co-author and equal contributor to the article. Delaunay described the use of GIS for capturing environmental data surrounding industries and named the “macro approach”. The part of the article that was written by the researcher covered the environmental exposures within the indoor environment of industries, and the phrase “micro approach” was coined. This article points to the fact that exposure data of the external and internal environment (exposome) can be captured and displayed by a single computer-based programme. The article (Delaunay et al., 2015) was written under the auspices of a network of European academic centres occupied with “Monitoring trends in Occupational Diseases and tracing New and Emerging Risks in a NETwork” (MODERNET). European Union funding via the thrust for Cooperation in Science and Technology (COST) was obtained for the development of new techniques for discovering trends in occupational and work-related diseases and tracing new and emerging risks (MODERNET). Attributes such as the ability to immediately identify and locate hazards, risks or non-conformances of an industrial plant by looking at a floor plan and then being able to delve into the planning, progress or data pertaining to that hazard, could assist in the management of OH stressors of a single or multiple plant, locally and internationally. It is postulated that it could also be used for the dissemination of information at management meetings with high visual impact.

2. Due to the ability of the programme to permeate silos and share relevant information amongst diverse professions and managers, it may serve towards more effective initiatives in preventing occupational diseases and accidents.

   This application of GIS on OH data may serve as a tool to effectively measure OH management programmes by evaluating early trends in exposures, demonstrate non-conformances and progress with outstanding matters.

3. With the proven ability of the model developed in this research to enhance the level of insight of information, it is tweaked to overcome the mentioned lack of insight that was mentioned at the onset of the article of Boschman et al., (2016:01), by providing a holistic view of information, which include not only OH data, but also medical data could be added to the model. The advantage of this for OH managers is that all information on an individual worker or site is made available at the click of a mouse.

4. Due to the strongly supported ability of the visual component of GIS to add new insights to information, it can be applied to the OH managers as to the anticipation, recognition, evaluation (risk assessment) and control of stressors. Thereby, not only serving as a tool for the prevention of occupational diseases, but this model also serves the purposes of a practical instrument for the monitoring of OH controls that were put in place, as well as the total management of OH data.

7.5 Critical aspects

When the model was built, the aim was to ascertain value added in terms of knowledge for making OH management decisions. For security reasons, the model was created on the computer of the researcher with data from the industries. At no stage was the model directly online or directly connected to company data. Consequently, the researcher cannot report on compatibility and ease of dovetailing with programmes on the servers and negotiating proxies and firewalls.

The use of the model would entail training of staff in this regard. It is anticipated that actual training on gaining access to the information should not take more than one day. Designing, operating and updating such a GIS model would require the services of a skilled person, which may be costly if such a person is not available amongst the staff.

It was experienced that the more layers were added to the model, processing and presenting of the data slowed down. The original model was built on a laptop with a standard hard drive. As the focus of the research was to determine the value added in terms of the knowledge cycle, the speed of computers was not investigated. New generation computers with static hard drives, faster processors and larger RAM, as well as later versions of ArcGIS may overcome this problem. Cloud computing applications were not investigated and consequently no comment can be provided in this regard. The capabilities of computers and advantages of cloud-based applications need to be investigated before selecting or implementing such a model.

The research was done in the manufacturing industry, but it may have application value in other areas such as the shipping, mining or military environments.

7.6 Implication for occupational hygiene

The need for data management has been described in earlier sections. This model offers a visual computer-based programme that translates occupational hygiene data into information. It was proved that it could be used successfully for the management of occupational hygiene stressors in the workplace by national or multinational companies.

Further research may investigate whether the combination of static monitors in the workplace, GIS, 3D computer modelling of the dispersion of chemicals or noise and a transponder worn by a worker, could provide a more accurate, real-time presentation of the exposure of a worker. In such a case, it will be not only the geographic location of stressors within an industry that is of importance but also the position and movement of a worker in relation to the stressors.

This research focussed and proved the ability of GIS to add value in respect of the conveying of information for a more holistic approach in the assessment and management of risks and OH stressors in the workplace. In the process, it offered a systematic approach and model for the capture of OH related data in a GIS.

With GIS as a platform, an improved holistic management programme for the management of the environment, occupational hygiene, energy usage and medical data could be developed for industries.

7.7 Recommendations

As this is a new line of research, it is recommended that that the following be done before the implementation of the model:

1. A cost-benefit analysis is conducted.
2. The creation of an instrument for deciding on the suitability of the model for a specific type of industry. Aspects such as the frequency of floor plan changes may be considered.
3. Investigation/research be done on the dovetailing of the model with existing hardware, software, firewalls and proxies used in the specific industry.

7.8 Conclusion

In this research, an attempt was made at finding a solution to the unification and presentation of OH data in such a way as to provide OH managers with a more holistic input for improved decision-making and management, in local and multinational industries. GIS were investigated as a possible solution in terms of the knowledge cycle. A model was built within GIS to accommodate OH data. Responses from participants proved that it added value within the knowledge paradigm.

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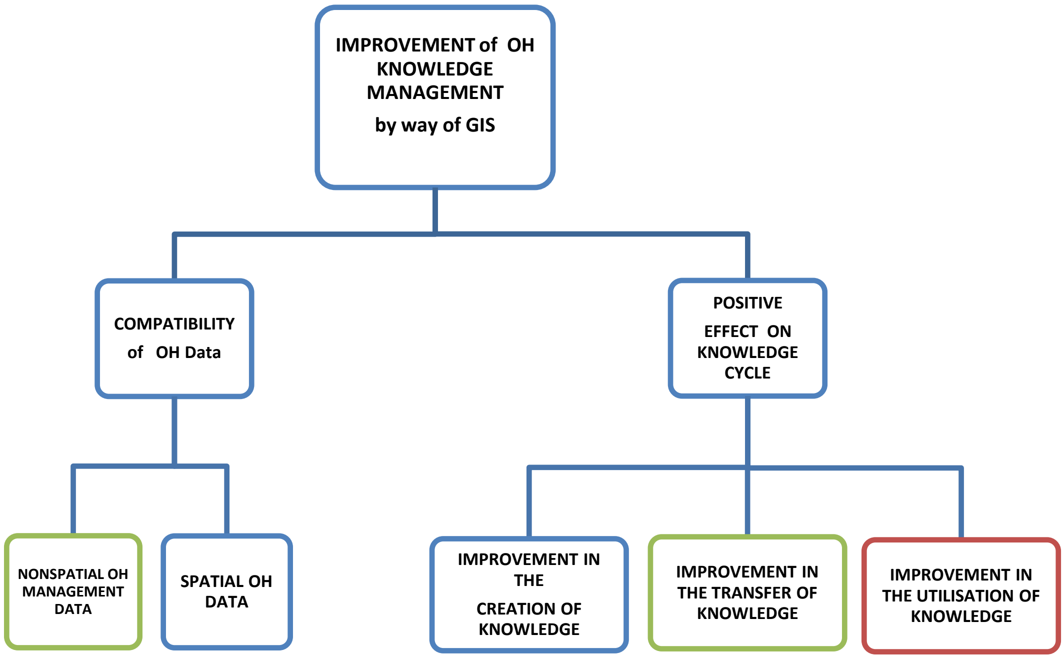
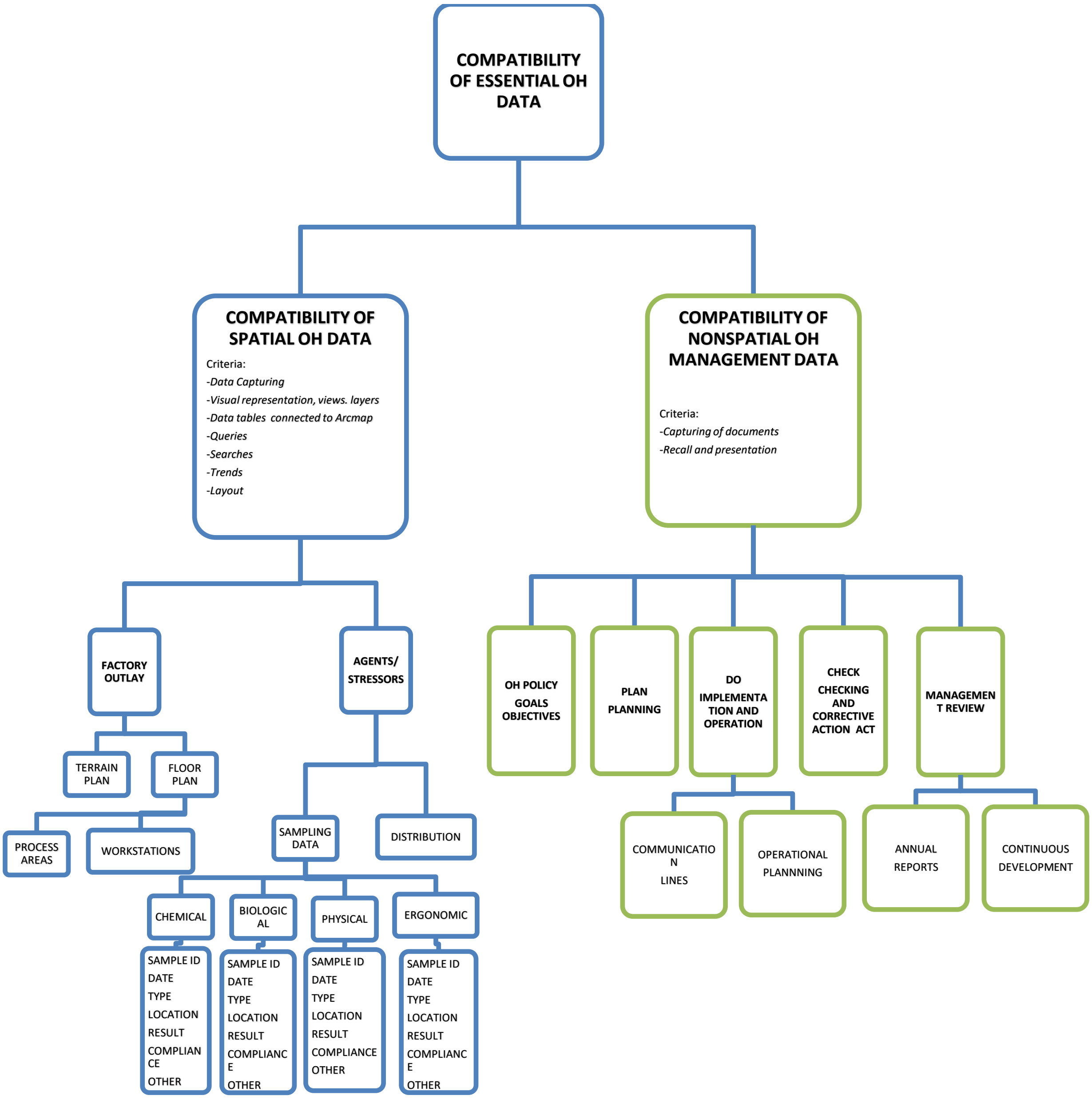
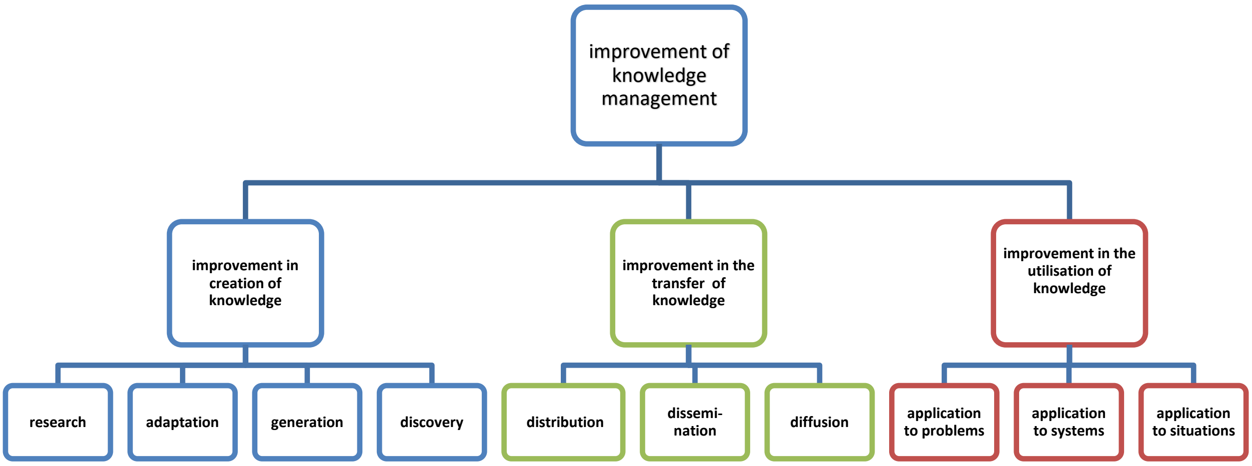
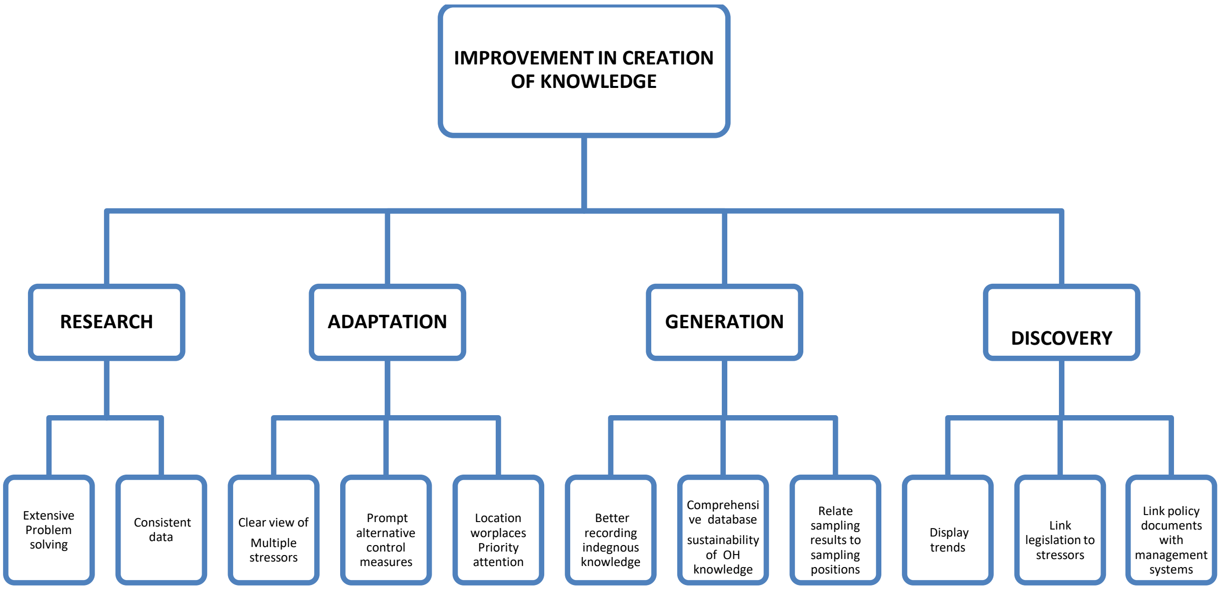
APPENDICES

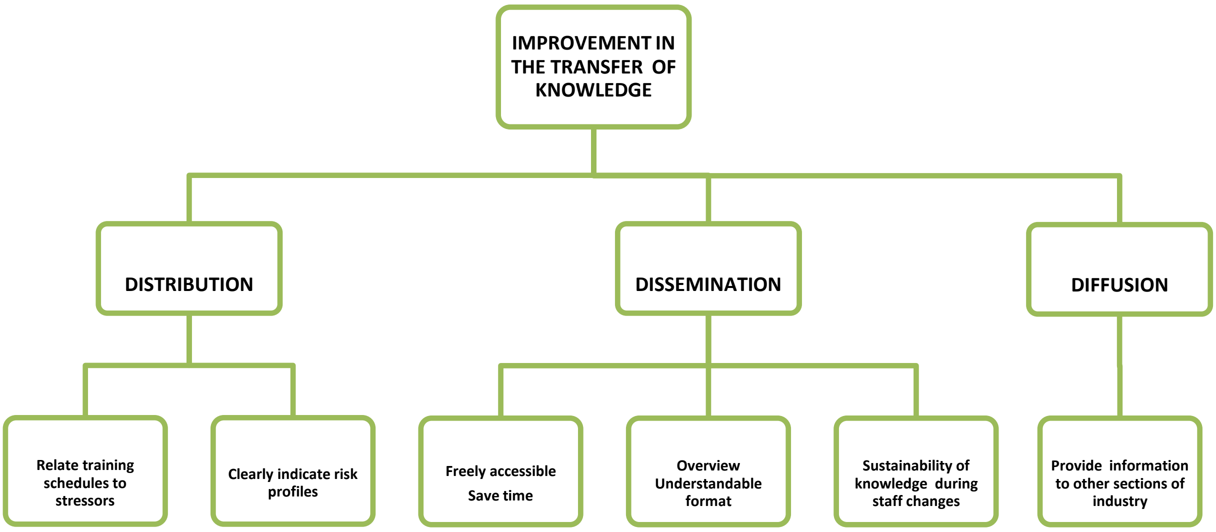
APPENDIX A: DENDROGRAM

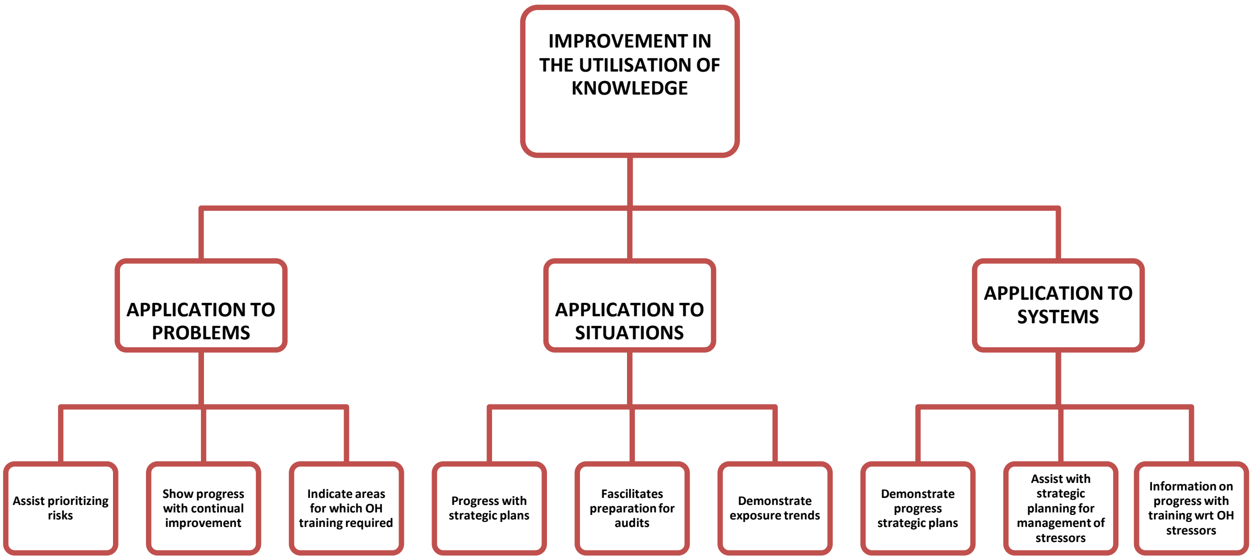



COMPATIBILITY OF ESSENTIAL OH DATA
COMPATIBILITY OF SPATIAL OH DATA
Criteria:
-Data Capturing
-Visual representation, views. layers
-Data tables connected to Arcmap
-Queries
-Searches
-Trends
-Layout
COMPATIBILITY OF NONSPATIAL OH MANAGEMENT DATA
Criteria:
-Capturing of documents
-Recall and presentation
FACTORY OUTLAY
AGENTS/ STRESSORS
TERRAIN PLAN
FLOOR PLAN
PROCESS AREAS
WORKSTATIONS
SAMPLING DATA
DISTRIBUTION
CHEMICAL
BIOLOGIC AL
PHYSICAL
ERGONOMIC
SAMPLE ID DATE TYPE LOCATION RESULT COMPLIAN CE OTHER
SAMPLE ID DATE TYPE LOCATION RESULT COMPLIANC E OTHER
SAMPLE ID DATE TYPE LOCATION RESULT COMPLIANCE OTHER
SAMPLE ID DATE TYPE LOCATION RESULT COMPLIANC E OTHER
OH POLICY GOALS OBJECTIVES
PLAN PLANNING
DO IMPLEMENTA TION AND OPERATION
CHECK CHECKING AND CORRECTIVE ACTION ACT
MANAGEMEN T REVIEW
COMMUNICATIO N LINES
OPERATIONAL PLANNNING
ANNUAL REPORTS
CONTINUOUS DEVELOPMENT


improvement of knowledge management
improvement in creation of knowledge
improvement in the transfer of knowledge
improvement in the utilisation of knowledge
research
adaptation
generation
discovery
distribution
dissemi-nation
diffusion
application to problems
application to systems
application to situations


