Advanced Solution for Managing and Improving Organisational Health, Safety & Environmental Procedures

by

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Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

In the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA
PRETORIA

October 2008

Abstract

This document represents the final and improved version of a document previously titled AxSHEQ (Axapta Safety, Health, Environment and Quality) ERP Module Completion and Implementation. Due to a broader project scope introduced during project phase two a new project title seemed appropriate.

It is very important to note that phase one (BPJ410) methodologies still applies and are integrated within the broader solution defined in this document (BPJ420).

Project phase one focused on the design and analysis of business modelling aspects for successful implementation of an ERP Health, Safety and Environment management solution named AxSHEQ. AxSHEQ still forms part of the broader HSE solution described in this document. An advanced approach to manage and analyse failures which cause Health, Safety and Environmental issues are introduced in this document. The approach uses Industrial Engineering principles like Operations Research to compliment the already powerful AxSHEQ ERP solution.

"The HSE solution" used throughout the project refers to the Advanced Solution for Managing and Improving Organisational Health, Safety & Environmental Procedures.

Generic data representing a typical data for mining operations is used throughout the project to demonstrate the HSE solution adequately.

Executive Summary

Today, Accidents and ill health in organisations are costly to workers and their families. They can also hurt companies because, in addition to the costs of personal injuries, they may incur far greater costs from damage to property or equipment, and lost production.

iSoft-Technologies developed an offering for Microsoft Dynamics AX ERP. This offering is called AxSHEQ (Axapta Safety, Health, Environment and Quality) and covers the Safety, Health, Environmental and Quality segment of the horizontal market. At the moment AxSHEQ is still in work-in-progress phase and still needs functions and more tweaking.

Functions include those that assist any organisation in managing their HSE business plan by establishing a set of solutions (the HSE solution) that works in parallel to support and improve an already existent HSE plan or implement an entirely new custom solution for a specific business environment.

Insight into solutions to enhance the current AxSHEQ module developed by using Industrial Engineering principles and the data gathered by the ERP system. These enhancements will be presented to iSoft Technologies and may become part of the standard solution if they are approved and deemed valuable add-ons for the ERP HSE solution

The solution assists any organisation in managing their HSE business plan by establishing a set of solutions (the HSE solution) that works in parallel to support and improve an already existent HSE plan or implement an entirely new custom solution for a specific business environment.

The solution includes enhancements of the current AxSHEQ module by using Industrial Engineering principles and the data gathered by the ERP system. These enhancements will be presented to iSoft Technologies and may become part of the standard solution if they are approved and deemed valuable add-ons for the ERP HSE solution.

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1. Introduction and Background

Why manage company Health, Safety & Environmental factors?

"Gold Fields: Elevator plummets, killing 9 in mine accident near Johannesburg, South Africa"

"Fatal accidents at Driefontein and South Deep gold mines"

"Gold Fields tests winder ropes at all mines after fatal accident"

"4 dead in 2 Gold Fields Ltd. gold mining accidents"

Headlines like these have swamped South African front pages in a startling rate the last couple of years. Every working day at least one person is killed and thousands are injured at work. Every year millions of people take time off work because of what they regard as work-related illness. Millions of work days are lost as a result.

Accidents and ill health are costly to workers and their families. They can also hurt companies because, in addition to the costs of personal injuries, they may incur far greater costs from damage to property or equipment, and lost production.

With very few exceptions, employers have to have liability insurance cover for injuries and ill health to their employees. They will also have insurance for accidents involving vehicles and possibly third-party and buildings insurance.

However, insurance policies only cover a small proportion of the costs of accidents. Costs not covered by insurance can include:
- Sick-pay;
- Damage or loss of product and raw materials;
- Repairs to plant and equipment;
- Overtime working and temporary labour;
- Production delays;
- Investigation time;
- Fines.
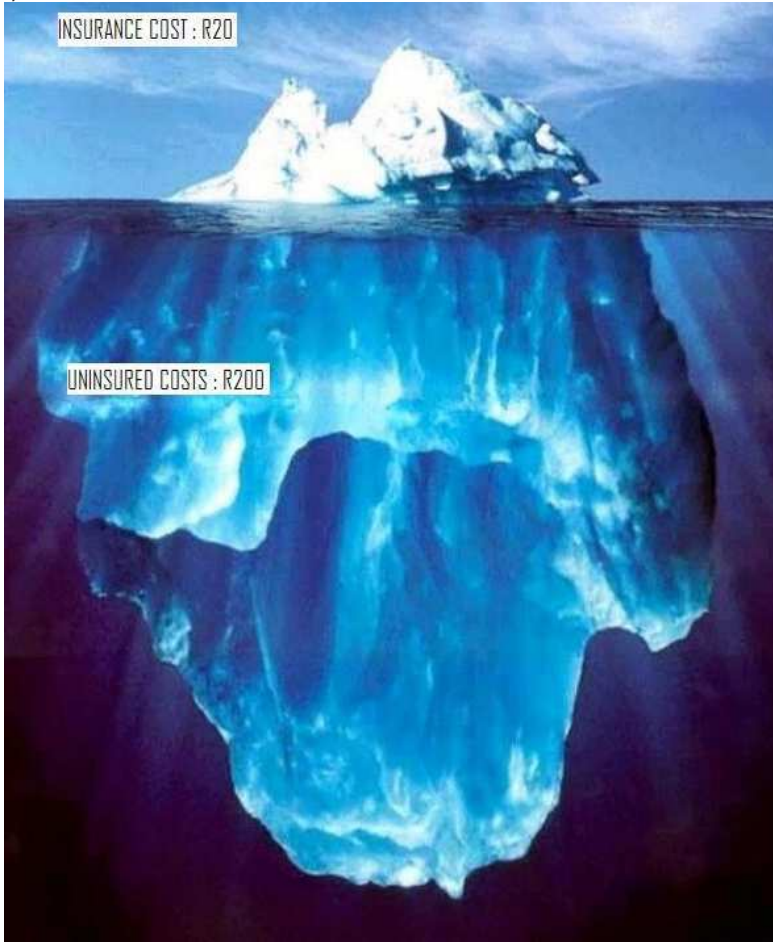
HSE studies have found that uninsured costs outweigh those covered by insurance policies. In a wide range of business sizes and activities, the total uninsured losses from day-to-day accidents ranged from twice up to 36 times the total paid in insurance premiums in the same year; the average was around ten times the amount paid in premiums. So in some cases, you could think of accident costs like an iceberg, with the majority of the losses uninsured and hidden below the water line.

Microsoft Dynamics AX

Designed for midsize and larger companies, Microsoft Dynamics AX (Axapta) is a multi-language, multicurrency enterprise resource planning (ERP) solution. Its core strengths are in manufacturing and e-business, and it includes strong functionality for the wholesale and services industries.

Microsoft Dynamics AX includes applications for financial management, customer relationship management, supply chain management, human resource management, project management, and analytics.

Because it integrates with widely-familiar Microsoft products (such as Microsoft SQL Server, BizTalk Server, Exchange, Office, and Windows) employees can work with the tools they are likely to be already familiar with, lowering training costs.

iSoft-Technologies and Wellpoint Systems

iSoft-Technologies was founded in 1998, as offspring from another company, the company based on its knowledge of the Aviation and Defence industry embarked on building a Best-Of-Breed product to handle all the intricacies of complex assets, operating in complex environments. The current owners of iSoft have all been active in the international Logistics IT systems arena for at least the past 15 years, mostly serving in key technical and management positions of various large international projects.

Wellpoint Systems is a Microsoft Dynamics AX company in Calgary, Canada. WellPoint Systems is dedicated to solving unique challenges faced by companies in the oil & gas, mining & exploration, chemical and utilities industries. Manifested in innovative and leading edge solutions, WellPoint Systems offers unparalleled vision of software solutions for the energy industry. With operations in more than sixty countries, they remain committed to providing solutions that allow clients to reap the benefits of technology to capitalize on the opportunities these industries present.

iSoft-Technologies were acquired by Wellpoint Systems during 2007.

iSoft-Technologies Solution Development

iSoft-Technologies offers a wide range of software products and associated implementation services. The range of software products are all based around and includes Microsoft's Dynamics Ax (Axapta) ERP.

Based on its international experience within the logistic and asset management industries, iSoft has developed various extensions (sub-modules) to Microsoft's Dynamics Ax. All these sub-modules have been designed based on best-practice principles and implemented within the same architecture as Dynamics Ax. iSoft's sub-modules are therefore referred to as plug-in modules, as these merge entirely into the rest of the Dynamics Ax ERP.

Development of a fourth generation logistics system started in 2001 and the initial technology selection was Delphi as development tool on an Oracle database. Early studies showed that stand-alone Enterprise Asset Management solutions do not have a long term future and that integration with a recognized ERP solution is essential, sparked iSoft to investigate the ERP vendor market.

