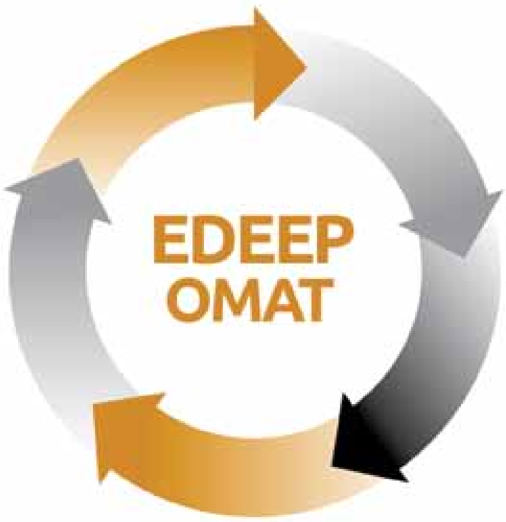
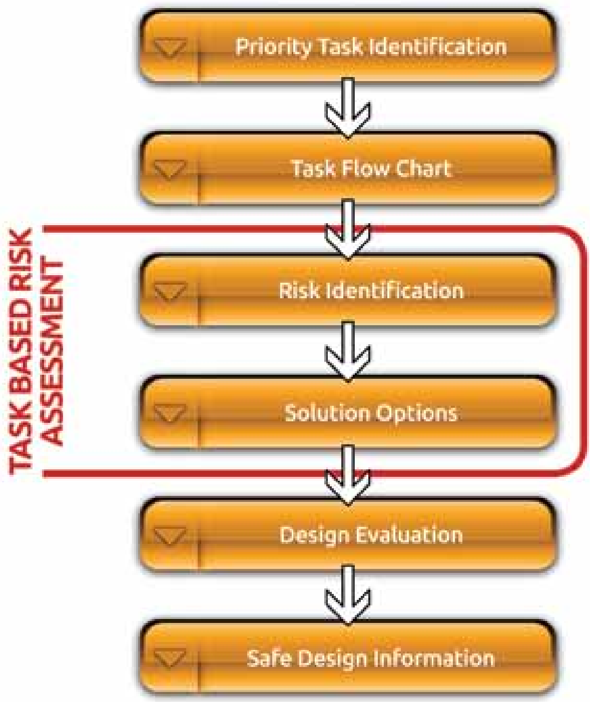
SECTION 4

EMESRT Design OMAT Training Manual





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PREFACE

For many years, the mining industry has suffered globally from equipment–related incidents that have resulted in losses including fatalities. In an effort to meet their workplace safety and health obligations, mining companies have engaged in after-market modifications. However mine sites and companies are not best placed for making such design changes which should ideally happen at the Original Equipment Manufacturer.

Mining companies recognize that Original Equipment Manufacturers have demonstrated improvements in equipment designs, especially when they have understood the operational and maintenance risks from the customer perspective.

This issue evolved in 2005 into a formal global mining initiative, driven by a desire to fill the knowledge gap between customers and equipment designers whilst focusing on new designs where opportunity for major change was not only possible but also more economic. A mining customer – OEM engagement strategy was developed and initial engagement was supported by resources such as Design Philosophies and a 'beyond Standards' analysis method called the Operation and Maintainability Analysis Technique (OMAT).

By 2011, this initiative had expanded to 14 mining companies operating from most major mining jurisdictions around the globe. The design challenges had also expanded from surface haul trucks to all large mining equipment used in surface, underground coal and metal mining, as well as exploration drilling. That year, the mining company representatives also decided to take the next step in the journey of OEM engagement and connect the OEM equipment design process with an EMESRT design evaluation method for use during procurement.

This publication outlines the EMESRT Design Evaluation for Equipment Procurement (EDEEP). The process provides an opportunity for OEMs to demonstrate their application of task-based design review, clearly linking design features to priority issues, demonstrating existing design features and assisting with effective continuous improvement.

Information about EDEEP, supported by a suite of materials including revised Design Philosophies and OMAT training materials, was provided as a draft to seven major OEMs of surface and underground mining equipment during the 2012 EMESRT OEM Tour (February-March, 2012). Feedback was requested, and the final EDEEP information and materials presented here have been modified in the light of feedback received.

On behalf of the 15 members of EMESRT in 2012, we look forward to making the next step change in equipment operability and maintainability improvements through effective customer – OEM engagement.

On behalf of EMESRT members,

Scott Rosenthal
Senior Director Mine Engineering
Newmont

Tony Egan
Manager Business Development & Special Projects
Xstrata Coal

Alan Miskin
General Manager Safety & Health
Peabody Energy Australia (formerly BHPB)

Vice President Safety, Health and Risk
Barrick Gold

DESIGN OPERABILITY AND MAINTAINABILITY ANALYSIS TECHNIQUE DESIGN OMAT

PROCESS AND SKILL DEVELOPMENT MANUAL

VERSION #4 SEPTEMBER 2012

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SECTION ONE:

INTRODUCTION TO THE OMAT MANUAL

‘Time is the dominant factor in gambling. Risk and time are opposite sides of the same coin, for if there were no tomorrow there would be no risk. Time transforms risk and the nature of risk is shaped by the time horizon: the future is the playing field.’

(Bernstein, 1996: 15)

THE EARTH-MOVING EQUIPMENT SAFETY ROUNDTABLE (EMESRT)

Mine operators have a legal obligation to ensure, so far as is reasonably practicable, that equipment provided for use on a mine site is without risks to the health and safety of people. Equipment designers have similar obligations. The United States agency – the Mine Safety and Health Administration (MSHA) – identified that, based on mining fatality information from 1995 through to 2005, the proportion of total mine fatalities with causes related to equipment ranged from 37% to 88% per year. In the Australian context, 'Of the 210 workplace fatalities [between 1997-2002], 77 (37%) definitely or probably had design related issues involved' (Commonwealth of Australia, 2006a: 6).

Adverse consequences arising from unwanted events such as collisions with light vehicles, isolation problems, falls from height, loss of control and problems such as fatigue, heat, noise and dust implicate poor risk management and human factors design issues. Improved risk management and human factors design practices are essential to eliminating or mitigating these risks.

In 2004 it was suggested that mining companies adopt a joint customer approach to improve their risk management practices by raising the profile of human factors knowledge in the design of heavy earth-moving equipment. In March 2006, the first meeting to discuss this new multi-company initiative took place in Australia, involving representatives from Xstrata Coal, BHP Billiton, Anglo Coal and the Minerals Industry Safety and Health Centre (MISHC) at The University of Queensland in Brisbane.

The Earth-Moving Equipment Safety Round Table (EMESRT) was formally established later that year by a group of these major global mining companies and they immediately took initial steps towards establishing a process of engagement with Original Equipment Manufacturers (OEMs) of earth-moving equipment. This joint customer idea has gradually gathered momentum.

Subsequently, the broad purpose of EMESRT was established. A major outcome of EMESRT has been to develop the Design Operability and Maintainability Analysis Technique, or Design OMAT – which aims to minimise safety and health risks by accelerating the development and adoption of improved equipment designs.

This risk assessment method can be used by designers within OEMs to become more aware of ergonomic and human factors risk management issues when designing heavy earth-moving equipment for mining companies. And in becoming more aware of ergonomics and human factors perspectives, designers can be more proactive in incorporating these ideas into their designs. The outcomes of the task based risk assessment also provides information for including in the Safe Design Information required by the EMESRT Design Evaluation for Equipment Procurement process.

ORIGINAL EQUIPMENT MANUFACTURERS (OEMS)

EMESRT has met with leading global OEMs each year since 2006. Further OEM engagement continues through 2012 and beyond. The current focus of EMESRT is to work with OEMs to develop a clear picture of the equipment's ability to address the priority design issues, culminating in an OEM design specific response to the new EMESRT Design Evaluation for EME Procurement (EDEEP) intended for use by all EMESRT member companies and sites when purchasing new equipment.

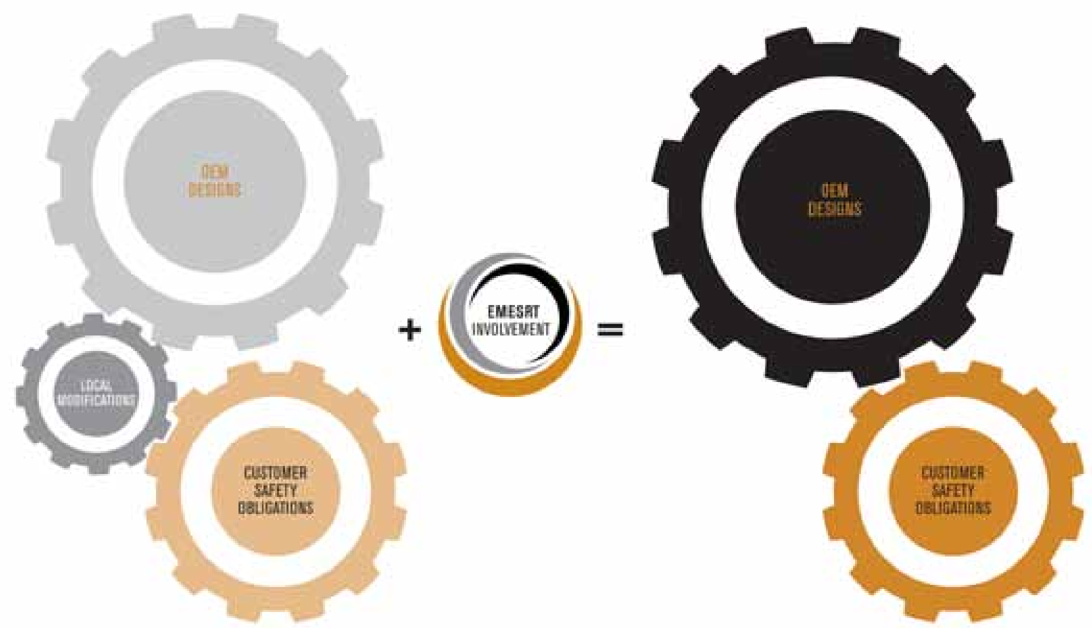
Indeed, the EDEEP might be one of the most important outcomes of the Design OMAT process. It is where the ergonomics/human factors, safety and health issues endemic to this heavy-duty earth-moving equipment will be addressed in a systematic way, by both the mining industry and the OEMs.

In 2012, membership of EMESRT comprises Anglo American, Barrick, BHP Billiton, Centennial Coal, Cliffs Natural Resources, Collahuasi, Newcrest, Newmont, Peabody, Rio Tinto, Sasol, Suncor, Syncrude, Vale and Xstrata ... with the potential for future expansion.

JKTech Pty Ltd and the MISHC, both University of Queensland organisations, actively support this innovative engagement process.

THE EQUIPMENT DESIGN VACUUM

EMESRT member companies believe that, despite the fact that mining equipment is generally designed to recognised national and international standards, aspects of equipment design often fails to meet customer requirements for fulfil their obligations to provide equipment for use on site which is, as far as reasonably practicable, without risk to safety and health of persons who operate and maintain the equipment. This has created a gap or 'design vacuum' between OEM designs and customer needs.



Over time, dealers have attempted to fill this vacuum by retrofitting customer driven solutions, which in turn have created new risk management/human factors issues. Redesign is not core business for most dealers or mining companies, who often lack appropriate design and production resources. The need for redesign also creates a long lead-time for users, resulting in higher procurement costs to mining companies. EMESRT was established as a mining industry project to address this gap.

EMESRT VISION

A mining industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining heavy-duty mining equipment.

EMESRT PURPOSE

To achieve the Vision, EMESRT will accelerate the development and consolidate the adoption of leading practice designs for mining equipment to minimise the risks to health and safety through a process of OEM and user engagement using the Design OMAT method as the structure for this interaction.

EMESRT STRATEGY

EMESRT has initiated an engagement process aimed at establishing an effective relationship between its members and the OEMs. The members have also agreed to work towards educating their own user mines about EMESRT aims and resources, as well as encouraging the use of a standardised requirement for safe design information for evaluation during equipment procurement.

THE DESIGN PHILOSOPHIES

The first stage of the EMESRT engagement process was the construction of the Design Philosophies (DPs). Within the Design OMAT process, DPs are a means of aligning various hazards (such as equipment access and egress, working at heights, dust, tires and rims, fire, isolation of energy, guarding, hydraulics, visibility, machine stability, manual handling, confined spaces, vibration, noise, controls and displays, operator workstation), by putting them into appropriately similar categories.

DPs present an aligned viewpoint on objectives, general design outcomes and the risks to be mitigated in a particular hazard category. The aim of the DPs is to provide information to help OEMs design equipment with the risk of unwanted events reduced to an acceptable level (ALARP), including consideration for foreseeable human error. They have been developed as single page sheets of information, supported by images aiming to illustrate an example of the issue presenting the risk or the human factor involved.

The original DPs developed in 2007/8 addressed fifteen topics. EMESRT champions used company and other resources to enhance the accuracy and validity of each selected topic. MISHC assisted with gathering input on design requirements, reviewing related ISO standards, and sourcing information about events or incidents related to the relevant DP.

These initial fifteen topics have now been consolidated into eight.

The 'risks to be mitigated' section of the DPs - now called 'Potential Unwanted Events' (PUEs) outline the significant and common equipment risks that are evident in the experience of the mining companies. Each statement has a corresponding image. The PUEs for each DP will serve as the areas of concern to be assessed when completing the Design OMAT. You will find a list of the current DP topics outlined in section 5 of this manual. Indeed, it is a good idea to pull the DPs out of section 5 of this folder so that they are easily accessible during the Design OMAT process because they will be frequently referred to.

Before we go into detail on the Design OMAT process, it is important that team members are familiar with the basic principles of both Minerals Industry Risk Management and Human Factors Engineering. Sections 3 and 4 of this manual will deal with these topics. If you are already familiar with these topics these two sections can be skipped over. However, it is sometimes a good idea to review these basics even if you are already familiar with them. Each team member will then be equally familiar with the subject matter and the Design OMAT process can proceed on this basis.

SECTION TWO:

FACILITATOR'S GUIDE

INTRODUCTION

This section contains advice for Facilitators of Design OMAT workshops. Ideally, the OEM in which the training is taking place will already employ the person conducting it. Even better, this person should be knowledgeable about minerals industry risk management and human factors engineering processes, which might suggest a Safety Officer, or the like, would be best placed to facilitate the workshop. If, however, this is not the case they should, at a minimum, be conversant with the content of Sections Three and Four of this manual, which provides a basic introduction to the Minerals Industry Risk Management tools and definitions and the basics of human factors engineering.

It is important to keep in mind that this manual is a guide, or better still, a roadmap of the Design OMAT process. When it comes to the variabilities of particular companies, the actual context of delivery, and the specific participants of the workshop itself, facilitators should use their common sense and adjust the actual delivery pattern as necessary. Learning is itself a highly variable activity and the Design OMAT process is no different in this respect.

BEFORE THE WORKSHOP BEGINS

If you are to facilitate this workshop you should first ensure that you have read and understood the scope and intention of this manual. It is more important that you are an active learner of this material rather an unwilling participant. If you are a reluctant facilitator this will shine through in the delivery. It is important to have more than an introductory familiarity with, firstly, the Minerals Industry Risk Management framework, and secondly, Human Factors Engineering. With these frames of knowledge in hand, the Design OMAT method should prove relatively straightforward. These two sections should be studied in the period immediately leading up to the workshop. There are additional readings in the Resources List at the end of this manual should facilitators want to delve deeper into the subject matter.

Before the day of the workshop you will need to book the space and arrange for the support materials (and any IT or secretarial support personnel) to be on hand as necessary. It would also be beneficial to have at least two Internet connected computers on hand in the training room. This will allow team members to gather potential online resources for the Design OMAT process, including downloading text and images from the Web and from workshop cameras as necessary.

