Critical task analysis

Key messages

- Human reliability plays a role in preventing or contributing to event causation.
- The role of error in event causation acts as a barrier-defeating factor.
- There appears to be opportunity for the industry to improve the ways in which error risk is identified and controlled to improve event prevention and mitigation.
- Error risk can be evaluated and controls implemented until the risk posed by error is as low as reasonably practicable (ALARP).
- Error risk management activities should primarily target those tasks positioned within control measures critical to event prevention and mitigation.
- Critical task analysis can facilitate robust error risk management.

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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.

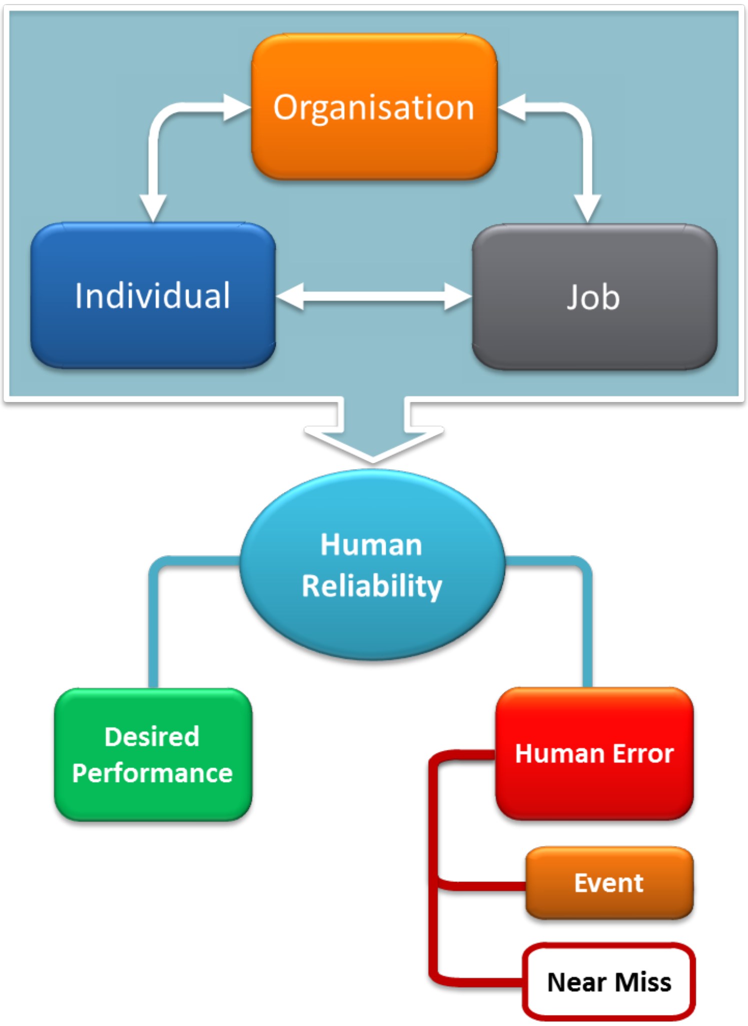
ALARP	This term refers to reducing risk to a level that is as low as reasonably practicable. In practice, this means that a duty-holder has to show through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.
Critical task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

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 may seem 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 environmental performance.

Further information on human error is available on the 'Human factors' web page at nopsema.gov.au.

1.1 Intent and purpose of this information paper

Human performance difficulties (HPD) have been identified as a root cause in 1909 notifications reported to NOPSEMA as of 31 December 2016, contributing to accidents, dangerous occurrences, environmental reportable incidents, and well integrity incidents. Specifically, HPDs have been identified in 61 instances of serious injury and 254 instances where death or serious injury could have occurred. Proportionally, this indicates that HPDs were found to contribute to 48% of all notified incidents, 81% of all occurrences resulting in serious injury, and 76% of all occurrences where death or serious injury could have occurred.

