INFORMATION PAPER

Human error risk reduction to ALARP

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Key messages

- Human reliability plays a role in preventing or contributing to event causation.
- Human error is frequently identified as a threat with the potential to lead to major accident events (MAE).
- The role of error in event causation can be more accurately conceptualised as a barrier-defeating factor.
- Approaches to error risk identification and control appear to be inconsistent throughout the Australian offshore petroleum industry.
- Approaches to error risk control appear to predominantly target error prevention, and typically do not include error reduction or mitigation strategies.
- There appears to be opportunity for the industry to improve the ways in which error risk is identified and controlled to improve MAE prevention.
- Error risk can be managed using the same basic approaches as are applied in traditional risk management activities, whereby error risk can be evaluated and controls implemented until the risk posed by error is as low as reasonably practicable (ALARP).

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Key definitions for this information paper

The following are some useful definitions for terms used in this information paper. They are a suggested starting point only and are not prescriptively defined, unless otherwise indicated.

ALARP	*This term refers to reducing risk to a level that is As Low as Reasonably Practicable. In practice, this means that a duty-holder has to show through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.*

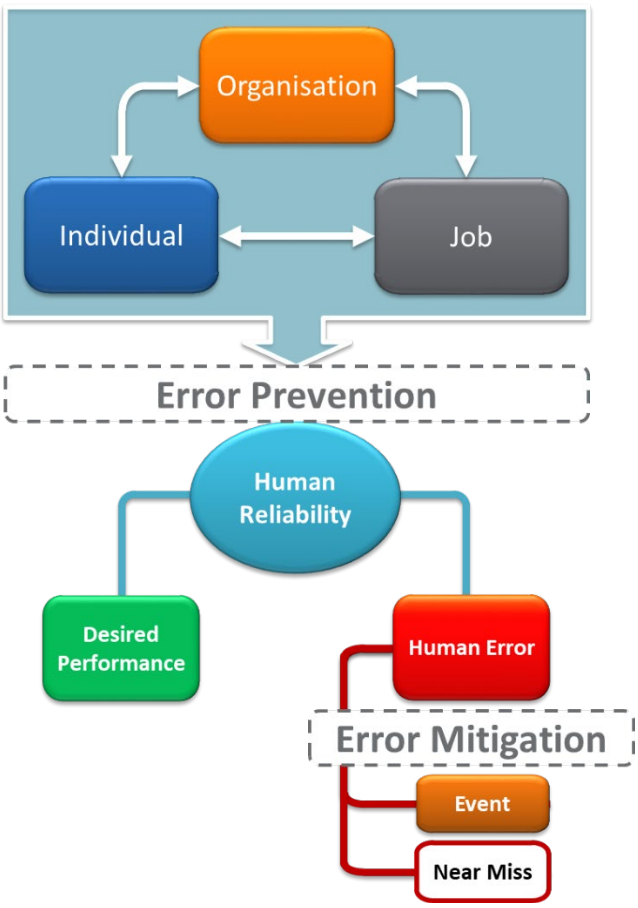
Critical human task	*Those activities people are expected to perform as barriers against the occurrence of an incident, or to prevent escalation in the event an incident does occur. They include activities required to support or maintain physical and technological barriers. (OGP, 2011)*
Escalation factor	*A condition that leads to an increased risk by defeating or reducing the effectiveness of a barrier (BowTie).*
Hazardous event	*A collective term encompassing safety, integrity, and environmental incidents, used for readability purposes within this information paper.*
Human error	*Failure of a planned action to achieve a desired outcome.*
Major accident event	*An event connected with a facility, including a natural event, having the potential to cause multiple fatalities of persons at or near the facility. Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2024, Regulation 1.5.*

1. Introduction to the Human Factors Information Paper Series

'Human Error' has long been identified as a contributing factor to incident causation. Commonly cited statistics claim that human error is responsible for anywhere between 70-100% of incidents. It seems logical, therefore, to blame incidents on individuals or small groups of people and to focus remedial actions at the individual level (e.g. training, disciplinary action, etc.). However, by taking this approach in addressing human error, organisations ignore the latent conditions in their work systems that contribute to human error across the workforce. Rather, human error should be recognised as an outcome of combined factors, instead of the root cause of an incident. Organisational, job, and individual factors all interact to influence human reliability, that is, the likelihood that an individual will perform their task effectively or make an error.

This publication forms part of a series of information papers focusing on human factors. NOPSEMA defines human factors as "the ways in which the organisation, the job, and the individual interact to influence human reliability in hazardous event causation". Reliable behaviour results in desired performance, while unreliable behaviour may result in human error, which can lead to events and near misses. This interaction is represented in Figure 1.