IMPROVEMENT IN CREATION OF KNOWLEDGE
RESEARCH
ADAPTATION
GENERATION
DISCOVERY
Extensive Problem solving
Consistent data
Clear view of Multiple stressors
Prompt alternative control measures
Location worplaces Priority attention
Better recording indegnous knowledge
Comprehensi ve database sustainability of OH knowledge
Relate sampling results to sampling positions
Display trends
Link legislation to stressors
Link policy documents with management systems


IMPROVEMENT IN THE TRANSFER OF KNOWLEDGE
DISTRIBUTION
DISSEMINATION
DIFFUSION
Relate training schedules to stressors
Clearly indicate risk profiles
Freely accessible
Save time
Overview
Understandable format
Sustainability of knowledge during staff changes
Provide information to other sections of industry


IMPROVEMENT IN THE UTILISATION OF KNOWLEDGE
APPLICATION TO PROBLEMS
APPLICATION TO SITUATIONS
APPLICATION TO SYSTEMS
Assist prioritizing risks
Show progress with continual improvement
Indicate areas for which OH training required
Progress with strategic plans
Fascilitates preparation for audits
Demonstrate exposure trends
Demonstrate progress strategic plans
Assist with strategic planning for management of stressors
Information on progress with training wrt OH stressors

APPENDIX B: COMMUNICATION WITH PROFESSIONALS

PANEL FOR THE CATEGORIZATION OF QUESTIONS (DELPHI APPROACH)

- Dr. Johan Schoeman MD. NERSHCO (Occupational Hygienist and past academic) **SA**
- Mr. Rob Ferrie Past President of IOHA, International accreditation Committee (2006-2008) (Occupational Hygienist) **SA**
- Mr. Terry McDonald. Chief Examiner for the Examination Board of the British Institute for Occupational Hygiene. (Occupational Hygienist, academic) **UK**
- Mr. Deon Janse van Vuuren Business Manager: Occupational Hygiene Management Services. (Chairman SAIOH examination board) **SA**
- Dr. Carien Weyers, Central University of Technology (Occupational Hygiene Academic) **SA**
- Mr. Jan van Bouwel. IBEWE, Occupational Hygienist. **Belgium**
- Dr. Dawie vd Heever, CEO, VDH Industrial Hygiene CC (Occupational Hygienist, past academic). **SA**
- Mr. Piet Marais Consultant (Occupational Hygienist) **SA**
- Professor Fritz Eloff University of North West. Academic/Occupational Hygienist. **SA**
- Professor Rik Veulemans. (Occupational Hygienist, Academic) **Belgium**
- Dr. Tom Geens, Chairman Belgium society for Occupational Hygiene (Scientist, Occupational Hygienist) **Belgium**

Hennie vd Westhuizen
Department of Environmental and Occupational Studies
Faculty of Applied Sciences
PO BOX 652
Cape town 8000
South Africa
Email: vanderwesthuizenh@cput.ac.za

REQUEST FOR VIEWS ON QUESTIONNAIRE

Dear Colleague

INTRODUCTION

Thank you for agreeing to assist us with the questionnaire.

As explained in the initial letter I am currently at the KU Leuven in Belgium conducting research on the effect of a geospatial information system (GIS) on the management of Occupational Hygiene information in industry.

BACKGROUND

The research question that I will be attempting to answer is whether the implementation of a GIS wil improve the knowledge management of Occupational Hygiene at an industry.

A questionnaire is to be used as research tool to measure the effect of GIS before and after implementation at industries in South Africa and in Belgium. The same questions will be posed before and after implementation and the difference in results will be recorded. Like any other tool the design of the tool must be such that it does what it is supposed to do and keep doing it consistently. This tool therefore needs to be standardized with regard to reliability and validity. Your opinion is required in the validation of the questions of the questionnaire.

The questionnaire was designed to measure changes in the knowledge cycle as applied to Occupational Hygiene. In order to achieve this, 10 elements of the knowledge cycle were used as a framework. Questions were then developed from principles captured in the ILO-OSH guidelines and matched to the elements. Approximately three questions were matched to an element. The questionnaire was designed to be short and simple.

For your convenience and to avoid long winded explanations some schematic information on the research is provided below and your attention is drawn to:

- The global perspective of the research: **Diagram 1**
- **Table 1:** Definitions associated with Knowledge management.
- The relationship between the elements of the knowledge cycle and the questionnaire: **Diagram 2.**
- **Table 2** where the actual aspects to be tested are matched with the knowledge elements.
- The questionnaire to be administered in industry is attached at the end of this document

DIAGRAM 1: GLOBAL PERSPECTIVE OF THE RESEARCH

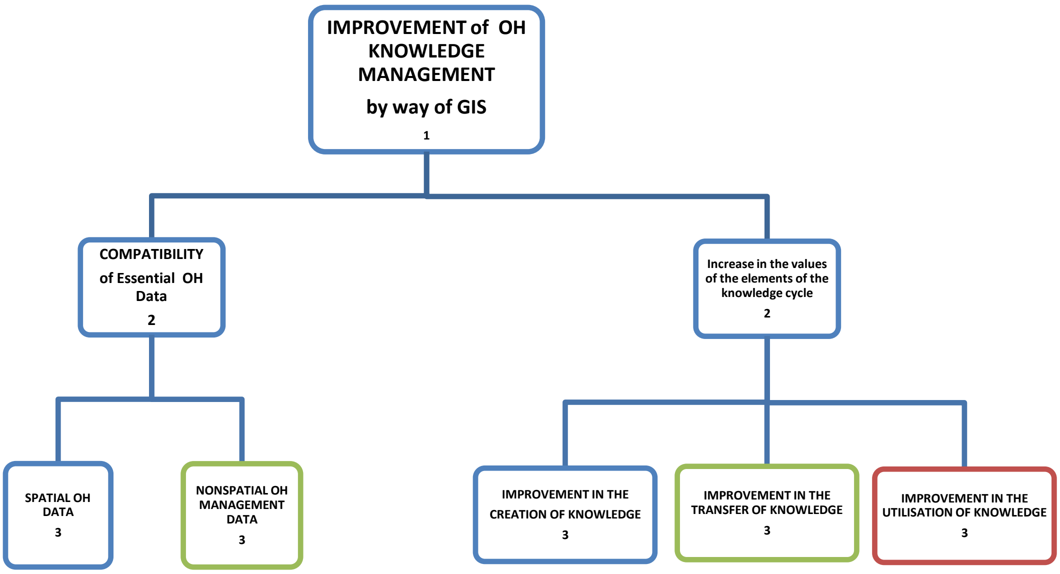


TABLE 1: DEFINITIONS

CONCEPT	DEFINITION
Data:	Unorganized facts and observances
Information:	Data + Concept
Knowledge:	Information + Judgement

DIAGRAM 2: RELATIONSHIP BETWEEN KNOWLEDGE CYCLE AND QUESTIONNAIRE

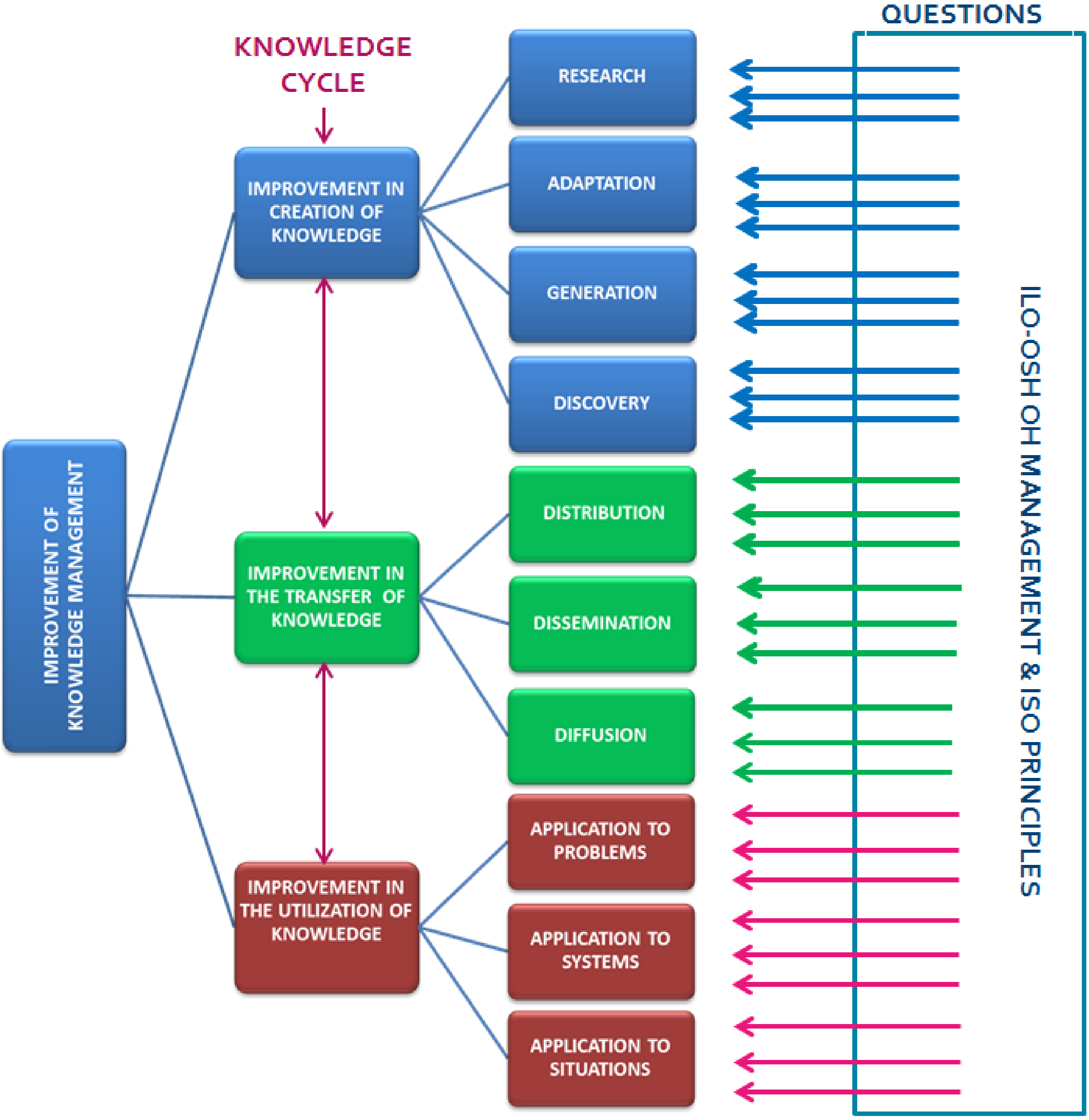


TABLE 2: ALLOCATION OF QUESTIONS PER KNOWLEDGE ELEMENT

CREATION OF KNOWLEDGE	**1. Research**	Contain an integrated database suitable for problem solving (indirect question)
		Contribute towards formal research by way of consistent data
	2. Adaptation ***Solving new problems from existing information.***	Provide a clear view of worker exposures to multiple stressors
		Prompt alternative control measures in the working environment
		Reflect the actual site of workplaces that requires priority attention
	3. Generation ***Creating information from data***	Allow for better recording of indigenous company (tacit) knowledge
		Ensure sustainability in the Occupational Hygiene knowledge of the industry by providing an integrated database
		Provide information on the sampling results in relation to the actual sampling positions
	4. Discovery ***Relationships***	Display trends which enable predictions to be made from existing data
		Link legislation to stressors in the workplace
		Link policy documents with management systems?
TRANSFER OF KNOWLEDGE	**5. Distribution** ***Through the organization***	Relate training schedules to stressors
		Provide a clear view of the distribution of hazards
		Clearly indicate risk profiles
	6. Dissemination ***Of data***	Save time seeking for information by having data freely accessible
		Presents OH knowledge in an understandable format
		Ensure sustainability of knowledge during changes of staff
	7. Diffusion Benefit to others	Provide planning information for other sections in the industry. E.g. HR. OH Medical practitioner
UTILISATION OF KNOWLEDGE	**8. Problems** ***Solving of***	Assist in prioritizing risks
		Show progress with continual improvement
		Indicate in which areas Occupational Hygiene training is required
	9. Situations	Provide information on progress with strategic plans
		Facilitates preparations for audits
		Demonstrate exposure trends
	10. Systems	Assist with the strategic planning for the management of stressors
		Demonstrate progress with strategic plans
		Provide information on progress with Occupational Hygiene training

PROCEDURE FOR EXPRESSING VIEWS ON THE QUESTIONNAIRE:

1. Scrutinize the questionnaire at the end of this document. Complete the questionnaire with an industry in mind. The actual ratings are not important. Simply provide an opinion on:
    - The clarity of the questions. (This is the main issue.)
    - Note any question with which problems were experienced or that needs rephrasing.
2. Scrutinize the allocation of questions per knowledge element as depicted in **Table 2**. Provide opinions on:
    - Whether the questions posed apply to the cateogory to which they were matched.
    - Whether more appropriate questions could be asked.
3. Any additional comment or advice would be appreciated.
4. Please return your comments in PDF format by email to the following email addresses by Friday 2 March 2012. vanderwesthuizenh@cput.ac.za and hennievdwest@gmail.com

Please note: Provide comments only where your views do not concur with the information provided or where it is felt that an opinion needs to be expressed that could improve the quality of the questionnaire.

UNDERTAKING

Recognition will be given to contributors in the thesis as well as all possible publications that may follow from the project. If contributors so wish, their names will be excluded from the list. It may be noted that the individual replies will be used for streamlining the system and that the replies from contributors will not be linked to their names.

The results of the research will be communicated electronically if required.

CURRENT CONTRIBUTERS

- Dr. Johan Schoeman. **SA**
- Mr. Rob Ferrie. **SA**
- Mr. Terry McDonald. **UK**
- Mr. Deon Janse van Vuuren **SA**
- Dr. Carien Weyers, Central University of Technology **SA**
- Mr. Jan van Bouwel. **Belgium**
- Dr. Dawie vd Heever. **SA**
- Mr. Piet Marais. **SA**
- Professor Fritz Eloff. **SA**
- Professor Hendrik Veulemans. **Belgium**

GENERAL

My email has been provided on this document should you wish to communicate with me.
Otherwise communication could take place by way of skype. My Skype address is: ………………..

In closing it needs to be said once again that your willingness, time and cognitive input are truly appreciated.

Kind Regards

Hennie vd Westhuizen

APPENDIX C: FEEDBACK FROM PROFESSIONALS

Report back from professionals on questionnaire (Delphi approach)

Names removed to avoid identification.

No	Resp. 1	Resp. 2	Resp. 3	Resp. 4	Resp. 5	Resp. 6	Resp. 7	Resp. 8	Resp. 9	Resp. 10	Resp. 11
1	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
2	OK	R	OK	R	OK	R	R	OK	R	OK	OK
3	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
4	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
5	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
6	OK	OK	OK	OK	OK	OK	OK	OK	R	OK	OK
7	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
8	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
9	OK	OK	OK	OK	OK	OK	R	OK	OK	OK	R
10	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
11	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
12	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
13	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
14	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
15	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
16	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
17	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
18	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
19	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
20	OK	R	OK	OK	OK	OK	OK	OK	OK	OK	OK
21	OK	R	OK	OK	OK	OK	OK	OK	OK	OK	OK
22	OK	OK	OK	OK	OK	OK	R	OK	OK	OK	OK
23	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
24	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
25	OK	R	OK	OK	OK	OK	OK	OK	OK	OK	OK
26	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
27	OK	R	OK	OK	OK	OK	OK	OK	OK	OK	OK
28	OK	R		R	OK	OK	R	OK	R	OK	OK

OK = Can be changed but revisit the question **OK =** Minor adaptations (Spelling, abbreviations, singular plural) **R =** Revisit question and revise

APPENDIX D: INTERVIEW DETAILS AND QUESTIONS

Department for Environmental Health and Occupational Studies

PO Box 652

Cape Town 8000

South Africa

Tel. +2721 460 3194

Fax: +2721 460 4244

Email: vanderwesthuizenh@cput.ac.za

Dear Participant,

As you are aware a study is being conducted by the KULeuven and Cape Peninsula University of Technology with Mr Hendrik van der Westhuizen conducting the research towards a PhD.

The title of the project is: **Representation of Occupational Hygiene Data by way of a Geospatial Information System** and this entails developing an application for Occupational Hygiene (OH) in a Geospatial Information System (GIS), populating it with data from Plant 1 and obtaining the views of staff involved in the management of OH, regarding the system. The aim being to establish whether such a system would be adding value (or not) to the management of OH data.

Formal consent was sought from your company for the study and to protect company data a confidentiality contract was signed between the following parties:

- Plant 1
- KU Leuven
- Cape Peninsula University of Technology
- The researcher – Hendrik van der Westhuizen

You are hereby kindly invited to be part of the team that expresses its views on the system.

HWJ vd Westhuizen

Researcher

QUESTIONS: SEMI-STRUCTURED INTERVIEW

- Any questions
- Request not to discuss with colleagues until all interviews have been done

- "Wablief's" are welcome
- Answers may contain Flemish words
- Questions presented in a specific order and manner but may return to questions

1	What comes to mind if you think of this system?
2	If you had to improve such a system what would you do?
3	What do you regard as a possible weakness of this system?
4	What would you regard as a possible strength of this system?
5	Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?
6	Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?
7	What problems do you experience with observing the distribution of hazards in the workplace?
8	Express your views on the ease of access to data.
9	Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?
10	Express your views on the possible use of such a system to professions other than occupational hygienists. Such as, medical practitioners, engineers, H&S staff, HR etc.
11	What do you think would the value of this system be (if any) in preparing for audits?
12	What would you think would the value of this system (if any) be in your planning during OH management?
13	Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?
	Any other views?