It is strongly recommend that you arrive at least one hour before the start of the workshop, particularly on the first day. Double check that all the technology is working, including computers and peripherals, chairs, tables, lights, any name-tags are displayed as appropriate. Food and refreshments should be finalised and the doors are opened for participants to quickly locate their destination.

Equally important to checking the technology is creating a warm social ambience in the learning environment. We suggest you shake hands with each participant as they come into the room and if you don't already know them introduce yourself.

This simple act helps breaks the ice and sets up a welcoming atmosphere that is conducive to good learning.

Ensure there is a slide displayed at the front of the room with the following information on it:

- Name of Workshop
- Facilitated by (Your Name)
- Your Organisation's Name
- Date & Location

After the workshop begins, a slide displaying the timetable/schedule for the two days should be viewable by participants. After introductory pleasantries are finalised, this timetable/schedule should be gone through in detail.

THE TRAINING METHOD

To keep learners mentally active, the Facilitator must do the following:

1. Ask open-ended questions, where applicable, and question learners before providing information.
2. Allow learners to generate their own ideas before presenting the answers.
3. Allow for reflection and revision of key learning points.
4. Encourage learners to:
   - set personal targets,
   - consider the purpose of everything they learn,
   - look at issues from different viewpoints, and
   - consider all the possible associated problems.
5. Using the learners' experiences, ask them to:
   - relate what they are learning to past and present experiences, and
   - find examples in their personal lives that relate to subject matter.
6. Use appropriate teaching and learning media.

ADDITIONAL RESOURCES

Ensure you have the following resources on hand in the workshop space:

- A photocopier (with paper) to make duplicates of the learning exercises
- Pencils and eraser
- A video camera and a digital camera
- A computer connected to the cameras & tripod (if necessary)

FACILITATOR PREPARATION FOR A DESIGN OMAT WORKSHOP

The Facilitator/Train the Facilitator should consider the following in terms of planning and preparing to run the workshops:

Begin to familiarise yourself with the learning content – you can make notes in the manual to assist you during presentation of the workshop.

One month before the time:

Make arrangements for the course where required, for example:

- Confirming venue/accommodation/travel arrangements, where required.
- Coffee break and lunch break arrangements.
- Confirming learner course attendance, and other arrangements, where required.

One week before the time:

Prepare yourself and troubleshoot course, for example:

- Study the different learning outcomes and activities as outlined in the Facilitator Guide.
- Familiarise yourself with the learning content – you can make notes in the manual to assist you during presentation of the workshop.
- Conduct a site visit.
- Conduct a dry run of your workshop with all the necessary elements (equipment, visuals, training aids/tools, etc).
- Consider the best grouping and placing together of learners from different divisions to achieve maximum interaction.
- Adapt the Facilitator Guide to the learners that are expected to attend the course – consider their specific working environment, level of literacy, etc.

One day before the time:

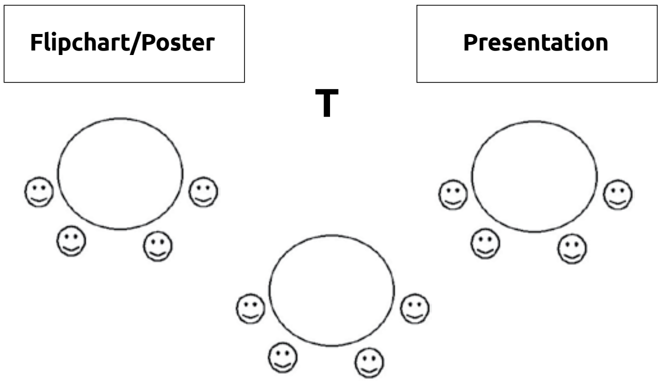
Prepare the training area by:

- Checking the room and setting up equipment – make sure that the layout is suitable and that all equipment is in working condition.
- Setting up flipcharts or other visual materials.
- Checking additional materials and handouts, example name tags, pens, Prestik, flipchart paper required for use by groups, etc.
- Setting out participant reference guides, workbooks, etc.
- Making sure you are familiar with the layout of the classroom.

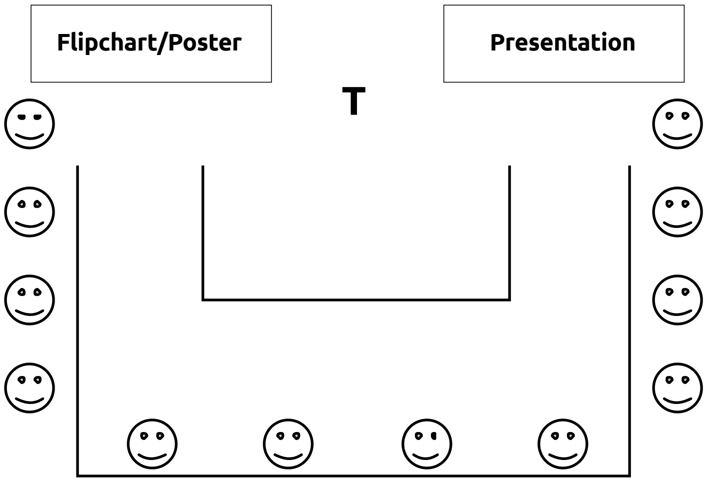
IDEAL CLASSROOM LAYOUT

The following types of layout will ensure that participants are able to participate in the group activities, as well as interact optimally with the Facilitator.

Group participants at round tables (preferred):



Group participants in U-shape (This may require participants to 'break away' to a pause area or other venue to complete activities):



Suggestions

- Keep working teams small (5 – 7 is ideal)
- Have a person with the role of facilitator leading the team through the programme and processes
- Use field observations to understand tasks, ideally with an operator demonstrating the task

PRESENTATION GUIDELINES

Learners will learn best if they are ***actively involved*** in the learning process. Make use of the following guidelines to involve the learner:

Provide a format that is easily understood by the learner:

- Explain the contents covered and the estimated duration of the course.
- Outline all the outcomes.
- Explain to learners what is expected of them during various stages and activities of the course.
- Indicate to the learners what material they need to memorise.
- Provide a summary/ponder at the end of each module.

Keep learners mentally active:

- Ask open-ended questions.
- Allow learners to generate their own ideas, comparing this with suggested answers.
- Brainstorm the different subjects before giving information.
- Ask questions using words such as:
  Identify, List, Describe, Define, Match, Name, Relate, State, and Summarise.

Allow for individual differences:

- Provide different media (paper, slides, graphics, and pictures).
- Provide slow and fast routes through the material.

Use learners' past or present experiences:

- Ask learners to relate what they are learning to past and present experiences.
- Ask learners to find examples in their own lives that relate to what they are learning.
- Provide learners with a range of everyday examples.

Provide a measure of learning:

- Set self-assessment questions – learners give an answer before checking with the one provided.
- Provide feedback on the answers that other learners have given – it will give the learners time to compare them with their own responses.

Provide support to all the learners.

AGENDA AND SESSION PLANNING

Welcome Learners	Welcome learners and introduce yourself as the Facilitator for the DESIGN OMAT Safety Risk Management Course. Thank learners for attending.	1. Briefly inform learners of your credentials and company background. 2. Thank learners for attending and assure them that you are there to help them understand the critical aspects of health and safety risk management as it applies to their workplace. 3. Encourage learners to make the most of this opportunity to ask questions, make suggestions, share ideas, etc. to benefit the class.
Admin. Announcements	1. Explain actions in event of fire/ emergency. 2. Review housekeeping rules. 3. Explain the 'smoking' policy. 4. Indicate where restrooms are. 5. Explain when/where refreshments are provided. 6. Review the programme. 7. Give an overview of the workshop and what it entails. 8. Request that any cellphones be switched off (or silenced). 9. Call for questions.	Familiarise yourself with the dos and don'ts of the training facility. Refer to the Workshop Programme to discuss the agenda for the day. Provide a brief outline of the workshop, explaining the different learning outcomes that will be covered and what they will learn. Explain the methodology, tools and props that will be used throughout the workshop. Make any additional announcements necessary to reduce interference and delays during the workshop. Explain how to get to the assembly point for roll call. Dos and don'ts in the event of an emergency. First aid. Fire equipment.
Overview of workshop	Work through info on slides	Work through the following points with the learners: • Workshop outline. • Assessment. • Workshop agenda. • The models and concepts we are going to cover over the course. • Emphasise that, although the word 'safety' is used in many contexts, this means 'safety and health'. Thus, always think of health risks whenever you are thinking of safety risks.

TIMETABLE OF ACTIVITIES

This workshop is designed to be conducted over two days. Below is a suggested timetable for these two days. A flyer with a short abstract of the workshop (with accompanying EMESRT graphics) and the timetable should be made available in advance to potential participants.

DAY ONE **[example only]**

8:30-9.00	Coffee/Tea & Team Introductions
9:00-9.30	Introductions, EMESRT Overview, Safety Share
9:30-10:00	Introduction to Minerals Industry Risk Management
10:00-10:30	Human Factors Engineering
10:30-11:00	Morning Tea Break
11:00-12:30	Introduction to the Priority Task Identification (CTI) OR the Task-Based Risk Assessment (TBRA) method (whichever is relevant)
12:30-1:30	Lunch
1:00-4:15	For PTI – listing of tasks and Risk Scoring of each task considering DP-based prompts For TBRA – Task Flow Charting
4:15-4:30	Day One Workshop Wrap-Up

DAY TWO

8:30-8:45	Coffee/Tea & Review of day One work
8:45-10:00	For PTI – Continued Risk Scoring of each task For TBRA – Identification of Potential Unwanted Events (PUEs) and Risk Scores
10:00-10:15	Break
10:15-12:00	For PTI – Continued Risk Scoring of each task For TBRA – Identification and evaluation of Existing Design Features
12:00-1:00	Lunch
1:15-4:15	For PTI – Identification of the Critical Tasks for TBRAs For TBRA – Identification of Suggested New Design Features
4:15-4:30	Workshop Wrap-Up

SECTION THREE:

MINERALS INDUSTRY RISK MANAGEMENT

'A system accident… must have multiple failures, and they are likely to be in independent units or subsystems. But system accidents, as with all accidents, start with a component failure, most commonly with the failure of a part; say a valve or an operator error. It is not the source of the accident that distinguishes the two types [component and system accidents], it is the presence or not of multiple failures that interact in unanticipated ways.'

(Perrow, 1999: 71, original emphasis)

INTRODUCTION

In complex high technology and tightly coupled systems like the mining industry, blame for accidents has often fallen to the one person that Charles Perrow called the 'first-party victim' (Perrow, 1999: 67), that is, the operator of the equipment or the worker/s on the frontline engaged in a given task, usually on equipment associated with the accident. This is the classic 'human error' argument. However, it is increasingly recognised that most accidents, if not all incidents, are the result of a series of interacting forces in roughly mutual 'co-operation' in any given system. Simultaneously, a 'whole-of-system' understanding is largely imperceptible to those who individually manage and perform specific tasks that keep that same system working co-operatively.

The objective of risk management is to articulate these explicit and implicit forces and to qualitatively, and quantitatively, evaluate them in terms of how they might contribute to both small-scale incidents and large-scale accidents. Knowing what the risks are, from a micro, meso and a macro perspective, is the first step in successfully managing those risks.

It is important to know the basics of the risk management framework when designing equipment for the mining industry. Largely because design is often one of those factors that remains implicit, and thus potentially invisible to a risk management understanding, it is important to make the latter's processes and assumptions explicit. Design can sometimes be an unexamined factor in any given incident or accident. If we remember that in complex systems, all components can be tightly and/or loosely coupled (Perrow, 1999: 89–93), design constitutes a feature of the latter coupling. Equipment design (that is, the way a piece of equipment is conceived cognitively by the designer), has a significant influence on the health and safety of those who operate and maintain it.

A BASIC EXAMPLE: THE HAND-HELD HAIR DRYER

There are many examples of this relationship between a good human factors design emphasis and health and safety outcomes. One well-known example is the hand-held hair dryer. In the early 1980s, there was an average of 18 electrocutions each year involving hand-held hair dryers. Most of these deaths occurred when the hair dryer fell, or was pulled, into a bathtub of water. From 1990 through 1992, there was an average of only four electrocutions a year associated with hair care equipment.

How did this decrease, from an average of 18 deaths a year to an average of 4 deaths a year, come about?

Recommendations by the Consumer Product Safety Commission (CPSC) in the USA to improve the Underwriters Laboratories (UL) standard for hair dryers made a substantial impact.

- By March 1980, products were required to have a pictorial warning against the use of hair dryers in bathtubs included in the Use and Care Instructions and on a label permanently attached to the cord.
- On May 1, 1985, hair dryers were required to have a polarized attachment plug and to include literature about the need to install ground fault circuit interrupters (GFCIs) in bathrooms.
- In October 1987, hair dryers were required to provide protection against electrocutions when the product was immersed in water with the switch off.
- Research by CPSC staff on the behaviour of small children led to further CPSC recommendations to UL that protection be required in both the 'on' and 'off' positions. This requirement became effective on January 1, 1991. It was estimated that with protection only in the 'off' position, about 8 deaths per year of children under 10 would continue to occur.
- With protection extended to the 'on' position, the average number of deaths for 1990-1992 dropped to four per year and in 1992 there were only two electrocution deaths involving hair dryers.
- Around the year 2000, CPSC expected no electrocutions due to hair dryer immersions when all the older, less safe hair dryers were replaced by the newer, complying models. The ability to provide complete protection for hand-held hair dryers was the direct result of CPSC research into miniaturised GFCIs that demonstrated the feasibility of building electrocution protection into these products.
- A leading manufacturer further developed the technology so that now all hand-held hair dryers are completely protected using an inexpensive component.

This is an example of the success that can be achieved through government, industry and voluntary standards organisations working together to prevent deaths and injuries.

(Source: http://www.cpsc.gov/cpscpub/pubs/success/dryers.html).

The re-design of the hand-held hair dryer is an excellent example of an effective risk management framework in operation. The simplest way to become accustomed with the risk management framework then is, firstly, to set out each of its steps, and secondly, provide a list of the terms it uses and their definitions, and finally, to point to some of its benefits.

Often, the terms used in risk management are ones that we use everyday. Take, for instance, consequence. However, the way these terms are used in risk management gives them a unique meaning. The following process, along with the terms and their definition, is based largely on the international standard in risk management – ISO/FDIS 31000:2009 – in the setting of this, Australia has led the world because the ISO standard used the AS/NZS 4360 as its starting point. Regardless of whether or not you are familiar with the language of risk management, it is useful to acknowledge and review this process (and the definitions) because it will greatly assist in completing the exercise in constructing a risk context statement of a potential company you are designing equipment for.