After evaluating various ERP vendors, Microsoft Dynamics AX was identified as a product with powerful architecture, with an owner (Microsoft) that supports the Independent software vendor (ISV) principle and a product with no offering in the EAM (Enterprise Asset Management) & MRO (Maintenance Repair and Operations) segments of the horizontal market. Under guidance from MBS (Microsoft Business Solutions) South Africa the entire iSoft suite of EAM

solutions were redeveloped into Microsoft Dynamics AX to offer a fully integrated Microsoft Dynamics AX MRO & EAM offering.

2. Project Aim and Scope

iSoft-Technologies developed another offering for Microsoft Dynamics AX. This offering is called AxSHEQ and covers the Safety, Health, Environmental and Quality segment of the horizontal market. At the moment AxSHEQ is still in work-in-progress phase and still needs functions and more tweaking before a full implementation can take place. The scope of this project during phase one was to cover the completion, tweaking and testing of AxSHEQ for iSoft followed by an implementation of the AxSHEQ module.

Due to unforeseen circumstances at the client, the project scope had to be broadened (clearly indicated in phase one documentation that the scope may change). AxSHEQ still forms part of the HSE (Health, Safety & Environment) solution described in this document but less emphasis is placed on a full implementation.

In this phase more emphasis is placed on the following:

- To assist any organisation in managing their HSE business plan by establishing a set of solutions (the HSE solution) that works in parallel to support and improve an already existent HSE plan or implement an entirely new custom solution for a specific business environment.

- The enhancement of the current AxSHEQ module by using Industrial Engineering principles and the data gathered by the ERP system. These enhancements will be presented to iSoft Technologies and may become part of the standard solution if they are approved and deemed valuable add-ons for the ERP HSE solution.

Certain business and user requirements have been identified during phase one to assist in a comprehensive implementation of the AxSHEQ ERP module (included in appendix). It is important to note that these business models are vital for a successful ERP implementation and will be responsible for the quality of data input when the HSE system is in full swing. With any ERP system it is always important to remember the following phrase: "garbage in garbage out". The management reports are only as good as the data input quality of the users.

3. Advanced HSE Management Impact on Organisations

According to the people at "Business Link", health, safety and environmental factors are key business concerns. The right approach helps a business control risks, cut costs and get a competitive edge. But making sure that a business deal with all the issues can be a challenge. It's easy to overlook requirements or repeat mistakes from the past.

A systematic approach helps a business to comply with all legal obligations. It makes sure that everyone in a business knows the right way of doing things. Perhaps most importantly, it provides a foundation for continually improving health and safety management within a business.
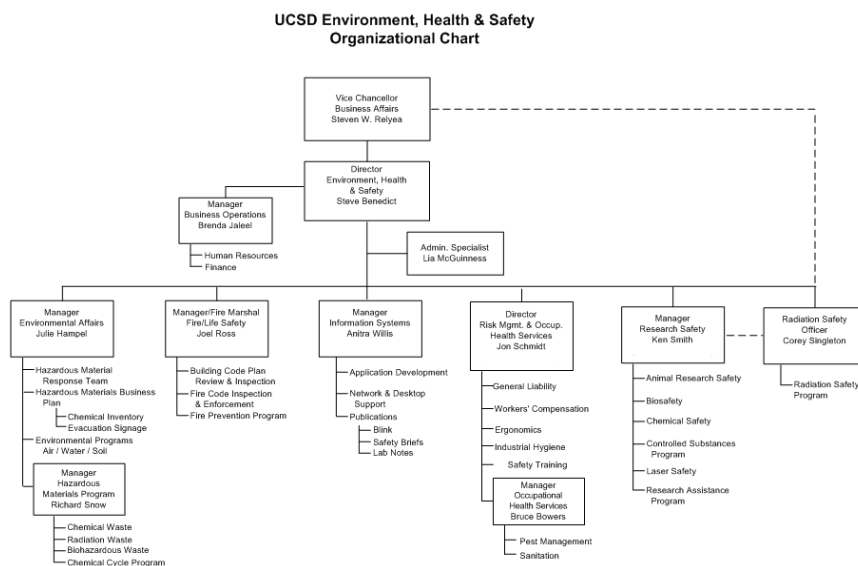
A well defined Environment, Health & Safety Organisational structure in a business is crucial in the susceptibility of an HSE Solution.

Figure 1: An Example of a Well Defined HSE Organisational Structure

4. Advanced HSE Management Benefits

Taking a systematic approach to HSE management makes managing a business both easier and more effective. The HSE solution works out the best way to handle key activities and make sure that everyone uses the same approach every time.

A consistent approach like the HSE solution reduces the number of mistakes and the cost of correcting problems. It also reduces the level of risk and ensures compliance with legislation.

This can positively influence a business:
- Improved health and safety performance by a business will reduce the costs associated with accidents and incidents.
- Improved awareness of regulatory requirements reduces the chance of committing any offences. The Health & Safety Executive will generally regulate a business with a lighter touch if it is well managed.
- If employees see that a business are actively looking after their health and safety, relations and morale will improve.
- The public see that a business is taking a responsible attitude towards their employees. This improves image and helps generate positive public relations for a business.
- Improving the efficiency of a business reduces costs.
- A business can demonstrate to their insurers that they are controlling risk effectively. This may help lower insurance premiums.
- Banks and investors will be more willing to finance a business if they can show that it is well managed.
- Business partners have more confidence in a business. Larger companies and government agencies may only buy from businesses that can show effective management systems.

5. Advanced Solution for Managing and Improving Organisational Health, Safety & Environmental Procedures

A Health, Safety and Environment management system for an organisation needs to take the following into account:

- HSE Policies
- Staff Organisation and motivation
- HSE solution Planning and Implementing
- Performance Measurement
- Reviewing Performance
- Auditing
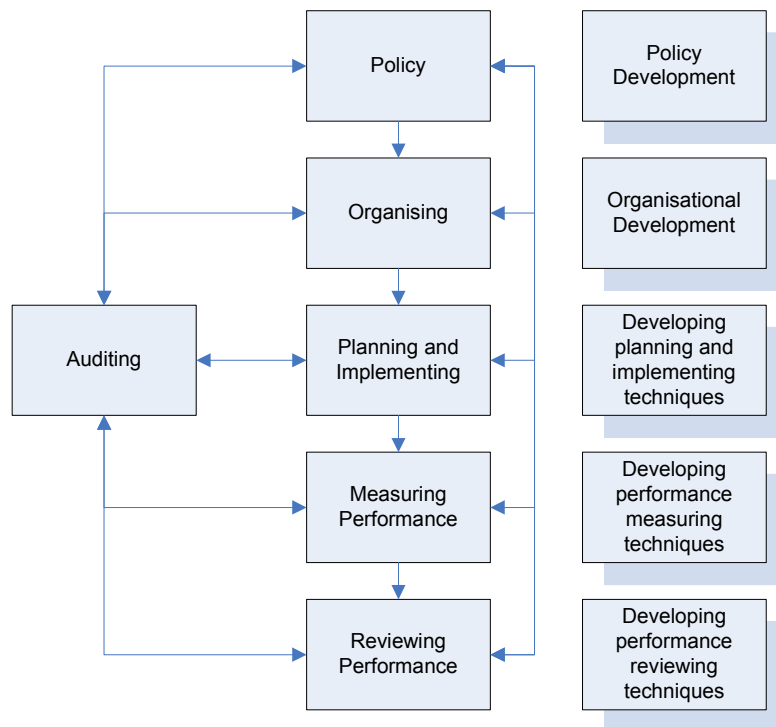
Figure 2: The Advanced HSE Management System

A step wise process can be used to identify crucial steps in the HSE solution for any business. The AxSHEQ module has functionality to manage the proposed principles in the HSE solution. AxSHEQ forms an integral part in the HSE solution and will be discussed further on in the document.

6. STEP 1: SET THE HSE POLICY

The same sorts of event that cause injuries and illness can also lead to property damage and interrupt production so you must aim to control all accidental loss. Identifying hazards and assessing risks (A hazard is something with potential to cause harm. The harm will vary in severity – some hazards may cause death, some serious illness or disability, others only cuts and bruises. Risk is the combination of the severity of harm with the likelihood of it happening.), deciding what precautions are needed, putting them in place and checking they are used, protects people, improves quality, and safeguards plant and production.

Your health and safety policy should influence all your activities, including the selection of people, equipment and materials, the way work is done and how you design and provide goods and services. A written statement of your policy and the organisation and arrangements for implementing and monitoring it shows your staff, and anyone else, that hazards have been identified and risks assessed, eliminated or controlled.

Business leaders can ask the following questions to assess a Health, Safety and Environmental Policy:

1. Do you have a clear policy for health and safety; is it documented?
2. What did you achieve in health and safety last year?
3. How much are you spending on health and safety and are you getting value for money?
4. How much money are you losing by not managing health and safety?
5. Does your policy prevent injuries, reduce losses and really affect the way you work?

Managers and business owners must discuss and analyse these questions comprehensively to ensure a successful HSE solution.

7. STEP 2: STAFF/EMPLOYEE ORGANISATION

To make a health and safety policy effective you need to get your staff involved and committed. This is often referred to as a 'positive health and safety culture'.