APPENDIX E: CONSENT FORMS

Participant's Consent Form

I……………………..……………………………… give my informed consent to Mr. Hendrik van der Westhuizen, a post-graduate student at the Cape Peninsula University of Technology and KULeuven to conduct an interview on my views of the application of GIS for the management of Occupational Hygiene data in an industrial plant.

I confirm the following:

- That I attended a presentation in which a basic introduction to GIS and the project was given as well as a demonstration of the presentation of the Occupational Hygiene data of Aleris.
- I have received and read an electronic explanation of the interview process.
- My participation in the study is voluntary and that it involves participating in the preparations for and presence at a semi-structured interview.
- I can refuse to participate or withdraw from the project or have the right to skip any particular question during the interview. This may be done without giving a reason or affecting my rights in any way.
- I understand that the researchers will hold all information and data collected securely and in confidence.
- Confidentiality will be maintained and none of the responses would be presented in such a way as to identify me.
- I have the right to ask any question before, during and after the interview.
- I have the right on feedback and outcome of the study.

I hereby give my consent to participate in this study on my own free will.

……………………………………………………..   ………………………….

Signature of Participant   Date

……………………………………………………..   ………………………….

Signature of Researcher   Date

APPENDIX F: SEMI-STRUCTURED INTERVIEW DATA

Coding Sheet Plant 1

		PLANT 1					
NO	**QUESTION**	**INTERVIEW 1**	**INTERVIEW 2**	**INTERVIEW 3**	**INTERVIEW 4**	**INTERVIEW 5**	**INTERVIEW 6**
1	What comes to mind if you think of this system?	Overview (3)	**Overview** of hazards and risks of whole factory down to workstations. (5)	**Overall view** (4)	**Overview** of data in (4)	Complex/comprehensive system (3)	Exessive (4)
			Visualisation of all **hazards and risks** (4)	Lots of information one programme/ ***comprehensive*** (4)	**visual** way (4)	Lot of information (3)	Elaborate (4)
				Easy to use (4)	**Locations** (6)	Good overview (5)	Demand lot of input (5)
			Other staff to understand e.g. physician (7) ***Ease of use***	**Few clicks provide access** (4)	Lot of work (**effort**) (6)	Easier to contain data (7)	
					Difficulty getting correct data (11)	Time-consuming initially (8)	
			Visualise work areas and risks within plant (21)		Excel compatible (18) ***Easy to use***	Time saving eventually (12)	
2	If you had to improve such a system what would you do?	No - Programme has everything (6) ***Complete***	Should portray improvement (50) ***Actually does****	Compact and comprehensive (11)	x	Make more user friendly (27)	x
			Action part of management system not visible (57) ***Is available****				
			Actions training and supervision not included (87) ***Possible***				
			Supervision and audit of superviser to be included (97)				
			Click on machine and all data (Training, safety etc.) should be available (104) ***Possible***				
			Risks and hazards visible and accessible to other staff e.g. physician. (23)				
			Must **illustrate legal compliance** (128) ***It does this***				
3	What do you regard as a possible weakness of this system?	**Updating difficult** (9)	Should portray improvement (50) ***Actually does****	Updating a problem (15)	Add photos easier to understand (31)	May crash due demands memory (41)	Time and work intensive. (22)
			Action part of management system not visible (57) ***Is available****				
			Actions training and supervision not included (87) ***Possible***				
			Supervision and audit of superviser to be included (97)				
			Click on machine and all data (Training, safety etc.) should be available (104) ***Possible***				
			Risks and hazards visible and accessible to other staff e.g. physician. (23) ***Easy access and availability***				
			Must **illustrate legal compliance** (128) ***It does this***				
4	What would you regard as a possible strength of this system?	Everybody can use it (12)	Visualization (140)	Accessible (21)	Integrated system (44)	Comprehensive system (47)	Overview (29)
		Simple to use (12)	Add photographs (141) ***Possible***	Simple to use (21)	Overview (44)	Availability of data (55)	Analysis of data (31)

			Safety ideas (141) Possible. ***Tacid knowledge***		Zoom in on problems (46)		Integrated system (31)
					Query data (47)		Links data to create information (31)
							Risks and analysis (37)
5	Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?	Assit understanding situtation at hand (17) ***Understanding***	Visualization part of communication (157)	Provides good OH information (31)	Easier to understand (54)	Overview (64)	Link worstations and hazards (51)
		New information / *perspectives* (17)	Risk analysis (160)	Reveals new information (28)	Overview (54)	Conduct queries (64)	Identify most heavily exposed (54)
		Assit understanding situtation at hand (17) ***Understanding***	Visualization part of communication (157)	Provides good OH information (31)	Easier to understand (54)	Overview (64)	Link worstations and hazards (51)
		New information / *perspectives* (17)	Risk analysis (160)	Reveals new information (28)	Overview (54)	Conduct queries (64)	Identify most heavily exposed (54)
		Assit understanding situtation at hand (17) ***Understanding***	Visualization part of communication (157)	Provides good OH information (31)	Easier to understand (54)	Overview (64)	Link worstations and hazards (51)
		New information / *perspectives* (17)	Risk analysis (160)	Reveals new information (28)	Overview (54)	Conduct queries (64)	Identify most heavily exposed (54)
		Assit understanding situtation at hand (17) ***Understanding***	Visualization part of communication (157)	Provides good OH information (31)	Easier to understand (54)	Overview (64)	Link worstations and hazards (51)
6	Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?	**Overview** (26)	Accessibility of information (173)	Colour identification of hazards (40)	Consolidated data (82)	Easier locate problems (81)	Link worstations and hazards (51)
		Indicates need for improvement by colour coding (26) ***Diagnostic***	Insight and new preventative measures (176)	Red areas need resolving (41)	Ease of finding data (83)		Identify most heavily exposed (54)
			Management function (188)				Prioritize monitoring (61)
			access controll (189)				Link pathology to areas (63)
							Comprehensive (64)
							Plan monitoring (76)
7	What problems do you experience with observing the distribution of hazards in the workplace?	x	Hazards Clear (216)	x	Visual aid (89)	Good management tool (90)	Determine combined exposures (84)
			Preventative measures (225) required		Wider access to data (90) departments	Inform workers current situation	
8	Express your views on the ease of access to data.	**Immediate information** (32)***Time saving***	Easy Acess (231)	Immediately available (55)	Easy to use (103)	Work with it easy (101)	Time and money investment (8)
		Not complicated (32)			Exchange data (105)	Training required (107)	
					Run queries (106)		

9	Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?	Will pass on information (37) ***Perpetuation of information***	Retention of information in one database (237)	Communicate information to newcomers (50)	Backup tinform replacements (115)	Comprehensive system (113)	Systematic organized service (99)
			Easier to find data (241)			Easy to access (114)	Provide overview newcomers (105)
			Easier to understand (243)			Easy to understand (114)	
			Avilable to newcomers (245)			Knowledge passed on (116)	
						Training required (119)	
10	Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.	x	Structured interdepartmental improvement (254)	x	Information for other professions (123)	Expand comprehensive (127)	Link pathology and workstations (116)
					Understnanding of exposures (126)	Easy access (138)	Link type of work and pathology (22)
					Problem identification (132)		
					Hazard management (135)		
11	What do you think would the value of this system be (if any) in preparing for audits	Overview available by clicking on layers (46) ***Information available***	Visual representation (262)	Perfect system (73)	Evaluate progress checks and controls (143)	Provide perspective on hazards and locations(145)	General insight in preparation for audit (138)
			Perfect for every audit (265)	Click and obtain data (73)	Demonstrate remedial actions (147)	Illustrate systems in place (149)	
			Training Newcomers (269)		Documenting hazards ((148)		
			Follow up legal compliance (270)				
			Combined in one system (264)				
12	What would you think would the value of this system (if any) be in your planning during OH management?	Identify areas that need to be rectified (51) ***Diagnostic***	Visualization perfect (277)	Plan to address areas in red (78)	Fascilitate decision making (156)	Fascillitates prioritization(155)	Overview of hazards (47)
					Prioritize actions (157)	Comprehensive view (155)	Prioritize policy (23)
						Retention of information (157)	Indicate cobination of exposures (149)
						Queries for prioritizing and planning (156)	Policy making (50)
13	Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?	Contains a lot of information (56) ***Comprehensive***	Visualiztion (188)	Difficult to upload data (85)	Facillitates understanding of data (166)	Startup time-consuming (165)	Insight in situations (156)
		Can be accessed by everyone (56) ***Ease of access***		Access control (86)	Identification of weaknesses (167)		Visual aid (161)
				Link to server for access (86)			
	Any other views?	Great if linked to the server (59) ***Available to all sections***		x	x	Expand to a complete system (170)	Would not like to update system. (171) Complimentary to systems x
	Questions?			x	x	Would implement	

						(175)	
						Easy to use (176)	

Coding Sheet Plant 2

						PLANT 2	
NO	QUESTION		INTERVIEW 1	INTERVIEW 2	INTERVIEW 3	INTERVIEW 4	INTERVIEW 5
1	What comes to mind if you think of this system?		**Visual** (3)	Overview (9)	Provides structure for data (4)	Overview of data (4)	Visual management (5)
			Shows **non compliances** (3)	Biggest risk (9) 5.2	Easy access (7)	Serve more than one sector (6) comprehensive	Diagnostic (6)
			More than one discipline / **comprehensive** (4)	Prompts alternative control (9) 2.2	Visual (8)	Analysis (6)	Logging and tracking progress (9)
			Good **visual Management** system (4)	Contrast biggest problem (19) 2.3	Identify and localize problem areas. (11)		Input work intensive(10)
2	If you had to improve such a system what would you do?		Extended comprehensive system (8)	x	x	Improve interface (11)	x
			Easier to use (9)				
			Compliances and non compliances (12)				
3	What do you regard as a possible weakness of this system?		Requires Updating (31)	Updating data (35)	x	Not helpful for small plants (20)	Search function (28)
			Reminders (35)			Combines data (35)	
4	What would you regard as a possible strength of this system?		View immediately 6.2 (45)	Visual (44)	Helicopter view (41)	Time saving (42)	Mapping (39)
			Compliance 4.2 (47)	Contrasts (45) 2.3	Identify areas with stressors (46)	Analysis (42)	Sites linked to data (40)
			Link results and sampling positions 3.3 (46)		Helps Prioritize (46)	Trends (50)	
			Problem locations (50)				
5	Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?		2.2 Problem solving (59)	Overview (62) 6.2	Prioritize (53)	Legal compliance (61)	Visual (51)
			2.3 Priority (58)	Priority sites (59) 2.3		Colour coding (59)	Simple (51) Easy to use
			Overview understanding	Immediate saves time (61) 5.1			A lot of information Hyperlinks (52)
			See immediately (50)	Integrated data base (64) 3.2			
				Help to understand (85) 6.2			
				Assist prioritizing risks (61) 8.1			
6	Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?		Solving problems (68)	Visual (99) 6.2	you can see a priority (62)	Understanding of data (70)	Easy to use (63)
			See immediately (72)	Problem solving (99) 1.1	Problem solving (64)	Problem solving (71) (75)	Time saving (62)
			All problems very visible (73)		Extensive (63)	Visual (71)	Links sites and hazards (63)

7	What problems do you experience with observing the distribution of hazards in the workplace?		Recognise areas (86)	x	x	Integrated (95)	Colour grading (73)
			See immediately (86)			Not for small plants (109)	Colour coding (72)
8	Express your views on the ease of access to data.		Easy to access data (91)	Easy to use (21) 6.2	Easy to access (98)	Good access (114)	Very simple (83)
			Easy to use (92)			Enables analysis (116)	
						A lot of data enabling problem analysis (116)	
9	Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?		`	New staff adapt. (48) 6.3	Structural view (14) Overview	Standardized data (124)	Advantage with staff changes (88)
					Easy to hand over (118)	Compliance (126)	Very Simple (100)
					Comprehensive (118)	Colour coding (126)	
					Time saving (134)	Enable formulation action plans (129)	
						Sustainability of knowledge (131)	
						Complete data set (132)	
						Time saving (138)	
						Visualized (139)	
10	Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.		Useful engineers (105)	Immediate access (57) 6.1	Use in logistics and production (142)	Uniform data (147)	Apply in other professions (10)
			Legal compliance (106)	Potential risks (63) 5.2	Comprehensive (159)	Integrated model (148)	
			Link exposure to site (120)	Position chemical lockery (64) 2.3		Visualization (149)	
			Trends: Exposure since (120)			Comprehensive integrated (150)	
			Accessible (22)			Applicable to MO (146)	
			Usefull to governent (26)				
			Provide insight (27)				
11	What do you think would the value of this system be (if any) in preparing for audits		Can use to prepare for audits (132)	Stressors (71) 2.1	Easy access to data (177)	Understandable (157)	Link audits to areas. (126)
			Provides proof for auditor (141)	Missed something (71) 1.1	Allow for better recording (177)	Quik way (157)	prioritize actions (127)
			Easy access via right mouse button (147)	Procedures in place (79) 9.1 10.4?		Proof of progress (162)	Visual (127)
			Tracking when data was entered (156)	See if something missing (79) 6.2			
12	What would you think would the value of this system (if any) be in your planning during OH management?		Useful for planning (162)	x	Planning (191)	Priorities (169)	Diagnostic (133)
			Comprehensive: findings from system (166)		Evaluation (191)	Planning (170)	Visual management (133)
			Planning for the next year. (67)		Easy access (194)	Visualize (188)	

					Time saving (196)	Improve (171)	
13	Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?		Identification weaknesses (172)	See (104) 6.2	View Priorities (104)	Visualization (183)	Visual (140)
				Problem solving (104) 1.1	Clear view (107)	Illustrates nonconformances (196)	Visual management (143)
					Priority linked to a site (110)	Accurate data (195)	Easy readable (143)
							Identify weaknesses (144)
	Any other views?		Overview (180)	Visual (10) 6.2	Need to create structure (119)	Not for a small plant (200)	x
			Analysis (183)	Actual site of problem (11) 2.3		Comprehensive (206)	
						Compare data (207)x	
	Questions?			x			Time saving (176)

Coding Sheet Plant 3

				PLANT 3		
NO	**QUESTION**	**INTERVIEW 1**	**INTERVIEW 2**	**INTERVIEW 3**	**INTERVIEW 4**	**INTERVIEW 5**
1	What comes to mind if you think of this system?	Overview (11)	Comprehensive – all data (4)	Comprehensive (4)	Ease of access (4)	Comprehensive (3)
		Assist audits (11)		Supports audits (5)		Ease of access (6)
		Track improvement (12)		Comprehensive (10)		
		Easy to use (14)				
2	If you had to improve such a system what would you do?	Schematics good (18)	Comprehensive all data (12)	Make it more user friendly (14)	x	More user friendly (12)
		Click and hover ove area (19)	Hazards and risks per area (14)			
		Track improvements (21)				
		Comprehensive (23)				
3	What do you regard as a possible weakness of this system?	Conduct searches (30)	Require training to use (48)	x	Training required (17)	Human data input (19)
		User friendly? (34)				
4	What would you regard as a possible strength of this system?	Good overview (37)	Comprehensive (53) store data	Comprehensive (28)	Easy access (26)	Extensive system (28)
		Track progress (37)	Easy access (54)	Easy access (30)	Timesaving (30)	Management overview (30)
				Understandable format (31)		Continuous improvement (36)
5	Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?	Visual (43)	Advantage for medical staff (69)	Improves understanding (36)	Understandable (38)	Diagnostic (47)
		Colour coding problem solving (43)	Easy access (74)	visual (37)		Overview (49)
		Links problems to worksites (44)	User friendly (76)	Easy access (38)		Links hazards to workplaces (50)
		Quick overview (45)				

		Assists planning (46)				
6	Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?	Problem solving (51)	It will contribute (83)	Visual (44)	Highlight risk (45)	Extensive system capturing data (58)
		Comprehensive (56)	See improvement (86)	Link areas to noise zones (45)	Immediate access (48)	Overview (60)
		Easy to understand (57)	Comprehensive (91)	Time saving (49)	Overview (49)	Link hazards to workplaces (63)
		Link issues to sites (57)	Planning (91)	Integrated problem solving (49)		
		Assist planning (58)				
		Shows immediately (62)				
7	What problems do you experience with observing the distribution of hazards in the workplace?	Actual location of workplaces (70) Prioritization	Promt alternative control (106)	x	x	Extensive problem solving (71)
						Demonstrate exposure Trends (77)
8	Express your views on the ease of access to data.	Easy to use (79)	Easy access (18)	Easy access (67)	Overview (59)	Visual thing (82)
			Ensure sustainability (33)		Ease of data access (65)	Data retrieval time saving (89)
			Overview (39)			Better recording company knowledge (91)
9	Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?	Contribute towards exit medical (89)	Understandable format (52)	x	Link workplace exposures to sraff (72)	Better recording company knowledge (101)
		Workers and exposures (90)	Time saving (57)			Visual (115)
		Induction new workers (91)	User friendly (66)			Integrated data base problem solving (116)
		Link hazards and workplaces (93)				
10	Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.	Beneficial all departments (106)	Use by clinic and production (76)	Of use other sections (82)	Doctor will benefit (86)	Can be used by other professions (123)
		Any sort of information (109)	Used worldwide (97)	Overview (83)	Greater understanding (87)	Easy access (127)
		Quality tracking (110)			Prioritizing risks (88)	Indicate risk profiles (128)
		anybody can use it (112)				
		Staff changes (118)				
		Legal issues (118)				
11	What do you think would the value of this system be (if any) in preparing for audits	Extremely easy (1123)	Hazards and risks (107)	Facillitates audits (88)	Exellent tool for audits (94)	Great tool (139)
		Display areas of concern (24)	Link hazards to areas (108)	Sustainable data (89)	Comprehensive (94)	All in one box (140)
		Colour coding (25)	Ease of access (108)			Better recording knowledge (141)
		Legal compliance (25)	Comprehensive database (109)			Legal compliance (142)
			Time saving (12)			Problem solving (143)
						Planning (144)

12	What would you think would the value of this system (if any) be in your planning during OH management?	Planning (49)	Assist with strategic planning (19)	Overview (96)	x	Time saving (149)
		Prepare for audit (50)		Track improvement (98)		Easy to use (149)
		Quickly review (51)		Prioritize problems (103)		Links hazards to workplaces (151)
		Time saving (52)		Planning controls (104)		
		Demonstrates issues (52)				
13	Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?	Flags issues (60)	Integrated database (133)	Identification weaknesses (10)	Overview (14)	Visual (158)
		Links legislation (61)	Assist planning (144)	Prioritize problems (112)		Workplaces priority attention (159)
						Training (165)
						Assists strategic planning (167)
	Any other views?	Easy to access (68)	Provide information to other staff (149)	x	User friendly (19)	Winner (186)
		User friendly (71)	Understandable format (150)			
	Questions?	x	x	x	No	Better recording company knowledge (192)