THE RISK MANAGEMENT PROCESS

Before listing the definitions, we will first provide a macro view of the risk management process. Figure 1 below provides an illustration of how the risk management process proceeds. ISO/FDIS 31000:2009 outlines seven stages in this process:

1. Establish the context

2. Identify the risks

3. Analyse risks

4. Evaluate risks

5. Treat risks

6. Communicate and Consult

7. Monitor and Review

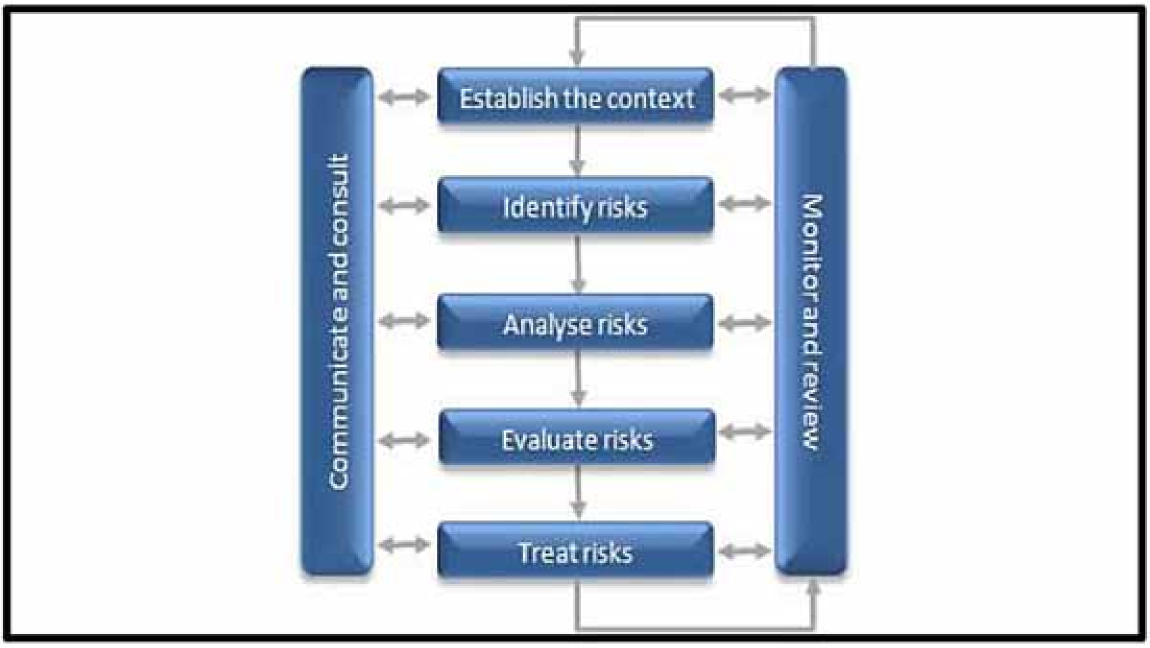


Figure 1: A Flow Chart of the Risk Management Process

While the first five steps are usually conducted in sequence, the final two are iterative, i.e. they continually appear and reappear in, and through, all the above steps as a constant feature of the entire risk management process.

It is important, then, that we are at least familiar with a basic outline of each step as set out by ISO/FDIS 31000:2009:

1. **Establish the Context:** Establish the external, internal and risk management context in which the rest of the OMAT process will take place. Criteria against which risks will be evaluated should be established and the structure of the analysis defined. The resources required, specific responsibilities and authorities, and the records to be kept, can also be specified.

2. **Identify Risks:** This stage identifies the source/s of risk associated with particular hazard/s. To identify risk effectively any potential hazard must be identified and understood before considering the potential unwanted event (or series of events) that might emerge from a given hazard. The aim of this step is to generate a comprehensive list of potential unwanted events based on those hazards that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives. Comprehensive identification is critical, because an event that is not identified at this early stage will not be included in any further analysis.

3. **Analyse Risks:** Risk analysis involves developing a contextual consideration of the causes and sources of potential unwanted events, their positive and negative consequences, and the likelihood that those consequences can occur. It involves identifying and evaluating existing controls (their effectiveness and efficiency) and determining consequences and their likelihood and other attributes of risk. An event can have multiple consequences and can affect multiple objectives.

   Risk analysis can be undertaken with varying degrees of detail, depending on the purpose of the analysis and the information, data and resources available. Analysis can be qualitative, semi-quantitative or quantitative, or a combination of these, depending on the circumstances.

4. **Evaluate Risks:** Evaluation compares estimated levels of risk established in the Risk Analysis step against any pre-established criteria (as outlined in Establishing the Context step) and considers the balance between potential benefits and adverse outcomes. This enables decisions to be made about the extent and nature of the treatments required, about priorities and potential additional controls to reduce unacceptable risk.

   Decisions here should take account of the wider context of the risk and include consideration of the tolerance of the risks borne by parties, other than the organisation, that benefit from the risk. Decisions should be made in accordance with legal, regulatory and other requirements.

5. **Treat Risks:** This step involves selecting options for modifying established risks and implementing those options. Once implemented, treatments provide or modify the controls. Risk treatment involves a cyclical process of:
   – assessing a risk treatment
   – deciding whether residual risk levels are tolerable
   – if not tolerable, generating a new risk treatment and
   – assessing the effectiveness of this new treatment.

Selecting the most appropriate risk treatment options involves balancing the costs and efforts of implementation against the benefits derived, with regard to legal, regulatory, and other requirements such as social responsibility and the protection of the natural environment.

The risk treatment plan should clearly identify the priority order in which individual risk treatments should be implemented.

6. **Communicate and Consult:** Communication and consultation with internal and external stakeholders should take place as appropriate during each stage of the risk management process and concerning the process as a whole.

7. **Monitor and Review:** It is necessary to monitor and review the effectiveness of all steps in the risk management process on an ongoing basis. This is important for continuous improvement. Risk and the effectiveness of treatment measures (or controls) need to be monitored to ensure changing circumstances do not alter priorities. The results of monitoring and review should be recorded and reported as appropriate and should also be used as an input to any review of the risk management framework itself.

   Monitoring and review acknowledges the fact that as external and internal events occur, context and knowledge change, hazards change, controls change, new risks emerge, existing risks may alter, while others disappear. Therefore, risk management continually senses and responds to change, which also suggests that monitoring and reviewing is part of the change management process.

Risk management can be applied to just about every human-related activity, process and technology. Mostly, we assess risk in an unconscious or semi conscious way. Through the OMAT process it is possible to systematically articulate, understand, evaluate and take action on the risks associated with designing earth moving equipment in mining contexts.

RISK MANAGEMENT DEFINITIONS

It is now time to turn to defining the terms used in a risk management framework. These terms are listed in alphabetical order and words in **bold** have their own definition:

Consequence: The outcome or impact of an **event** affecting objectives.

NOTE 1: An event can lead to a range of consequences.

NOTE 2: A consequence can be certain or uncertain and can have positive or negative effects on objectives.

NOTE 3: Consequences can be expressed qualitatively or quantitatively.

NOTE 4: Initial consequences can escalate through knock-on effects.

Control: Any measure that is modifying or mitigating a **risk**.

NOTE 1: Controls include any process, policy, device, practice, or other actions that modify risk.

NOTE 2: Controls may not always exert the intended or assumed modifying or mitigating effect.

Control Assessment: Systematic review of processes to ensure that **controls** are still affective and appropriate.

NOTE: Periodic line management review of controls is often called 'control self -assessment'.

Event: Occurrence or change of a particular set of circumstances.

NOTE 1: An event can be one or more occurrences, and can have several causes.

NOTE 2: An event can consist of something not happening.

NOTE 3: An event can sometimes be referred to an as 'incident' or 'accident'.

NOTE 4: An event without consequences can also be referred to as a 'near miss', 'incident', 'near hit', or a 'close call'.

Frequency: A measure of the number of occurrences per unit of time.

Hazard: A source of potential harm.

Likelihood: The chance of something happening.

Loss: Any negative **consequence** or adverse effect, financial or otherwise.

Monitor: Continual checking, supervising, critically observing or measuring the progress of an activity, action or system on a regular basis to identify change from the performance level required or expected.

Organisation: Group of people and facilities with an arrangement of responsibilities, authorities and relationships. Examples include: company, corporation, firm, enterprise, institution, charity, sole trader, association, or parts or combination thereof.

NOTE 1: The arrangement is generally orderly.

NOTE 2: An organisation can be public or private.

Probability: The extent to which an event is likely to occur.

NOTE 1: **'Frequency'** or **'likelihood'** rather than 'probability' may be used in describing **risk**.

Residual Risk: The **risk** remaining after the implementation of **risk treatment**.

Risk: The effect of uncertainty on objectives.

NOTE 1: An effect is a deviation from the expected – positive and/or negative.

NOTE 2: Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organisation-wide, project, product and process).

NOTE 3: Risk is often characterised by reference to potential **events** and **consequences**, or a combination
of these.

NOTE 4: **Risk** is often expressed in terms of a combination of the **consequences** of an event (including changes in circumstances) and its associated **likelihood** of occurrence.

NOTE 5: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of an **event**, its **consequences** or **likelihood**.

Risk Analysis: A systematic process to comprehend the nature of **risk** and to determine the level of **risk**.

NOTE 1: Risk analysis provides the basis for **risk evaluation** and decisions about **risk treatment**.

NOTE 2: Risk analysis includes risk estimation.

Risk Assessment: The overall process of **risk identification**, **risk analysis** and **risk evaluation**.

Risk Aversion: A decision to turn away from **risk**.

Risk Criteria: Terms of reference by which the significance of **risk** is assessed.

NOTE: Risk criteria can include associated costs and benefits, legal and statutory requirements, socioeconomic and environmental aspects, the concerns of **stakeholders**, priorities and other inputs to the assessment.

Risk Evaluation: Process of comparing the level of **risk** against **risk criteria**.

NOTE: Risk evaluation assists in decisions about **risk treatment**.

Risk Identification: The process of finding, recognising and describing **risks**.

NOTE: Risk identification involves the identification of risk sources, **events**, and their causes and their potential **consequences**. Risk identification can involve historical data, theoretical analysis, informed and expert opinions, and **stakeholder's** needs

Risk Management: Coordinated activities to direct and control an organisation with regard to **risk**.

Risk Management Process: The systematic application of management policies, procedures and practices to the task of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring and reviewing **risk**.

Risk Management Framework: Set of components that provide the foundations and organisational arrangements for designing, implementing, **monitoring**, **reviewing** and continually improving **risk management** throughout the organisation.

NOTE 1: The foundations include the policy, objectives, mandate and commitment to manage **risk**.

NOTE 2: The organisational arrangements include plans, relationships, accountabilities, resources, processes, and activities.

NOTE 3: The risk management is embedded within the organisation's overall strategic and operational policies and practices.

Risk Reduction: Actions taken to lessen the **likelihood**, negative **consequences**, or both, associated with a **risk**.

Risk Retention: Acceptance of the burden of loss, or benefit of gain, from a particular **risk**.

NOTE 1: Risk retention includes the acceptance of risks that have not been identified.

NOTE 2: The level of **risk** retained may depend on **risk criteria**.

Risk Sharing: Sharing with another party the burden of loss, or benefit of gain from a particular **risk**.

NOTE 1: Legal or statutory requirements can limit, prohibit or mandate the sharing of some **risks**.

NOTE 2: Risk sharing can be carried out through insurance or other agreements.

NOTE 3: Risk sharing can create new risks or modify an existing risk.

Risk Source: An element which alone or in combination has the intrinsic potential to give rise to **risk**.

NOTE 1: A risk source can be tangible or intangible.

Risk Treatment: Process of selection and implementation of measures to modify **risk**.

NOTE 1: Risk treatment can involve:

- avoiding the risk by deciding not to start or continue with the activity that gives rise to the **risk**;
- taking or increasing **risk** to pursue an opportunity;
- removing the risk source;
- changing the **likelihood**;
- changing the **consequences**;
- sharing the risk with another party or parties (including contracts and risk financing); and
- retaining the **risk** by informed choice.

NOTE 2: Risk treatments that deal with negative consequences are sometimes referred to as 'risk mitigation', 'risk elimination', 'risk prevention' and 'risk reduction'.

NOTE 3: Risk treatment can create new risks or modify existing risks.

Stakeholders: Those people, organisations and interested parties who may affect, be affected by, or perceive themselves to be affected by a decision, activity or **risk**.

NOTE: A decision maker can also be a stakeholder.

These are the basic terms used when discussing the risk management process, so it is important that the team is familiar with them and that each team member uses them in the way they are defined in the Standards on the subject.

An integrated risk management process in any given context or company has many advantages. It provides specific tools and techniques for improving outcomes, actualising the company as a learning organisation, enhancing a climate of continuous improvement and constant innovation, provides for fewer surprises, improves company reputation, contributes to the health and safety of employees and others and, above all, of dealing more proactively with uncertainty and potentially adverse events.

As a risk management tool, the OMAT process provides a particular sequence of techniques to systematically address many of these issues.

LEARNING ACTIVITY #1: THE RISK CONTEXT STATEMENT

As already suggested, a common starting point in risk management is to outline the context in which the risks are to be managed. In this instance, context is the actual place in which the constantly iterative trio at the heart of the Design OMAT process – **equipment/person/task** – is located.

Writing a Risk Context Statement is a good way to develop a deeper understanding of the systemic conditions of the **equipment/person/task** interface and thus of the workings of risk management more generally.

To begin the exercise, first select a mining company that uses a representative sample of a piece of equipment the team is familiar with. If necessary, the Internet can be used to gather resources to complete the exercise. The team now have a hypothetical piece of equipment in use in its context. Later, in looking at user-centred design, we look more closely at the user and finally in the OMAT process itself we examine the task/s associated with a particular machine.

In this exercise, the context dealt with is the actual (or potential) mine-site in which the proposed piece of equipment will be operated. A Risk Context Statement is largely about the macro influences operating in a given context; it provides the broad picture which the finer details of the Design OMAT process will later fill out.

The Risk Context Statement is broken down into two categories: the **Internal Context** and the **External Context**:

1.The Internal Context

What are the name, address and contact details of the company that owns the mine site where the equipment is to be used?

Who are the actual people responsible (and their roles) for the equipment's procurement?

What kind of corporate culture exists within this company, especially its occupational health and safety record?

How would you physically, and mentally, characterise the people who will operate the purchased equipment?

What kind of training and competency levels do the equipment users have?

Describe the contextual conditions under which the equipment will operate.

2.The External Context

What specific mining industry is the purchasing company a part of? What are some of the social, regulatory, cultural, financial and political pressures operating on it?

What corporate structure is the selected company enmeshed in?

What competitive pressures might be operating on the selected company?

While you may not know the actual answers to some of these questions, it is still possible to invent responses, or at least give them some thought.

The learning objective is to think deeply about the potential systemic influences on the safe operation of the **equipment/person/task** interface in a given company/operational context.

After you finish the EDEEP at the end of this training you might like to come back and adjust the responses accordingly.

What other aspects can potentially be included in a Risk Context Statement?

SECTION FOUR:

HUMAN FACTORS ENGINEERING

INTRODUCTION

At the heart of human factors engineering is the interface between the human body and the machine. This is not merely an abstract question. The mining industry has changed significantly since the days of the pick and shovel. While the back-breaking, manual labour intensity of those days are partly gone, the large scale intensity of the machines that now do a large part of that manual labour bring with them a differing set of risks. Scale wise, the pick and shovel had a very straightforward human equivalence, whereas the haul trucks, the long-wall miners and the super shovels of today, largely dwarf their human operators.

As previously suggested, at the heart of the Design OMAT method is an equipment/person/task orientation. The Design OMAT method is designed to fill the gap between a regulations-orientated Standards approach to risk management and human factors engineering and how actual people in the workplace conduct themselves in-situ. It is human factors engineering that is best placed to investigate the workplace health and safety aspects of this interface between equipment/person/task. As an extension of a systemic or an holistic analysis of this interface (as evidenced in the Risk Context Statement), Design OMAT examines the sequencing of each task in its particularity, especially high risk maintenance and operational tasks pertinent to the particular machine under investigation.

HUMAN FACTORS: ITS NATURE AND HISTORY

'Human factors' is an umbrella term for several areas of research that cover aspects of human performance related to technology, design, and human-computer interaction. It is a profession that discovers and applies information about human behaviour, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use (Sanders et al, 1992).