Figure 1 – A Model of Human Factors



The Human Factors Information Paper Series is designed to provide information about the ways in which organisational, individual, and job factors influence human reliability, and how organisations can minimise or optimise the effect of these factors, to assist in the prevention and mitigation of hazardous events and drive continuous improvement in safety, integrity and environment performance.

1.1. Intent and purpose of this information paper

It is widely accepted that human reliability plays a role in preventing or contributing to major accident events (MAE) and hazardous events in the Australian offshore petroleum industry (the industry). Indeed, human performance difficulties have been identified as a root cause in 1917 notifiable occupational health and safety (OHS) occurrences reported to NOPSEMA, including 61 instances of serious injury, and 255 instances where death or serious injury could have occurred. Proportionally, this indicates that human performance difficulties were found to contribute to 48% of all notified OHS occurrences, 81% of all occurrences resulting in death or serious injury, and 75% of all occurrences where death or serious injury could have occurred.

Safety case submissions frequently identify human error as a hazard or threat with the potential to lead to a MAE. Typically training and/or competency assurance is identified as an associated control measure, with other controls sometimes identified, including permit to work systems, role-specific procedures, and supervision. Error-related control measures predominantly target error prevention, with few control measures identified which target error reduction or mitigation.

This conceptualisation of human error as a hazard or threat is inaccurate. Rather, the potential for human error represents a barrier-defeating factor, or *escalation factor*. That is, where MAE control measures require human interaction, error can contribute to a failure of those control measures.

There appears to be significant variability in the quality and rigour of approaches to identify and control error risk, as reflected in the content of safety cases. There is no specific legislated requirement for duty holders to address error potential or error management within their safety case. However when error is considered during the formal safety assessment a thorough approach to control should be taken.

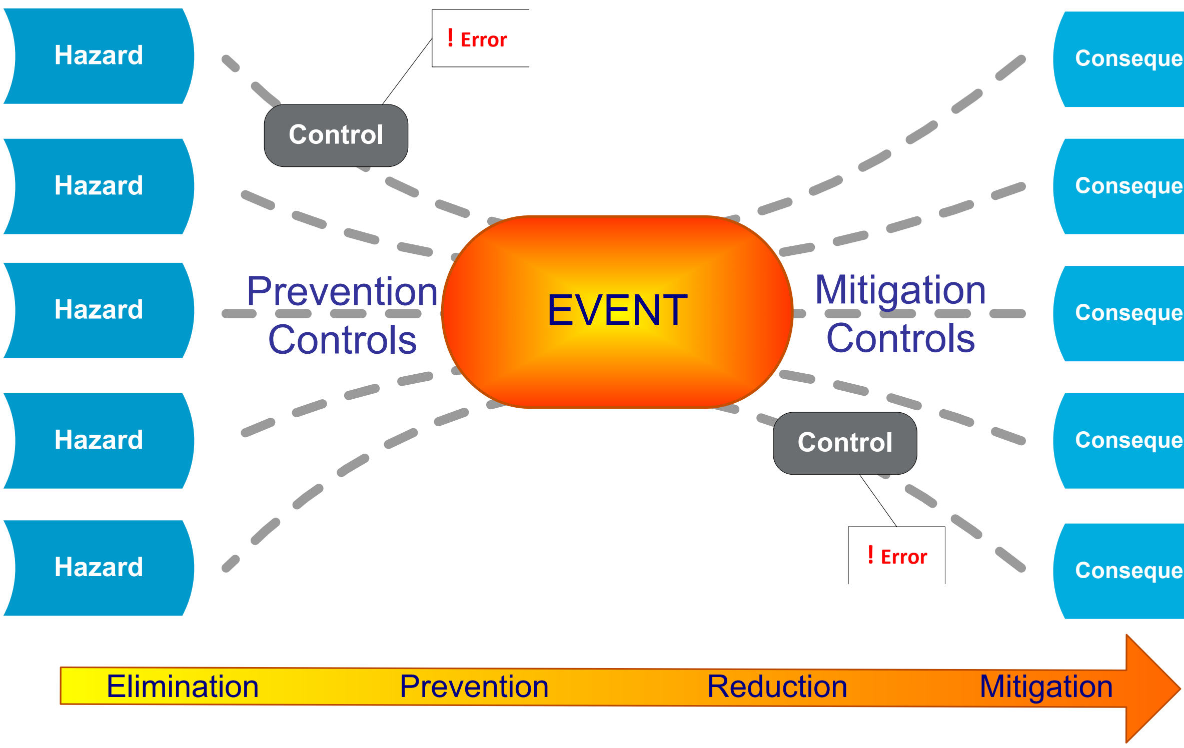
This information paper seeks to facilitate continuous improvement in error risk management throughout the industry. It outlines a suggested approach to error risk management, with the intention of improving the rigour with which error risk is identified and controlled in relation to MAE prevention. The suggested approach demonstrates how error risk can be managed using the same basic frameworks and models as traditional risk management approaches, whereby error risk can be evaluated and controls implemented until the risk posed by error is as low as reasonably practicable (ALARP).