The four 'Cs' of positive health and safety culture:

1. Competence: recruitment, training and advisory support.
2. Control: allocating responsibilities, securing commitment, instruction and supervision.
3. Co-operation: between individuals and groups.
4. Communication: spoken, written and visible.

Competence
- Assess the skills needed to carry out all tasks safely.
- Provide the means to ensure that all employees, including your managers, supervisors and temporary staff, are adequately instructed and trained.
- Ensure that people doing especially dangerous work have the necessary training, experience and other qualities to carry out the work safely.
- Arrange for access to sound advice and help.
- Carry out restructuring or reorganisation to ensure the competence of those taking on new health and safety responsibilities.

Control
- Lead by example: demonstrate your commitment and provide clear direction - let everyone know health and safety is important.
- Identify people responsible for particular health and safety jobs - especially where special expertise is called for, e.g. doing risk assessments, driving fork-lift trucks.
- Ensure that managers, supervisors and team leaders understand their responsibilities and have the time and resources to carry them out.
- Ensure everyone knows what they must do and how they will be held accountable - set objectives.

Co-operation
- Chair your health and safety committee - if you have one. Consult your staff and their representatives.
- Involve staff in planning and reviewing performance, writing procedures and solving problems.
- Co-ordinate and co-operate with those contractors who work on your premises.

Communication

- Provide information about hazards, risks and preventive measures to employees and contractors working on your premises. Discuss health and safety regularly.
- Be 'visible' on health and safety.

The following questions can be asked by business leaders to assess the state of staff organisation:

- Have you allocated responsibilities for health and safety to specific people - are they clear on what they have to do and are they held accountable?
- Do you consult and involve your staff and their representatives effectively?
- Do your staff have sufficient information about the risks they run and the preventive measures?
- Do you have the right levels of expertise? Are your people properly trained?
- Do you need specialist advice from outside and have you arranged to obtain it?

Employee competence, control, co-operation and communication are particularly important when dealing with life threatening equipment in the workplace.

Figure 3: Typical Life Threatening Equipment

8. STEP 3: PLAN AND SET STANDARDS

Planning is the key to ensuring that health, safety and environmental efforts really work. Planning for the HSE solution involves setting objectives, identifying hazards, assessing risks, implementing standards of performance and developing a positive culture. It is often useful to record plans in writing.

Planning should provide for the following:
- identifying hazards and assessing risks, and deciding how they can be eliminated or controlled;
- complying with the health and safety laws that apply to a business;
- agreeing health and safety targets with managers and supervisors;
- a purchasing and supply policy which takes health and safety into account;
- design of tasks, processes, equipment, products and services, safe systems of work;
- procedures to deal with serious and imminent danger;
- co-operation with neighbours, and/or subcontractors;
- setting standards against which performance can be measured.

Standards help to build a positive culture and control risks. They set out what people in an organisation will do to deliver the policy and control risk. They should identify who does what, when and with what result. Three key points about standards - Standards must be:
- measurable;
- achievable;
- realistic.

Statements such as 'staff must be trained' are difficult to measure if you don't know exactly what "trained" means and who is to do the work. "All machines will be guarded" is difficult to achieve if there is no measure of the adequacy of the guarding. Industry-based standards already exist and businesses can adopt them where applicable. In other cases businesses will have to take advice and set their own, preferably referring to numbers, quantities and levels which are seen to be realistic and can be checked. For example:
- completing risk assessments and implementing the controls required;
- maintaining workshop temperatures within a specified range;
- specifying levels of waste, effluent or emissions that are acceptable;
- specifying methods and frequency for checking guards on machines, ergonomic design criteria for tasks and workstations, levels of training;
- arranging to consult staff or their representatives at set intervals;
- monitoring performance in particular ways at set times.

Vital questions to be asked during the HSE planning and standards step include:

- Do you have a health and safety plan?
- Is health and safety always considered before any new work is started?
- Have you identified hazards and assessed risks to your own staff and the public, and set standards for premises, plant, substances, procedures, people and products?
- Do you have a plan to deal with serious or imminent danger, e.g. fires, process deviations etc?
- Are the standards put in place and risks effectively controlled?

Water trucks are an effective way to manage dust at coal mines. Dust is not only responsible for lung-related illnesses but also negatively affects productivity in various ways.

Figure 4: Water Truck improving safety and productivity at a coal mine

9. STEP 4: PERFORMANCE MEASUREMENT

Just like finance, production or sales, a business need to measure health and safety performance to find out if the HSE solution is successful.

Businesses need to know:
- where they are;
- where they want to be;
- what is the difference - and why.

Active monitoring (Preventive monitoring), before things go wrong, involves regular inspection and checking to ensure that standards are being implemented and management controls are working. Reactive monitoring (Corrective monitoring), after things go wrong, involves learning from mistakes, whether they have resulted in injuries and illness, property damage or near misses.

Two key components of monitoring systems:
- Active monitoring (before things go wrong). Are you achieving the objectives and standards you set yourself and are they effective?
- Reactive monitoring (after things go wrong). Investigating injuries, cases of illness, property damage and near misses - identifying in each case why performance was substandard.

Businesses need to ensure that information from active and reactive monitoring is used to identify situations that create risks, and do something about them. Priority should be given where risks are greatest. Look closely at serious events and those with potential for serious harm. Both require an understanding of the immediate and the underlying causes of events. Investigate and record what happened - find out why. Refer the information to the people with authority to take remedial action, including organisational and policy changes.

Performance measurement in the HSE solution is important and the following questions can be asked by managers when assessment takes place:

- Do you know how well you perform in health and safety?
- How do you know if you are meeting your own objectives and standards for health and safety? Are your controls for risks good enough?
- How do you know you are complying with the health and safety laws that affect your business?
- Do your accident investigations get to all the underlying causes - or do they stop when you find the first person who has made a mistake?
- Do you have accurate records of injuries, ill health and accidental loss?

10. STEP 5: LEARN FROM EXPERIENCE - AUDIT AND REVIEW

Monitoring provides the information to let businesses review activities and decide how to improve performance. Audits, by staff or outsiders, complement monitoring activities by looking to see if the HSE policy, organisation and systems are actually achieving the right results. They inform about the reliability and effectiveness of the systems. Businesses can learn from previous experiences. Businesses can combine the results from measuring performance with information from audits to improve the approach to health and safety management.

The effectiveness of a health and safety policy can be reviewed by paying particular attention to:

- the degree of compliance with health and safety performance standards (including legislation);
- areas where standards are absent or inadequate;
- achievement of stated objectives within given time-scales;
- injury, illness and incident data - analyses of immediate and underlying causes, trends and common features. These indicators will show where a business needs to improve.

Managers can ask the following questions when assessing the audit and review process:

- How do you learn from your mistakes and your successes?
- Do you carry out health and safety audits?
- What action is taken on audit findings?
- Do the audits involve staff at all levels?
- When did you last review your policy and performance?

Any business can manage health, safety and environmental factors effectively by considering the HSE solution steps thoroughly and by investing in an ERP HSE management system named AxSHEQ (Axapta Safety, Health, Environment and Quality).

1. Health and Safety Policy Statement

total section points = 40

Element		Guidelines	Purpose	Yes	No	Verify
1.1		*The employer's health and safety policy contains the following:*				
1.1(a)	**Employer** commitment	• Commitment to preventing occupational illness and injury in the workplace.	**Rationale:** • Demonstrates the employer's dedication to their leadership role in the quest to eliminate workplace injury and illness.	5	0	D
1.1(b)	Employer responsibility	• Responsibility to implement and maintain a safe and healthy work environment.	**Rationale:** • Confirms the employer's willingness to accept their responsibility to strive towards the elimination of workplace injury and illness.	5	0	D
1.1(c)	**Supervisor** responsibility	• Responsibility to ensure that safe and healthy work conditions are maintained in his/her assigned work area.	**Rationale:** • Reinforces the employer's demand that every member of the workforce be responsible for eliminating workplace injury and illness.	5	0	D
1.1(d)	**Worker** responsibility	• Responsibility to work safely following legislated and employer Safe Work Procedures/Practices.	**Rationale:** • Confirms the employer's desire that worker's actively participate in the goal to achieve the elimination of workplace injury and illness.	5	0	D
1.1(e)	Dated	• The posted copy is dated, within a 12 month-period.	**Rationale:** • Expresses the employer's desire to sustain and maintain his/her health and safety initiatives.	5	0	D/O
1.1(f)	Signed	• The posted copy is signed by, the most senior management person on site. (can have other signatures e.g. JHSC)	**Rationale:** • Management's signature demonstrates their commitment to workplace health and safety. • A worker representative signature would imply recognition and approval of the team approach toward workplace health and safety.	5	0	D/O
1.1(g)	Posted	• Posted in a high traffic area (employee entrance, near time clock, bulletin board, site trailers/vehicles) • Accessible to all employees on site and off site	**Rationale:** • Emphasizes the employer's desire to develop and maintain a health and safety culture. **Legislation:** • Post at a conspicuous location in the workplace a copy of the occupational health and safety policy. OHSA Section 25(2)(k).	10	0	O

Figure 5: Typical HSE Audit Assessment Framework

11. AxSHEQ Overview

As established it is clear that any business needs to manage health, safety and environmental factors effectively. Various HSE management systems are available but one system in particular stands out above them all. This system is called AxSHEQ.

iSoft-Technologies developed another offering for Microsoft Dynamics AX (Enterprise Resource Planning System). This offering is called AxSHEQ and covers the Safety, Health, Environmental and Quality segment of the horizontal market.