Although often thought of as the domain of psychologists, kinesiologists and physiologists, human factors is a critical aspect of industrial engineering (Chapanis, 1996). Early human beings made axes by using selected sizes and weights of stones for ease of and efficiency. They shaped tools that would fit their hands (Chapanis, 1996). The same principle is still applied in today's modern world. The human component of the human-machine system has progressively become even more important due to complexity of the operators tasks and demanding work. Machines have become highly sophisticated with complicated controls, and higher outputs (Grandjean, 1982). The consequences of errors are also increased due to the increasing magnitude of the energy sources.

The human factors field emerged with the industrial revolution in the late 1800s and early 1900s (Sanders and McCormick, 1992). During World War II, human factors were considered in the design and use of aircraft to improve aviation safety. The human factors profession was born immediately after the Second World War. By the 1980s, there was a rapid growth in military and space applications of the human factors in the U.S., and in during the same time period, human factors applications gradually expanded to pharmaceutical, computer, car, and other industries. However, it was only with the revolution of computers, that understanding of the concept of human factors has started to develop among the community, and become known through its application on computer equipment and workplace design, and development of user friendly software (Sanders et al, 1992).

Unfortunately, the 1980s witnessed a number of technological disasters:

- In 1979, the Three Mile Island (TMI) nuclear power station in the U.S. came dangerously close to meltdown. Many studies suggested that residents near the Three Mile Island suffered from chronic stress (Baum et al, 1983) and other findings implicated that the condition remained as long as five years after the accident (Davidson et al, 1986).
- In 1984, in Bhopal, India, nearly 4,000 people were killed, and more than 200,000 people were injured, when a hazardous substance, Methylisocyanate (MIC) leaked from a pesticide plant. According to Meshkati, two of the 200,000 injured people died every day (Meshkati, 1991).
- In 1986, an explosion and fire at Chernobyl nuclear power station resulted in more than 300 deaths and widespread radioactive contamination.

Meshkati's (1989, 1991) analysis of these three events identified human factors as a significant contributing factor to each of these disasters. Meshkati suggested that the common two-stage human factors causes of these accidents were:

a) lack of human factors considerations at the (system) Design Stage, and

b) lack of human factors considerations at the (system) Operating Stage.

In the 1980s, human factors professionals were challenged by fast growing technological developments. While nuclear and space accidents were catastrophic, daily human-machine interaction at homes, on roads, and industrial settings resulted in occurrence of thousands of accidents around the world. Between 1982 and 1993, 8,200 people died in all commercial and civilian air and transport accidents, but 460,038 died at car accidents, 106,900 died in industrial accidents, and 214,300 deaths were attributed to accidents at home (U.S. National Safety Council, 1993).

In the years towards the late 1990s, it was gradually understood that many difficulties related to human-machine interaction occurred because of the way the machines were designed (Chapanis, 1996).

Sammarco (2001) identified some of the causes for unplanned movement of Programmable Electronics controlled mining equipment and they include design errors, and poor human-machine interfaces. Sammarco further reported the significance of establishing functional safety recommendations for programmable electronics (PE) in mining.

The Figure below shows changes and their impact during equipment development and operational phases.

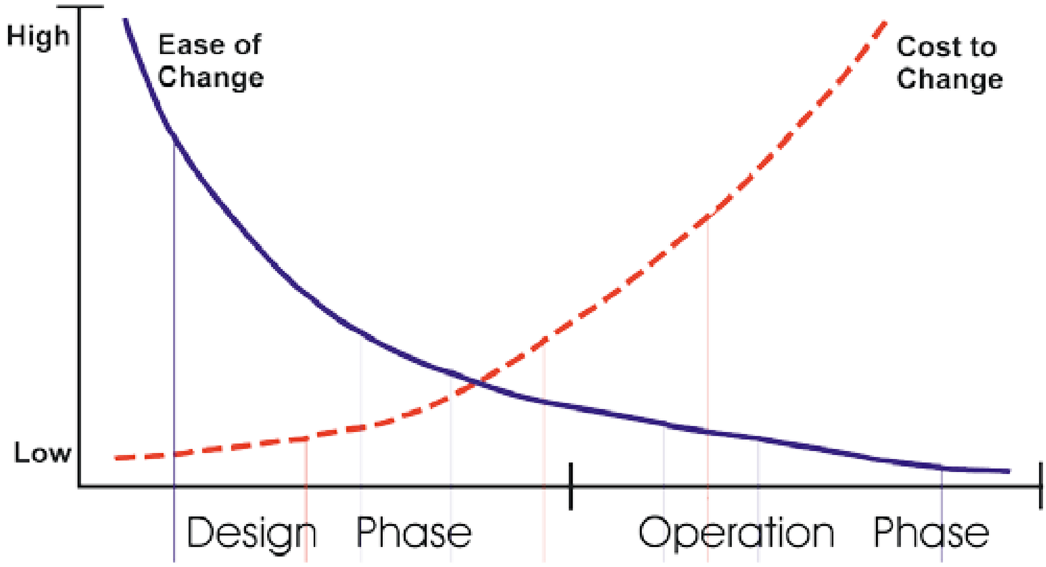


Figure: The impact of change during development and operational phases (Sammarco, 2001)

Research to date demonstrates that a strategy targeting improvement of Earth Moving Equipment (EME) at the design stage of the equipment should be developed. Chapanis and others have defined that improving the design process at various points is the most effective strategy.

Joy (Joy et al, 2003) concluded that optimization of machine controls design to prevent stereotypic / topographic type of human errors in the operation of machine controls would be done most effectively and efficiently by the OEMs during the design phase of a new piece of equipment.

An earlier study introduced a simple method to systematically review the human factors and safety implications of specialized mobile equipment at the design stage (Joy, 1983). The study developed a Human Factors Engineering Specific Analysis (HFESA) Matrix to identify relevant human factors criteria over the life cycle of vehicle operation. The HFESA was a basic tool that illustrated an example approach to analysis in an equipment design process.

HUMAN FACTORS ENGINEERING IN EQUIPMENT DESIGN

There are many definitions of Human Factors Engineering (HFE). Joy (1983) describes HFE as '…the application of human sciences information to design and management of the workplace where human performance is critical to productivity'. Joy (1983) also states that the terms 'human factors' and 'ergonomics' have been used interchangeably, and with the addition of 'engineering' to human factors the focus is on designing or modifying hardware, software, or the controllable physical environment.

HFE systematically focuses on the human-machine interaction. A human-machine system could be described as an integration of a human operator and a machine. An operator working with a single machine, such as driving a car, would represent a simple model of a human-machine system (Wikipedia, 2006). While driving, the driver continually absorbs and evaluates information received from both outside the car such as sound, visual, obstructions, signs, and inside the car, such as displays for speedometer, fuel indicator, and temperature gauge. The driver processes the inputs, and makes decisions on what course of action to take. The decisions are transformed into actions by using the controls, such as accelerator, steering wheel, gear lever, and brake pedal. Environmental factors like excessive noise, poor air quality due to dust, fumes, and excessive heat also have an effect on the driver's decisions. HFE would attempt to design the person-car interface to optimise operator strengths, and minimise situations and impacts of operator limitations.

To help the engineer, HFE guidance information is usually organized into design topics. Major HFE design criteria sources and much more complex information can be found in many references including websites. HFE information is often very specific to applications such as space, aviation or military hardware.

Following is a general, principle-based overview of the **very basic** areas of Human Factors Engineering (Joy, 1999).

a) Accessibility principles

Equipment should have access to operating or maintenance locations that ensures three fixed points of contact if climbing, acceptable step height, size and angle, acceptable sizes of openings where all or part of the body must access and protection from falls greater than two meters. Figure 2 shows an example of an improved design of a driver cabin access of a mining truck.

Figure 2: A mining truck showing access to the driver cabin (Courtesy of BHP Billiton)

b) Work space and posture principles

Operator and trades work locations should not require work postures that overload in the short term or fatigue in the long term due to poor foot/body support locations and/or awkward work access. General criteria based on perceived comfort and 'strain' can be used to identify potential problems.

Figure 3: Operator's cabin designed to improve seating (Courtesy of Rio Tinto)

c) Manual handling principles

Operation and maintenance requirements should not lead to lifting, pulling, pushing, twisting loads that may exceed physical capabilities. General criteria such as worker perceptions of duties/objects that are overly cumbersome, hard to handle, heavy, frequent, awkward, difficult to carry, difficult to handle and access, etc. can often identify unacceptable risks.

d) Visibility principles

Operators should be able to clearly see the area where their equipment is moving to ensure no obstruction or collision can occur, considering all potential environments. Obviously with large surface equipment and underground equipment, there are issues which make this difficult to design and impossible to retrofit. Criteria for this area could not be 100% required visibility but rather effective visual assist technology or, lastly, operational controls to reduce need for visibility where not available. Figure 4 shows a grader with installed rear video camera to improve visibility.

Figure 4: Rear camera system installed on a grader (Courtesy of BHP Billiton)

e) Controls principles

Frequently used and critical controls should be located within an easy reach zone of the operator as seen in Figure 5, with stereotyped direction, type of action and appropriate feedback to the operator. Consistency of these priority controls between equipment should also exist. Criteria for control review could be to International control type and direction guidelines plus operating zones. This information should only apply to frequently used and critical controls. Critical controls are those that, if inadvertently miss-operated, can have major consequence.

Figure 5: A machine control system (Courtesy of BHP Billiton)

f) Display principles

Information intended to give operators critical guidance for equipment operation should be displayed using a method and location that provides easy viewing and interpretation. Again, criteria exists which could be applied to frequently used and critical displays that effect operator or equipment safety. The Figure 5 shows displays located within vision field of an operator.

g) Work environment principles

The work environment where equipment operators and tradesman work should meet accepted criteria for noise, air contamination, heat, cold, vibration, lighting, etc. International Human Factors Guidelines could be used to suggest criteria and, where they are exceeded, design as well as operational controls should be considered. Note that working at height for maintenance or operational purposes would be included in this area.

Figure: Operator's work environment (Courtesy of BHP Billiton)

THE HUMAN FACTORS ENGINEERING PROCESS

Systems engineering is the process by which systems are analyzed, designed, and constructed. The life cycle of a system is a sequence of stages or phases in the life cycle of a system. Systems engineering process involves series of activities aligned with the system life cycle phases. (Chapanis, 1996)

'For a system to be successful, three lines of development – the user, hardware, and software – have to be managed and woven into an integrated product throughout this process (Chapanis, 1996)' 'The Waterfall Model characterizes the systems-engineering process as a series of steps organized serially, one leading to the next' (Chapanis, 1996) .

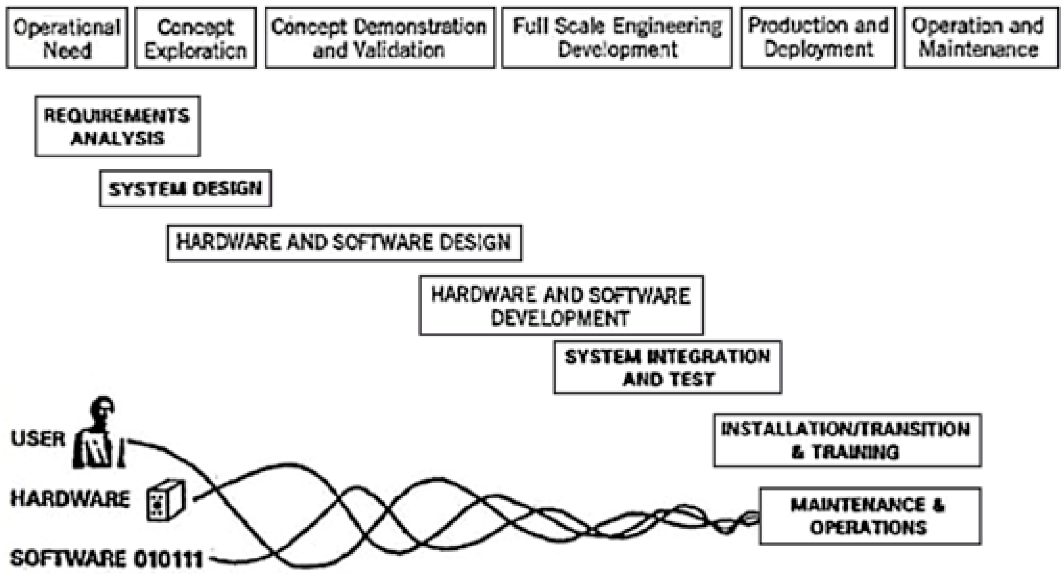
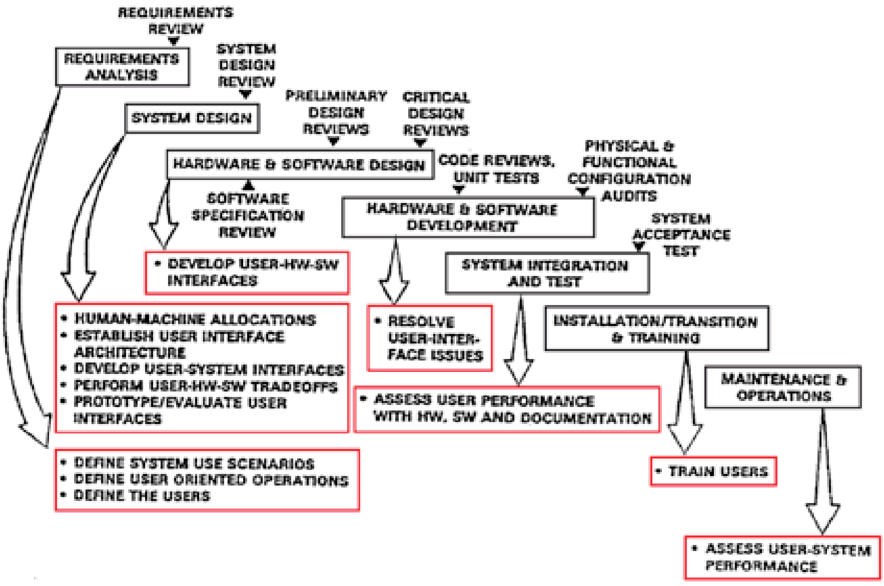


Figure: The Waterfall Model. The systems-engineering process weaves three lines of development together as design processes (Chapanis, 1996)

Activities in the system-engineering process (centre) are shown in their approximate relationships to life cycle phases (top). Note that the sizes of the rectangles are not intended to represent the amount of time taken up by each life cycle phase or activity (Chapanis, 1996)



This Figure expands the process with more details about the human factors activities that should be performed at each step. It also shows some of the reviews, audits, and tests that are typically required at various times. (Chapanis, 1996). This figure also illustrates a systematic approach to the application of HFE in the design process. The general approach is used by many industries where good human factors are important to safe production.

Another product-specific Human Factors Engineering Process is shown below. In this case the process is part of an international Standard that defines the elements of human factors (HF) in the life cycle of medical equipment.

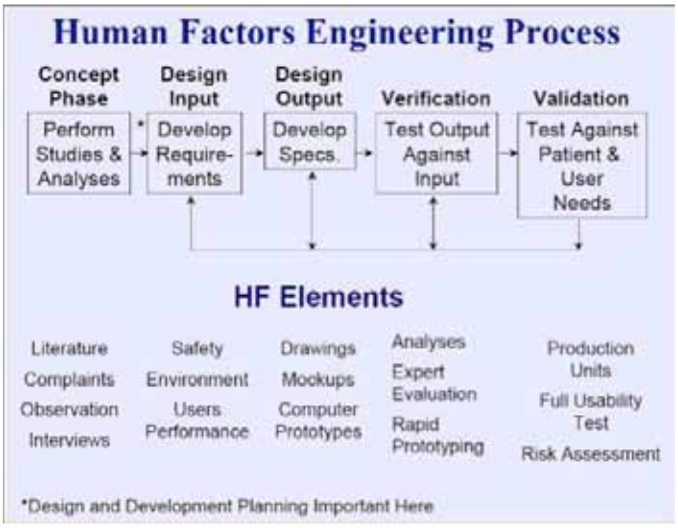


Figure: IEC Standard for Medical Equipment Design (IEC 60601-1-6)

Involvement in all stages of the design process but especially in early stages such as concept design phase influences the manufacturer in its key design assumptions is significantly important.