Individual scores for each industrial plant

PLANT 1

Combined: Clusters	Grand Total	%	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Views	QResp
Research	**13**	**8**	2	0	0	4	3	1	0	1	0	1	1	0	0	0	0
Adaptation	**21**	**12**	2	0	0	1	2	7	2	0	0	2	2	2	1	0	0
Generation	**30**	**17**	3	4	2	4	2	2	0	0	6	1	0	3	1	2	0
Discovery	**3**	**2**	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Distribution	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dissemination	**58**	**34**	10	1	2	8	5	4	2	7	7	1	3	2	5	0	1
Diffusion	**5**	**3**	0	1	1	0	0	0	0	0	0	3	0	0	0	0	0
Problems	**5**	**3**	0	0	0	0	1	1	0	0	0	0	2	1	0	0	0
Situations	**4**	**2**	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0
Systems	**13**	**8**	0	1	0	0	0	1	1	0	0	1	2	7	0	0	0
Other	**21**	**12**	4	1	3	0	0	3	0	2	1	0	0	0	4	2	1
	173	100															

Knowledge Cycle	Total N	Total %
Creation of Knowledge	67	44.1
Knowledge Transfer	63	41.4
Utilisation of Knowledge	22	14.5
	152	**100**

PLANT 2																	
Combined: Clusters	**Grand Total**	**%**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**	**Q 7**	**Q 8**	**Q 9**	**Q1 0**	**Q1 1**	**Q1 2**	**Q1 3**	**Vie ws**	**QRe sp**
Research	**15**	**9**	3	0	0	1	1	5	1	1	0	0	1	1	0	1	0
Adaptation	**24**	**14**	2	0	0	3	4	3	2	1	1	2	1	1	3	1	0
Generation	**21**	**12**	3	1	1	2	2	0	0	0	4	3	2	0	1	2	0
Discovery	**8**	**5**	1	1	0	2	1	0	0	0	1	1	0	0	1	0	0
Distribution	**3**	**2**	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Dissemination	**61**	**35**	6	1	1	5	7	5	2	6	6	4	6	4	5	2	1
Diffusion	**10**	**6**	2	0	0	0	0	0	0	0	3	5	0	0	0	0	0
Problems	**7**	**4**	2	0	0	1	1	0	0	0	0	0	0	2	1	0	0
Situations	**6**	**3**	2	0	0	0	0	0	0	0	0	1	3	0	0	0	0
Systems	**10**	**6**	1	0	0	0	0	0	0	0	1	0	3	4	1	0	0
Other	**8**	**5**	1	1	3	0	0	0	1	0	0	0	0	0	0	2	0
	173	100															

Knowledge Cycle	**Total N**	**Total %**
Creation of Knowledge	68	41
Knowledge Transfer	74	45
Utilisation of Knowledge	23	14
	165	**100**

PLANT 3																	
Combined: Clusters	**Grand Total**	**%**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**	**Q 7**	**Q 8**	**Q 9**	**Q1 0**	**Q1 1**	**Q1 2**	**Q1 3**	**Vie ws**	**Q Res p**
Research	**11**	**7**	1	0	0	1	1	3	2	0	1	0	1	0	1	0	0
Adaptation	**17**	**11**	0	1	0	0	3	3	1	0	3	0	3	0	3	0	0
Generation	**22**	**14**	3	3	0	2	0	2	0	2	1	1	6	1	0	0	1
Discovery	**4**	**2**	0	0	0	0	0	0	0	0	0	1	2	0	1	0	0
Distribution	**3**	**2**	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
Dissemination	**62**	**39**	4	2	2	6	8	7	0	8	5	5	3	6	2	4	0
Diffusion	**8**	**5**	0	0	0	0	1	0	0	0	0	6	0	0	0	1	0
Problems	**4**	**2**	0	0	0	2	0	0	0	0	0	1	0	0	1	0	0
Situations	**9**	**6**	2	0	0	1	0	0	1	0	0	0	4	1	0	0	0
Systems	**14**	**9**	1	0	0	0	1	3	0	0	0	0	1	5	3	0	0
Other	**7**	**4**	0	2	3	0	0	0	0	0	1	0	0	0	0	1	0
Total	**161**	**100**															

Knowledge Cycle	**Total N**	**Total %**

Creation of Knowledge	54	35
Knowledge Transfer	73	47
Utilisation of Knowledge	27	18
	154	**100**

APPENDIX G: TRANSCRIPTS

1 What comes to mind if you think of this system?

Interviewee

Provides an overview.

2 If you had to improve such a system what would you do?

Interviewee

No , The programme has everything in it.

3 What do you regard as a possible weakness of this system?

Interviewee

Needs to be updated everytime there is new data. Not so easy to do it.

4 What would you regard as a possible strength of this system?

Interviewee

Everybody can use it. Simple to use.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

It helps to understand the situation in front of you. It provides good information that you may not be aware of in the factory.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

I provides an overview of the situation and the colour coding indicates where improvements should be made.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

No, the workers come and report when they have problems. If not by way of complaints the hazards are identified by walking through the factory.

8 Express your views on the ease of access to data.

Interviewee

The system provides the information immediately and it is not a complicated system.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Will assist in communicating and passing information on to the next person.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

No audible reply.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

They can get an overview of what is happening by clicking on the various layers.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

Yes it will be of value due to the fact that one can identify the areas the needs to be rectified

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

Contains a lot of information that can be accessed by everyone.

Any other views?

Interviewee

It is great if all the information can be linked to the server.

Questions

No

Plant 1: Interview 2

1 What comes to mind if you think of this system?

Interviewee

For me it is a visualisation programme, of all hazards and risks in the complete factory. It gives an overview of the hazards and risks.

The visualisation is very good. People are not aware of the factory. For instance, our physician. He just knows the factory, but do not know all installations and having a visual overview, of the installations, it is easier for him to understand. So, in my case, if you are talking about half past six or structure 1700, I do know where that is and I can find it with my eyes closed, but for some people it is more difficult. Because they don't know the installation, they don't know the departments, maybe they didn't see the installation yet.

Now we are using more tables and spreadsheets but it is not so visual. People are not ... people doesn't know so good these installations.

For instance, if you have people coming here first, we give them an introduction training and we always ask to these people, where do you come, in which department do you come, and they say I will go to cast house, and I will go to the maintenance department of the cold mill and with a system like this you can visualise, oh you will go there, you will go there and you will go there and these are the risks that are on that spot.

What we now do, we explain them a little bit about the general risks and I explain also a little about the department risks, but it is difficult to talk about the machine level because if you have risks you will always have risks on the . For instance, in the morning I was busy with a problem with blackouts, which means that it affects production, and secondly our electricity goes down for the complete company. Also, for Belgium. In Belgium we don't have any power anymore. What will happen? So, we have some risks and hazards and we have some measures, and with this you can see the risk and hazards of the complete factory, of your department and then on the installation level.

2 If you had to improve such a system what would you do?

Interviewee

In Belgium, according to our law, we have to have a dynamic risk management system. And this dynamic risk management system, we need to know what are risks we have now, hazards, what we do now to prevent these risks to get into an accident and what we can do to improve it in the future. So that is our Belgium law. So, for me it is a huge PDCA (plan, do, check, act.) that we have. From plan, do, check act, where we are doing now this. I have a new factory here next door, a new installation. If I go there, I will see some risks and hazards which will determine preventative measures. People will do these preventative measures, they will tell us we finished them, and then we will redo it and we will be able to improve continuously.

We always need to go to work but if you are looking for improvements . . . what I am missing here, in this system, you see your risks and hazards, what you have now. But you need to see also what can we do, what do we do now about it, what do we do to improve it? It is not just a general map for the complete factory, but also on machine level, and department level.

Yes, more detailed, but also that different people have access to a system like it. So for instance, an operations manager of a finishing department should have access to all the preventative measures to be taken for his department. But I'm meaning that we don't want to have a static system; a static is a system where today we have these problems but even tomorrow is not today anymore. We have a near-miss accident, out of this near-miss accident we have some measures and for me that is part of a management system; that you need to have a near-miss, out of the near-miss you have a factory analysis, out of the factory analysis, you have seven different preventative measures and people will do these measures and then they will sign it off and so we will continuously improve. That is the idea of safety in Belgium, also described in our law, it must be dynamic. If tomorrow we have somebody of the unions coming to me and he says, we have a huge problem, that can be catastrophic, we need to do something there. We will need to take preventative measures. There will be somebody assigned to that job and he will have to tell us I did the job and the job will be closed down. So, I am missing a little bit the action (Referring to action part of management system) in the system.

So, if we have a problem in the cast house and my action is we need to make a safety instruction to tell our people not to do it this way, but that way, because that is not a safe way, this is a safe way. We will have somebody at times to do the safety instruction and somebody at times to do the training and then if the training is done, that job is finished and then it is OK, it is over. The training for that hazard will continue for the rest of our life here in our factory, so even after three years I will need to be able to find back that I need to do it this way because we had a problem. That is what we had before; we had a serious accident, a fatal accident, with an incident, and measures which were there weren't in such a way made that after a year, two years, three years, people forgot it, they continued to do it like before and then we had a fatal accident.

For me, our system is based on a risk analysis. You saw our big excel sheets, they were huge. It is what do we do now? How can we do it safe? How can we improve it? For me, it is a risk analysis. For me it is not something theoretical, it is a practical tool which people need to work with continuously.

So, I have my hazards, I have my measures. Then can be safety instruction, I have training and I have supervision. That is very important part. So that I don't find it here. It is like . . .

Interviewee

This is very basic. You have it on factory level, you have it on department level, you have it on machine level. For me, safety is something where you need to do something. If you don't do something, it is having luck or bad luck, for having accidents or no accidents. It is about thinking about risks and hazards, determining your measures, not having these risks and hazards occurring to an accident, and then having supervision and having risks and measures.

Also, the complete supervision and audit of our supervisor is missing on this.

HvdW

Supervision measures, audits, need to be here. At all levels?

Interviewee

At all levels. Factory level, department level, machine level.

And then if I go to your drawing of the factory and I have here machines and I click on the machine, I would be able to see all the risks and hazards for all the measures. I would be able to see all the safety instructions, etc, I would be able to see the training, whether people have their training or not. If I make a safety instruction that people are not allowed to drive a forklift this way, they must drive it that way, but I don't tell it to the people, I don't give training. Then it is no use to make a safety instruction. So, the training, and then I need also to have the supervision. The audit to do the plan do check act procedure and to see the reason for making the risk assessment? It is because I don't want people to get hurt. I want to really define the necessary measures to do it. When is it ready, my risk assessment? When I have a good feeling that there won't be any accidents, then I have a good risk assessment. Then out of the risk assessment is basic to make my technical measures, to make my safety instructions, to make my chemical carts (charts?), for my operating sections, for my chemical substances, and then I need to do the training. The training, and then I need to do the supervision to check if all that I did in theory is there in practice. If I made marvellous trainings, marvellous risk assessment, marvellous safety instructions, but in the end the people are still doing what they want to do, I will still have accidents. All that is a little bit I'm missing. Now I only see the first line of the complete cycle of safety. First line: Risk and hazards. So for our physician, it must be very good. Because he can see I have got a guy in extrusion department, he has got some biological hazards, some ergonomical hazards, some chemical hazards, for him it is very good. I am missing the complete part.

Also, legal compliance is also some part. So, you can do a risk assessment, you have some job's legal compliance, which are not OK, you have preventative measures, it should be one of them.

3 What do you regard as a possible weakness of this system?

Interviewee

As mentioned previously

4 What would you regard as a possible strength of this system?

Interviewee

It is the first . . . the visualisation. It is what we don't have at the moment.

For improvement of the system there could also be some pictures in there. If I go there to that machine and I can click on it, I can see some pictures of the machine.

The risk assessment is dynamic thinking. It is something you need continuously. You have a near-miss, you have an incident. A guy comes to me, he says if he can do it this way it is much better, we won't get accidents. So that safety ideas can also be in here.

5 Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?

Interviewee

If you can inform people about risk analysis in their department, it will only have a positive effect because people will start to think about that. They will see the risks and hazards of their installations. So the visualisation is part of communication.

People are working here and lots of people are not aware of the risks we have here. And having a system like this could help to make them more visual. It is like a little bit, like working with children. You can give a child a book of 300 pages or you can give him another book with a lot of pictures and he will achieve more with pictures than a complete book.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

If you have 20 different systems, one for noise , one for chemical hazards, one for ionization hazards, etc, and you don't integrate the information in such a way that it is reachable for everybody, then people will not see the risk; they won't do something about it. To make one system is an advantage, to integrate all the different aspects. In the end it is about having measures and taking new measures, whether it is radiation or ionisation or noise whatever, it is all the same.

So, having all the information in one system is an advantage but you need also to work with - in a system like that - to have some roles and responsibilities. What I mean is that if everybody has access to this, and everybody can change whatever they want, it will end up into a mess. So normally in a database you have a system: where I am an administrator, I am from the EH&S department, and I will be able to create everything. But for instance, the manager of the finishing department should only be able to create and modify his part. Also there, if safety in our department, is at our level here, in our department, and only in our department, then there will not be safety in the factory. Safety must be on the level of the management. So, they need to have access to this tool, but with some limits.

HvdW

When you say safety, you are including occupational hygiene as part of the safety programme?

Interviewee

For me it is one. Whether he is dying in 20 seconds because he is run over by a fork lift, or if he is 65 and he goes home without going to work anymore, and his back is down, he has economic problems, or some lung problems in the end, it is all the same. We are concerned with the health and safety of our people not now, today, but also the future.

But you need to have a system where I, for instance, can make a new department, I can put in a new machine, but not everybody must be able to have access to it. So the manager of the finishing department should be able to see to his risks and hazards, to work on his preventative measures, but I don't want him to work on the preventative measures of the cast house.

Normally, in a database, you need to have input protection and you need to have also . . . in a database you work with an input protection. So if people start to fill in things which are making nonsense, the system should protect itself from that. But I didn't see it . . . maybe the time was too short for the demonstration, maybe it is in, I don't know.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

I think all the hazards are clear. But for me the preventative actions are not clear.

The same with the second question. Preventative actions can be technical measures, which are there or which need to be taken. They can be on the level of instructions, trainings, they can be on the level of signs, safety signs, etc.

Interviewee

Knowing the hazard is one thing but knowing what we will do now to prevent these hazards to come into an accident is also important, and to improving the future is also important. I'm missing the second and the third parts.

8 Express your views on the ease of access to data.

Interviewee

If you know how to work with a PC, it is easy.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

You will always have inheritances of the past incidents or measures that were taken in the past or which still need to be taken, and if you can combine them into one system and you don't easily have the loss of information.

If you combine all data into one system, then it is easier to find something.

Because of the fact that you can visualise it, it will be much easier for other people to understand it. So it will be the same for question one, the answer. The first answer I talked a little bit about new people, newcomers . . .

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

We have here three departments: the quality department, the H&S department, and the E department, the environment department. The way we need to improve in a structured way is the same for quality, as for environment, as for H&S, so I think there we have some nice opportunities to work together. So it would be the same for the ISO systems.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

If you have a system like I described there in question two, where you see what do we do now, what can go wrong, what do we do to prevent it from going wrong, what can we do to improve it -if you have that in one system, and you visualise it like your system, it is perfect for every form of audit. We have an environmental audit, a quality audit, a safety audit. So safety is not looking at hazards, but doing something about hazards. That is safety. If you follow up your actions in a proper way, if you follow up your incidents in a proper way, if you give proper training, if you give good supervision, if you train newcomers, etc., then you can only have a positive outcome. If you follow up your legal compliance problems, etc., then you can only have good audits.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

So, as I described in question two, with the visualisation it is perfect. It is a perfect solution to get people involved with EH&S. Because the first step is to get people involved in that part. And if you can visualise it, it is easier than giving somebody a list.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

In our system we have a good follow up of the existing system, we should have a good follow up of our measures to be taken, of our measures taken today, but we are very lousy in visualisation. At the moment we still have some different systems.

Any other views?

Interviewee

No

Questions?

No

Plant 1: Interview 3

1 What comes to mind if you think of this system?

Interviewee

Overall view, easy to use, a few clicks provide access, Lots of information in one programme,

2 If you had to improve such a system what would you do?

HvdW

Interviewee

No, I think it is compact. Everything you have to know, it is in it. Let me think . . .

3 What do you regard as a possible weakness of this system?

Interviewee

The update I think. Somebody has to update it every time there is new data. One person has to do it, because it is not so easy for all the data.

4 What would you regard as a possible strength of this system?

Interviewee

Everybody can use it. It is simple, it is simple to use.

5 Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?

Interviewee

There are many things you just don't know, when you don't use the system. Many . . .

It provides good information related to Occupational Hygiene in the factory. Provides good information.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

When you see a plan and there are hazards one must solve them. It is the meaning of that. The colour coding allows a person to see the hazardous situations. The matters in the red areas then need to be resolved to ie. red to green.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

There are always problems.

The people who come for medical examinations often to complain about hazards.

8 Express your views on the ease of access to data.

Interviewee

Information is immediately available.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Communicate and pass information through to newcomers.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

Inaudible reply.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee

This is a perfect system for audits. All a person needs to do is to click and obtain the data.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

Yes, I think it will help. By looking at the map one can plan to address the areas marked in red.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

Concerns expressed on the difficulty to upload data. A lot of information available, who have access? It is good if the data is linked to the server for access.

Any other views?

Interviewee

No additional comment

Questions?

Interviewee

No additional comment.

1 What comes to mind if you think of this system?

Interviewee

It seems to be fantastic. You get an overview of the data in a visual way and you can it must much more visible than just by looking up some text documents. You have locations. It is also a lot of work you have to do to get to the result you like. A lot of work, I think. And it never stops because the company is always evaluating, so it means you have to keep doing the work.

The thing is we have a problem with the data capturing for the moment. It is rather huge here. So, it is not easy to collect all the correct data in the first place and then manage them. Because we have some hidden doors, but that people can buy something and you don't know something about it and then it is to keep all the data covered and secure and well managed. It is a job in the company. But that is not. . . we have to do that even if we use such a kind of application or another.

So, if you have data in an excel-based system then you can import it to the system.

2 If you had to improve such a system what would you do?

Interviewee

I don't know for the moment. OK, we have to do with a floor plan with general drawing, that can be improved. But otherwise I think I am not well placed for the moment.

3 What do you regard as a possible weakness of this system?

Interviewee

I don't know if it is possible, but I would suggest building some photos into it, if it is possible.

For the moment we just see some floor plans and with some indication of there is that and there is that, and we get an overall view of OK, we have to deal with that kind of chemical over there or that kind of danger or hazard, but I know from experience that a photo does much more . .

So you have a chemical or ergonomics issue and you have a photo. It makes it much easier for the people to understand.

4 What would you regard as a possible strength of this system?

Interviewee

It is all integrated in just one application. You have an overview, you can go into it, so you start from general overview. If you want to get something about chemicals or something about ergonomics, you can zoom into the things you like to question at that moment. And also the queries.

5 Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?

Interviewee

I think it just can make it easier to understand things, to get an overview, to get reports, to manage the data. I don't think for a company like us . . . there are not many people who are going to use this system. It is going to be used on a certain level, a manager or something.