Current AxSHEQ Functionality

The typical Health, Safety and Environmental Management system, including AxSHEQ, must be capable of controlling the following processes:

Health & Safety Department:

- Corrective Action Plan (CAP) - Establishment of a plan to approach and correct any incident or accident related event;
- Incident Reporting – Capability to capture and interpret accident and incident related occurrences;
- WCB Claims – Capability to manage injury related worker compensation claims;
- Formal Inspection – Scheduling and managing formal inspections;
- Auditing – Capability to manage audits done by staff or outsiders to complement monitoring activities by looking to see if the HSE policy, organisation and system are actually achieving the right results;
- Pre-qualification of contractors – Capability to evaluate and keep track of contractors for on-site work;
- Orientation of contractors – Capability to manage contractor knowledge of company policies;
- Contractor Suspension – Capability to manage history of contractor suspensions;
- Equipment maintenance/repair/calibration – Schedule and manage equipment;
- Monitoring - Air;
- Monitoring - Noise;
- Personal Protection Equipment Tracking;
- Safety Training;
- Compliance Management – Management of organisation compliance with government legislation;
- HSE Performance Tracking;

- HSE Organization and Role Documentation.

Environmental Department:

- Incidents – Capability to manage incidents impacting the environment;
- Corrections - Establishment of a plan to approach and correct any environmental incident or accident;
- Process Audits – Management of environmental process audits;
- System Audits – Management of system audits;
- Inspections;
- Monitoring;
- Contractor Management;
- Equipment Management;
- Reclamation – Capability to manage the land reclamation process especially at mines;
- Waste Management.

During phase one a complete health, safety and environmental system user requirement assessment has been done (included in the appendix for further reference.). This framework can be used to implement a successful AxSHEQ HSE system.

AxSHEQ is capable of gathering valuable data regarding all of the above mentioned processes.

12. AxSHEQ Improvement Proposal

A successful implementation of AxSHEQ can produce valuable health, safety and environment related information regarding an applicable business environment. At the moment within AxSHEQ's core business rules very little (in the form of straight forward management reports) business intelligence has been designed to make use of this accumulated wealth of data.

Preventive- and Corrective Maintenance

Wikipedia explains that preventive maintenance (PM) has the following meanings:
- The care and servicing by personnel for the purpose of maintaining equipment and facilities in satisfactory operating condition by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects.
- Maintenance, including tests, measurements, adjustments, and parts replacement, performed specifically to prevent faults from occurring.

To make it simple:
- Preventive maintenance is conducted to keep equipment working and/or extend the life of the equipment.
- Corrective maintenance, sometimes called "repair", is conducted to get equipment working again.

The primary goal of maintenance is to avoid or mitigate the consequences of failure of equipment. This may be by preventing the failure before it actually occurs which PM and condition based maintenance help to achieve. It is designed to preserve and restore equipment reliability by replacing worn components before they actually fail.

Preventive maintenance activities include partial or complete overhauls at specified periods, oil changes, lubrication and so on. In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. The ideal preventive maintenance program would prevent all equipment failure before it occurs.

AxSHEQ Preventive Maintenance

AxSHEQ is capable of scheduling preventive maintenance inspections and services on equipment and the environment. This can be done to minimize employee injuries due to failing equipment or to monitor the impact of equipment

on the environment. Typically these inspections will result in feedback data collected by the inspector such as:

- equipment noise levels in decibels – hearing related illness;
- dust particles per cm^3 – lung related illness;
- air samples – Hazardous gas notification;
- water samples – Hazardous chemical substances;

AxSHEQ Corrective Maintenance

AxSHEQ is capable of capturing and managing failures on equipment that will cause harm to the environment or employees if not tended to.

Identified AxSHEQ Shortcoming / Problem definition

There is no question about the following statement: Failures can cause havoc in any business environment, this is especially true for Health, Safety and Environment related failures. Media releases are included in the appendix just to show the necessity of proper failure/maintenance management.

Businesses need to ensure that information from preventive- and corrective monitoring is used to identify situations that create risks, and do something about them.

Priority should be given where risks are greatest. Look closely at serious events and those with potential for serious harm. Both require an understanding of the immediate and the underlying causes of events. Investigate and record what happened. Refer the information to the people with authority to take remedial action, including organisational health, safety and environment policy changes.

The daily number of preventive and corrective maintenance events waiting to be done at an organisation can reach into the thousands. Who decides what corrective or preventive event must take place first with a limited amount of resources. AxSHEQ doesn't have any form of prioritisation between those events. It is better to tackle "high risk", "high potential to be hazardous if failure occurs" events first. This is a crucial part of any HSE management system because no value can be placed on an employees live.

Prioritisation of the events in the corrective- and preventive maintenance backlog at an organisation can be managed by using AxSHEQ in parallel with certain identified operational research principles.

Solution Approach

Operational Research

According to Wikipedia Operations Research (OR) is an interdisciplinary branch of applied mathematics and formal science that uses methods such as mathematical modelling, statistics, and algorithms to arrive at optimal or near optimal solutions to complex problems. It is typically concerned with optimizing the maxima (profit, assembly line performance, crop yield, bandwidth, etc) or minima (loss, risk, etc.) of some objective function. Operations research helps management achieve its goals using the scientific process

Solution Approach Figure
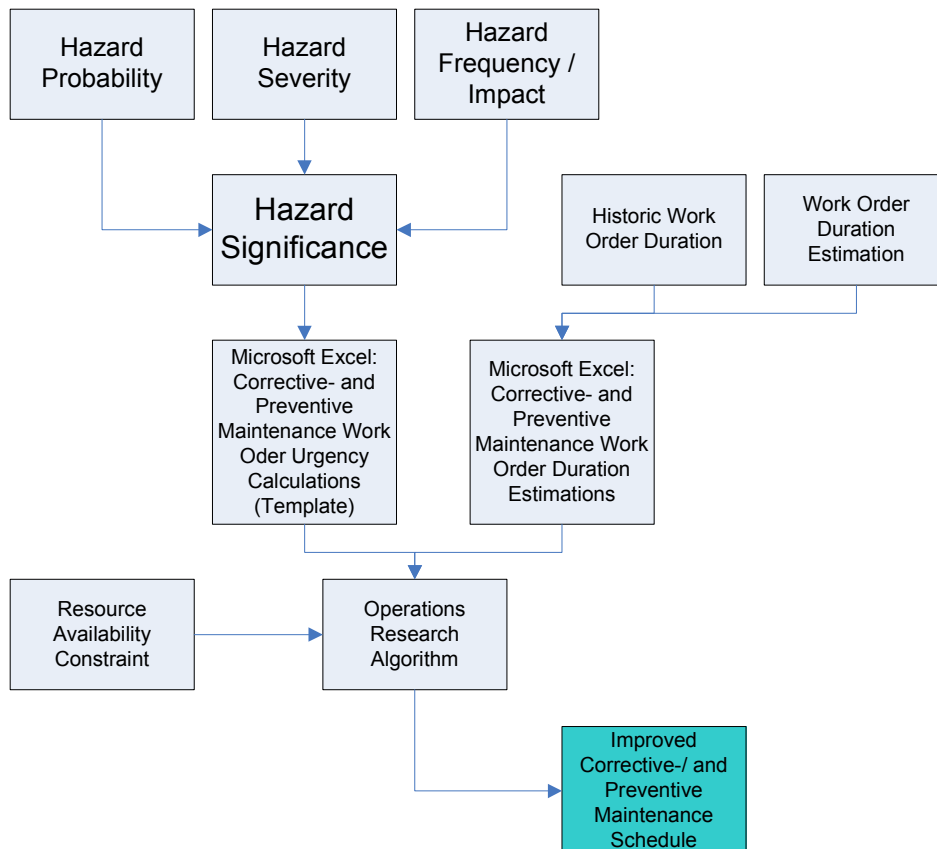
Figure 6: Preventive-/ Corrective Maintenance Improvement Model

The following excel models are used within the operations research model. These forms will typically be used by businesses on a daily basis to assess the work orders of corrective- and predictive maintenance.