Please note: Information papers provide information, background and practices to foster continuous improvement within industry. NOPSEMA acknowledges that what is good practice, and what approaches are valid and viable, will vary according to the nature of different organisations, offshore facilities and their hazards.

2. Risk management

The risk management approach within the Australian offshore petroleum industry is one of hazard identification, risk assessment, and implementation of control measures to eliminate, prevent, reduce, and mitigate a major accident event (MAE). Within this context, error is often presented as a threat or hazard with the potential to lead to an event; however this representation of error within an event model is inaccurate. Rather, error should be understood as a potential failure mechanism of a control measure, where that control measure involves human interaction; these types of controls include procedures, supervision, permit systems, inspections, risk assessments, and other administrative controls.

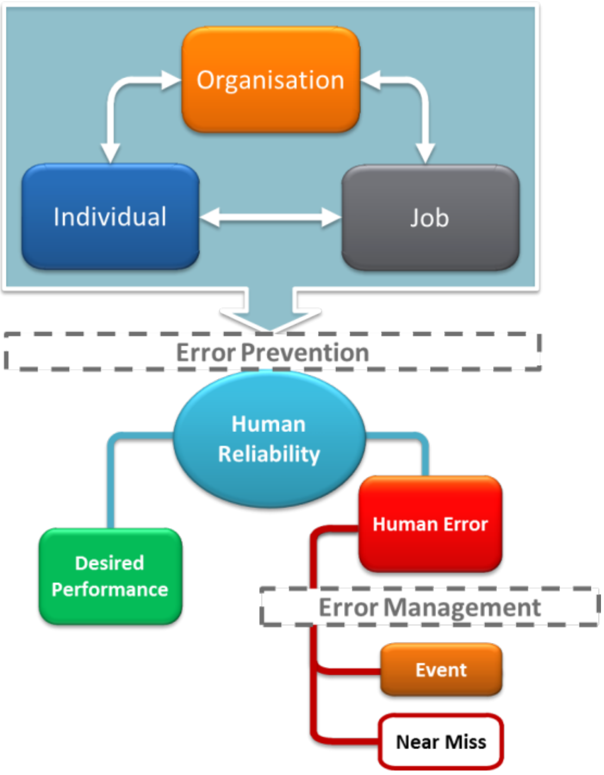
Figure 2 – Error as an escalation factor within a Bow-Tie diagram