If we need to present something on the committee for safety. But it can make it easy to do something. It has a visual aspect. It is also a benefit if you can learn something visual and not just text. That is the main benefit I see into it.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

I don't know if it is a benefit, but I don't see the link function between ergonomic issues, for instance, and chemical issues, although they are in the same application. You have some ergonomic issues and you have to deal with them, but you have to deal with them from an ergonomic manner, but you also have the chemicals and you have to take preventions there for the chemicals. The one is not really related to the other. What I can say, also from our system we have some standards and, in those standards, also all things are covered. All things about hygienic problems must be covered in the same standards. According to the standards, we must evaluate the ergonomic risks, the chemical risks, the risk of noise and so on. So, it is all covered. But I think it is also . . . I mean, the overall hygienic must be covered; you can’t look at only one topic of it, for instance ergonomics. You must look at all topics of occupational hygiene. In my opinion, they are not all related to each other. But it makes sense that if you are doing the job that you put them all together. That you don’t have to look in different places for related topics.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

It is a visual aid. So that is a benefit. It can be . . . I think the central application for when you put the data into it, it can be viewed for instance by our department but also by the manager from the cast house, he can have a look at his own situation over there. So that is the benefit.

I am talking about my experience with emergency situations, something like that, when the fire department comes in – at that moment we can’t rely on just this, we still need some paper. Or will it be (indistinct) but at that moment you need something to hold in your hand and you can’t rely on the computer. But the main benefit is the visibility.

8 Express your views on the ease of access to data.

Interviewee

From what I have seen, it is easy to use. You have the check marks and you can put down some layers. People nowadays are used to working with layers, to hide, not to present something. It is very easy to exchange data. For the moment I have no idea about how to manage the difficult queries.

From what I have been demonstrated, it is not that hard to use.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Good thing! As I told you earlier it is a lot of work you need to put into it, to get the data all together, to maintain it. You need more than one person to maintain it. So, you need a back-up if someone is out, leave the office for a long time, you need to get another person in place to keep on doing the work.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

The medical part, I think . . . if I look at our doctor over here he needs that information also to deal with the consults of the people, the working people. But also he has to deal with hygiene problems that people suffer from, caused by dust or chemicals, I don’t know what. So, he needs to have an understanding that those people are maybe exposed to some dangers over there, so it might help certainly the medical part of our company here. For engineers . . . I don’t see immediately a benefit, but it is possible. We have, for instance, reactive sources or something, if you have to deal with that and you have information, you follow the checks. It might be a benefit for them.

The main advantages for the safety and health environment department and also for the manager of the department itself, because they also need to know to know what the problems and the hazards are in their department. So they can take adequate measures.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

In an audit, you start mostly from a kind of a procedure that you can also . . . then the next question is, how do you deal with the tasks that are in the procedure, such as checks, controls, and so on; then you can use this tool to look up those checks, those controls, and show them. There is also a view of those kinds of danger so you can link it to the audits.

I think it is a useful help for us because you can prove that you have done something, you can prove you are managing those hazards by inventorying it and following them up.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

I think we need to have data, if he uses this kind of application or not. You must need data to make the decision that we have to do before attending to some priorities in taking actions. It might help in taking those decisions, in prioritising the actions.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

No, I am just thinking. In my opinion, the first thing we have to do is we need the data. We can put it in the system. It is another way of presenting the data. It makes it easier, it makes it more visible, something like that. But it really helps in identifying the weaknesses, I don't know. I think mostly those things come out of audits. Maybe because it is visible perhaps, we can quickly identify some weaknesses, but I'm not sure of it.

So I think the weaknesses are mostly identified by audits, perhaps because it is visible, I can't say at this moment it will help identify the weaknesses.

Anything else on the system?

Interviewee

Not for the moment.

Any questions?

Interviewee

No

1 What comes to mind if you think of this system?

Interviewee

I think it is a very complex system that can contain a lot of information and help the plant or organization that uses it, to maintain the data to control data and also to give a good overview of the plant I think it's helpful for bigger plants to do this than for a very small plant because then you can.. it's is easier contain your data. That's the positive idea I have about it. What I can say the negative idea about it due to its complex nature that it will consume a lot of time to pull it together everything and to insert all data and when I think of all the data that we already have in this plant and also the data that is still lacking that can go into the system I think it will consume quite some months to feed such a system. But once you have done it I think you will gain or win time. So time-consuming at first but afterwards it can yea help get you time.

2 If you had to improve such a system what would you do?

Interviewee

Difficult question because there I …. You've shown me quite some things, but I haven't seen how it was being built up. I think ... to my opinion there is some more room a to make, to optimize the system. Then I mean... I have seen that you can add data by adding excel tables and stuff like that but I think there is some room inside the programme also to make it a little bit easier. I am not an IT guy but I've seen other things not like ... for this --- For example what I have seen you do Hennie is that every time you need to ... let's say you go from noise to Biohazard or whatever you have to dome quite some steps, the floor plan and things like that. I have seen things that are very easier to... that have more... let's say more operational buttons on the left side or the top side that can help you make it easier because now you have to… Once you are used to this programme it is easy. But I think for a new user have to find his way into the different screens and the file drop down list that you have and for me also it is sometimes easier I say if you make buttons more on a sort of start screen. I think it is something you can do; it is not easy I know but it gains a lot of time. Industry is always looking for tools to use but they can't consume too much time to put it in otherwise they won't do it.

3 What do you regard as a possible weakness of this system?

A weakness to my opinion is... at the moment it is like you said I'm taking out an Xxxxx example, if you started from a plan that our engineering guy gave you with a lot of layers on it takes a lot of time just to load everything. I think you have to have the newest computer the fastest computers. I think if we should run it on our pc that we have here it will crash. I think that is the main downside of it but not every company will have state of the art IT equipment. Ja... I think that is really the major downside of the programme... that it just consumes so much memory and that it can crash.

4 What would you regard as a possible strength of this system?

Interviewee

The main…most positive thing is that you have all the information in one system. At the moment we don't have that here, most of the information is available but are most of it is not on an online database system… certainly not a GIS system. UM now you have to consult everything separate and not all the data is also available at the same location and sometimes we have to search round for things. When you use a system like this when once have fed the system everything is in there and you only have to use one system and you can let say the workstation at the rolling mill to give an example you can take everything out of that system everything that you need to know.

And that is the strength.

5 Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?

Interviewee

You mean that displaying all your data on a floorplan of the plant. I think it is a good thing to have an overview and like you said that when you can make queries compliant non-compliant if you want to see a non-compliant issue then you can also see it on a map at the moment that you will…when you need to know something you will see it on paper but all separate hey. Here you have them all together. It is easy to show It is always easy to show people let's say inform people that way. Easier than just doing it in a presentation in telling something. Visualization is always a good helpful tool to do things.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

I think it directly won't contribute. In that way I mean it's not because now it will be in a … Now what I was saying in my opinion I don't think that it should matter that you have it on a GIS system or say on a other paper system or whatever. If there is non-compliance or another issue, then you will have to solve it anyway. It will make it easier to see where the issues are. That's true. But I don't think that it will contribute extra in solving problems or it shouldn't it should already cover it but it will make it easier to see it.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

My opinion is that again ... I give a bit different answer to Q5 it is a very good tool to manage everything and also to inform your workers on the current situation on the shop floor. Hey, it is like I said it's something different that you can show it to them. Even it's only a map colours and circles or whatever on it, it shows more and tells you more than only giving a presentation you are telling them ok we have this and this and this. No, the main thing I think .. but for the rest it works fine to do that. It serves the purpose that it is built for. So otherwise it wouldn't be a good system if it didn't do that.

8 Express your views on the ease of access to data.

Interviewee

I think once you are used to work with it it's easy. But I think it will take some time to get used to it. To work with it. The first time we saw it last year and now I saw it again some tools and it's not that difficult. I think you need to be already computer minded and with a system like that I would say more excel or access database minded to work with. If you are not used to working with these systems, then I think it will be difficult in the beginning to get it out or to put in or whatever…you will need training to use it.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Ja advantage again that everything is in one system, so it makes it very easy to access when you are used to it and easy to see what's going on. If the position changes from person A to person B it will be rather easy for him to get an overview to focus on that because you can also get details from departments and stuff and more detail. That will be the good thing. Again, there are disadvantages in that you need to train the people again in use. Once the users are familiar with it, it is a good system.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

What I would do, if we should implement a system like that here in Duffel my first thing would be is to expand it, not just to only put data in about exposure but you have already in the system build more out of it so that it serves not only a health purpose but most of it like ergonomics and noise and stuff but serves the' purpose.

I think it would be benefit it you can in a way maybe I don't know if it is possible in this system to have different users, different levels of security, then I think that it makes sense because if you can't do that and the guys start changing stuff then that is a very dangerous thing. You have to give them only limited rights maybe also a then create a start-up interface you can do in databases so that they can easy access the parts that they need and not... the extra things are baggage for them. One guy may need only something about noise and he is not interested in the other stuff that is in there. It should be easy for them then to take that part out of it.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

Very easy for internal audits e,g chemicals can see what is being used where. Would personally add quantities to get a more comprehensive picture. That to my opinion very good to thing to do. Also, very important to know if you have one or one thousand litres.

External audits. Could illustrate to auditor that systems are in place.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

It makes it easier to prioritize. See everything in one view. Run a query to identify and prioritize and plan. Overview helps you not to forget. Things that are in the system cannot be forgotten because the query will get it out.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

Implement involve other departments in management programme. How do you ensure that people have the right data? Access could be problematic.

Start-up for a company could be time-consuming.

Any other views?

Interviewee

Include other aspects like safety and environment and have a complete system for all. No. Everything is clear for me. Could be costly.

Questions

Interviewee

For me it was clear. It would be something that I would use. No other questions. Easy to use.

1 What comes to mind if you think of this system?

Interviewee

It is quite excessive, elaborative, but it will demand a lot of input and investment to establish it, to merge it with data. To nourish it with data. Feed it.

2 If you had to improve such a system what would you do?

Interviewee

I only think you have to use it for the right application and if you use it for the right application, the system as such should be effective, dependent on the purpose you want to use it for. If you have the right purpose, you don't have to change anything in the system.

3 What do you regard as a possible weakness of this system?

Interviewee

A combination of the answers I gave to the questions one and two. That I don't think it is applicable in every situation, every step, because you have a certain problem with the availability of data, and it is very complicated to organise data in such a way that you can integrate it in your GIS, in your system. I think it is demanding a lot of work to build it up, to keep it up to date in such a way that it is effective as a management system.

4 What would you regard as a possible strength of this system?

Interviewee

What would you regard as a possible strength of the system?

A possible strength of the system is that it I think gives an overview, a possibility to make some changes and analysis of some analysis of certain findings, to make links between different data, and elaborating and integration of the elements that constitute the wellbeing of the workers on the floor. You can make integration of ergonomics or health findings, exposure to substances. It's an integrating system, and I think that's the strength of the system.

I am thinking about it. Yes, it can be handy in use and stimulate your thinking on risks and risks analysis. And give a global idea of the load or the workload, all the possible constraints that workers are exposed to in one time.

5 Explain the possible effect, if any, that the way that GIS combine, and display information could have on the understanding the overall OH situation at hand?

Interviewee

Imagine that you are able to put every substance that we have here in your system, all the thousands of commercial products and all the other exposures like machine dust, oil mist, noise, you can make a global application of the total exposure that people experience For instance, if you want to have an idea of the solvent exposure for people you can track where people are exposed to the highest levels of solvents. Thinking about metal dust exposure. You can track where the combinations of metal exposures are combined, coming together.

Compare different exposures and add them, in fact. By adding the exposures, you can see which people are most heavily exposed. Also different methods for different kinds of exposure that are linked to certain kinds of pathology. Thinking about, for instance, neurological damage by solvents, you can add the exposure you have in the factory. You can see which people, and which work posts have the most heavily exposed . . . addition of most solvents. Be aware of these people, these places, because they have the biggest solvent exposure, general exposure. That’s why you have . . . I don’t know how to say this . . . you can put priorities for monitoring . . . if you expect to have certain kinds of pathology among these people anywhere in this factory, you know where to search for it, which people have to submitted for certain tests or monitoring. Because all the data comes together.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

This is what I explained to you. This is the same answer.

How the integration of the surplus value, the sure value of the integration, is that you can keep in mind which people are not heavily exposed to combinations of products that have the same effect on health. It helps you to keep in mind which steps you are going to develop, to monitor and to survey their health.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

Chemical exposure, risks by substances, and ergonomics.

Can be used for chronic exposure, not for accident hazards. It is a value for combined exposures to determine where the combined exposures could be found.

8 Express your views on the ease of access to data.

Interviewee

I have the impression that it is working well, but I didn’t use it myself so I can’t express myself on it. I have the impression that it is excellent.

Ah, OK. But you have to put everything in before you can get anything out. And that is the real question in terms of time and money.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

That really gets to the question, if you really will organise or work following the structure of the system it will you organise your service, your section, your occupational health section in the company, following that system. Thus, every officer has the obligation to put in data that he is obtaining in the field, measurements, into the system. Who is doing that? The secretary? He, himself? Is it documented? How to do it? If there is a change of staff . . .

It would be an advantage to give a newcomer an overview. Such a person will have an easy overview of the global situation by the system. But he will be informed in a general way, not in a particular way. It is good to have a note in those situations.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

If I could have my data, my medical data, on a display like that, then probably I would be able to have insight in the distribution of certain pathological findings and local distribution of those pathological findings. If, for instance, five people have a shoulder problem and I see them consecutively here in my office, I probably won't make the link between their section and the work stations they are at. Certainly if two were working next to each other, I won't see the people one after the other. So I can make the finding on the site, on the view, that is the link between the same kind of work and the same kind of pathology.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

I think that maybe . . . audits are directed to finding out the procedures are prepared and followed, and I don't think on first reflection this system is giving a clear view on what kind of procedures and behaviour is actually present on the work floor. It doesn't show if things are really working as they should be working. A geological overview but not an overview of the processes behind it. On the other hand, I think good elaborative audits have to be based on overview of what the work situation is, to get a better insight in the global way of working. It can be important to have this overview but . . . it is good for orientation and audit, and have general ideas, develop general ideas and determine which questions and which procedures are, the most important. Yes, Gives you an insight in the general situation and then you go from the general situation to the more particular findings that have to be checked.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

For planning your need an inventory first. An inventory of every exposure, every hazard, that is present on the floor. If you want to be reacting on hazards, it is clear that if you do a hazard rating, you will be finding these hazards on your overview and then that way you can help to prioritise your occupational health policy. Another aspect is that it will indicate the combinations of certain exposures. It will help to prioritise your actions and so making up a policy.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

The system could lead to a certain awareness certain insight in things, in information, that you will miss when you look at only a serial way. Information on a excel sheet will not give you the insight that you can obtain when you are looking at a geographical distributive way. So, I already gave you the example of one division with two same kind of activities. You only make the link when you see it before your eyes. On an excel sheet you won't see that two machines are just next to each other, for instance. In a geological distributive presentation, you can (indistinct) and come to conclusions and develop some insight that you miss when you go ahead with information in a more narrative way.

Any other views?

Interviewee

Any other views? I would not like to be the one and only that is responsible for furnishing and nourishing all the data that it needs. I think that is a very complicated responsibility for someone, because you have find the way how to link the files in that way, to that, and from data files it could also be used in another way, let's say in a narrative way. You have to organise it in a complementary way of other management structures that are used.

I think it is very complementary to the conventional ways of working but the only complication is that it demands a lot of time and energy to feed it with data and organise your data so that it can be used. Maybe that is possible to do that in a more informed and organised way.

Questions?

Interviewee

No further questions related to the research.

Plant 2: Interview 1

1 What comes to mind if you think of this system?

Interviewee

I think it is a very good system. You can see immediately your non compliances in your plans and especial in different kinds of disciplines. Very good visible management system.

2 If you had to improve such a system what would you do?

Interviewee

At least make it a little bit not only to help an occupation but also for the rest of the plant. All the disciplines, as I told you before already. Easier to use maybe, but that is maybe, that is my first impression, that you need to push twice, you need to do that one, that one and that one.

Also when you will see the non-compliances, you need to click on it, you need to do that one, you can see that for example the noise levels, you go to the view noise level, I can see ten points where you mention it, but all the points are green. Why not in the first time immediately one red and the rest in green? For example, the sanding machine? You know what I mean?

HvdW

I can answer you on that one, so we just get some clarity. I can set that thing to show the different noise levels as well. So, it will show all the colours of the rainbow with the legends on the side so that you can see the red ones are above 90. So, it can be set. Is that what you mean?

Interviewee

Yes. That is what I want to see.

HvdW

Yes, it can be done, I just didn't set it . . . but those are still valid points that you make. 3.3 and 4.2

3 What do you regard as a possible weakness of this system?

Interviewee

The classic FFF – find, find, forget. You know, it is nice to have an excel sheet somewhere on the server, or somewhere on the computer, but you need to update it or otherwise you will lose the whole system.

In the system, an approval sequence, a reminder sequencing that you will have in mind that you need to update the data for this one, this one, yearly, weekly.

In Belgium you need to measure the welding gases once a year. Can you give a reminder on the system that you need to do it every 12 months, for example in September, October?

HvdW

OK, reminders.

I have an idea it can be done. I will check on that, but it is a good point.

What your system does not show very well, in the management plan itself, at the top, your annual work plan will be there. *System can link annual work plan to man syst.*

4 What would you regard as a possible strength of this system?

Interviewee

Of course, it is beautiful to see immediately for each machine, for each exposure place, exactly the correct value and if possible, also immediately a difference between good and not good, between compliant and non compliant. In a small plant, it is not too complicated, but you will see in some other plants where they have much more machines, much more exposure, it will be nice to see immediately the area where we have a problem. That is beautiful to see.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

I think it is very helpful to have this system. When you go with one of your problems to management, to top management, and you can open your lap top and you say this is the plan, the drawing plan, look all the red things are exposure risks, it is not good for health, it is not good for this one, this one, this one. They will see immediately that you have a problem. You can write ten pages of blah, blah, blah, but when they see it visible, in front of you, with all the points that are not complaint, they will sign maybe the money immediately instead of discussing ten years to have some money to solve some problems.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

Of course. Yes, it can definitely help us in solving problems.

Interviewee

For example, if you want to see your exposure of welding fumes, you can go to a supplier for example, and say on this line we have a problem, and you can see it immediately. You don't need to measure it again and to look for what happens. Very visible, all your problems.

HvdW

Do you think there would be drawbacks, for instance, in this? If you look at that section there?

Interviewee

I don't think so.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

It is between good and very good. It can be better of course. All can be better! I was very surprised to see that now, on your laptop, in a real plant. The first time we met you showed us something, but it was not my plant, not a chemical plant. But now you see immediately on a chemical plant, wow, yes, you recognise the areas and you see immediately the hazards.

8 Express your views on the ease of access to data.

Interviewee

I think it is very easy. If you just need to update an excel file, open an access file, and that thing pulls this data automatically to the system, it is very easy to do.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

In Xxxxxxx we change the management team every five years. A lot of information is gone, and this system will give the information. It is good. I think it is very helpful for the management team.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

Medical, can be difficult. It will be nice but can be difficult, but for engineers and especially for my profession, like machine safety, it can be very, very helpful when you can say this machine is complaint with legislation, not this machine, not this machine. It will be very, very helpful.

HvdW

Just one other thing: so you can say it is useful. But now if you as an engineer had to look at occupational hygiene data, would this be of use to you? We have two aspects to this. The first aspect is in your field, it would be useful, but if you had to look at occupational hygiene data, would it be of use, or no use to you?