Preventive-/ Corrective Work Order Urgency (Original Template with Example Data)

				ASSESSMENT						
1. Number	2. Corrective- /Predictive Maintenance Work Order Number	3. Work Order Description	4. Mandatory to include in strategy? (Input:y/n)	5. Employee / Environment Hazard Category (Physical/ Chemical/ Biological/ Ergonomic/ Environmental/ Safety/ Other)	Identified Hazards	6. Severity (0-6)	7. Frequency (1-3)	8. Probability (1 - +1)	9. Significance (0 - 10)	10. Work Order Urgency Factor
1	AxSHEQ00567	Methane Gas Leakage: Shaft 2	n	Safety	Gas	6	3	1	10	1
2	AxSHEQ02345	Watertruck 2 road spray routine: Dust control	n	Biological	Lung Illness	3	3	0	6	0.6
3	AxSHEQ03455	Routine maintenance: CAT EH4500 Haul Truck	n	Safety	Failure Prevention	2	1	0	3	0.3
4	AxSHEQ02264	Noise Monitoring: Generator room	n	Physical	Employee Hearing	1	3	0	4	0.4
5	AxSHEQ07673	Lagoon B Water sampling	n	Chemical	Toxic metals	5	3	0	8	0.8
6	AxSHEQ02664	Production Plant B: Airconditioner 1 Failure	n	Safety	Employee Lung Illness	2	3	0	5	0.5
7	AxSHEQ07833	Routine maintenance: Workshop Lathe	n	Safety	Failure Prevention	1	1	0	2	0.2
8	AxSHEQ03767	Isuzu KB200 brake failure	n	Safety	Employee Accident	4	1	1	6	0.6
9	AxSHEQ02965	Air Sampling Shaft 3	n	Environmental	Employee Lung Illness	2	3	0	5	0.5
10	AxSHEQ09866	Routine cleanup: Production Plant 1	y	Other	Employee Accident	0	3	0	3	1
11	AxSHEQ00045	Oil Spill: Lagoon C	y	Environmental	Oil in main stream	6	3	1	10	1
12	AxSHEQ03478	Routine maintenance: Shaft elevator 2	n	Safety	Elevator failure	6	2	0	8	0.8
13	AxSHEQ02452	Noise Monitoring: Production Conveyor 3	n	Physical	Employee Hearing	3	3	0	6	0.6
14	AxSHEQ02111	Routine maintenance: Watertruck 3	n	Other	Employee Accident	0	1	0	1	0.1
15	AxSHEQ04609	Inspection: Forklift 34	n	Other	Employee Accident	2	1	0	3	0.3

Table 1: Preventive-/ Corrective Maintenance Work Order Urgency Template

Table 1 explanation example:
Discussion of an upper extreme example in generic data for a coal mine shown in Table 1 by using provided Work Order Urgency Template below:

Work Order AxSHEQ00567. A methane gas leak was detected in shaft 2 which obviously bears high priority for attention in the Safety and Health department.

Severity:
Situation can result in permanent disability or loss of life or body part; and/or extensive loss of structure, equipment, or material; quality, production, or other losses exceeding R50 000 (assigned value 6).

Frequency:
Number of persons who may be exposed to or have contact with the hazard – Heavy/Large amount of people are exposed to hazard.
Number of times persons may be exposed to or have contact with the hazard - Many Times per day (Frequency value shown in table is obtained from frequency legend below. Assigned value 3).

Probability:
There is a greater than average chance that the identified issue can cause a loss –financially, operational or fatalities (assigned value 1).

Significance:
Combined sum of severity, frequency and probability values derived from legend.

Work Order Urgency Factor:
Field with 1 being the highest – and 0 the lowest urgency. Auto fills with value 1 in case input "y" value exist in "Mandatory to include in strategy?" field.

Legend to be used by the user for the Preventive-/ Corrective Work Order Urgency Template:

Mandatory to include field

Indicate whether or not the Work Order should be scheduled for completion regardless of other factors.

Health Hazard Category Classification

Health hazards can lead to illnesses or disorders such as inflamed or irritated joints (e.g., tendonitis, epicondylitis), skin diseases (such as dermatitis), carpal tunnel syndrome, hernias and various cancers. Some health hazards can also have harmful reproductive effects.

1. Physical hazards
Physical hazards are forms of energy that can harm the body if exposed. Examples include: noise, vibration, temperature extremes (hot or cold), and radiation. The effects of exposure can respectively include: temporary or permanent hearing loss; damage to the small blood vessels and nerves; heat cramps, exhaustion and stroke; frostbite and hypothermia; cancer and eye damage.

2. Chemical hazards
Chemical hazards can take the form of solids, liquids, vapours, gases, dusts, fumes or mists. They can be inhaled, ingested or absorbed into the body. Examples include: paints, solvents, cleaners, degreasers, acids, and cutting oils. Exposure to chemical hazards can cause irritation, allergic reactions, depression of the nervous system, asphyxia, lung disease and cancer. Some chemicals can also have harmful effects on the reproductive system.

3. Biological hazards
Biological hazards are living things or substances produced by living things that can cause illness in humans. These hazards enter the body by inhalation, ingestion or absorption. Examples of biological hazards include: bacteria, viruses, fungi, parasites and plants. Effects of exposure include: tuberculosis, tetanus, food poisoning, boils, blood poisoning, ringworm, thrush, hepatitis, mumps, German measles, and rabies.

4. Ergonomic or work design hazards
Ergonomic hazards arise from the design and organization of work. They can harm the body by placing strain on the musculoskeletal system and overloading the muscles, tendons, joints, ligaments, nerves and blood vessels. Look for ergonomic hazards in: workstation layout and design, tool and equipment design, the work environment, and general work organization.

5. Stress or psychosocial hazards
Workplace stressors can lead to excess stress or distress and have been identified as important factors in many types of illness, including heart disease and high blood pressure. There are two main types of stressors: physical (e.g., noise and vibration) and organizational stressors (e.g, lack of job control, work overload, role uncertainty and conflict, isolation and workplace violence).

Safety Hazard Category Classification

Safety hazards can lead to traumatic types of injuries such as sprains, bruises, fractures and cuts.

1. Material handling hazards
Manual material handling can involve lifting, carrying, lowering, pushing, and pulling. All of these activities can lead to muscle strains, tears and pulls of the back, shoulders, arms and abdomen.

Mechanical material handling can involve such devices as forklift trucks, conveyors, cranes, and hand carts and trucks. These devices can introduce many hazards including accidental contact with moving equipment or parts, loads, or electricity.

Handling of hazardous materials, such as corrosives, flammables and reactives is another key area. Exposure can cause serious harm to people and extensive damage to property.

2. Machine hazards
Any machine can be a hazard, especially those with moving parts that can get tangled in a worker's clothes or come into contact with a worker's body. Here are some examples:
- workers may be crushed if they get caught in rotating shafts, belts or pulleys
- body parts may be injured or severed by presses, blades and saws
- workers may be struck by flying projectiles from machines

3. Energy hazards
Workers can be seriously injured by the sudden movement of machine components, electrical shock or other releases of energy when they are adjusting or maintaining equipment. Energy sources include: electricity, steam, heat, pneumatic or hydraulic pressure and gravity as well as mechanical and chemical energy.

4. Work practice hazards

Failure to have or to follow safe work practices is a significant cause of injuries. Performing work safely in accordance with established safe work procedures is a fundamental element in the control of safety hazards. Employers, supervisors and workers all share a responsibility in this.

5. Confined space hazards

Confined spaces are work spaces where hazardous gases, vapours, dusts or fumes may build up or where an oxygen-deficient atmosphere may be created. Examples include: storage tanks, vaults, pits, vats, silos, pipelines, ducts and tunnels. Other hazards of confined spaces include: difficulty of entry and exit and working in awkward spaces, poor walking surfaces, poor visibility, and extremes of temperature and noise.

Potential Hazard Assessment Guidelines

Severity (0-6)

0: No injury or illness; or quality, production, or other loss of less than R 1000
2: Minor injury or illness without lost time; non-disruptive property damage or a quality, production, or loss of R 1000 to R 10,000
4: A lost-time injury or illness without permanent disability; or disruptive property damage; or quality, production, or other loss of more than R 10,000 but not exceeding R 50,000
6: Permanent disability or loss of life or body part; and/or extensive loss of structure, equipment, or material; quality, production, or other losses exceeding R50,000
Note: Make Rand figures relative to the specific company. Define a major loss. How much money does that involve?

Table 2: Work Order Hazard Severity Assessment

Frequency (1-3)

Number of persons who may be exposed to or have contact with the hazard	Number of times persons may be exposed to or have contact with the hazard		
	Less than daily	Few Times per day	Many Times per day
Few	1	1	2
Moderate	1	2	3
Heavy	2	3	3

Table 3: Work Order Hazard Frequency Assessment

Probability (-1 to +1)

- 1: Less than average chance of loss
0: Average chance of loss
+1: Greater than average chance of loss

Table 4: Work Order Hazard Probability Assessment

Significance (0-10)

0-2: Low
3-5: Medium
6-10: High

Table 5: Work Order Hazard Significance

The significance rating is the combined sum of severity, frequency and probability.