2.1. Error risk management

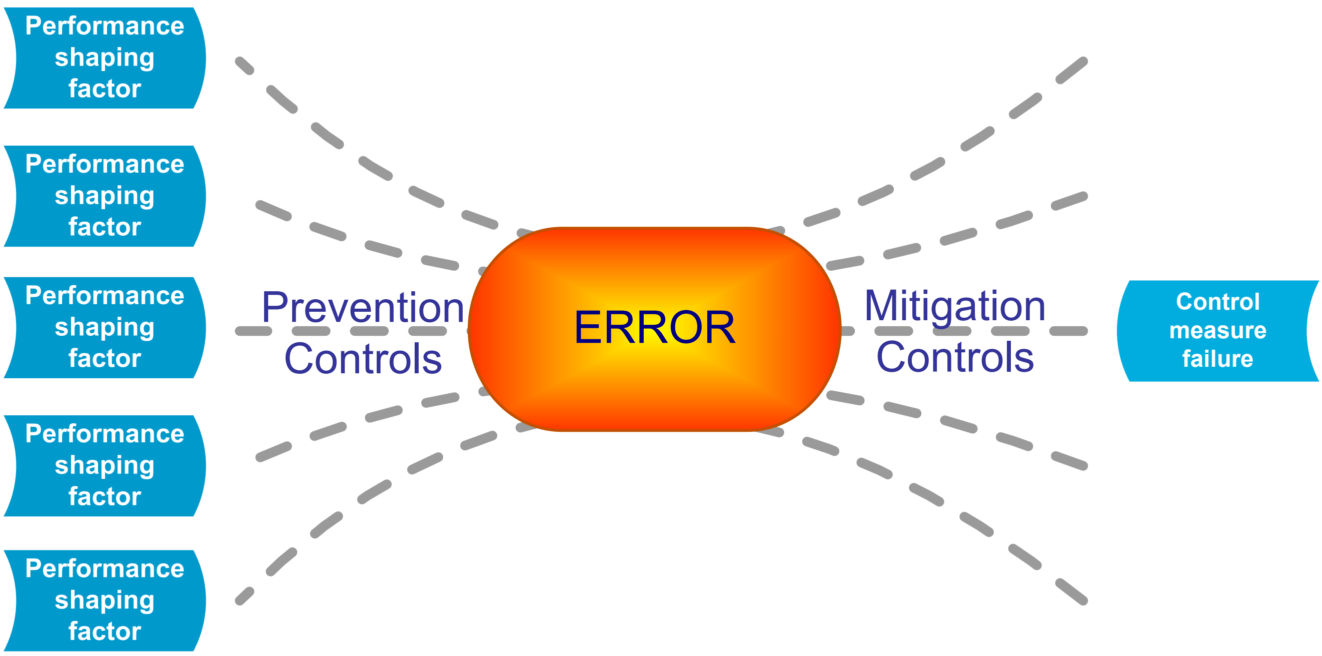
Error risk management should be approached in the same manner as any other risk. That is, where error has the potential to lead or contribute to an MAE, combinations of controls should be implemented to prevent and mitigate error. This approach to error management is presented in Figure 3, where error prevention strategies target performance shaping factors (PSFs) as a means of improving human reliability (i.e. minimising error likelihood); while error management strategies seek to provide opportunities for error identification and recovery, before the associated MAE is initiated.

Figure 3 – Error control within a human factors model



This approach to error management can be further explained through use of the Bow-Tie methodology, where the error escalation factor can be explored in greater detail. As Figure 4 illustrates, a range of PSFs have the potential to contribute to an error, which can lead to failure of a control measure. *Please note that this image is used for illustrative purposes only and does not represent a regulatory requirement.*

Figure 4 – Bow-Tie illustrating error control



When considered in this manner, error is not a hazard; rather error is the result of hazardous PSFs and forms part of the chain leading to an event and subsequent consequences. This more detailed view of error can facilitate the identification of a comprehensive set of error control measures designed to eliminate the error, minimise its likelihood (prevent), identify and recover from the error (reduce), and mitigate the consequences of the error before an event is initiated.

3. Reducing error risk

The following sections provide an overview of a process that organisations may wish to apply in order to reduce the risk posed by human error to a level that is ALARP. It is a suggested process only and does not represent a regulatory requirement.

Reducing error risk: A brief guide

1. Identify critical human tasks.
2. Identify error potential:
   a. What errors are possible?
   b. What are the potential consequences of those errors?
3. Identify performance-shaping factors:
   a. People-level factors.
   b. Job-level factors.
   c. Organisation-level factors.
4. Evaluate existing controls:
   a. Are controls in place to prevent error?
   b. Are controls in place to mitigate error?
   c. Is error risk ALARP?
5. Develop additional controls:
   a. Eliminate the opportunity for error.
   b. Prevent – lower the likelihood of error.
   c. Reduce – facilitate error identification and recovery.
   d. Mitigate the consequences of error.

3.1. Identify critical human tasks

Identification of *critical human tasks* should be the first step for organisations seeking to improve their control of error risk. Critical human tasks are defined as those activities people are expected to perform as barriers against the occurrence of an incident, or to prevent escalation in the event that an incident does occur, including activities required to support or maintain physical and technological barriers (OGP, 2011).

3.2. Identify error potential

Once critical human tasks have been identified, the error potential associated with those tasks should be considered. Various task analysis techniques can be applied to develop a granular description of task steps, facilitating the identification and classification of potential errors. The classification of error type is an important step as this facilitates the identification of appropriate controls. For example, training and competency can be an effective prevention and mitigation control for mistakes made while planning an action (i.e. knowledge-based or rule-based mistakes), but is typically ineffective for skill-based errors which occur during action execution (i.e. slips of action and memory lapses).

Following the identification and classification of potential errors, risk assessment processes can be applied to estimate the risk associated with error; that is, the severity of consequence/s of error and the likelihood that each consequence will occur. The outcomes from the risk assessment can be used to identify potential errors that pose an unacceptable level of risk. Those high-risk potential errors can then be subject to further exploration, which may lead to the development of additional control measures.