The conclusion is that Human Factors Engineering is a recognized need in equipment design, optimally focused on selected topic areas and applied systematically through a defined design process that incorporates effective analysis at the appropriate points in the process.

LEARNING ACTIVITY 2: EQUIPMENT/PERSON/TASK INTERFACE

In this exercise, the objective is to become aware of the necessary fit between humans and their machines.

How is human factors engineering done presently at your manufacturing site?

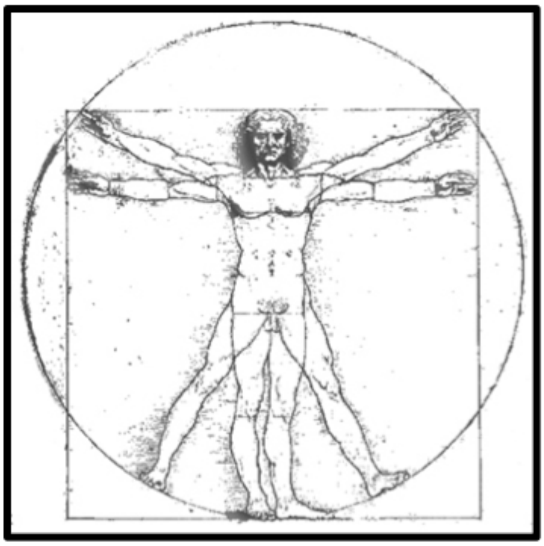
What analysis methods are used to review human factors at your manufacturing site?

TEAM EXERCISE 3: USER-CENTRED DESIGN

The whole point of human-entered design is to tame complexity, to turn what would appear to be a complicated tool into one that fits the task, one that is understandable, usable, and enjoyable.

(Norman, 2011: 52–53)

Before examining the OMAT methods for task-based human factors engineering, it is important the team have a broad understanding of the philosophy underpinning an ergonomics/human factors design approach. This approach is often referred to as 'user-centred design' (Pheasant & Haslegrave, 2006, 13–15; see also, Norman, 2011, for a broader complexity view on user-centred design).



It may be helpful to assemble a design team and, after each member of the team has reflected on the features of user-centred design listed below, use the ideas generated as the basis for a group discussion on the subject. The space after the list should be used to make notes, both in the discussion itself as well as in documenting its outcomes.

Pheasant & Haslegrave outline eight features of user-centred design:

1. User-centred design is empirical

It seeks to base the decisions of the design process upon hard data concerning the physical and mental characteristics of human beings, their observed behaviour and their reported experiences. It is distrustful both of grand theories and intuitive judgments – except insomuch as these may be used as the starting points for empirical studies.

2. User-centred design is iterative

It is a cyclic process in which a research phase of empirical studies is followed by a design phase, in which solutions are generated which can in turn be evaluated empirically.

3. User-centred design is participative

It seeks to enrol the end-user of the product as an active participant in the design process.

4. User-centred design is not Procrustean (trying to fit people to the machine)

It deals with people as they are rather than as they might be; it aims to fit the product to the user rather than vice-versa.

5. User-centred design takes due account of human diversity

It aims to achieve the best possible match for the greatest possible number of people.

6. User-centred design takes due account of the user's task

It recognises that the match between product and user is commonly task-specific.

7. User-centred design is systems orientated

It recognises that the interaction between product and user takes place in the context of a bigger socio-technical system, which in turn operates within the context of economic and political systems, environmental ecosystems and so on.

8. User-centred design is pragmatic

It recognises that there may be limits to what is reasonably practicable in any particular case and seeks to reach the best possible outcome within the constraints imposed by those limits.

LEARNING ACTIVITY: USER-CENTRED DESIGN

SECTION FIVE:

THE DESIGN PHILOSOPHIES

i. The EMESRT Design Philosophies

Within the OMAT framework, the EMESRT Design Philosophies (DPs) guide the risk assessment process by providing a source of issues or topics to focus the human factors analysis. They cover human factors risk potentialities such as equipment access and egress, working at heights, tires and rims, fire, exposure to harmful energies, manual tasks, confined spaces, operator workstation and interface, and health impacting factors. This list may change as new design risk factors are identified or others eradicated.

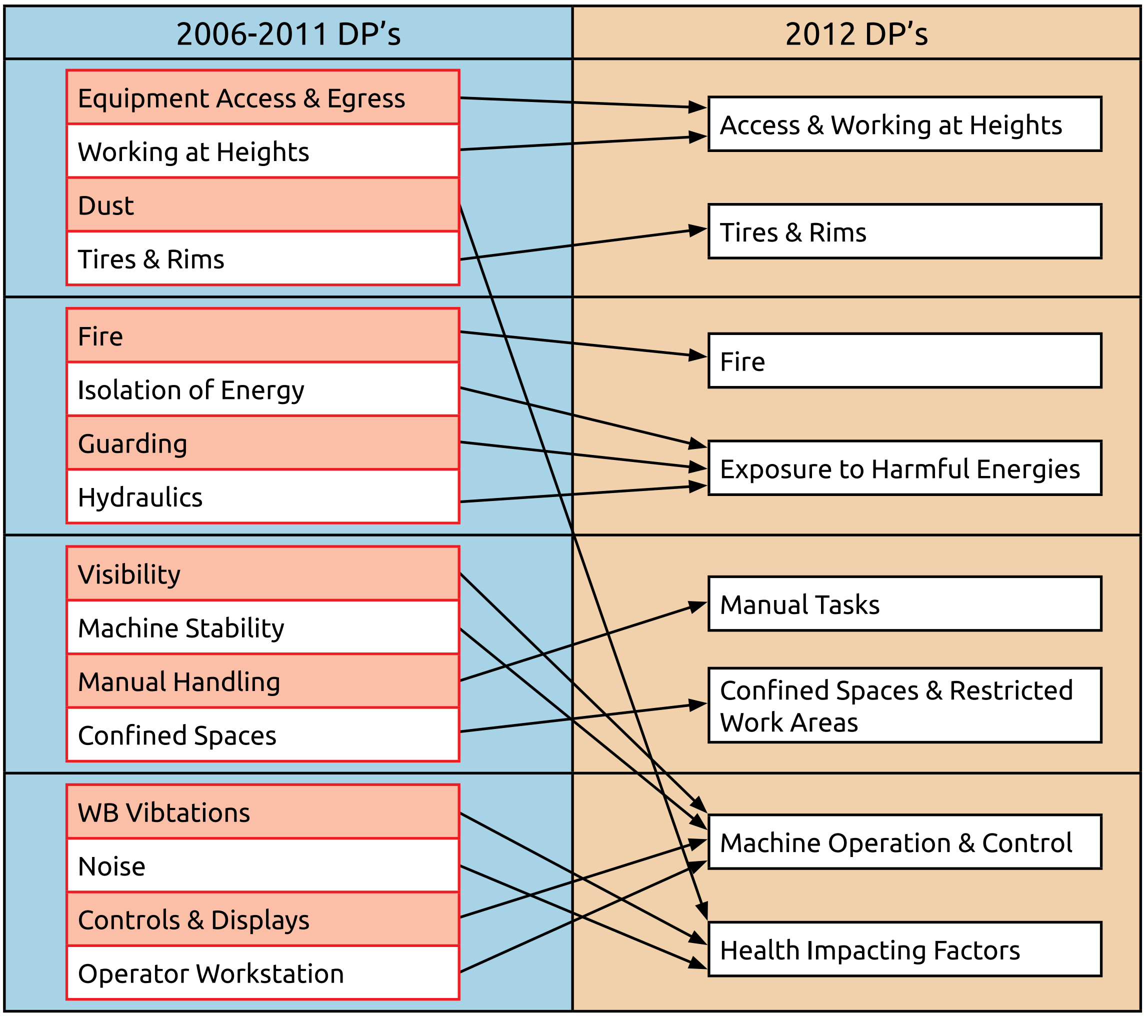
DPs present an EMESRT aligned viewpoint on objectives, general design outcomes and risks to be mitigated. The aim of the DPs is to provide information to help the OEM design equipment with risks reduced to an acceptable level, including consideration for foreseeable human error. They have been developed as set of pages of information, supported by images that depict an example of the issue.

The original DPs developed in 2007/8 had fifteen topics. EMESRT 'DP champions' used company and other resources to enhance the accuracy and validity of each selected topic. MISHC assisted with gathering input on design requirements, reviewing related ISO standards, and sourcing information about events or incidents related to the relevant design philosophy.

The 'risks to be mitigated' section (now termed 'potential unwanted events') documents the significant and common risks that are evident through the use of equipment at mine sites and which could be improved through human factors engineering by the OEM. Each statement has a corresponding illustration. The potential unwanted events found in each design philosophy will serve as the main risks to be assessed when completing the OMAT.

EMESRT expanded from a surface mining group in 2006-9 to a group considering four technical areas in 2010. Now EMESRT has four subgroups; surface mining, underground hard rock, underground soft rock and coal, and exploration.

In 2011, EMESRT reconsidered the existing list of 15 topics, listed on the left in the illustration below. The eight new 2011 DP topics are noted on the right.



The DP information has been modified in 2011 to link more closely to the OMAT process and, as such is an integral part of the EMESRT Design Evaluation for Equipment Procurement 'Kit'. As part of these changes, the 'risks to be mitigated' sections also changed and are now called 'Potential Unwanted Events' (PUEs).

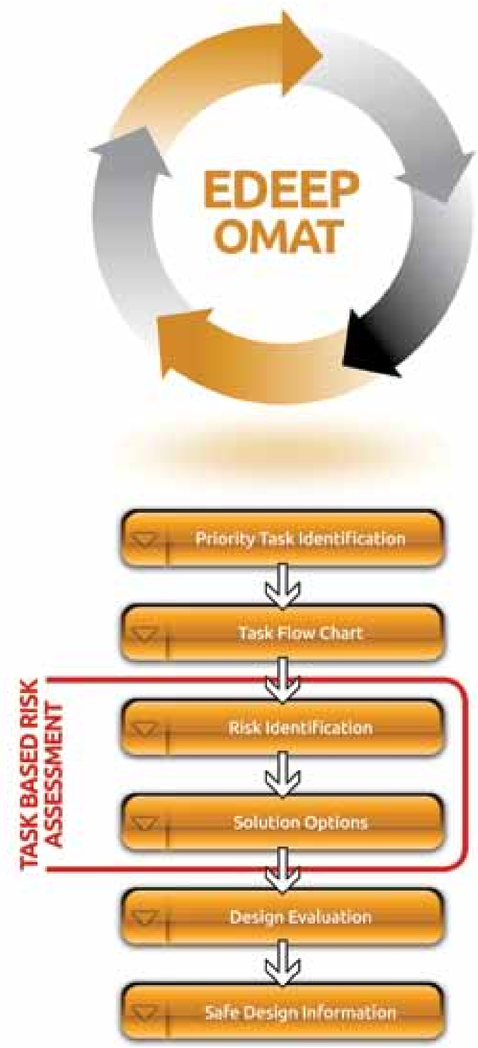
A separate section of this kit provides up-to-date Design Philosophy information. It may be helpful to examine that information at this point to understand the potential value and applicability to the OEM design process.

SECTION SIX:

THE DESIGN OMAT METHOD

INTRODUCTION

Design OMAT is a risk assessment technique intended to form part of the **EMESRT Design Evaluation for Equipment Procurement (EDEEP)** process.



It is ideally performed by designers in conjunction with their managers and supervisors in the OEMs. While the success of the technique is improved if procurement personnel and experienced mine site operators and maintainers engage with designer team during the whole process, EDEEP requires as a minimum that mining company-based operation and maintenance personnel are involved during the task-based risk assessment component of the process.

The Design OMAT process is task based. It focuses on all operation and maintenance tasks that may arise with any particular piece of earth-moving, mining equipment. Design OMAT uses basic qualitative risk assessment methods that do not try to establish an objective acceptability of risk.

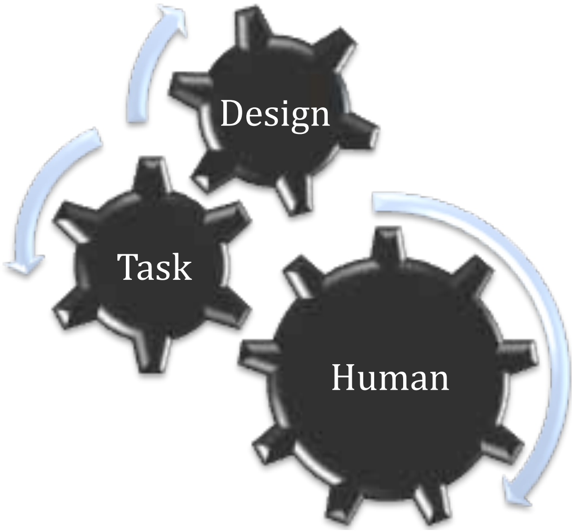
Methods such as the included 'risk ranking' determine relative levels of inherent risk, ranging from a high rank to a low rank. Acceptability is based on the human factors adequacy of the important design controls or features on a particular piece of heavy-duty equipment.

To increase this awareness of ergonomics/human factors risks when designing earth-moving equipment, the Design OMAT method has two central themes: **operability** and **maintainability**.

Within Design OMAT, operability is 'the ease with which equipment can be operated safely and in the optimal amount of time' (Horberry et. al. 2011: 30). An operability design focus works at the cutting edge of technological, organisational and strategic innovation to bring about blueprints for mining equipment that are centred on the health and safety of those who operate and maintain them. An operability and maintainability design focus is firmly within the ambit of human factors concerns.

Maintainability is 'the ease with which equipment can be repaired safely in the least [amount of] time' (Horberry et. al. 2011: 30). Designing with maintainability in mind encompasses measures that reduce the necessary resources spent in keeping the machine performing well. It benefits the end-user by reducing the total ownership costs through less downtime (that is, more productivity), lower maintenance costs, less inventory on hand, fewer tools and improved health and safety outcomes.

OMAT is a tool that systematically examines the health, safety and other risks imposed on operators and maintainers of mining and exploration equipment by equipment design. The included qualitative risk assessment technique distinguishes relative levels of risk to highlight the priority design concerns at the interface of the particular piece of **equipment**, its **user** and the **task** being performed on it. As suggested earlier, **equipment**, **user** and **task** are the iterative hearts of user-centred design.



Risk management practices are most effective when utilized early in the equipment's design lifecycle. Design OMAT aligns with, and spans across, the OEM design milestones and ideally begins at the concept phase of the design process. This is a foundation principle of risk management (alluded to in the Minerals Industry Risk Management section): health and safety risks are tied to economic, operational, maintenance and aesthetic choices when first initiating the design of mining equipment.

A modified version of the Design OMAT can also be used at a mine site during the operation or modification phases of existing equipment or to address any residual risks or site-specific risks of newly purchased equipment. This process is now called the Legacy OMAT - Legacy Operability and Maintainability Analysis Technique. Legacy refers to the fact that this equipment is currently in operation and requires further retrofitting to rectify any operational and maintenance issues found in the field.

The **objective** of the Design OMAT process is to provide OEM designers with a user-centred, task-based design framework to identify and document existing design controls and identify opportunities for implementation of additional controls.