The most frequently reported HPD root cause classifications are procedures and human engineering, which in combination account for more than half of all HPDs reported to NOPSEMA since 2005. Further, procedures and human engineering are consistently the most frequently reported HPDs each year. This consistent pattern of HPD root causes suggests that existing risk management methodologies fail to appropriately consider, understand, and address error risk; indicating that hazardous event risk may not be reduced to a level that is as low as reasonably practicable (ALARP).

An improvement to error risk management processes is required to effectively manage error risk and so reduce the frequency and severity of hazardous events. To assist duty holders in facilitating this improvement, NOPSEMA published information paper IP1509 outlining a process for the reduction of error risk to ALARP. The purpose of this information paper is to provide supplementary information for section 3.2 of IP1509 (Identify error potential). Specifically, this information paper provides a basic description of how to conduct critical task analysis.

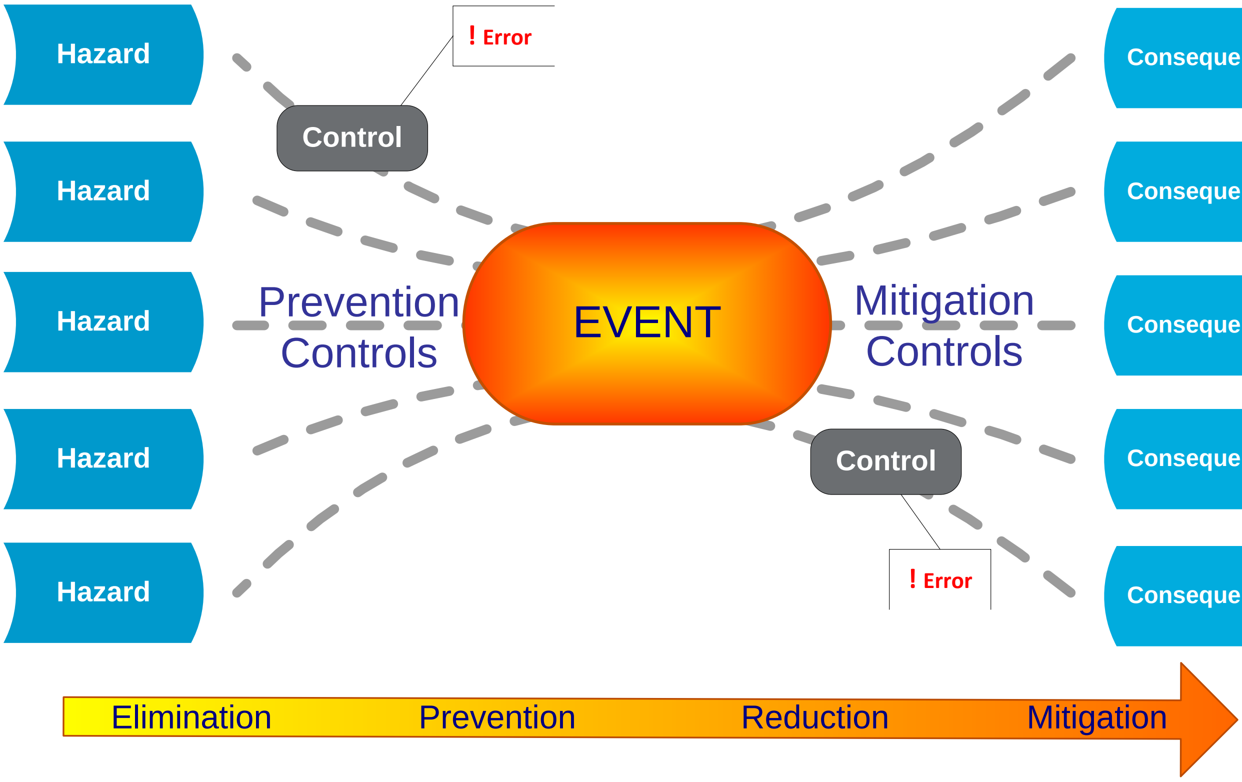
Some duty-holders may have already implemented task analysis techniques and procedures. The legislation does not oblige duty-holders to apply the steps outlined in this information paper. The information provided is intended as a guide for those organisations who desire assistance in this area.