3.3. Identify performance-shaping factors

The high-risk potential errors should be evaluated to identify those PSFs most likely to contribute to error, as previously illustrated in Figure 4. Human reliability analysis tools can be used to guide the evaluation of the contribution made by various PSFs, and can provide some insight into the significance of each PSF on task performance and error likelihood. When applying such tools, the calculation of error probabilities alone is likely to be of limited use. In particular, error probabilities should not be used as targets or cut-off points (e.g., error probability must be below x to perform this task). Rather information generated throughout the analysis can help to highlight those PSFs most likely to influence error, leading to the development of more targeted control measures. Table 1 provides some examples of people-, job-, and organisation-level PSFs. Note that this is not an exhaustive list.

Table 1 – Examples of performance-shaping factors

People-level PSFs	Job-level PSFs	Organisation-level PSFs
Knowledge	Human-machine interfaces	Organisational culture
Competence	Workload	Organisational priorities
Skill	Procedures	Resource availability
Attitude	Task requirements	Communication systems
Physical capabilities/limitations	Relationships with co-workers	Policy and direction
Psychological health	Relationships with supervisors	Leadership commitment
Physical health (disease, medication, fatigue, substance abuse, etc.)	Physical environment (noise, lighting, vibration, temperature, humidity, etc.)	Workforce planning

Further information on human reliability analysis can be found in the ***Human Reliability Analysis*** section within the ***Human Factors*** page of the NOPSEMA website (www.nopsema.gov.au).

3.4. Evaluate existing controls

At this stage consideration should be given to existing controls and their expected impact on error risk, even if those controls were not designed for the purposes of error management. For each relevant PSF identified, existing controls should be evaluated to determine their ability to eliminate the risk posed by the PSF or to prevent it leading to error. Similarly, for each potential consequence of error, existing controls should be evaluated to determine their ability to prevent and mitigate that consequence. A decision should then be made as to whether error risk is ALARP or whether the inclusion of additional controls is likely to further reduce risk.

3.5. Develop and implement additional controls

Where it is identified that existing controls do not reduce error risk to a level that is ALARP, additional controls should be developed and implemented. Controls should include strategies targeting error prevention and mitigation, with prevention controls tailored to the type of error in question.

Table 2 provides examples of control measures for different types of error.

Table 2 – Example controls for different error types

	Eliminate	*Prevent*	*Reduce*	*Mitigate*
Mistake	Competency assurance	Communication conventions	Software interface logic and layout	Engineering controls
Slip of action	Design for tactile differentiation	Confirm action prompt	Error management training	Engineering controls
Memory lapse	Checklist	Independent check	Alert/Alarm	Engineering controls

Some controls will be relevant to many error types and can facilitate both prevention and mitigation of error. These controls include but are not limited to the following:

- design and construction philosophies and standards
- active supervision
- planning and resource allocation, including manning levels
- fatigue risk management
- substance monitoring and control (i.e. medications, alcohol and illicit drugs, etc.)
- job observation and feedback processes.

4. A suggested starting point

The evaluation of all critical human tasks for error potential and control represents a large and complex project. An effective approach may be to first target those critical human tasks that have previously demonstrated evidence of uncontrolled error; that is, accidents and hazardous events (events). Where critical human tasks have failed to prevent or mitigate events, those tasks should be analysed to identify and classify the corresponding errors.

Once the key errors have been identified and classified, relevant PSFs should be explored to determine their likely contributions to each error. This process is likely to lead to the identification of two groups of PSFs – those whose influence is limited to the error in question, and those whose influence is likely to impact performance in other critical human tasks (i.e. latent hazards). Table 3 provides some examples of specific and general PSFs that can contribute to a knowledge-based mistake.

Table 3 – Example PSFs for a knowledge-based mistake

Error-specific performance-shaping factors	**Systemic performance-shaping factors**
Training content	Fatigue
Competence assurance items	Change management
Content of drills and simulations	Leadership and supervision
Control panel display layout	Communication conventions

Following the identification of relevant PSFs, existing controls can then be evaluated to identify gaps within the layers of defence. Evaluation findings should identify improvements required for existing controls and where necessary make recommendations for additional controls to further reduce error risk. Recommendations should be subject to appropriate approvals, change management processes, and tracking and closeout requirements.

5. References, acknowledgments & notes

BowTieXP Quick Start Manual.

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Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2024

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