Designers will already be familiar with the notion of a 'product lifecycle' (Commonwealth of Australia, 2006a: 9), or in the case of OMAT, the 'equipment lifecycle'. This is an eight-stage process:

1. Develop Concept

2. Design

3. Construct/Manufacture

4. Supply/Install

5. Commission/Use

6. Maintain

7. De-commission

8. Disposal/Recycle

It should be clear that ergonomics/human factors issues are more easily and cost-effectively addressed at the 'concept' and 'design' stages of the equipment lifecycle than at other stages. However, thinking about ergonomics/human factors issues throughout the entire equipment lifecycle is also important.

It should also be clear that designing large mining equipment is a collective procedure involving a wide range of personnel ranging from industrial designers through to management and supervisors, as well as potential end-users of the equipment. This collective design task is constituted in a constant process of negotiation and consultation.

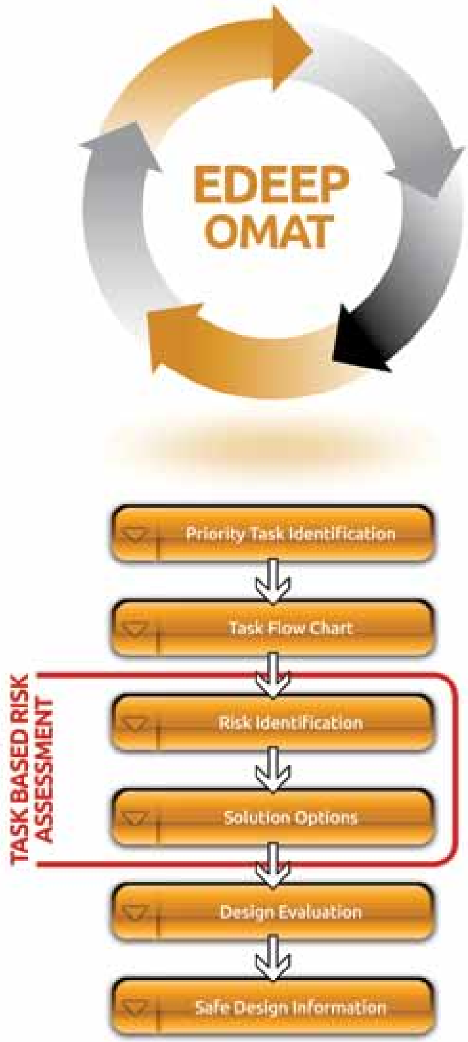
Design is the 'conceptual process used to bring together innovation, aesthetics and functionality to plan and create an artefact, a product, a process or a system to meet an artistic or industrial requirement of an individual or a group. It includes research and development, conceptual design, general design, drawings, plans, systems, quantities, method of construction or manufacture, detailed cost and risk analysis (including analysis of OHS risks), feasibility, detailed design, technical specification and redesign' (Commonwealth of Australia, 2006a: 9).

Clearly, designing a piece of mining equipment is a complex activity. For Design OMAT to work affectively, the team must be fully cognizant of design as a complex activity, and this method of this process within that larger process.

If the reader has used the other materials in this EDEEP Kit, we are now ready to examine the Design OMAT process. We should have an introductory understanding of user-centred design and an understanding of the equipment lifecycle. Now it is time to self-select a specific piece of mining equipment to take through the Design OMAT process.

If the reader or team doesn't already have a specific piece of equipment in mind, it may help here to have access the Internet so as to download already existing product information from an Original Equipment manufacturer.

It will also help to now bring out the EMESRT DPs, which will offer suggestions for particular categories of tasks e.g. access and egress, visibility, fire, tires and rims to help us address as ergonomic/human factors risk issues.



EMESRT DESIGN EVALUATION FOR EQUIPMENT PROCUREMENT (EDEEP) PROCESS

The objectives of EDEEP are:

1. To provide equipment purchasers with a common way of assessing how well the equipment design addresses issues identified in the EMESRT Design Philosophies.
2. To provide OEMs with additional information for use during subsequent equipment design activities to facilitate 'designing beyond standards' and further reduce the risks to health and safety associated with operation and maintenance tasks.

The process has three steps:

(i) priority task identification

(ii) task based risk assessment involving mining company-based operation and maintenance personnel and

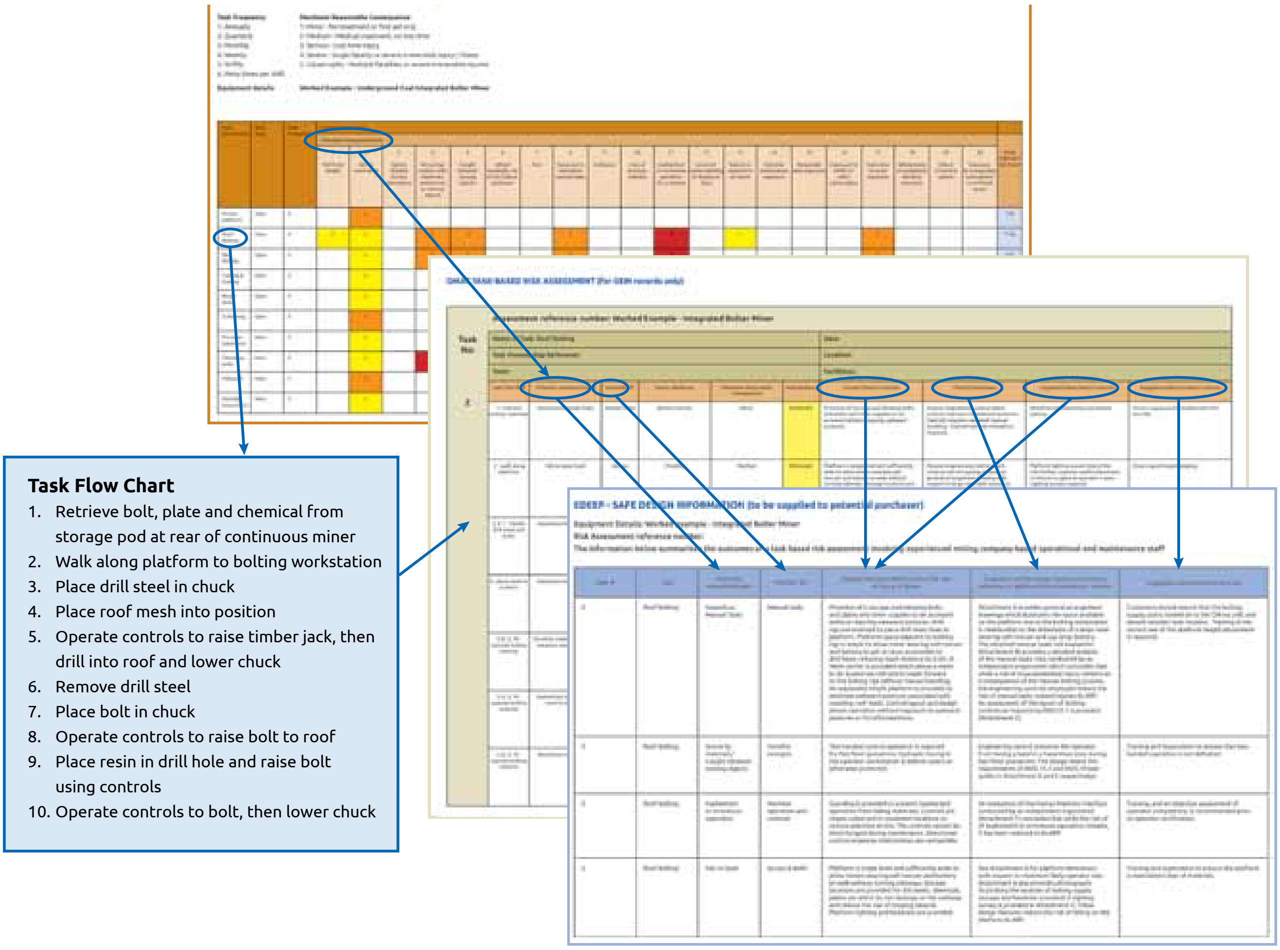
iii) documentation of the outcomes in the form of Safe Design Information.

Priority Task Identification begins with the generation of a list of operation and maintenance tasks associated with the equipment. The tasks will be equipment specific, and they will likely be effectively generated through consideration of operation and service manuals for the equipment. The frequency with which each task is performed is estimated and coded on a seven point scale. For each task identified, each of 20 potential unwanted events is then examined to determine whether they might occur during the task, and if so, the maximum reasonable consequence of the unwanted event is coded on a five point scale. The frequency and consequence values for each task are combined to provide a prioritisation of the tasks for further assessment.

The second step in the OMAT process is to undertake a detailed risk assessment of each priority task and relevant potential unwanted events (which may include events in addition to those identified by the EMESRT DPs). In addition to an analysis and evaluation of the inherent risks, the aim of OMAT is to identify both existing design control measures and potential design improvements which may be implemented to eliminate or reduce the risk for each potential unwanted event; as well as relevant administrative controls which should be considered by purchasers. It is essential that mining company-based operators and maintenance personnel are involved at this stage to ensure that: an accurate understanding is gained of the ways the tasks are actually performed; the likelihood of the unwanted events is validly estimated; and to ensure that site experience is utilised in the evaluation of existing control measures and the development of new control measures. Any additional investigations required to evaluate the effectiveness of design safety such as visibility or illumination surveys, vibration or noise measurements, or ergonomics assessments should be noted during the risk assessment and the results of the investigations included in the Safe Design Information.

Neither the details of the priority task identification, nor the task-based risk assessment, are requested by companies as part of the EDEEP process. Rather, the outcomes of the task-based risk assessment are documented in the form of Safe Design Information which will be requested by EMESRT member companies during procurement. In addition to the details of the tasks and potential unwanted events for which risk assessments were undertaken, the design features, and suggested administrative controls, the Safe Design Information is also required to include an evaluation of the effectiveness of the design features and reference to additional reports where appropriate. As well as assisting mining companies make purchasing decisions, this information will assist the purchasers of equipment to undertake the operational risk assessments required before equipment may be used on site.

From the point of view of the procurement process, the 'bottom line' is the Safe Design Information. While this information may be obtained by processes other than those described here, EMESRT members require confidence that a systematic process for identifying hazard situations including those identified in EMESRT DPs has been employed; and a task-based risk assessment process involving mining company-base operation and maintenance personnel has been used to generate the information. If an alternate process to that described here is utilised, a description of the process is requested to be provided with the Safe Design Information.



Relationship between Priority Task identification, Task Based Risk Assessment and Safe Design Information

Relationship to ISO 12100

ISO12100-2010 'Safety of machinery — General principles for design — Risk assessment and risk reduction' provides a strategy for risk assessment which stipulates that the designer shall: (i) determine the intended use and foreseeable misuse of the equipment; (ii) systematically identify the hazards and associated hazardous situations; (iii) estimate the risk for each circumstance and hazard; (iv) evaluate the risk; and (v) eliminate the hazard or reduce the risk. Task-based risk assessment is required in that the 'hazardous situations' referred to in step (ii) of this strategy are defined as 'circumstances in which a person is exposed to at least one hazard'. The standard requires the systematic identification of these circumstances, and notes that to achieve this it is necessary to 'identify the operations to be performed by the machinery and the tasks to be performed by persons who interact with it, taking into account the different parts, mechanisms or functions of the machine, the materials to be process, if any, and the environment in which the machine can be used. ... All reasonably foreseeable hazards, hazardous situations or hazardous events associated with the various tasks shall then be identified' (section 5.4, p.15, emphasis added).

Further, ISO12100 section 5.2 stipulates that the information required for risk assessment (analysis & evaluation) should include 'the experience of users of similar machines and, wherever practicable, an exchange of information with the potential users'. That is, ISO12100 requires task-based risk assessments, and recommends user involvement. ISO/TR14121-2 similarly notes that the team conducting a risk assessment should include those with 'actual experience' of how the machine is operated and maintained.

The OMAT process outlined here is thus entirely consistent with the requirements and recommendations of ISO 12100. OEMs may use equivalent processes to undertake the risk assessment, and if these are similarly consistent with the the requirements and recommendations of ISO 12100, then the information to populate the 'Safe Design Feature' template requested by EMESRT should be readily available. However, whatever process is employed, it must:

(i) include identification and risk assessment of the tasks associated with the equipment in which people are exposed to hazards;

(ii) include consideration of the relevant potential unwanted events identified by EMESRT;

(iii) involve mining company based operators and maintenance personnel in the risk assessment; and

(iv) provide documentation of the tasks and hazards assessed (although not necessarily the risk scores), and the design features which have been employed to eliminate the hazards or reduce the risks as far as reasonably practicable.

If an alternate process to that described here is utilised, a description of the process is requested to be provided with the Safe Design Information.

PRIORITY TASK IDENTIFICATION

The first step in the OMAT process is the **Priority Task Identification**. The outcomes of this step are not required to be provided to companies as part of the EDEEP procurement process. The aim of this step is to identify all operation and maintenance tasks associated with the equipment and determine the priority for further detailed risk assessment. It is not essential at this stage of the process to involve site-based operation and maintenance personnel, however designers and other persons with a general understanding of the operation and maintenance of the equipment should undertake the assessment.

A 'task' is a self-contained undertaking that may or may not be an element in a larger work process. For example, changing an air filter is both a self-contained task and part of a broader overall maintenance program. Other examples of 'tasks' would include: conducting pre-start checks, accessing or egressing the operators cab, cleaning the cab windows, driving the equipment, filling fuel, or changing a tyre. When generating the list of tasks, it may be helpful to utilise the operation and service manuals for the equipment. This information may be entered into the Priority Task Identification worksheet of the EDEEP spreadsheet.

As each task is identified, the estimated frequency with which the task is performed by any person is coded using a six point scale as follows.