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 hazardous event. Within this context, error represents a potential failure mechanism, or escalation factor, of a control measure, where that control measure involves human interaction. The potential impact of error on control measures is presented in Figure 2. Control measures requiring human interaction include procedures, training and competence, 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 should be approached in the same manner as any other risk, where combinations of controls are implemented to reduce risk through prevention and mitigation strategies. A systematic and risk-based approach to error risk management can contribute to the reduction of hazardous event risk to ALARP. NOPSEMA has published information on error risk management in the information paper IP1509. Task analysis can assist in the identification of error risk within critical tasks and so facilitate the development of appropriate controls to reduce hazardous event risk to ALARP.

3 Critical task analysis

Task analysis can be broadly defined as the study of what an individual or team is required to do in order to achieve a goal. Within task analysis, activities and scenarios are broken down into component task steps or physical operations, which are then recorded within a documented representation of the analysed activity or scenario.

Task analysis involves the collection of specific data to develop a step-by-step description of the activity in question, including:

- the individual task steps required
- the technology used for task completion
- the sequence of steps within the overall task.

The task description can then be subject to further analysis such as error identification, performance evaluation, or process charting techniques.

Critical task analysis (CTA) involves the application of task analysis techniques to tasks critical to safety, integrity, and environment, to facilitate the identification of uncontrolled or poorly controlled error risk. The identification of such risk can then drive the development of more robust control measures to reduce risk to a level that is ALARP.

3.1 Task analysis methods

There are numerous task analysis methods available for use. Various methods have been developed for analysis of specific types of tasks, such as cognitive tasks or system design. Other methods aim to facilitate delivery of a desired data type as an output, such as dialogue transcripts or individual operations. Duty holders choosing to implement task analysis should determine which method is most appropriate to the task in question, noting that the examples described below are provided for illustrative purposes only.

Hierarchical task analysis (HTA) is described because it is generally viewed as a framework for task analysis rather than a specific technique, and therefore provides a useful general guide to task analysis. A description of tabular task analysis (TTA) then follows to demonstrate how HTA output can be further analysed to achieve the specific purpose of the analysis.