Work Order Duration Model Template (Original Template with Example data)

Corrective-/Predictive Work Order Duration					
Work Order	**Description**	**Historical Data Available?**	**Historical Work Order Duration (minutes)**	**Estimated/Predicted Work Order Duration (minutes)**	**Duration**
AxSHEQ00567	Methane Gas Leakage: Shaft 2	n		100	100
AxSHEQ02345	Watertruck 2 road spray routine: Dust control	n		110	110
AxSHEQ03455	Routine maintenance: CAT EH4500 Haul Truck	n		100	100
AxSHEQ02264	Noise Monitoring: Generator room	n		120	120
AxSHEQ07673	Lagoon B Water sampling	n		300	300
AxSHEQ02664	Production Plant B: Airconditioner 1 Failure	n		40	40
AxSHEQ07833	Routine maintenance: Workshop Lathe	n		120	120
AxSHEQ03767	Isuzu KB200 brake failure	n		140	140
AxSHEQ02965	Air Sampling Shaft 3	y	120		120
AxSHEQ09866	Routine cleanup: Production Plant 1	n		50	50
AxSHEQ00045	Oil Spill: Lagoon C	n		135	135
AxSHEQ03478	Routine maintenance: Shaft elevator 2	n		120	120
AxSHEQ02452	Noise Monitoring: Production Conveyor 3	n		210	210
AxSHEQ02111	Routine maintenance: Watertruck 3	n		200	200
AxSHEQ04609	Inspection: Forklift 34	n		60	60

Table 6: Work Order Duration Template

This template is a summary of the selected work orders for prioritisation. If a similar work order has been executed in the past , historic data is used from AxSHEQ as the default duration. In other cases an experienced employee estimates durations for work orders.

Total Resource Availability Estimation

The total number of available resource-minutes to work on the work orders must be established.

Operational Research Model Formulation

$x_i = \{$ 1: Work order i is included in the maintenance strategy for the applicable time period.

      Where $i = \{1, 2,\ldots,$ "Total number of Work Orders to Include in strategy"$\}$

  0: Otherwise$\}$

$d_i =$ The associated work order durations for work order i.

      Where $i = \{1, 2,\ldots,$ "Total number of Work Orders to Include in strategy"$\}$

$t =$ The time constraint or resource constraint for the applicable time period during which maintenance takes place.

$u_i =$ The applicable work order urgency for work order i. Where i $= \{1, 2,\ldots,$ "Total number of Work Orders to Include in strategy"$\}$

$z =$ The objective function value.

Maximize $z = \sum_{i=1}^{Tota\ln umberofWO} (u_i)(x_i)$

St:

$$\sum_{i=1}^{Tota\ln umberofWO} (d_i)(x_i) \leq t \qquad \text{\{Time Constraint\}}$$

$x_i = (0,1) \forall i \in \{1,2,\ldots,$ "Total number of Work Orders to Include in strategy"$\}$

Operational Research Lingo Model

```
MODEL:
SETS:

WorkOrders /

!Work Orders to be included in maintenance strategy plan;
AxSHEQ00567, AxSHEQ02345, AxSHEQ03455, AxSHEQ02264, AxSHEQ07673, AxSHEQ02664,
AxSHEQ07833, AxSHEQ03767, AxSHEQ02965, AxSHEQ09866, AxSHEQ00045, AxSHEQ03478,
AxSHEQ02452, AxSHEQ02111, AxSHEQ04609

/:WorkOrder_Included, WorkOrder_Duration, WorkOrder_Urgency;
```

Advanced Solution for Managing and Improving Organisational Health, Safety & Environmental Procedures

```
ENDSETS

DATA:

WorkOrder_Duration WorkOrder_Urgency =


!Excel Model Details.

First Column: Estimated Work Order Duration in minutes
Second Column: Work Order Maintenance Urgency;

100    1
110    0.6
100    0.3
120    0.4
300    0.8
40     0.5
120    0.2
140    0.6
120    0.5
50     1
135    1
120    0.8
210    0.6
200    0.1
60     0.3;

!Available resource minutes during time period.;

Resource_Minutes = 480;

ENDDATA

MAX = @SUM( WorkOrders: WorkOrder_Urgency  * WorkOrder_Included);

@SUM( WorkOrders: WorkOrder_Duration  * WorkOrder_Included) <=
Resource_Minutes;

@FOR( WorkOrders: @BIN( WorkOrder_Included));

END
```

Example Proposed Solution by using OR Algorithm

According to the Lingo model devised for this AxSHEQ enhancement the
following can be said regarding the example data provided throughout the
solution (Complete Lingo solution included in Appendix):

```
WORKORDER_INCLUDED( AXSHEQ0056        1.000000            -1.000000
WORKORDER_INCLUDED( AXSHEQ0266        1.000000            -0.5000000
```

```
WORKORDER_INCLUDED( AXSHEQ0986        1.000000        -1.000000
WORKORDER_INCLUDED( AXSHEQ0004        1.000000        -1.000000
WORKORDER_INCLUDED( AXSHEQ0347        1.000000        -0.8000000
```

The following Work Orders needs to be included in the Corrective-/ Preventive maintenance strategy:

AxSHEQ02664	Production Plant B: Airconditioner 1 Failure
AxSHEQ09866	Routine cleanup: Production Plant 1
AxSHEQ00045	Oil Spill: Lagoon C
AxSHEQ03478	Routine maintenance: Shaft elevator 2

Table 7: Example Data Model Solution

This process can be done for real world situations and can be a valuable asset in any business. A problem statement and solution will be presented to iSoft Technologies for inclusion in the current AxSHEQ package.

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Appendix A: Advanced HSE Solution Development Motivation - Media Releases

Gold Fields: Elevator plummets, killing 9 in mine accident near Johannesburg, South Africa

An elevator plunged 58 meters (90 feet) to the bottom of a South African mining shaft Thursday, killing nine workers, Gold Fields Limited said.

It was the third fatal Gold Fields accident this week.

The elevator had been carrying the miners _ working on South Africa's national labor day holiday _ from one level to another near the bottom of a shaft that reached nearly 3 kilometers (nearly 2 miles), Gold Fields spokesman Andrew Davidson said. No one aboard survived.

Davidson said the accident at South Deep mine, just west of Johannesburg, was under investigation by the government and his company, but that it appeared a rope had failed.

The elevator and rope were "inspected regularly, I understand. That also will be the subject of the inquiry," Davidson said.

Davidson said one person died at the same mine in a rock fall on Tuesday and four people died in a rock fall at another Gold Fields mine Tuesday.

South Africa is home to some of the world's largest gold and platinum producers. More than 200 workers were killed in mining accidents last year here.

Fatal accidents at Driefontein and South Deep gold mines

Johannesburg, 29 April 2008. Gold Fields Limited ("Gold Fields") (NYSE, JSE, DIFX: GFI) deeply regrets to report that four mineworkers were fatally injured in two separate underground accidents at its Driefontein and South Deep gold mines on the West Rand today.

Three employees at Driefontein lost their lives as a result of a fall of ground in a stope 1,900 metres below surface at No 10 Shaft. Two others were injured, one of them seriously, and taken to hospital for treatment. The accident occurred at 8-17am and followed a seismic event of 1.7 magnitude.

In a separate accident a driller's assistant was fatally injured in a fall of ground at South Deep. The accident happened at 10-30am in a development end on 100 level - 2,700 metres below surface of the Twin Shaft complex.

Investigations into both accidents will be carried out by the respective mine management teams as well as the Department of Minerals and Energy. The trade unions were also informed.

The names of the deceased and injured are being withheld until next of kin have been informed.

Vishnu Pillay, head of Gold Fields South African operations, said: "We deeply regret the loss of lives of our colleagues. These accidents have occurred despite considerable efforts to improve management of safety at our operations. We remain committed to our quest of achieving zero harm at all our operations. Safety is still our number one priority."

Gold Fields tests winder ropes at all mines after fatal accident

By: Liezel Hill

Gold miner Gold Fields expected to have completed thorough testing of all the winding ropes at its South African mines by Saturday, the company said on Friday morning.

The Department of Minerals and Energy (DME) issued a directive ordering the safety checks, following an accident on Thursday in which nine people were killed when a cage fell almost 60 m down a shaft at the company's South Deep gold mine.

The accident was believed to have been caused by a snapped cable.

The directive had ordered all winding to be halted at Gold Fields' South Deep, Kloof and Driefontein mines until the integrity of the ropes had been tested, and the company was also testing ropes at its Beatrix mine, in the Free State.

"The safety of our people is paramount...if we cannot mine safely, we will not mine," Gold Fields CEO Nick Holland said in a statement.

Minerals and Energy Minister Buyelwa Sonjica, who has called the accident "unforgiveable", was to visit the South Deep mine on Friday afternoon.

Thursday's accident brought the number of fatalities this week at Gold Fields' operations to 14, after four people were killed after an underground accident at Driefontein on Tuesday, and a driller's assistant was fatally injured in a fall of ground at South Deep on the same day.

Meanwhile, engineering and construction giant Murray & Roberts' CEO Brian Bruce confirmed on Friday that eight of the nine people killed at South Deep on Thurday were employed by the company's contract mining subsidiary, Murray & Roberts Cementation.

"I and my executive team are deeply shocked by this tragedy," Bruce said in a statement.

South Africa's mines, which reported more that 200 fatalities last year, are coming under growing criticism for poor safety records.

Most South African gold- and platinum-miners took a production knock in the December quarter of last year, after the DME began forcing operations to close after fatal accidents, and the country's biggest mining union held an industrywide strike in December.