1 - Annually

2 - Quarterly

3 - Monthly

4 - Weekly

5 - Shiftly

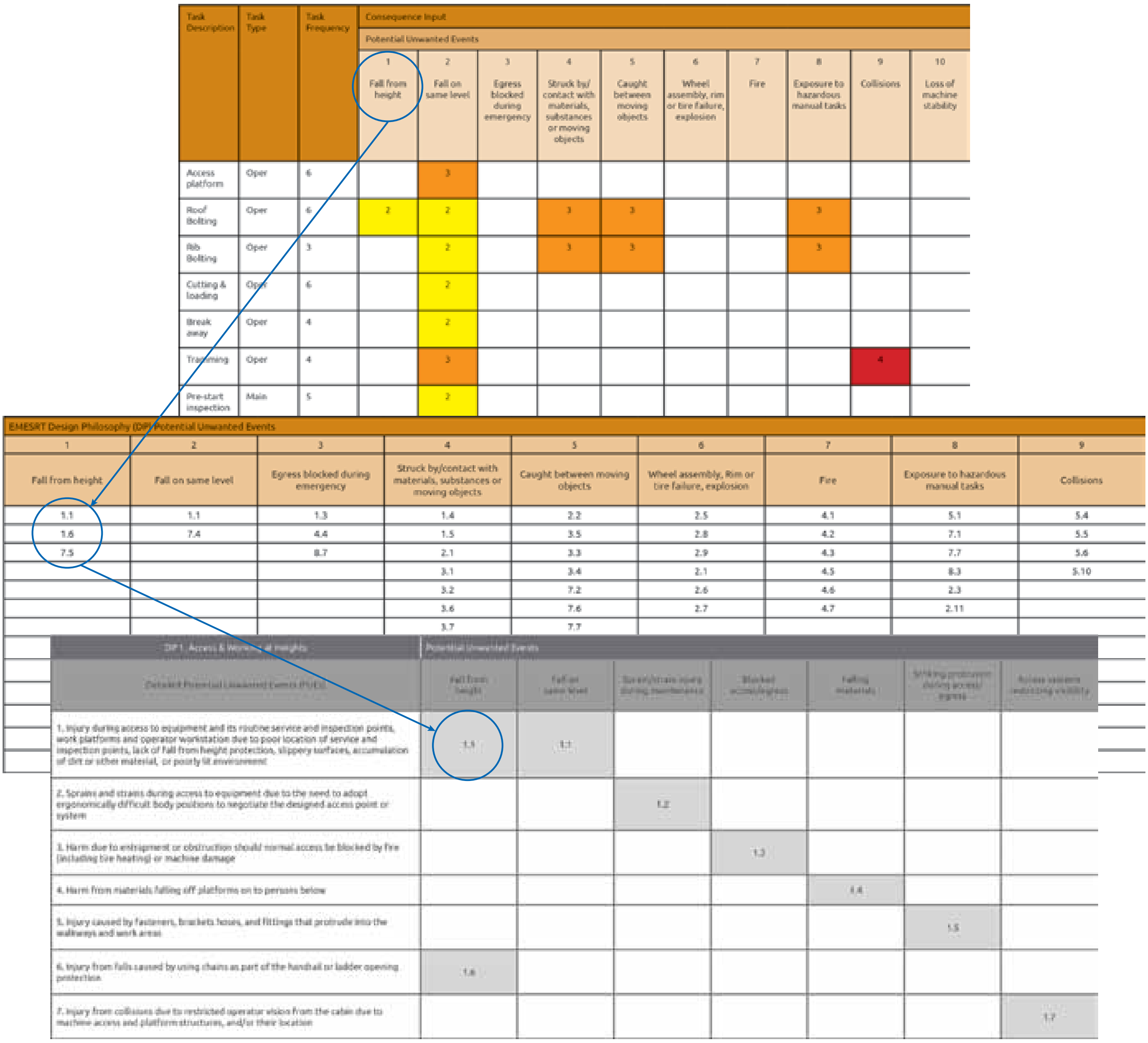
6 - Many times per shift

The next step is to consider whether any of the 20 Potential Unwanted Events drawn from the EMERST Design philosophies may occur during the performance of the task. The Potential Unwanted Events identified by EMERST are:

1. Fall from height
2. Fall on same level
3. Egress blocked during emergency
4. Struck by/contact with materials, substances or objects
5. Caught between moving objects
6. Wheel assembly, rim or tyre failure or explosion
7. Fire
8. Exposure to hazardous manual tasks
9. Collision

10. Loss of machine stability
11. Inadvertent or erroneous operation of a control
12. Incorrect understanding of a display or label
13. Failure to respond to an alarm
14. Extreme temperature exposure
15. Respirable dust exposure
16. Exposure to DPM or other particulates
17. Noise exposure
18. Whole-body or peripheral vibration exposure
19. Failure of control system
20. Exposure to irrespirable atmosphere in confined space

Each of the 20 Potential Unwanted Events utilized within the Priority Task Identification template is associated with one or more references to the EMESRT Design Philosophies. Hyperlinks within the PTI template link the unwanted events to associated DP references and, in turn, to the 8 EMESRT Design Philosophies. The team conducting the Priority Task Identification should become familiar with this information prior to commencing the identification of Priority Tasks.



Task Description	Task Type	Task Frequency	Consequence Input									
			Potential Unwanted Events									
			1 Fall from height	2 Fall on same level	3 Egress blocked during emergency	4 Struck by/ contact with materials, substances or moving objects	5 Caught between moving objects	6 Wheel assembly, rim or tire failure, explosion	7 Fire	8 Exposure to hazardous manual tasks	9 Collisions	10 Loss of machine stability
Access platform	Oper	6		3								
Roof Bolting	Oper	6	2	2		3	3			3		
Rib Bolting	Oper	3		2		3	3			3		
Cutting & loading	Oper	6		2								
Break away	Oper	4		2								
Tramming	Oper	4		3							4	
Pre-start inspection	Main	5		2								

EMESRT Design Philosophy (DP) Potential Unwanted Events								
1	2	3	4	5	6	7	8	9
Fall from height	Fall on same level	Egress blocked during emergency	Struck by/contact with materials, substances or moving objects	Caught between moving objects	Wheel assembly, Rim or tire failure, explosion	Fire	Exposure to hazardous manual tasks	Collisions
1.1	1.1	1.3	1.4	2.2	2.5	4.1	5.1	5.4
1.6	7.4	4.4	1.5	3.5	2.8	4.2	7.1	5.5
7.5		8.7	2.1	3.3	2.9	4.3	7.7	5.6
			3.1	3.4	2.1	4.5	8.3	5.10
			3.2	7.2	2.6	4.6	2.3	
			3.6	7.6	2.7	4.7	2.11	
			3.7	7.7				

DP1. Access & Working at Heights	Potential Unwanted Events						
Detailed Potential Unwanted Events (PUEs)	Fall from height	Fall on same level	Sprain/strain injury during maintenance	Blocked access/egress	Falling materials	Striking protrusions during access/ egress	Access system restricting visibility
1. Injury during access to equipment and its routine service and inspection points, work platforms and operator workstation due to poor location of service and inspection points, lack of fall from height protection, slippery surfaces, accumulation of dirt or other material, or poorly lit environment	1.1	1.1					
2. Sprains and strains during access to equipment due to the need to adopt ergonomically difficult body positions to negotiate the designed access point or system			1.2				
3. Harm due to entrapment or obstruction should normal access be blocked by fire (including tire heating) or machine damage				1.3			
4. Harm from materials falling off platforms on to persons below					1.4		
5. Injury caused by fasteners, brackets hoses, and fittings that protrude into the walkways and work areas						1.5	
6. Injury from falls caused by using chains as part of the handrail or ladder opening protection	1.6						
7. Injury from collisions due to restricted operator vision from the cabin due to machine access and platform structures, and/or their location							1.7

Screen shots illustrating links between Potential Unwanted Events & Design Philosophies

For each unwanted event which might occur during the task, the maximum reasonable consequence associated with that event is coded on a five point scale. Consideration of the consequences should include both the equipment operator and/or maintainer, as well as other persons.

1 - Minor - No treatment or first aid only

2 - Medium - Medical treatment, no lost time

3 - Serious - Lost time injury

4 - Major - Single fatality or severe irreversible injury / illness

5 - Catastrophic - Multiple fatalities or severe irreversible injuries

This information is combined with the task frequency to provide a score for each PUE as illustrated below, and these scores are summed to provide a task priority score.

		Consequence				
		1	2	3	4	5
Frequency	1	1	5	25	75	100
	2	2	10	50	150	200
	3	3	15	75	225	300
	4	4	20	100	300	400
	5	5	25	125	375	500
	6	6	30	150	450	600

The task priority scores provide a principled basis on which to prioritise the tasks identified for detailed risk assessment. Such attention may not be justified for all tasks, however EMESRT recommends that all tasks which have serious, major, or catastrophic maximum reasonable consequences associated with any Potential Unwanted Event should be examined further.

It is important to note that the aim of this step is to gain an appreciation of the inherent risks associated with each task. Neither the task frequency nor the maximum reasonable consequence will be impacted upon appreciably by existing design controls, unless the design controls eliminate the hazard. If a particular potential unwanted event which is typically associated with a task performed with equipment of this type has been eliminated by a design change, then it need not be considered further. However, the OEM may wish to make a note of the hazard and design feature for inclusion in the Safe Design Information for communication to potential purchasers.

PRIORITY TASK IDENTIFICATION (for OEM records only)

Task Frequency
1. Annually
2. Quarterly
3. Monthly
4. Weekly
5. Shiftly
6. Many times per shift

Maximum Reasonable Consequence
1. Minor - No treatment or first aid only
2. Medium - Medical treatment, no lost time
3. Serious - Lost time injury
4. Severe - Single fatality or severe irreversible injury / illness
5. Catastrophic - Multiple fatalities or severe irreversible injuries

Equipment details **Worked Example - Underground Coal Integrated Bolter Miner**

Task Description	Task Type	Task Frequency	Consequence Input – Potential Unwanted Events												
			1 Fall from height	2 Fall on same level	3 Egress blocked during emergency	4 Struck by/ contact with materials, substances or moving objects	5 Caught between moving objects	6 Wheel assembly, rim or tire failure, explosion	7 Fire	8 Exposure to hazardous manual tasks	9 Collisions	10 Loss of machine stability	11 Inadvertent or erroneous operation of a controls	12 Incorrect understanding of display or label	13 Failure to respond to an alarm
Access platform	Oper	6		3											
Roof Bolting	Oper	6	2	2		3	3			3			4		1
Rib Bolting	Oper	3		2		3	3			3			4		
Cutting & loading	Oper	6		2											
Break away	Oper	4		2											
Tramming	Oper	4		3							4		4		1
Pre-start inspection	Main	5		2											
Changing picks	Main	4		2		4				3					
Filling oil	Main	5		3						3					
Monthly inspections	Main	3		2											

Screenshot illustrating partially worked example of a Priority Task Identification

DETAILED TASK-BASED RISK ASSESSMENT

Having identified the priority tasks for which detailed risk assessment is required, the next step is to assemble a suitable team and gather necessary resources. The team must include mining company-based operation and maintenance personnel who have experience in undertaking the tasks to be examined. It would be beneficial to have participation from staff from different sites, and different experience levels. OEM service personnel may also be useful contributors, but cannot substitute for the experience of mining company-based staff. Resources to be obtained in advance of the assessment would usefully include video footage of the priority tasks being undertaken. This is particularly important if the equipment to be assessed is not readily available for inspection. Outcomes of previous risk assessments on related equipment, and evaluations of issues such as visibility, lighting, vibration, noise, workstation ergonomics etc which have been undertaken should be made available to the assessment team, as well as analysis of any historical data which are available regarding injuries or incidents associated with the equipment type.

TASK FLOW CHART

Next, it is important to ensure that all steps required for the completion of the task to be assessed are understood through construction of a task flow chart. The flow chart identifies the discrete steps which were expected by the designer (as reflected in the OEM operation or service manual instructions) as well as steps that may be reasonable deviations away from the recommended method. Involvement of mining company-based personnel at this stage is essential to ensure that a realistic picture of the task is considered.

The task flow chart is a visual representation of the task and if complex it may be useful to construct the flow chart of a large surface such as a whiteboard or on a wall. Begin by defining the first and last step in the task to define the boundaries of the task, and then the 'expected' task steps as defined by the OEM operation or service manual. Foreseeable deviations from the process should then be added to the flow chart. These additions may be provided by the experienced operator or maintenance persons on the team or simply through thinking about possible, slips, lapses, mistakes or cultural violations.

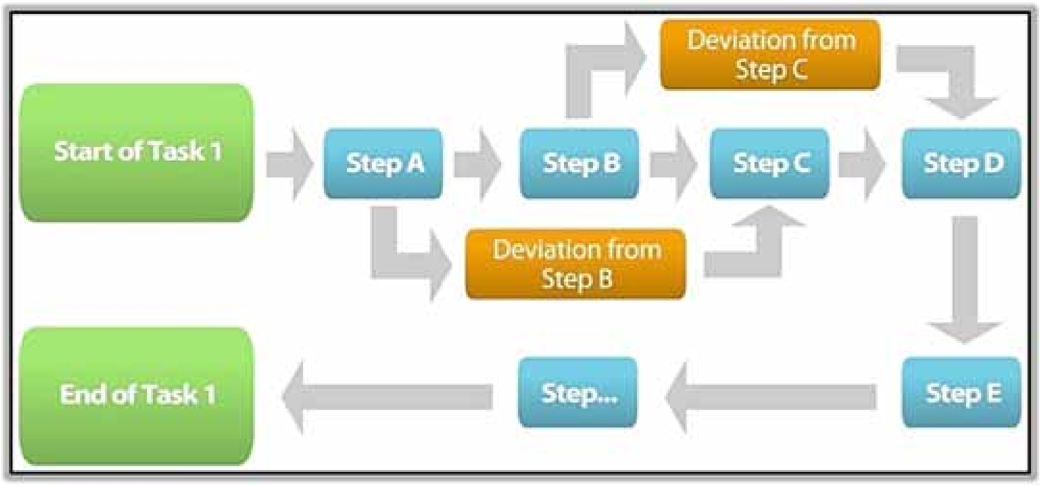
For example, a task flow chart for roof bolting conducted during the operation of an integrated bolter miner in an underground coal mine as envisaged by the designer might be as follows:

1. Retrieve bolt, plate and chemical from storage pod at rear of continuous miner
2. Walk along platform to bolting workstation
3. Place drill steel in chuck
4. Place roof mesh into position
5. Operate controls to raise timber jack, then drill into roof and lower chuck
6. Remove drill steel
7. Place bolt in chuck
8. Operate controls to raise bolt to roof

9. Place resin in drill hole and raise bolt using controls

10. Operate controls to bolt, then lower chuck

During subsequent discussions with experienced roof bolter operators it is likely that foreseeable deviations associated with, for example, stuck drill steels, or other predictable events would be identified, leading to additional steps being added to the task flow chart.



Schematic of Priority Task Flow Chart

RISK ANALYSIS AND EVALUATION

Risk Assessment involves the overall process of risk identification, analysis, and evaluation. Having defined the tasks and associated hazards, and gained a thorough understanding of the task steps, the next stages of the assessment process are to analyse and evaluate the risks associated with the task steps, and to document existing and potential design controls and suggested administrative controls. It is essential that experienced mining company-based operators and maintenance personnel are involved at this stage to ensure that the likelihood of the unwanted events is validly estimated, and to ensure that site experience is utilized in the evaluation of existing control measures and the development of new control measures.

The team considers each step in the task flow chart, including the foreseeable deviations, identifying any Potential Unwanted Events associated with the EMESRT Design Philosophies. The possibility of other potential unwanted events which are relevant to the specific situations should also be considered. In thinking about other potential unwanted events it is helpful to think in terms of hazards, or the sources of potential harm which exist. For health and safety, hazards will always be energy sources related to the task that, should an unwanted release occur, cause damage to the person in the release pathway.

This illustration shows the relationship between Hazards or Energy Sources, Controls (in this case failed Controls) and the Losses which could be a person. There are many types of energies present on a mine site including the example short list below:

Chemical	Electrical	Mechanical
Pressure	Noise	Gravity
Noise	Thermal	Radiation
Biomechanical	Magnetism	Biological

If the team considers each step in the Task Flow Chart, identifying the relevant Energy, then any additional potential unwanted events can be captured.

For each task step, the inherent risk associated with each potential unwanted event should be evaluated by determining the maximum reasonable consequence (using the same scale as used in the Priority Task Identification). Consequences for persons other than the operator or maintainer should be considered. The likelihood of the event occurring in the absence of any design controls should be estimated using a five point scale as follows. Similar task steps may be grouped for assessment.

A - Almost certain - the event occurs more than twice a year

B - Likely - the event occurs once or twice a year

C - Possible - the event occurs less than annually, but multiple times during the life of the equipment

D - Unlikely - the event is expected to occur at some time during the life of the equipment

E - Rare - the event is not expected to ever occur during the life of the equipment

(NB. this is the likelihood of the event occurring, not the likelihood of the consequence occurring, and note again that the aim is to assess inherent risk in the absence of any existing design controls). It is important to have input of experienced mining company-base operation and maintenance personnel to gain a defensible estimate of event likelihood.

The Consequence and Likelihood estimates are combined to provide a risk ranking according to the Risk Classification Table illustrated below. These risk scores are to guide the manufacturers' decision making only, and are not required to be provided to companies as part of the EDEEP procurement process.