Interviewee

Yes, of course. The same with the whole line I think.

HvdW

Why? Why would it be useful to you, if you had to motivate?

Interviewee

You can see immediately if you have a problem somewhere, but with the exposure since.

I understood from you that you can see the old data, the new data as well, so you can immediately see it. You don't need to go to some place to find, and you see it visible immediately in front of you. And you can discuss, for example, with the government about it, you can show the government inspectors and so on and so on.

The government would see this as a good system to show good and bad things.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee

In preparing for audits? Of course, you can use it to prepare for audits but I am not sure if it fits in the audit protocols we have now. I am not sure about this one.

When you talk about internal audits by the company that will be very useful, but when you talk about audits to external companies and so on, I am not sure.

HvdW

So, there is a question of compatibility with externals, but for internal it is OK.

Interviewee

For example, when you have an (ISO 14000), I am not so often involved in that, but the auditor will ask, can you prove it? Yes, we can prove it, we can show them. What was the last information? Can you show me the data updated, and so on and so on?

HvdW

External, internal, ISO 14000

Interviewee

You show an excel sheet, but he immediately goes to the right button of your mouse and he will see the creation data, then he will be happy. I don't know maybe it is possible with this system when the last data was updated, I don't know.

HvdW

The system works on dates. So, every time a sample is done, the update goes with it. It is just the way you load your data, that's all.

And in preparation for audits, would you say could this be of use or no use?

Interviewee

Definitely, you can use it. And if you can use it for tracking, when the data was entered, then you can use it definitely for external audits as well.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

Ah, OK. If you want to do your planning and you have this system in place, of course it is very useful.

HvdW

Example?

Interviewee

You can prepare your… you can make your findings out of the system and you can prepare for the next year to improve your occupational hygiene system.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

Of course, it will help you in identifying weaknesses in your overall system. You will see it if you use the data correctly, if you keep your data up to date, it will help you of course. 100% sure.

Any other views?

Interviewee

. . . with this special view, where you see all the green, blue or red dots. For each question, you have a green or a blue or a red dot. When it is green it is perfect; blue means not yet answered, question is still open; red, there is some problem with this question. This is an overview, when you can implement that overview in your system and you can see for each machine you will have a green or a blue dot or a red dot, you can immediately see whether your machines are with some technical problems. That would be very beautiful to have that system in-house.

Questions?

Interviewee

No.

Plant 2: Interview 2

1 What comes to mind if you think of this system?

Interviewee

I think it is maybe a nice tool, maybe our plant is a little bit too small, especially also for the data that is not much that we have here to work with, but for other industrial . . . data, it is maybe useful to think more in the direction of productivity, quality. Maybe also for accidents, where you can see on which area, or which production line, do we have specific accidents, or burns, or something like that. To have an overview on which lines do we have most accidents or the biggest risk, and then to put some actions against them.

It all depends on how many efforts or energy you have to put into the system to have all your data, to have it up to date. If it just automatically uploads all your latest data, it can be very useful. But if you every week on Monday have to start uploading all your data and that takes a couple of hours.

That will be too nice too, if all data is in, but you need to keep your data up to date first, so . . . and what is the effort to put all the data into the system?

I see it in front of me with contrasts, also for example, for scrap, that you can on see which lines do we produce most of the scrap, what is the problem over there, the contrasts? Also like you have shown us, green is OK, red ones, we have a contrast to see OK, this is my biggest problem over there. It can be useful.

2 If you had to improve such a system what would you do?

Interviewee

That's early to give an answer on that. You first have to work with a tool to have an impression.

Mostly when you start with something new you start with something basic, and then afterwards you will see on which kind of direction you have to optimise some things ... but it is difficult to answer that one if you don't use the system by yourself or play with it . . .

3 What do you regard as a possible weakness of this system?

Interviewee

Depends on how much time it takes to keep the data up to date, I don't know. Maybe it is easy, but I don't know. It can be a weakness, because it will be a lot of data that you . . .

To put in all data, not only for this one, an easy one. Well, not easy but it's not that much data.

4 What would you regard as a possible strength of this system?

Interviewee

The visual aspect. It is clear where you have a problem. The visual aspect. I like to see contrasts.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

It can help.

HvdW

To what extent? Can you motivate?

Interviewee

Because we have a lot of data available for everything but then you have to start to work with the data and see where do we have to work on, what are the priorities? And therefore it can be useful or easier to see where are the points or the weaknesses where we have to work on. It gives you immediately an overview. It depends on which layer then you can see, OK, the situation there we have a problem.

I am even thinking of course you can go as deep as you want to a place, but to integrate an ISO QS or something. Because you start also from the process flow; the same for an ISO QS too, you start with all your processes and then all your steps and your procedures and the next step. Also in layers.

HvdW

How do you see that relating to occupational hygiene?

Interviewee

Something, maybe also a possibility to integrate that in that system.

Also in layers. (Indistinct) All your processes, and then start down each layer . . .

You start with your processes, then you have your procedures, then down procedure you have some, for example, work instructions for each line. You can see for that line is that work instruction and you click on it.

HvdW

How do you relate that to understanding occupational hygiene? Remember, we are looking at this stage at an occupational hygiene system. If we integrate that, then how do you relate it, the occupational health, if you bring in the other system, will it help you understand . . .

Interviewee

Maybe yes, you have the contrast you see where the chemical ones, maybe you can click on, or have another layer with how to treat with chemicals. Of course, the procedures, how to work with chemicals, to link that also with that. Something like that.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

It can be. The first thing is you have to see the problem and that is where you have the tools, to make it visual, it will help to solve it. It can help. For example, the chemicals are just beside the place where they have dinner.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

Yes.

Interviewee

Not really. It is clear. Not immediately, no. Maybe leave it open, but . . .

It is quite clear, yes.

8 Express your views on the ease of access to data.

Interviewee

That is the question? Can it be automatically, or do we have to upload all the data one by one? That is a question? I don’t know.

HvdW

Let’s assume that the data is already on your system and you want to access it. So, there it is on your system, and you want to get the data.

Interviewee

That is easy if the data is in. Just a layer function. It is easy to use.

HvdW

If we talk about not only about sampling, but managerial data?

Interviewee

Access to data. It is easy to access data, ones that are in . . . but I have not the experience.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

So the company and the responsible plant managers, production managers, somebody leaves, you have to update all that information. It will also be the communication flow; that will change, so if you have a lot of data and you change something, you have to know what you need to update. I think the more information you have, the more difficult it will be to specify what you have to update. After some change of staff, or whatever.

HvdW

Let's suppose you get ill, but it's on the system. Hygiene is your responsibility; you get sick, but everything you did was on the system and it's updated. How would you view that situation then if someone had to come into your position for six months? Let's say you broke a leg or something.

Interviewee

OK, specific for that one. Not really a problem then. Not that much changes. Someone can take that over on the grounds of the information.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

Like I said before, there are a lot of possibilities and I think for big plants, it can be very useful. To immediately have all the data, but at the end you need an overview of the data.

It could help an influence on absenteeism.

If you say safety engineers, H&S. If it would be safety engineers, then I would say yes.

To have an overview of the potential risks. For example, the chemical . . . the position of the chemical lockery.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee

Internal and external. Like I said before, if you can work something out for the plant, with all kinds of stressors you can see if you have missed something. For example, if there is a production line – it's also related to hygiene?

HvdW

Yes, it is! You say you can identify where there are gaps.

Interviewee

It can be that a work instruction helps treat with chemicals. You can link that also on your layers. You can click on and then the procedures you can see, if there is something missing or not. If procedures are in place or not.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

(Sigh)… too small.

HvdW

Why do you think the size is going to make a difference?

Interviewee

It is not so much related to hygiene. It must be a benefit.

HvdW

It doesn’t have to be there. I want your views.

Interviewee

Combine it with other things, I would say yes, but only for that one.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

Hmmm. Yes, it can help to see places where you need to improve your system.

Any other views?

Interviewee

You mean, if you see the plan, you have to work with it, if it can help to identify the value of the work. It is clear. It is visual, it is clear where you have to work on for the elimination; for example, it is clear where you have a problem or not. So the hazards will help, so it is easy to see and to detect.

Questions?

Interviewee

Questions? I don’t know. For the investigation, is this just the start or are other people, or colleagues of you, working with such kinds of tools also for production-related . . .? This can be very interesting.

Plant 2: Interview 3

1 What comes to mind if you think of this system?

Interviewee

The first thing that comes to my mind is that it is a system that provides structure. And that is what we lack, we as a plant. First of all, we have a lot of data but we don’t have a structure. This gives you structure around the data that you have and as far as I can see, it is an easy tool to access all the data out of the central view, let’s say. A visual plan. It is not searching for data. It is actually . . . specifically I see a lot of opportunities – because that is part of my business – and that is ergonomics. Because there you can easily spot where you have ergonomical issues and in what, let’s say, in what status they are in. Also for accidents, for example. You can use it as a concentration diagram to see where your hot spots are. It is an interesting tool, let’s say. That is my first opinion.

2 If you had to improve such a system what would you do?

Interviewee

Yes, because I don’t know enough about the system so far to see improvements. I think you can evaluate that once you work it, that kind of system, and you have it in the fingers and be able to say OK, that is missing. But mostly it is based on your experience, to answer that kind of question.

HvdW

Yes, I just want to find out if something strikes you the moment you see it, because sometimes something is very obvious which I don't see.

Interviewee

Not directly. But I don't see, let's say, immediate opportunities right now.

3 What do you regard as a possible weakness of this system?

Interviewee

No, not directly. It's a database, and databases have weaknesses. Specifically for this one, I don't see a weakness directly. You have to accept that there are weaknesses.

4 What would you regard as a possible strength of this system?

Interviewee

Partly I mentioned that in the first question already. The strength is the helicopter view that you can over your complete assembly. Of course we are a smaller plant. It would be more difficult to have it in an environment like larger plants of Xxxxxxx for example.

You can go above to see where's your, let's say, where your hot spots, difficulties, are, and where you need to work first, priorities.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

How can it have an effect? That the effect it can have on me to see the priorities . . .

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

Of course, like the data that you showed, let's say from the noise measurement that you did, the data that you require to start trying to solve a problem . . . without data you cannot start problem solving of course. Because you have to analyse the data first before . . . you can see a priority or a hot spot, but you need to see the data behind it to know what the actual problem is before you can start problem solving. The system would not be worth anything if the data is not behind. Data is available

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

The question was . . . there is an ability to display them, you showed me that, the question is how far you can go on that, I don't know. Because what you have shown is . . . but I think it is a possibility in the workplace. You showed the entire hall over there, production. Can you do it on cell level, can you do it on operative level, can you divide it, say, into smaller areas? That would be nice of course.

HvdW

It can be done. So what would your opinion then be if it could be done?

Interviewee

To do it! My opinion would be to bring it up to cell level.

HvdW

So to bring it up to cell level.

Interviewee

It is nice that you can do it, but for our purposes, up to cell level.

HvdW

I know a lot of good and bad things, but I don't want to mention them here. Express your views on the ease of access to data. OK, this is on your system now and you want to access that data.

8 Express your views on the ease of access to data.

Interviewee

It is, let's say, it's a drop-down structure I can see, so it is rather easy to access data. You can go to a specific spot and every data behind it you can access from there so you don't have to go back into the normal SRP system which is much more difficult than this one I believe. As far as I have seen so far in your presentation. Of course here you have to really work with the data to give a very honest answer to that. I did not work with the data. . . You mostly experience difficulties or opportunities the moment that you are actually working with it.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Advantages there are. Of course, what the advantage . . . what is the specific advantage? Again, a specific advantage is, and purely looking at mechanical, locally, that we have a lack of clear structures in some places and this gives you a structural view, it gives you a real structure. You don’t have to go and search for, say . . . for K…, because K… will be working with this most. If we suppose that we would work with this, first it would be K… who would work with it. For him, it would be easy to hand over to a successor or a replacement, if he has one, two, then all data concerning this specific information is concentrated.

HvdW

Provide structure for . . . I’m getting the essence of what you said now.

Interviewee

Actually, concentration of data into one clear structure.

The disadvantage of not having this would be . . .

You sometimes you have to look at the disadvantages of not having it to see the advantages. But if you have a successor and you have to go with him through everything because he needs to be provided with the information, then in this database you can find that and that, and in this file I have this and then you as a successor you can start writing . . . there I need that and there I need that. And then you are, let's say, hours and hours of communicating which, if you have a tool like this which you can communicate in ten, maybe half an hour, it saves time.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

I was thinking about using this . . . I think you can even use it; you can use it in logistics, you can use it in . . . you can even use it in production, I believe. If you have the same view over your production and you can see again down to possibly cell level, where you have . . . let's say we record data of losses that we have during technical installations. You can use the same view to point out where you have the most incidents on technical side, on the machines. Or your productivity. You can show it there as well.

HvdW

That is an interesting angle. How would you relate it to occupational hygiene?

Interviewee

Not specifically to occupational hygiene, but specifically to the tools you use for that.

What I see is . . . because you say a system to professions other than . . . because this is specifically about occupational hygiene, but if I do not think about occupational hygiene and I just look at the tool, then my feeling is that you can use the tool for a lot of other things, than, of course, occupational hygiene. You can use it for plant infrastructure as well. Maybe you can use the data that you use on the plan that you have, you can maybe even use it to see how your future layout of your plant will be.

11 What do you think would the value of this system be (if any) in preparing for audits

Interviewee

What an auditor wants to see is a clear structure. What you showed with the . . . what symbol was it?

HvdW

The hyperlink?

Interviewee

Yes, the hyperlink signal. There you showed like an organogram, there you showed management review as one of the things that you showed. So with an 77)easy access to all the documents that are behind it – and that's what an auditor wants to see – that was one of the comments that we had from our audit, not our latest audit, but in 2011, that it was very hard to find some data. We were also changing, we were a new management, a completely new management. Therefore one of the comments of the auditor was that it took a lot of time for us and for them to find . . . mostly the data was available, but it could not be found and we created, then created, let's say, a kind of structure like you showed, just to have very easy access whenever an auditor asks a question.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

What the help of course would be for planning but also for evaluation I think. What you showed in the presentation, if you have a management meeting around this, or around those topics, we can . . . in a management meeting we can put the data on the screen of course and we can flip from one thing into another directly, if we can directly make a management review directly into the system which stays in the system. I think again it is maybe a tool that can save us time in preparation and in finding information, gathering information before starting . . .

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

That is what I said before. You can easily see your priorities. You know that this is an absolute priority.

It is a clear view and it is easy to prioritise. You don't have to discuss about priorities also. If you are in a management review, if you show the pictures, everybody will look at the same spot, there will be no discussion, there will be no . . . directly your attention will be drawn to one spot and I think for everybody around the table it is clear what the absolute priority is then.

Any other views?

Interviewee

Partly it is coming from, let's say, partly it is coming from the things that I feel are necessary for us, that is why I am talking about structure that much. You have a lot of data. To give you some background, where my ideas come from or where I feel the need for structure so hard or the need to create structures for us is.

Questions?

Interviewee

No

Plant 2: Interview 4

1 What comes to mind if you think of this system?

Interviewee

I think it is very good to give overviews, common overviews of data, I think it is the main purpose, it is ideal for that. Of any type of data. It doesn't have to be typically like you did now. It can also be production or for analysing purposes.

2 If you had to improve such a system what would you do?

Interviewee

If I would improve the system I would make the interface a lot smoother, a lot simpler because I think the interface like you do now, with the boxes and then you have to go upstairs and bookmarks inside the bookmarks and things like that. I think in the development of the programme that is something that they have to take out.

3 What do you regard as a possible weakness of this system?

Interviewee

For me the weakness of the system is that it is not helpful for small plants, small areas and locations. When you only have 10 measurements, for example. It is really is not fast to put it in a system like that. Because if you look at the value against the return you have on the system . . . So, I don't think it is really helpful for small plants.

HvdW

OK. Could you give me your opinion – while we are on this, a thought just occurred to me – for an international company, would it from an international point of view?

Interviewee

Yes, it could be interesting if you want to compare some of the plants, then it could be interesting. If you have, for example, same plants with same type of activities like Xxxxxxx does, then you can have . . . for example, if you have three or four plants then you can put all the data on the same floor diagram. And can take data (indistinct) . . .

4 What would you regard as a possible strength of this system?

Interviewee

I think it is very good strength if you have a lot of data and you want to make very quick analyses. If you had a very big plant for example, if you had a thousand workers and I wanted work-related disease for example, to look at health risks, especially on emission, for example. Or ergonomic, for example, where do you have the people with the most back problems? And things like that. When you have a thousand people, it is very difficult to look in four, five, six seven pages of data. But on that system, then you can have a quick view and maybe you can take out an area and you say, hmmm, maybe we have to work on that area because for example the data shows that in that area the problems are 20% higher than the rest of the factory. And then it is a very good useful.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

It depends on how you want to present it of course. For me, I think that it works very well if you work with the different kinds of colours and the different kinds of levels. I think it is also very good that you don't have to stick with the two levels. – compliant and non-compliant – but you can make a wider range of levels and, like you say, you have the legal value, you can have for yourself an accident value, an OK value, things like that.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

Of course, if the understanding of the data is much better and it is good, then of course the problem solving is going that way. Problem solving are visualized.

It depends a lot . . . I think it is difficult to answer that question because it depends not only the data but it depends on how people input the data and on how the people visualise the data on the map. It will always be a margin of interpretation, that you will always have. You will always have some people, even if they see it on a map, even if it is like that, even with colours and levels.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

I think it is very good. No doubt about it, it is very good. Of course, if we take out a situation . . . but that's also because it's very . . . if you have a big plant with ten times the areas and twenty types of different machines, then you will see much more. Here on this, Tenneco is again a bit of a disadvantage because the plant is too small. That's the whole production area and we don't have something else. So what do you do, you call up a complete production area.

HvdW

What you can do, if you have the larger ones like we have in South Africa, you do that and you zoom in . . .

Interviewee

And then you will have much more different agents, much more different locations inside the plant. And then it is interesting and then you can put values on it maybe, or results from risk assessments to it, on that level. There is high risk, there is a lower risk, there you already took some things like that.

HvdW

Right, OK, let's get back to the question. Provide your opinion the ability of the system to display . . . how does the system display this?

Interviewee

For here it is not good. I think Tenneco is not that good, the plant is too small. It is not the fault of the system, it is a fault because of the fact that our company is not . . . is not a reference to use a system like this, let me phrase it like that.

The system is too complicated for our company.

8 Express your views on the ease of access to data.

Interviewee

That is quite good. I find it quite good because you can direct extract the tables, you can view the tables, view some graphs, and that is quite good. Because, it lets you analyse . . . you have a whole lot of data, then you go to the problem data and you still have the possibility to analyse the problem data also and that is a very good thing.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Of course, because the data is uniformised so of course it is very good.

What I mean is that the data is . . . when I put in the colours, for non-compliant for example – I give an example of lighting for non-compliant, I give orange for an action level and I give green for OK level. Then I can say, for example, that I start working on an action plan for the non-comformities and I start on an action plan for the way for the action levels, for example. I stop halfway the work; I can leave it to somebody else. Because then you have the data, I have started on some points, you can continue, because the person has all the data.