The strike was held after 3 200 workers were trapped underground at Harmony Gold's Elandsrand mine.

While all the trapped miners were safely brought to surface, the incident attracted international media attention, and prompted President Thabo Mbeki to order a safety audit into the country's mines, which is currently under way.

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4 dead in 2 Gold Fields Ltd. gold mining accidents

NEW YORK - Gold Fields Ltd., a South Africa-based gold-mining company, said Tuesday four workers died in two underground mining accidents.

Three workers died early Tuesday at the Driefontein gold mine in an accident that also left two workers injured one seriously enough to require hospitalization.

Also Tuesday, a fourth worker died in a separate accident at company's the South Deep gold mine.

Victims' names were being withheld until family members could be notified.

Company and government investigations into the accidents are under way.

Shares fell 44 cents, or 3.2 percent, to $13.38.

Appendix B: AxSHEQ Business Model Analysis

Certain business and user requirements have been identified during phase one to assist in a comprehensive implementation of the AxSHEQ ERP module. It is important to note that these business models are vital for a successful ERP implementation and will be responsible for the quality of data input when the HSE system is in full swing. With any ERP system it is always important to remember the following phrase: "garbage in garbage out". The management reports are only as good as the data input quality of the users.

In order to successfully implement AxSHEQ ERP module at a company the following business and user requirements have been identified.

Health and Safety

	Process Name: Corrective Action Plan (CAP)
ID	User Requirements:
1	User can update status of CAP (open/pending/closed)
2	User can enter description of what action is required
3	User can assign a due date for the CAP
4	User can assign CAP to a person
5	User can link a corrective action to an incident, if it is generated from an incident report
6	User can classify what initiated the corrective action
7	System notifies when CAP is assigned to a person
8	System tracks when CAP was first acknowledged by assignee
9	System re-notifies when CAP is about to be due (T-2 weeks)
10	Escalates notification when passed due date
11	System tracks if work order is generated from CAP
12	System is updated when work order is complete
13	User can confirm CAP is complete
14	System date/time/user stamps when CAP is closed
15	User can report on # of Caps Open
16	User can report on # of Caps Closed
17	User can report on # of Caps Due
18	User can report on Monthly Totals
19	User can report on Annual Totals
20	User can sort by department, perosn, location
	Process Name: Incident Reporting
	User Requirements:
21	User can print out a hard copy of an incident investigation form in order to complete it on site
22	User able to print out hard copy of a completed incident report

23	User can enter information collected during incident investigation into the application
24	User can attach photos and other documents to incident investigation record
25	System auto notifies business hierarchy depending on incident
26	User able to initiate a CAP from the investigation incident
27	Each investigation has a unique ID for tracking
28	User able to search on incidents based on Classification of incident
29	User able to search on incidents based on Name of employee
30	User able to search on incidents based on employee position
31	User able to search on incidents based on Type of injury
32	User able to change status of report (Open/Pending/Closed)
33	User able to search on incidents based on Supervisor name
34	User able to generate an incident summary report
35	User able to attach incident reports as an email.
36	User is able to re-open Closed Investigations in order to update both classification and status
37	User permissions can be set to limit who's is able to re-open Closed Investigations
38	User can see who made changes to an incident report - what and when (System provide audit functionality)
	Process Name: WCB Claims
	User Requirements:
39	User can link First Aid file to the incident investigation report (work related first aid)
40	User can read/write/save First Aid report in employee (ER) file
41	User can see company wide list of available "Modified Work" tasks throughout organization for assignment
42	System auto-reminds Safety Department to follow up with employee on Modified Work
43	User can document and save Modified Work follow up reports to ER file
	Process Name: Formal Inspection
	User Requirements:
44	User can retrieve blank inspection form based on type
45	User can save/modify blank inspection form based on type
46	User can print hard copy of inspection form
47	User can scan completed inspection document
48	User can attach meta data/descriptive information to scanned documents
49	User can complete form using remote electronics (i.e. pda)
50	User can reference an inspection documentation from within a CAP
51	User can reference a CAP from an inspection document
	Process Name: Auditing
	User Requirements:
52	User scan and save completed documents
53	User can reference an audit documentation from within a CAP
54	User can reference a CAP from Audit document
55	User can search for and print specific audit documents
	Process Name: Pre-qualification of contractors

	User Requirements:
56	User can retrieve blank qualification form
57	User can save both hard copy and electronic version of complete form
58	User can retrieve completed forms from contractor record in materials management
59	User can see pre-qualified contractors from a single source record
60	User can add/edit/delete contractor from pre-qualified list
	Process Name: Orientation of contractors
	User Requirements:
61	User can save completed quiz and link it to a contractor employee record
62	User can record qualified contractor employee information
63	User can view qualified contractor employee information
64	System automatically changes status of contractor and alerts when contractor orientation is about to expire
	Process Name: Contractor Suspension
	User Requirements:
65	User can link suspension letter to contractor record
66	User can update qualification status to suspended in contractor record
67	User can update qualification status for contractor so all people hiring contractors are aware
	Process Name: Hazard Assessment
	User Requirements:
68	User can print off a hard copy of the form
69	User can scan and save form
70	User can link completed Hazard Assessment form to incident and/or record that triggered assessment
71	User can complete form on a PDA
72	User can enter info into system so that users can search information
	Process Name: Equipment maintenance/repair/calibration
	User Requirements:
73	User can enter new safety equipment into inventory
74	User can track equipment's physical location
75	User can read/write/edit an employees training capabilities in relation to testing equipment
76	User can see when safety equipment training has expired for an employee
77	User can track when equipment was maintained or repaired
78	User can track what equipment was maintained or repaired
79	User can track what was done during equipment maintenance or repaired
80	User can schedule equipment maintenance tasks
	Process Name: Monitoring - Air
	User Requirements:
81	User can schedule monitoring tasks
82	User can access up to day sampling protocols
83	User can access all instructional documentation (manuals) related to testing
84	System alerts user as to when scheduled monitoring tasks are due

85	User can enter initial monitoring data into application
86	User can enter the results returned from lab
87	User can attach documentation returned from lab to monitoring record
88	User can report on trends from monitoring data
89	User can locate equipment in application
	Process Name: Monitoring - Noise
	User Requirements:
90	User can schedule employees for audiometric testing
91	User can see when last test was done/when testing is due for all employees
92	User can locate equipment in application
93	User can create a follow up memo which can be attached to employee record
94	User can save testing result findings as an attachment
95	User can send follow up memo to ER to be attached to employee record
96	User can save testing result findings and forward to ER
	Process Name: Personal Protection Equipment Tracking
	User Requirements:
97	User can attach respirator fit test information (pass/fail) to employee record
98	User can include multiple parameters in fit test information (date/type/expiry etc)
99	User can scan and attach doctors note to employee file
100	User can search for fit test information for employee (type/expiry date/etc..)
	Process Name: Safety Training
	User Requirements:
101	System advises user prior to training expiring
102	System advised of missing training for employees
103	User can attach new training requirements to one or many employees
104	System alerts employee before (T-30 days) training expires
105	System alerts safety department before employee's(T-30 days) training expires
106	System alerts employee supervisor before (T-30 days) employee's training expires
107	User can find employee's immediate supervisor in system
108	User can schedule employee for necessary training
109	User can scan and save signed SPP's to employee file/record
110	User can view/update list of all signed and outstanding SPP's with date if signed
111	All exams are accessible from a single location
112	User can administer exam in an electronic format
113	User can score exam in an electronic format
114	User can record exam results in employee file/record with expiry date
	Process Name: Compliance Management
	User Requirements:
115	User can enter and document applicability of compliance and other requirements (permits, federal and provincial regulations, local agreements, industry standards)
116	User can view a legal registry of legal requirements (permit, letter, provincial, federal)
117	User can assign compliance tasks to roles/positions/persons

118	System auto notifies persons responsible for compliance tasks
119	System performs action tracking, notification and overdue escalation of compliance tasks
120	User can deactivate compliance requirements ("closed") and system retains record
121	User can query database for compliance task completion status
122	User can assign EHS task to a work location
123	User can query database for work location or job function compliance tasks
124	User can prioritize critical compliance tasks
125	User can query compliance requirements by media, regulatory authority, type (permit, work plan, etc.) and status (closed, expired, active)
126	User can identify roles, training, operational procedures and records associated with compliance tasks
127	User can generate reports to communicate compliance requirements, tasks, completion dates and records.
128	User can provide notification of changed compliance requirements to operations personnel
129	User can create EHS management tasks derived from corrective actions, objectives/targets, audit findings, training, external reporting, management review
130	System can link to and display current and authorized procedures, work instructions, forms, checklists, reports, etc.
131	System keeps a complete compliance history
132	System records completed tasks and task-specific comments
133	Users can temporarily assign tasks when task owners go on vacation or are assigned elsewhere
134	User can create report of past instances of EHS task completion records
135	User can enter non-tracked compliance requirements and assign to roles
	Process Name: EHS Performance Tracking
	User Requirements:
136	User can define objectives, targets and implementation plans
137	User can track completion status of actions associated with EHS improvement implementation plans
138	User can display results/progress of specific EHS improvement plans.
	Process Name: EHS Organization and Role Documentation
	User Requirements:
139	User can define an organizational structure for EHS management
140	User can define roles and document responsibilities for EHS management
141	Users can determine if all critical EHS roles are assigned and occupied (accommodates rotational schedules)
142	System allows transfer of critical roles between personnel
143	System has the ability to track changes to personnel status (newly hired, changing position, released, etc.)
144	Users can query the system for documented EHS responsibilities