CONSEQUENCE

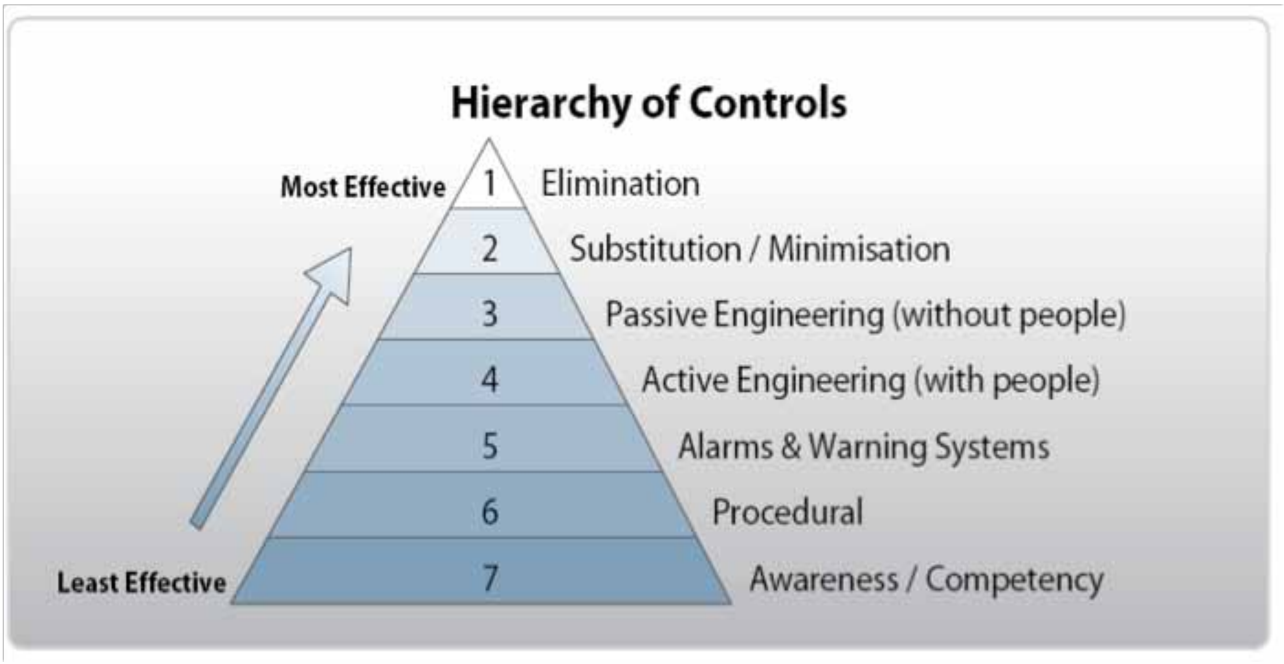
LIKELIHOOD	MINOR	MEDIUM	SERIOUS	MAJOR	CATASTROPHIC
Almost Certain	Moderate	High	Critical	Critical	Critical
Likely	Moderate	High	High	Critical	Critical
Possible	Low	Moderate	High	Critical	Critical
Unlikely	Low	Low	Moderate	High	Critical
Rare	Low	Low	Moderate	High	High

IDENTIFY AND EVALUATE CURRENT AND NEW CONTROLS

Using a brainstorming approach, the workshop team should now discuss current and potential design controls to eliminate or reduce the risk associated with each potential unwanted event and consider the likely effectiveness of both current and proposed control measures in terms of the hierarchy of control. Any additional investigations required to evaluate the effectiveness of design safety such as visibility or illumination surveys, vibration or noise measurements, or ergonomics assessments should be noted during the risk assessment and the results of the investigations included in the Safe Design Information. Suggested administrative controls for consideration by equipment purchasers should also be documented at this point, however administrative controls alone should not be relied upon to treat high or critical inherent risks.

The Hierarchy of Controls, sometimes called the Safety Precedence Sequence, can be helpful in the discussion. This concept provides an image of control types in order of effectiveness, the levels of the hierarchy are:

- Eliminate the energy source
- Substitute or minimize the energy source
- Implement a passive engineering control that does not require human involvement (example, kickboards)
- Implement an active engineering control that does require human involvement (example, tie off point for safety harness)
- Install a warning or alarm system
- Implement procedural controls, including personal protective equipment; and lastly and least effectively
- Awareness and competency controls



SAFE DESIGN INFORMATION

What happens next in the process depends on what stage of the design cycle the assessment has been conducted at. If the assessment has been conducted for an existing product primarily as a means of generating the Safe Design Information requested by EMESRT, then the relevant outcomes of the risk assessment are transferred to the Safe Design Information template, to which are added references to additional documentation or reports required to demonstrate the evaluation of the design features. These reports might include, for example: visibility survey; noise measurements; whole body vibration assessments under a range of realistic operating conditions; ergonomics review of controls and displays; manual tasks risk analyses; and audits against relevant standards and Mining Design Guidelines.

OMAT TASK-BASED RISK ASSESSMENT (for OEM records only)

Assessment reference number: Worked Example - Integrated Bolter Miner

Task No:	Name of Task: Roof Bolting	Date:
	Task Process Map Reference:	Location:
	Team:	Facilitator:

Task No: 2

Task Step ID #	Potential Unwanted Event	Relevant DP	Event Likelihood	Maximum Reasonable Consequence	Risk Ranking	Current Design Controls	Control Evaluation	Suggested New Design Controls
1 - retrieve bolting materials	Hazardous Manual Tasks	Manual Tasks	Almost Certain	Minor	Moderate	Provision of storage pod allowing bolts and plates and other supplies to be accessed without requring awkward postures.	Passive engineering control which reduces exposure to awkward postures. Task still requires repeated manual handling - manual task risk evaluation required.	Would be eliminated by automated bolting.
2 - walk along platform	Fall on same level	Access	Possible	Medium	Moderate	Platform is single level and sufficiently wide to allow miners wearing self-rescuer and battery to walk without turning sideways. Storage locations are provided for dril steels, chemicals, plates etc which do not impinge on the walkway and reduce the risk of tripping hazards. Platform handrails are provided.	Passive engineering control which reduces risk of tripping. Assess via general arrangement drawing with respect to large male with rescuer & battery.	Platform lighting would reduce the risk further, requires careful placement to ensure no glare in operator's eyes. Lighting survey required.
3, 6, 7 - handle drill steel and bolts	Hazardous Manual Tasks	Manual Tasks	Almost Certain	Serious	Critical	Drill rigs are oriented to place drill head close to platform. Platform space adjacent to bolting rigs is ample to allow miner wearing self-rescuer and battery to get as close as possible to drill head, reducing reach distance to 0.5m.	Passive engineering control which reduces reach distances, and thus shoulder load during these tasks steps. The task still requires repeated manual handling - manual tasks risk evaluation required.	Would be eliminated by automated bolting.
4 - place mesh in position	Hazardous Manual Tasks	Manual Tasks	Almost Certain	Medium	High	A mesh carrier is provided which allows a mesh to be loaded via LHD and brought forward to the bolting rigs without manual handling. A step is provided to allow bolters to reach roof mesh.	The engineering control allows bolters the option of reducing the awkward posture required to reach roof mesh, however it creates a slip/trip hazard. manual tasks risk evaluation required.	Provision of a height adjustable platform would allow the reach distance to be minimised regardless of cutting height. Would be eliminated by automated bolting (and automated mesh placement) or use of a spray on polymer to provide skin protection.
5, 8, 9, 10 - operate bolting controls	Struck by materials / Caught between moving objects	Machine operation and controls	Possible	Major	Critical	Two handed control operation is required for fast feed operations. Hydraulic hosing in the operator workstation is behind covers or otherwise protected.	Engineering control prevents the operator from having a hand in a hazardous zone during fast-feed operations. Operator is isolated from hydraulic fluid as far as possible. Audit with respect to MDG35.1 & MDG41.	Would be eliminated by automated bolting.
5, 8, 9, 10 - operate bolting controls	Inadvertant or erroneous control operation	Machine operation and controls	Likely	Major	Critical	Guarding is provided to prevent inadvertent operation from falling materials. Controls are shape coded and in consistent loactions to reduce selection errors. Directional control-response relationships are compatible.	Engineering control will reduce but not eliminate probability of unwanted event. Shape coded controls could be swapped during maintenance. Requires ergonomist to assess HMI.	Ensure different shape handles cannot be swapped during maintenance. Would be eliminated by automated bolting.
5, 8, 9, 10 - operate bolting controls	Hazardous manual tasks	Manual Tasks	Possible	Minor	Low	Control layout and design allows operation without exposure to awkward postures or forceful exertions.	Passive engineering control which reduces manual tasks risks ALARP. MDG35.1 requires assessment of reach distances etc.	Would be eliminated by automated bolting.

Screenshot of Task-based risk assessment example

EDEEP - SAFE DESIGN INFORMATION (to be supplied to potential purchaser)

Equipment Details: Worked example - Integrated Bolter Miner

Risk Assessment reference number:

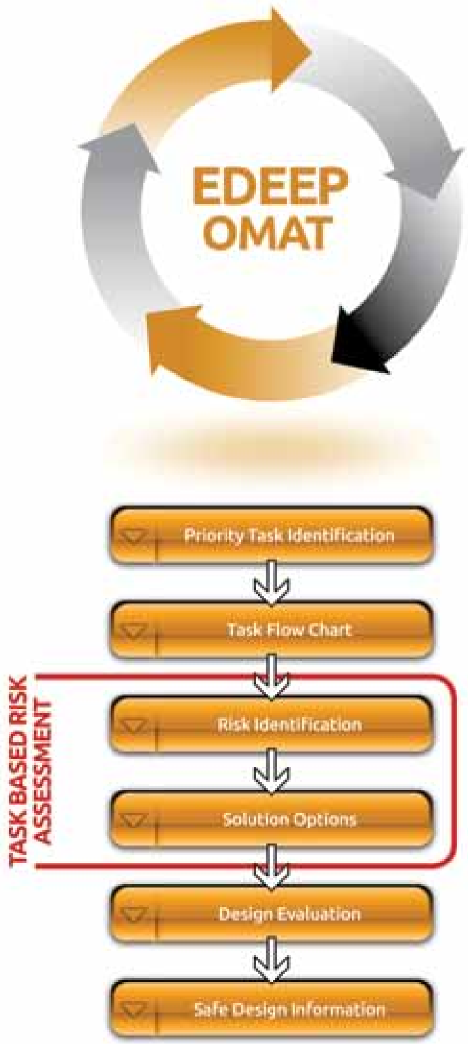
The information below summarises the outcomes of a task based risk assessment involving experienced mining company-based operational and maintenance sta

Task #	Task	Potential Unwanted Event	EMESRT DP	Design feature/s which control the risk of injury or illness	Evaluation of the design feature/s including reference to additional documentation / reports	Sug
2	Roof bolting	Hazardous Manual Tasks	Manual tasks	Provision of a storage pod allowing bolts and plates and other supplies to be accessed without requring awkward postures. Drill rigs are oriented to place drill head close to platform. Platform space adjacent to bolting rigs is ample to allow miner wearing self-rescuer and battery to get as close as possible to drill head, reducing reach distance to 0.5m. A mesh carrier is provided which allows a mesh to be loaded via LHD and brought forward to the bolting rigs without manual handling. An adjustable height platform is provided to minimise awkward postures associated with reaching roof mesh. Control layout and design allows operation without exposure to awkward postures or forceful exertions.	Attachment A provides general arrangement drawings which illustrates the space available on the platform and at the bolting workstation in relationship to the dimension of a large male wearing self-rescuer and cap lamp battery. The attached manual tasks risk evaluation (Attachment B) provides a detailed analysis of the manual tasks risks conducted by an independent ergonomist which concludes that while a risk of musculoskeletal injury remains as a consequence of the manual bolting process, the engineering controls employed reduce the risk of manual tasks related injuries ALARP. An assessment of the layout of bolting controls as required by MDG35.1 is provided (Attachment C).	Customers supply pod should con correct use is required.
2	Roof bolting	Struck by materials/ Caught between moving objects	Harmful energies	Two handed control operation is required for fast feed operations. Hydraulic hosing in the operator workstation is behind covers or otherwise protected.	Engineering control prevents the operator from having a hand in a hazardous zone during fast-feed operations. The design meets the requirements of MDG 35.1 and MDG 41(see audits in Attachment D and E respectively).	Training an handed op
2	Roof bolting	Inadvertent or erroneous operation	Machine operation and controls	Guarding is provided to prevent inadvertent operation from falling materials. Controls are shape coded and in consistent locations to reduce selection errors. The controls cannot be interchanged during maintenance. Directional control-response relationships are compatible.	An evaluation of the Human Machine Interface conducted by an independent ergonomist (Attachment F) concludes that while the risk of of inadvertent or erroneous operation remains, it has been reduced to ALARP.	Training, ar operator c to operato
2	Roof bolting	Fall on level	Access & WAH	Platform is single level and sufficiently wide to allow miners wearing self-rescuer and battery to walk without turning sideways. Storage locations are provided for dril steels, chemicals, plates etc which do not impinge on the walkway and reduce the risk of tripping hazards. Platform lighting and handrails are provided.	See Attachment A for platform dimensions with respect to maximum likely operator size. Attachment A also provides photographs illustrating the location of bolting supply storage and handrails provided. A lighting survey is provided in Attachment G. These design features reduce the risk of falling on the platform ALARP.	Training an is maintain

Screenshot of Safe Design Information

THE STEP-BY-STEP EDEEP PREPARATION PROCESS

The following step-by-step information is intended to assist the OEM in developing the required information effectively, once the overall process is understood. After the OEM has acquired the EDEEP format documents and/or the related EDEEP Excel spreadsheets, the process is as follows.



Part 1 - Priority Task Identification

1. Generate the list of operating and maintenance task for the relevant piece of equipment and enter them into the Priority Task Identification format.
2. Enter the expected task frequency for each of the operating and maintenance tasks.
3. Identify the Potential Unwanted Events which may occur during each task and the maximum reasonable consequence should the events occur.
4. Repeat for each relevant Potential Unwanted Event. The Excel sheet will add the scores into a Total Inherent Risk Score in the right column.
5. Repeat the process for all tasks related to the equipment.
6. Define the list of Priority Tasks to be analyzed further.

Part 2 – OMAT Task-Based Risk Assessment

1. Select the priority operating or maintenance task to be assessed.
2. Gather the appropriate team and information required to undertake the assessments, ensuring input from mining company-based operation and maintenance personnel is available.
3. Develop the Task Flow Chart for the task, including expected and possible task steps.
4. Identify the Potential Unwanted Events which may occur during each task step.
5. Assess the likelihood and maximum reasonable consequence of each unwanted event.
6. Document existing design controls and evaluate, noting additional investigations / assessment which may be required.
7. Determine additional suggested design controls and administrative controls if required.
8. Undertake the control evaluation and additional investigations

Part 3 - Preparing the Safe Design Information

After the Design OMAT TBRA or equivalent task-based analysis is completed, use the information as input for the Safe Design Information which will allow prospective purchasers to assess whether the equipment is, as far as reasonably practicable, without risk to the safety and health during operation and maintenance tasks.

1. Note the tasks and potential unwanted events assessed (and relevant EMESRT DPs considered)
2. Describe the functional consequences of the design features which exist to control these risks
3. Provide an evaluation of the expected effectiveness of these features
4. Append additional reports / documentation to allow the evaluation of relevant issues such as visibility, control and display layout, usability, human error, manual tasks, whole body vibration & noise.
5. Provide a description of the process used (if the PTI / OMAT process not employed).

SECTION SEVEN:

RESOURCES LIST

The following list of references is not merely what has been referenced in this manual although they do constitute that function. They also represent the diverse range of backgrounds in which both risk and design, in one form or another, are discussed and analysed. They are provided here so that if you would like to do more reading in the area it is easy to follow them up.

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