I think if I wasn't you and I had a choice to present me the data and tables, locations, and I am new to the factory, I am obliged to take a plan next to me, to look where it is, maybe look on site, master the problem myself . . . if you have a small plant like here OK, it is doable, but if you have a big plant and you have to visit yourself 20 or 30 locations all the time, you lose a lot of time; for that it is very easy, it is very visualised, the data is very visualised.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

Of course it will be very good, even in the same evaluation as I gave my answer before. The data is uniform displayed. Maybe always be a big discussion of the integration, of the level, but for the rest . . . interpretation always be a bit at liberty but the visualisation will be the same for everyone. That does not have to be limited to occupational hygiene.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee

I think it is very good because I think the whole idea of the project is to make the data understandable in a very quick way. Maybe a negative point on that is when we do, for example, when we do an audit, we have to have two or three or four, for example, see where the light is a problem, as we discussed, and we are working on it, and I have an audit – environmental health - I will have to show that I advanced since the previous audit. Maybe at the end the tables of data will support the arguments and serve as proof progress.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

I don’t know, the system helps really quite . . . on one domain yes, for example, if you like you can put priorities. I think on one or two domains it can really help to put priorities, for example, to step out, to make the steps for the planning of next year, to put on the phases, what are we going to do to improve, things like that. Then it will be OK.

It is a good system to visualise but it still demands . . . the system itself will not give the priorities. You are still . . .there is still an action required for someone to say, OK, we take that as a priority or we take that as a priority. That the system won’t do itself.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

I think it is very good for visualisation. Very good for visualisation. But it still asks the input from somebody to, for example, to put priority on certain points. Or not to overflow the map with too much data.

If you say it all non-conform data display, or display below level data . . . that is no problem.

HvdW

Do you think it can miss some data?

Interviewee

Difficult. When will it miss the data when the data is inputted?

If the data is correctly inputted, there will be no mistakes.

Any other views?

Interviewee

I think it is a very good system but not for a small plant. I think that is a big weakness of the system.

Also we don’t do a lot of activities, we only do one core business activity. If you have a complete production plant, for example like Volvo, and you have a division where you do painting and you have a division where you do assembly, it will be much better. Because every region will have its particularities, its particular risks, its different risk assessments and you have a lot of data and then you want to do a comparison and then the system is top notch. But not in a plant where you have one type of machine, 9 copies of the machine.

Questions?

Interviewee

No. Not for now.

Plant 2: Interview 5

1 What comes to mind if you think of this system?

Interviewee

It looks a bit like a map you see on the TV when the weather is on. You see the temperatures and the scaling and so on. It is pure visual management, I think. Obvious where the good and bad, or the high and the low, the young and the old.

I had some pre information maybe from Pierot when I thought could be good for visual management on action logging, logging of things to do where I couldn't really find that maybe a bit . . . too much work to put it in and too little return of that.

2 If you had to improve such a system what would you do?

HvdW

Interviewee

Difficult. It looks good . . .

HvdW

I just want to know if anything struck you that you would like to see different.

Interviewee

No. It looks . . . except for what I think now you can do it, I think it looks fine.

3 What do you regard as a possible weakness of this system?

Interviewee

Maybe the search function. For the moment I don't see that clear enough to see how that could work quick, let's say. A lot of search functions already existing in like Excel. It goes a bit in the direction of that. Maybe that is something to improve, although I haven't seen it too much in detail, the search function. Maybe if you say improve a weakness, you could maybe say the search function could be a bit more at fault but difficult to say because maybe the information . . .

4 What would you regard as a possible strength of this system?

Interviewee

The mapping. The mapping and the links behind the… what do you call it? The hotspots? The links. Several links behind one hotspot. Where you usually have a hyperlink that goes to only one website you have the chance to go to several locations. With a bit more text in the list you see what could be more of your interest.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee

I think it is a bit like question number 4 in my opinion. I think the information behind the very simple visual tool, or a coloured sign where there is a lot of information behind. Mapping the hyperlinks is the strength.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee

The difficulty of that information if you usually get it on a report, it is like a list and figures and words combined in one shot, it doesn’t give you a lot. You have to look at it for 10 minutes before you see something This of course gives you . . . you can easily go to what is the worst in your environment and then go in detail. After the sorting is done, you can go in that. While in a table you go in that from the first site and it makes it very confusing, so . . .

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee

Fulfil the expectations I think because we have asked if you could divide the area like you have on a weather map. All colours, not only a dot. For example, this area has this colour, that area has this colour. For example, you have a roster and then you say OK, that cell goes into that area and it has a look of 200, that automatically it scales you between 0 and 1000 as black and very white. If you say this area has this light strength, it automatically colours your map, for example. So, you have a link between figures and your, um, what you call that, your numbers and your measurement data, for example.

8 Express your views on the ease of access to data.

Interviewee

Very simple.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee

Like every software, I think there is an advantage for sure when there is staff leaving or changing because first of all experience and knowledge, people tend to work with certain softwares. My former boss was very good in Word; I'm very good in Excel so I work more in Excel. If I'm expert in power point, I may overrule the abilities of this software and I'll do it with power point. I think it is person-driven. The disadvantage is that it is still a tool; you can't force people I think to use it unless it is obliged from top management let's say.

HvdW

And from the perspective of data management?

Interviewee

Very simple. Because it is a tool everybody uses, it is a table, an Excel table, or an access table, that is more . . . if the data is existing in a simple unspecific tool which everybody has done it on the computer, easy I think. But the visual factor is a maybe a bit more difficult.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee

I think you can apply it in every process which is geometry-driven. For disease, for example, medical stuff, if there is, for an example, in this period there is a lot of illness in that area, you can maybe scope illness, for example, on the map and say there is a lot of viruses, flu, a lot of flu going on in that area. Maybe in can spread or it can move week after week, things like that.

I think simple data . . . if every doctor, like they do right now, records who had the flu for example, at what day, maybe after a month you can evaluate where the flu has gone through, through the country, or how it went day after day. A bit like satellite pictures from the weather. Take a picture every day, so read your table after one day and see how many people had the flu and then you see the highest concentration for example in a certain area and day after day it moves through the country.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee

You can link your audit – formal audit remarks or internal audits remarks – to an area and then you see which area you need to work.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee

You can see easily where you need to work. It's easy. Goes to the visual management.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee

But the ability is to make visuals for anyone else who doesn't know anything about the parameters you use – by the colours, children can read – figures you have to know exactly what you are reading to evaluate. So again that visual management, which makes it easy readable.

The weaknesses are easy to identify on the map.

Any other views?

Interviewee

no

Questions?

Interviewee

No. It is pretty clear.

HvdW

Thank you very much for your time, and your staff.

Oh yes, before implementing such a system after what you have said, can I do this without a cost-benefit analysis? Time-wise and money-wise. That is what you said, and that's why I ask, if I understood you correctly. Because you said the effort that goes into it . . .

Interviewee

If, for example, every action you are planning to do in your facility you would load there so you would address it to certain area. The return you get, I see on the map how many actions you still need to do in your facility it is probably less than the effort you need to put in the tool to make it obvious. I mean, measurement data are difficult to read if they are in a list. Actions? Sometimes you need to split them per area so you can see where and how, but you don't need a visual tool to see which activities you need to do. It rather . . . for activities it is what is the return on the activities than visually. You don't see in an action list a measure. You see? Or you can put priorities, or you can put cost on return, or the effect. That you can put in. It is really good in my opinion for measurement data per area and then you can read through thousand measurements, you can read through in a second. That is for me I think the strength of this.

Plant 3: Interview 1

1 What comes to mind if you think of this system?

Interviewee:

Well clearly for us health and safety and environmental is our top priority of the plant, so not only from a legal perspective but also for the safety and wellbeing of our employees. It is extremely important Xxxxxxxx globally, not just this plant, so any system that can help us improve our safety and environmental is a good system. We spoke earlier about some of the challenges with this system, we still don't understand the system fully, we've been through a quick tutorial with you, perhaps if we spend more time with you we will understand it a bit better, but for me it is really important it gives an overview of the current system with all the different audits how you doing, you can track exactly how you are improving because that is what we have to do, we have to improve … we are not perfect we know we are not perfect, so that is why for me it is a very good system and it seems fairly easy to use too.

2 If you had to improve such a system what would you do?

Interviewee:

For me the schematics are very good where you can click and hover over a certain areas – that's very good, but as I said earlier to pull information into a table or a graph which we said it can do but we didn't see it, it makes it a lot easier, so we can check from survey one to survey ten and track the improvements, we can see where we are going wrong or where we are going right and as long as it is adaptable to take any information like most data bases are … you can put whatever you want into the database

3 What do you regard as a possible weakness of this system?

Interviewee:

Well, it needs to be easy to go into and to make changes. If you want to look up something, there must be different options, so as you said if you go to Gumtree to find a car, you can search by either model type, car type, year type, mileage or price. There should be a way that we can search the system as well to do the same thing. It might just be a generic way of searching at the moment … I am not sure if you can change it, if there are more options to search, for me that is important. It needs to be user friendly at the end of the day.

4 What would you regard as a possible strength of this system?

Interviewee:

It gives you a good overview and you can track the progress … that for me is the best strength about it.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee:

It is live, it is very visual, I like the colours … if there is an issue it flags as red immediately you know there is a problem, it directs your attention immediately to where there is a problem and you can have a very quick overview if your health of your plant is good or bad and where to focus.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee:

No, of course it contributes towards problem solving. At the moment … as we spoke earlier we did a lot of surveys currently. This information is only shared between one or two people in the plant and Justin knows it, I know it and maybe Leandre and Liesl know it. The rest of the management team does not know and to try and explain to them how we do it is very difficult. This system, having all the information in the system with the colour code will make it very easy to explain to my whole management team how we do it, where the issues are and what we need to work on, whereas before they not even aware of the issues that we got, unless we discuss it in our management meeting. It is difficult to bring the message across, that and we asked them about how many decibels are acceptable in the rod shop nobody will have a clue… and how we doing, nobody will have a clue. With this system it shows it immediately.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee:

Well at the moment it is not clear. It isn't clear unless we have a report done and then we get a report back from somebody who does the audit, we can say okay there is an issue there but just on a day to day basis we got no idea. We will say there is an oil spill and we will know there is a problem but we won't know if there is a problem with chrome or with noise, we just anticipate that we are doing okay, where the system now makes it absolutely clear but naturally you need to update the system on a regular basis as well. It is only as good as the last survey basically.

8 Express your views on the ease of access to data.

Interviewee:

I think it can be improved. I think also you are not a specialist in the systems, so you don't know how to act to everything as quickly as possible, I am sure there are easier ways to do it as well. I think it is like any system, once you use it for a couple of hours or a couple of days it will come very easy. We don't know the strength of the system at all, we had a short tutorial but if we spend time with it, it is the same as anything, it is the same as learning CAD, once you used it, it opens up a lot more doors and you learn as you use, so I think it seems okay for now but I think there are quicker ways to maybe use it and that will come out with using it even more.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee:

For sure, if people change or people leave the organisation, you know you like to have an exit medical, this can contribute towards exit medical, what sort of exposures did they have when they were working in the areas is very important, they can tie together with the medical records and also with new people coming in to make them aware we have very good robust induction training system in the company and this could explain the hazards and the potential hazards that there are in the work environment and they need to be careful of, why they need to hearing protection, which areas they going to be working in, you need to understand that the decibels is above the certain limit in this area, it is not acceptable that you don’t wear earplugs. All those sorts of items can be addressed.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee:

We covered some of that already so it all ties together you know with health and safety and environmental being our top priority and our people are our top priority and as it is its all tied together nicely, it doesn’t matter which department it is, this information can be used as beneficial. You can even use a system like this for not just health and safety environmental issues or whatever – quality you can use a similar system, so we looking at it purely from the health and environmental side but a system like this could be used for any sort of information you want, quality tracking, our PPM’s, our scrap … anything is possible, databases are unlimited but from the health and safety point of view anybody can use it, obviously they need to have access and they mustn't be able to tamper with information that is in there because you know they can just delete files and we have a problem… so ja anybody can use it and I think it will be beneficial for everybody especially even all the employees when they leave and we have issues later on, we still got a couple of people on disability but they basically on pension and if there are any comebacks on that going forward, if there happens to be a legal issue then you got information all there …

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee:

It would make it extremely easy and efficient to justify and to prove to the auditor where we focus in, what the issues are, very easy. As again I say that the way that it shows by area with the colour codes, the schematics makes it very simple. I just don't know if it gives you an overall report without going into all the different areas, if it gives an overall report saying what is the health level like of your organisation – that is maybe something that can be used to improve that …if it doesn't have it.

HvdW:

..at the moment we will have to look at a way of doing that yes – you are quite right.

Interviewee:

I don't know Hennie if it does it … can you formulate a report and it formulates a report for you and prints it out for you with graphs by area by this and that, I am not sure if the system can do that …

HvdW

I can do layouts as I said, but the report I don't think it is going to formulate that, I will have to investigate that – thanks for that that.

Interviewee:

…that would be easier and then we it comes to audit you click the report and say go through it and ask me your questions and it is all there, instead of us sitting okay this area is a problem and lets investigate it and type it all out, maybe it can do it all for you with a certain amount of input, obviously it is going to need some manual intervention.

12 What would you think would the value of this system (if any) be in your

Interviewee:

We have spoken about it already …so definitely it will help you be proactive, tell you where to focus, take action before we have drama in a situation that is out of control so ja it is a live system as such so if you know you got an audit coming up or something coming up you can just quickly review it, it doesn't take long and you would know what the issues are and what we have to focus on but again it is only as good as its latest audit, so if you haven't done an audit for six to eight months you might need to do one ahead of the audit again just to make sure that you are still on track.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee:

As we said … it immediately flags out where your issues are already. You need the criteria, it is there, it is clear as day and then you can take action from it. You can even start tracking it, it might not be red yet, but you can see the trend is going in the incorrect way and you can take action before you even get into the situation where it is red.

Any other views?

Interviewee:

it is just very interesting for me. I always liked to have databases where it is easy to access information but usable information. It is pointless us tracking stuff that … we do a lot of stuff in Xxxxxxx, a lot of paperwork, a lot of things and they mean nothing, something that is practical that is user friendly that we can use and get benefit from is important … and the system seems like it is.

Questions?

Interviewee:

No

Plant 3: Interview 2

1 What comes to mind if you think of this system?

Interviewee:

The system is developed in such a way that you can actually have that instead of all the paperwork that you have on your desk or all the files. If you have this programme and adding whatever papers you have, important documents, monitoring of documents and everything can be mapped because we do everything per area in our department, so I think that is the most important thing.

2 If you had to improve such a system what would you do?

Interviewee:

I will add I would say health safety, environmental energy, the entire system per area, I will add the aspect in impact register which is your environmental impacts and aspects and then your hazards and risks in per area but it will be more specific.

HvdW:

If you had to improve in health and safety only, what would you do if you had to make anything better. What you said is good, I've got it down but if had to specifically improve health and safety the system you have with this, how would you go about it

Interviewee:

Most important will be employees that are exposed to chemicals which is not your good chemicals, it is chemicals that could either give you cancer or not the chemicals and the monitoring the sister does on them when they go and take urine tests every week, like the chrome plant and the paint shop, that are the two areas that are critical areas so from a health and safety point of view I will go deeper in those areas, even though the results is okay and the type of chemicals that are involved there, from a health and safety point of view I will monitor it on this specific system better or more in-depth.

3 What do you regard as a possible weakness of this system?

Interviewee:

The only thing is that I would like to have training on it even though I spent some time with the system for the past four years or so and at the beginning I didn't understand anything at all, but if it can be just a little bit simpler, like Justin mentioned, if you can have a touch screen and just push a button and if something flickers up and that is the only thing. For me at the moment I don't really have a problem because I know you go to bookmarks or whatever the case might be but to make it simpler for others to use, especially operators if you want to get them involved and I think that having computers on the production lines, if you have something like this it will be fantastic to have it…

HvdW

Okay so something more like front page

Interviewee:

or train the trainer type … so that we can train other

HvdW

Am I right if say that the weakness is that you need to training for it?

Interviewee:

Not specifically me but I mean if we want to get production involved

4 What would you regard as a possible strength of this system?

Interviewee:

If it's possible for the system to have the entire … if I may use EH&A's and energy, you can implement the entire system … on this system. Your documentation everything can be linked to an area and that is what I like, you don't have to go and jump around to this folder and that folder, and everything is hyperlinked. You can hyperlink everything to one another so that is the advantage of this system, you don't have to jump to energy folder and have loads of folders on your computer. Just by pressing a button it can give you all that area's information.

HvdW:

So, if you have to put it one word what would you say it would be?

Interviewee:

Basically systems friendly. Yes, it puts everything together.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee:

The advantage from occupational health point of view, especially from occupational health point of view, it's a massive advantage for our medical point of view, when you go for your medical surveillance and for the clinic sister as well. I mean if she can have this and she would be able to enter employees names there which is confidential and have their folders interact there per area, I am taking specifically now about the chrome plant where they have the urine tests done every week. She can just go to the system, click on the area and have the names, she can put all their results on there as well. So, from an occupational health point of view I think this is very user friendly for especially medical surveillances.

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee:

It will contribute. If you can put in … if I can use noise or elimination, if you can have results put in there from where Xxxxxxx started with their noise surveys and mechanically and technically fix machines to make noise less in the plant, that will be an advantage to see your improvement on noise exposure and the same with elimination and the same with chemicals, and that is what is good about the system, you can put in all the data you have for the past few years and the areas of concerns and you see that things are not getting better and it is five years already, you can have that as an objective and target then and put really something in place to bring down the noise because the last resort is always PPE, but we always look at what we can mechanically or technically do and that is with any survey, whether it is noise, elimination, chemical exposure, asbestos … anything.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee:

No we do! We do have some concerns in the chrome plant and we do have some concerns in the paint shop. Some of the employees sometimes complains and say that it smells like thinners and paint in the paint shop etc but once again because we do exposure monitoring, that they smell is either xylene or whatever is in the paint that they put the shocks in or that the shock go through, so there are hazards but the controls we have in place minimizes that, but having this system can also show you where you can improve if you didn't think about something

8 Express your views on the ease of access to data.

Interviewee:

Look once or if this system can be on our everyone drive, we can maybe create a home page like we have our own page for quality, with all quality's information we got a Sheens home page which is the safety health and environment and energy systems home page where people just click ad open, its opens the policy, it opens your EH&S documents, you can have this and everybody got access. We got TV screens up where Tina can present stuff on the TV screens area when they in the plant so the access of this, should this be on our system and should we use it, access won't be a problem at all.

HvdW:

What would you say internationally?

Interviewee:

I wish we can get this … I wish we can this, no this will be possible … it will be possible. We have to currently help other plants in the world that can and that makes enough profit. They were told by the financial director of Xxxxxxx that they have to implement ISO fifty thousand and one. South Africa is busy helping them and our EMS or energy management system are communicated with them. So, to have this globally would be no problem at all. Nothing for our team that they can't fix, no problem at all … nothing for our team that they can't fix.

HvdW:

...so how could it improve the information then?