Table 8: Health & Safety User Requirements

Environment

ID	Process Name: Incidents
	User Requirements:
1	A user can enter incident details in a standard format across all sites
2	System validates entered data
3	Administrator can control/define required fields on form
4	System prompts user to next steps in completing an incident report
5	A user, depending on department/role, can review incident form
6	A user, depending on department/role, can electronically sign off on incident form
7	System notifies EO, GM, LPO Supervisor and relevant superintendent when spill incident form is first entered.
8	A user can add comments to incident form.
9	System creates a time stamp when a new comment is added.
10	After user completes sign off, incident report is automatically sent to next recipient in chain.
11	Administrator can define time parameter between each sign off in chain.
12	System alerts user and immediate supervisor if time parameter is missed.
13	User can attach documents/photos to incident form.
14	User can link a CAP to the incident.
15	User can close incident.
16	User can query incidents based on time/date/location/amount spilled etc
17	User can define custom queries to complete their reporting requirements
	Process Name: Corrections
	User Requirements:
18	User requires permissions to update status of CAP to prevent unauthorized closing of CAP
19	User can query CAP's based on time/date/location/
20	User can define custom queries to complete their reporting requirements
21	User can enter whether a CAP is approved by a 3rd party (i.e. auditor)
	Process Name: Process Audits
	User Requirements:
23	User can locate procedure documents from a central source repository
24	User can search for specific document based on key word or doc id
25	User can print a blank standard process audit form.
26	User can enter written form process audit information into an electronic form.
27	User can specify whether compliance was met
28	User can query non conformances based on frequency, department, or type for reporting purposes
29	User can attach documents and pictures to audit record.
	Process Name: System Audits
	User Requirements:
30	User can enter audit schedule into a shared location for all employees

31	User can see a schedule which contains audit time across all sites
32	System alerts user (EO) to upcoming system tasks
33	EMS manager can see a list of qualified internal auditors and their availability
34	User can locate procedure documents from a central source repository
35	User can print a blank standard internal system audit form.
36	User can enter written form internal system audit information into an electronic form.
37	User can attach documents and pictures to audit record.
38	User can be linked to a single or multiple CAPS.
39	User can change audit form from draft to final status, making the document read only.
40	User can define system audit type (internal/external/corporate compliance)
	Process Name: Inspections
	User Requirements:
41	User can enter inspection schedule into a shared location for qualified users
42	User can view inspection schedule for specific sites
43	System alerts user (EO) to upcoming inspection tasks
44	User can print a blank standard inspection form.
45	User can enter inspection form information electronically.
46	User can attach documents and pictures to inspection record
47	User can specify whether compliance was met or not.
48	User can query non conformances for reporting purposes
49	User can associate a CAP with an inspection
50	System alerts superintendent when non conformance entered in system.
	Process Name: Monitoring
	User Requirements:
51	User can enter inspection schedule into a shared location for qualified users
52	User can view inspection schedule for specific sites
53	System alerts user (EO) to upcoming monitoring tasks
54	User can enter/import lab results into a central data repository
55	Administrator can define compliance ranges for report findings
56	System alerts user when outside of compliance ranges.
	Process Name: Contractor Management
	User Requirements:
57	User can create a Purchase Requisition for contract services
58	User can create and save a pre-work form with contractors signature/sign off
	Process Name: Equipment Mangement
	User Requirements:
59	User can order new equipment
60	User can create and update equipment inventory at individual mine site
61	User can view inventory at their individual mine site.
62	User can see total purchases for a time period to monitor budget.
	Process Name: Reclamation

	User Requirements:
63	User can forecast equipment requirements for 1 - 3 years in advance
64	User can send forecast to mine operations superintendent
65	User can enter purchasing requirements (equipment/contractors/materials) into materials management application
66	User can control rights to planning documentation for other users
67	User can schedule reporting schedule for government and corporate
68	System alerts user to upcoming report deadlines
	Process Name: Waste Management
	User Requirements:
69	System provides users with a searchable data resource to access key waste management information tailored to the user's location, department, and waste stream
70	System provide users with key information such as simple management methods, links to Standard Operating Procedures (SOPs), waste packaging and labelling information, and special instructions
71	User can track waste generation activities and manage compliance according to applicable regulations, including manifesting, real-time monthly generator status displays (web), and custom alerts/reports
72	User can monitor waste characterization and sampling requirements for each waste stream

Table 9: Environmental User Requirements

Appendix C: Solutions from Lingo

```
Global optimal solution found at iteration:                   0
  Objective value:                                    4.300000


                  Variable           Value        Reduced Cost
          RESOURCE_MINUTES        480.0000            0.000000
WORKORDER_INCLUDED( AXSHEQ0056    1.000000           -1.000000
WORKORDER_INCLUDED( AXSHEQ0234    0.000000           -0.6000000
WORKORDER_INCLUDED( AXSHEQ0345    0.000000           -0.3000000
WORKORDER_INCLUDED( AXSHEQ0226    0.000000           -0.4000000
WORKORDER_INCLUDED( AXSHEQ0767    0.000000           -0.8000000
WORKORDER_INCLUDED( AXSHEQ0266    1.000000           -0.5000000
WORKORDER_INCLUDED( AXSHEQ0783    0.000000           -0.2000000
WORKORDER_INCLUDED( AXSHEQ0376    0.000000           -0.6000000
WORKORDER_INCLUDED( AXSHEQ0296    0.000000           -0.5000000
WORKORDER_INCLUDED( AXSHEQ0986    1.000000           -1.000000
WORKORDER_INCLUDED( AXSHEQ0004    1.000000           -1.000000
WORKORDER_INCLUDED( AXSHEQ0347    1.000000           -0.8000000
WORKORDER_INCLUDED( AXSHEQ0245    0.000000           -0.6000000
WORKORDER_INCLUDED( AXSHEQ0211    0.000000           -0.1000000
WORKORDER_INCLUDED( AXSHEQ0460    0.000000           -0.3000000
WORKORDER_DURATION( AXSHEQ0056    100.0000            0.000000
WORKORDER_DURATION( AXSHEQ0234    110.0000            0.000000
WORKORDER_DURATION( AXSHEQ0345    100.0000            0.000000
WORKORDER_DURATION( AXSHEQ0226    120.0000            0.000000
WORKORDER_DURATION( AXSHEQ0767    300.0000            0.000000
WORKORDER_DURATION( AXSHEQ0266    40.00000            0.000000
WORKORDER_DURATION( AXSHEQ0783    120.0000            0.000000
WORKORDER_DURATION( AXSHEQ0376    140.0000            0.000000
WORKORDER_DURATION( AXSHEQ0296    120.0000            0.000000
WORKORDER_DURATION( AXSHEQ0986    50.00000            0.000000
WORKORDER_DURATION( AXSHEQ0004    135.0000            0.000000
WORKORDER_DURATION( AXSHEQ0347    120.0000            0.000000
WORKORDER_DURATION( AXSHEQ0245    210.0000            0.000000
WORKORDER_DURATION( AXSHEQ0211    200.0000            0.000000
WORKORDER_DURATION( AXSHEQ0460    60.00000            0.000000
WORKORDER_URGENCY( AXSHEQ00567    1.000000            0.000000
WORKORDER_URGENCY( AXSHEQ02345    0.6000000           0.000000
WORKORDER_URGENCY( AXSHEQ03455    0.3000000           0.000000
WORKORDER_URGENCY( AXSHEQ02264    0.4000000           0.000000
WORKORDER_URGENCY( AXSHEQ07673    0.8000000           0.000000
WORKORDER_URGENCY( AXSHEQ02664    0.5000000           0.000000
WORKORDER_URGENCY( AXSHEQ07833    0.2000000           0.000000
WORKORDER_URGENCY( AXSHEQ03767    0.6000000           0.000000
WORKORDER_URGENCY( AXSHEQ02965    0.5000000           0.000000
WORKORDER_URGENCY( AXSHEQ09866    1.000000            0.000000
WORKORDER_URGENCY( AXSHEQ00045    1.000000            0.000000
WORKORDER_URGENCY( AXSHEQ03478    0.8000000           0.000000
WORKORDER_URGENCY( AXSHEQ02452    0.6000000           0.000000
WORKORDER_URGENCY( AXSHEQ02111    0.1000000           0.000000
WORKORDER_URGENCY( AXSHEQ04609    0.3000000           0.000000
```

```
Row     Slack or Surplus     Dual Price
 1          4.300000          1.000000
 2          35.00000          0.000000
```