Interviewee:

I think to get ideas from other countries, I mean you only in your own environment but if this can be communicated to for example to other plants might have ideas that can add value to it even Belgium or the other plants in Europe and even in America, but access to this will not be a problem and I think that if they can have like a conference call with whoever they think is possible and with a conference call usually you can display it and email to them and show them how it works, I think they can add valuable information.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee:

No, I don’t think it will be a negative or have a negative impact, because if for example our EH&S team …look our exposure is mainly EH&S based and hygiene as well, so if we already know how the system works – if somebody comes new into the company having the medical time and coming to us for SHE induction, we can take them through the programme or if there is any operator that passed away maybe and there is another operator that works there, they come to us and tell us ‘something is not right on my machine and I have got these extreme smells’, you don’t have to take out a survey and explain to them. You can take out of the system and show them, and they will even understand it.

HvdW:

So am I right in assuming that you are saying that it will be quicker?

Interviewee:

It will be quicker to explain to somebody and having something to show to them would be better than communicating. Pictures always are better than word … sometimes it is always better than words.

HvdW:

by the way, do you know where that came from – a picture is worth a thousand words? It was in a soft drink advertisement; it wasn't the Chinese [laughter]. We said now new staff, we talked about staff loss, staff leave … would that be of any use?

Interviewee:

It will ja! Even if we lose staff it will be … the system is so user friendly, I mean even if we don't get training, I think even if you show this to a normal operator they will understand it, I don't think it will influence staff loss because the communication within Xxxxxxx and the commitment in the departments are so good and should we use this it will be impossible…

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee:

Yes to everybody. No not only the clinic sister, production – especially the production manager they are the most important people even quality. If we manufacture a new product and there is another chemical that we need to use that maintenance need to pour into something to manufacture the shock, I think it will even be an advantage and contribute to quality because whatever they are using, if is for example another chemical … look there is good communication within the company so they first inform us of what chemical it is before we use it but I think it will not only for HR, for any department except now for accounts and ladies that pays the bills, I don't think they will find any interest in it, but the other departments and even development .

HvdW:

Can this information be useful to them, the occupational hygiene information?

Interviewee:

yes, most definitely, especially our company doctors as well. Dr B… I think he will have a massive interest in this, it's our company doctor that's here on Mondays and Thursdays, I mean if we have this and we show him this, I don't even think he knows about it …

HvdW:

I can always arrange an interview if is he is willing …

Interviewee:

Ja and Dr YYYY on the other side, even though it is emission control it doesn’t matter, this can be effective at both of our companies or any Xxxxxxx in the world I think.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee:

Oh audits are much easier! If I have my objectives and targets and my … as for the impact and Liesl’s hazards and risks and her objectives and target and the auditor would ask me ‘listen we not going to contact a hawk now but can you maybe show me cut off out of objectives and targets, the impacts it got on the environment, the hazards and risks that is there and the chemicals that is used in that area. Then you can just click a button, it opens the area, you can all of that information displayed and you can even hyperlink the material safety to a data sheet of which chemical she will pick, so you can be with an auditor and without walking into the plant … you got the plant with everything hyperlinked, not running up and down with files and folders …the audit will go much quicker and we will get rid of them quicker.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee:

I think especially the chrome plant, there is an issue at the moment with the chrome plant right in the in the entire Xxxxxxx world and that is the audit exposure that we had to do before Friday last week. Xxxxxxx really cares about the health of their employees and for them not be exposed and be in danger, and to minimize them from risks and hazards. So I think that this system with occupational health will improve it so much and give us more ideas, I think the more you work with it, the further you are going to think and you are going to see something and say 'wait why don't we add that and that and that' so I think it will be an advantage for improving.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee:

Ja I think so … if we can use monitoring again, sometimes you realise that you missed areas afterwards. If you have this data from 2003 till date and you say 'wait a minute' we've never taken noise at this point and it is already nine years, so I think if there is a lack of an area or an area is maybe not tested with everything and maybe employees, even exposure to employees, this employee works here for forty years – you never did personal monitoring on him. I think that will also be an advantage.

HvdW:

So the process that you will be going through in this it actually enables you to better evaluation…

Interviewee:

Yes and that what will help you to pick up where you have missed out or lacked to give attention to**.**

Any other views?

Interviewee:

No I just think we need to get involved more employees on this. I think we need to involve especially production, supervisors, team leaders and our company doctor as I said. I think this will maybe be like a lightbulb for them.

HvdW:

Are you saying, if I may summarise, that this could serve to spread information to the employees … is that what you are saying?

Interviewee:

Yes and our sister plant as well because we got a sister plant and they are not perfect, they look like a hospital inside compared with ride control but I think with any of our plants, I think you can involve any Xxxxxxx with this and I think people like Pyyyy and Pzzz they will be over the moon to see that we use something like this.

Questions?

Interviewee:

Nothing.

Plant 3: Interview 3

1 What comes to mind if you think of this system?

Interviewee:

Information. I think it is a very good system. If we can use it to put other information in the system as well not just hygiene. If we can do that it will be very nice to use. It will be useful if we get audited to just quickly go to the documents that they want to see.

HvdW:

Why do you think it is a good system?

Interviewee:

Everything is in one place, everything you need or look for is there.

2 If you had to improve such a system what would you do?

Interviewee:

Like Justin said in the meeting just make it more user friendly with the click of one button or maybe to put some filters in where you can just say you looking for specific items then**…**

HvdW:

Am I right if I say that what you say is to improve the interface?

Interviewee:

Yes

3 What do you regard as a possible weakness of this system?

Interviewee:

Weakness …not that I can think of now, maybe if I worked on it for a while then maybe … maybe then I can comment

4 What would you regard as a possible strength of this system?

Interviewee:

Strength … also the amount of information that you can store on it and also the way that you can get to the information by just looking at the plant map and you can go a specific area and immediately get that specific that areas information.

The display is very good.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee:

I think it does improve the understanding of the situation because it is visual and it is better to understand visual than data, so if you need specific data you can just go to a specific area or information button and click on that, so I think it is …

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee:

I think so, if you got a medical situation you can immediately go to the visual seeing like the plant layout and you can see which areas are for instance the noise zones and if there is a problem with people getting deaf, you can immediately go to the system and see where in the plant there could be a problem and you can get information, extra information, about it.

So for instance the chemical exposure and the noise exposure, it shows that together … so ja I think it is a good thing. If there is a problem and it could be a problem of combined things then I think it is good.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee:

Because of our BBS systems (Behaviour Based System) that we run, we got about 21 observers and they do all the observations and they report to me and out of that system there comes a lot of problems in the plant…

Interviewee: Ja not only that but that is a big of source of information yes

HVDW:

okay is there any problems that you can identify with such a system?

Interviewee:

Relying on people's perceptions of … and what other people are telling them and how they interpret it and eventually how it comes to me.

8 Express your views on the ease of access to data.

Interviewee:

It looks fairly easy. If you know the system I think it will be of great value

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee:

I don't think so because it is based on the workplace not the staff, so I don't think there will be any.

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee:

Yes I suppose they will benefit because of the … when there is a problem in the plant it always come back to HR or the production manager and if they can look at this they will have a pretty good idea from where the problem may be.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee:

It will be very valuable. Everything is on there. Everything that the auditors always ask us is on there, they are always asking for surveys and information about the areas and they don't even have to walk the plant then

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee:

I would say definitely. It will be definitely of value if you need to manage because again everything is in one place and if you know the system, all the information is in there you can just put everything in there as well, new information you can see how you've improved or …

HvdW:

why do you want to see the trend?

Interviewee:

See if you have improvements or if there is one area that is always a problem area and you can maybe then put it as an objective on targets…

The objectives mean to where you can improve on that specific item and target means what date, it means you can put a date to it

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee:

It definitely will yes

You can look if you have done the surveys, the information will be on there and you can see where you don't comply and then you can work on that specific areas.

Any other views?

Interviewee:

I definitely think it can add value to our plant

Questions?

Interviewee:

Can we get training on this?

Plant 3: Interview 4

1 What comes to mind if you think of this system?

Interviewee:

I think having a system like that … that people have access to is actually quite a security because you need info relatively put there at the hit of a button and you got the information there **…**

2 If you had to improve such a system what would you do?

Interviewee:

It’s a bit out of my field to say how to improve it. I mean so long knowledge is regularly updated and kept abreast with everything then someone is putting the knowledge in and updating it all the time … I think just regular update

3 What do you regard as a possible weakness of this system?

Interviewee:

I think of someone who didn’t actually know how to use the programme.

I still answer … everyone is familiarized how the programme runs, where they get their info and if people are not trained you know can’t just go and say what’s this programme you need to be ….

4 What would you regard as a possible strength of this system?

Interviewee:

I think it will keep the company on its toes because of there is any changes in legislation or anything or changes within the environment, that programme is updated all the time so no one can say they didn't know about it, they got access to the programme and they know how to operate it then they can go in at any time and just see the updates and keep abreast with it, so it is positive from that sid**e …**

and it will be good for me because when the doctor actually wants surveys, at the moment I have to phone L… to send it to me and I mean if I got something like that, he got direct access to it as well … that would be brilliant

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee:

Yes definitely. Look I am new to the plant, so to have something like that if I am not familiar or I am unsure of something, at least I got the access to go and understand it, especially if we are doing our biological monitoring on the employees …

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee:

I think it does because obviously it is going to highlight our risk carriers and for myself where for the chrome plant, at least the survey is done, the information is imported into the programme, I got it at my fingertips, so if we got any problems – you got immediate access to it.

It will certainly give me a better understanding of the plant ... of the business

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee:

No Reply

8 Express your views on the ease of access to data.

Interviewee:

Well if you look at internationally there is going to be comparisons for our plant to the ones overseas

HvdW:

No its fine. Assuming that you have access to it. Let's put it a total different way. Is it easy to get into the data base - assuming you had a level of training?

Interviewee:

Yes

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee:

Well the only thing that I am thinking that could be captured is when we do the biological exposure index of the people that we are monitoring, especially like in the chrome plant or in the spray booth the paint booth, then management also can see well this is our levels and here the exposure and they well below, we have just done all our guys and they well below the exposure rate. I think it will alert the managers that we are on track and we are doing it and that this is all in place, but when you talking about exiting – I don't quite get that means because you are not going to say how many …unless you saying how many people are coming into the plant and going out of the plant …

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee:

I think that whatever is specific to them and that they can learn from it, it will obviously benefit in the long run, I mean I think the doctor will benefit from a programme like this, it is going to give him a lot more insight and make his risk analysis a lot more easier when he sees these are the areas and everything is highlighted for him.

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee:

As long as it is updated regularly, I think it would be an excellent tool for audits.

Because they got everything at hand. I mean surely when an auditor comes in – what he is going to find must correlate with what's on the programme, so to have a programme like that I think is a huge asset to them.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee:

I think the whole programme is a benefit.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee:

Definitely because most people tend to focus on where the high risk is and sometimes we oversight an area that could become a potential risk and I think with a programme like that where you see what you call a “lame” spot, I think it is going to overall manifest and it will show them that ‘hey guys wake up smell the coffee… you know we all tend to focus on where the high risk is and sometimes there are other problems brewing, so if you got a programme like this as I keep saying is regular updated and imported with everything, there is no excuse for them to oversee something.

Any other views?

Interviewee:

Just that the programme is pretty good, and it is user friendly.

Questions?

Interviewee:

No

Plant 3: Interview 5

1 What comes to mind if you think of this system?

Interviewee:

The first thing that comes to my mind is a place where a central data storage that will give us a sort of one stop place where a person can see the status of the health system in our plant, in other words you don't have to go scratch in multiple areas and different file and things like this, it is like all in one – if I can say it like that.

2 If you had to improve such a system what would you do?

Interviewee:

It would be very definitely like I explained to you the drop down box arrangement where a person can … it can be more user friendly and don't have to be an expert in the software of the programme as it is now, in other words just to navigate a little easier – that is all I would say.

3 What do you regard as a possible weakness of this system?

Interviewee:

The weakness of this system. The system is a fantastic system but the weakness of it is it is only as good as the person who is inputting the data. It doesn't suck up the data on its own, so that will be a weakness in the system.

So you got a very good system but it still relies on somebody inputting the data, so if you don't input the data accurately the system will come to nothing.

4 What would you regard as a possible strength of this system?

Interviewee:

The strength of the system if I understand it correctly would be that we can start it with baby steps, but I think the strength of the system is that a person can add on going forward, that you can actually make it an all-encompassing system where it can actually be cascaded to various other things where you want the management overview for the health status, I say health status … it could be or in other words 'how healthy are we? so I think it can be built on to, it can be expanded**.**

HvdW

What would the advantage be of expanding it?

Interviewee:

Continuous improvement, expanding it … in other words you start small and eventually you can add different little things on maybe by machine, in other words 'noise produced by machine' a person can actually expand that into different little bubbles.

5 Explain the possible effect, if any, that the way that GIS combine and display information could have on the understanding the overall OH situation at hand?

Interviewee:

I would say its reproducing what the actuals are, in other words – whether there is data that is positive data it stays that where the things are under the exposure limits and things like this, it also shows you where the problem areas are. So it tells you what you need to know. It is telling you the health status of the plant, I keep going back to this, it tells you what you need to know = guys the problem areas are that that and that – the good areas are that that and that

6 Explain how the integration of information could possibly (or not) contribute towards the solving of OH related problems in your work environment?

Interviewee:

In Xxxxxxx whether it is right or whether it is wrong, the medical centre doesn't report to me directly, it reports to HR. I think the system would be very good in actually breaking down that barrier whereby the information from various disciplines will be all centralised, where a person can have an overview of exactly what is going on, in other words if there are health risks which maybe I have not caught on the health and safety side but the sister has caught it, and then all that data gets put into a central system where a person can have an overview of exactly where the problematic areas would be.

7 What problems do you experience with observing the distribution of hazards in the workplace?

Interviewee:

Yes. I don't think that this system will help this but very differently from when we take samples to when the information becomes available there is always a lag. I know that this system can't fix that but maybe historical it can tell you to be more proactive. For arguments sake – you haven't dealt effluent analysis here … which can be incorporated, it can be very useful because it is an integral part of our value system and our waste into effluent, where the guy takes a sample and then we have it analysed and sometimes up to two months later the results come back ah we had an exceedance at the end of July – that means nothing, but I think that a person could have … we don't trend it where this system could trend it for us.

8 Express your views on the ease of access to data.

Interviewee:

All the data, this is basically a glorified database that is exactly what it is, The database information is in the database and this visual thing it pulls from the data that is embedded in the database which will make it visual where our current system is not like that, in other words – the data is available, myself I don't know where to fetch it hey, I phone Ms LlI 'Juf LlI gee my die report van verlede maand' then she comes and scratches in the cupboard and she gives me the report or she emails it to me, where with this thing everything is on one, so if you know how to navigate your way through, the data retrieval will be very very quick.

We talking principle here. in other words, if a person has an international thing all plants will be comparing apples with apples where currently we don't compare apples with apples that there are huge differences in plants, both in data coming out and actually operational things – big difference – we even build shocks differently. So never mind the health and safety, even the processes of building shocks is very different where this system will be apples with apples.

9 Are there to your views any possible advantages/disadvantages of this system during staff changes or staff loss?

Interviewee: There would very very definitely be advantages for staff turnover … for the simple reason all the filing will remain the same, the data base will be the same and the retrieval will be the same, unlike what we got now, Ms Lll works differently to Ms Xxx, who in turn works differently to somebody else and it is exactly what happened to the woman before Ms Lll, she got there and she new she was leaving so she buggered the filing up a little bit because she didn't give a damn, …..where this thing … I don't think it allows you to have variation,

HvdW

It allows variation but it ensures continuity.

For sure for sure. Interviewee: So if you sampled 150 places for noise, I don't think that you can next year only sample 100, for arguments sake you can be 149 or 151 but I don't think that you can do a half job.

HvdW

Yes you must do it right. This system will allow less or more depending on what …

Interviewee:

yes but you would see it right away because you have last years and you compared last year to this year and if you see that you have only taken half the samples then you not comparing apples with apples

10 Express your views on the possible use of such a system to professions other than occupational hygienists. E.g. Medical practitioners, engineers, H&S staff, HR etc.

Interviewee:

Yes they could for sure, for the simple reason straightaway when I said to your this morning that you have not included lineage, this because you have a thing called an SEU (scientific and energy user) that's what it is, so you can actually plot in a lay hand and say 10% of our energy goes to this area, 30% of our energy goes to that area and you just hovering your mouse over it and can see guys where are the problems, where should we be focussing our own energy to go see where we can have a reduction in energy consumption. So very definitely I do think that you can expand it to other things, on the medical side – well I don't know enough to truthfully say but the energy very definitely, in maybe even on maintenance layout. We have a percentage of breakdowns you could say okay guys 20% of our lost time comes from that area … I am just thinking

11 What do you think would the value of this system be (if any) in preparing for audits?

Interviewee:

It will be a great useful tool in preparing for audit because you going to know what the questions are, its all in one box, it's an audit like have you checked this have you checked that, it will be like a checkbox. Very definitely it will be a great tool. I mean that you know your legal compliance is up to date, you can go and shift around there and actually check so again we forgot about the legal audits for this year, come guys let's get a legal audit done quickly.

12 What would you think would the value of this system (if any) be in your planning during OH management?

Interviewee:

I mean straightaway you can home in to the areas where there is risk – simple! Why if there is exposure or risk whether it is health and safety or hygiene, why are you going to waste your time going to an area where there are no chemicals or the chemicals that are there are like hand soap, you don't want to worry about that, you rather going to worry about where there is chrome and exposure and things like that.

13 Express your views on the practical application of the system in identifying weaknesses in your overall OH management programme?

Interviewee:

It is a visual thing where this thing will tell you if it is programmed correctly it will tell you where you over the exposure limits and under, so it's a no nonsense thing, it will save you guys … that's where the problems are. So, it focusses on things where that can get you into trouble with the Department of Labour.

HvdW:

What about of interim and internal goals?

Interviewee: Yes for sure for sure, it could also be a tool that is used for a person's personal development and also for appraisal setting, if your boss looked at a layer and say "guys I want you to work on noise induced hearing loss and I want that area reduced by half", it is very difficult to argue here and here if this area is so much and he gives you a goal to reduce it by 30% and it was so much that it must now be this much this year.

HvdW:

So, it will be good for planning

Interviewee: Yes, yes, objective setting.

Any other views?

Interviewee:

I don't think so. Not a view … it would be to have a mind-set change of people, there is nobody I heard said it is a crummy system … not one. Everybody has spoken positively but it is to actually suck this thing into the company system because we have EH in this database, we have our SHEMS … this will be another one and I think that will be the challenge. To have it on an individual PC I don't see that as a challenge to be honest, I seriously don't thing that is a challenge but to get it sold that would be a challenge.

Interviewee:

for the purposes of what you want to do, for your purposes I think it is a winner. It is definitely a winner**.**

Questions?

Interviewee:

What would be nice on this system is something that we haven't thought which may you have thought about it that maybe I haven't thought about it or heard about it would be that we don't have a proper, proper waste stream in this plant, we don't. So to have just as a thought have different layers, you have a layer of where all the papers generated as a layer, you have different areas and then you have where all the cardboard has generated in different layers, chrome sludge different layers…so where a person … that will be a brilliant thing because we have been tasked to do that, to have a proper, proper waste feed.