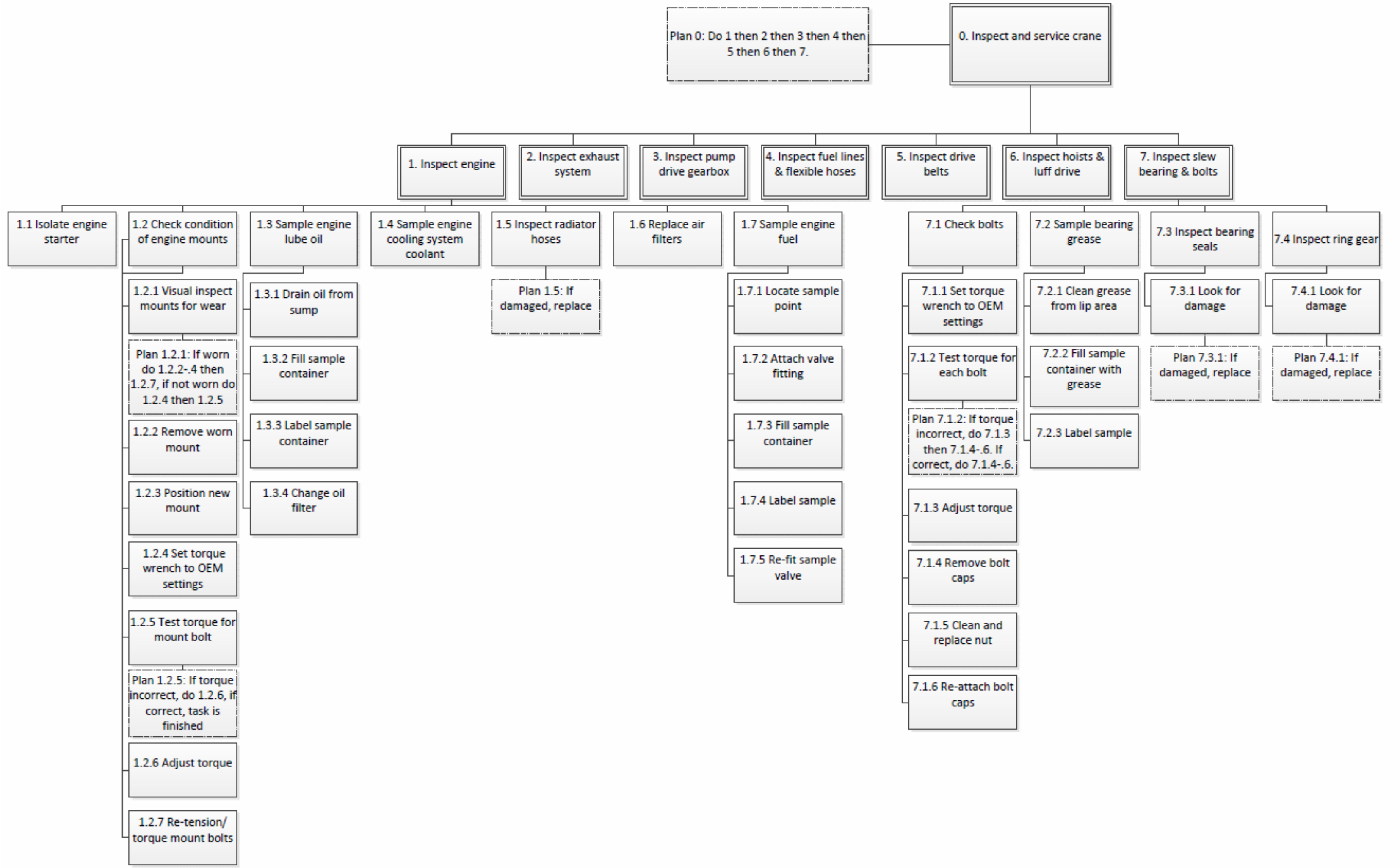
3.2 Hierarchical task analysis

Hierarchical task analysis provides a framework for conducting task analysis, where a task is broken into a nested hierarchy of goals, operations, and plans. Its outputs can be subject to more specialised forms of task analysis, and can provide source data for human factors analysis methods including error analysis. The steps below describe the basic process involved in conducting a HTA, referencing the example provided in Figure 3.

Example HTA

Figure 3 provides an example of a HTA for a six-monthly crane service and inspection. The example contains extracts for illustrative purposes and does not represent a comprehensive analysis of the task in question.

Figure 3 – Hierarchical task analysis example



Step 1 – Task definition

The first step in the HTA process is to determine which critical task should be analysed[1], define the task (in the case of new task development rather than analysis of existing tasks), and describe the purpose of the analysis. The purpose of the HTA process described below is to develop input data for error analysis.

Step 2 – Data collection

A variety of data sources should be accessed to ensure comprehensive coverage of the task in question. Data can be collected through task observation, interviews with subject matter experts, questionnaires, and review of procedures and work instructions. Data collected should pertain to all aspects of the task including:

- the task steps
- technology used
- interactions between individuals and objects
- interactions between individuals and other persons
- decision making
- task constraints.

Step 3 – Determine the goal

The overall goal of the task, or the problem that the actor must solve, is specified at the top of the hierarchy. For example, in Figure 3 the goal is to inspect and service the crane. Further examples of such goals include:

- isolate valve
- bleed pressure vessel
- maintain diver life support
- deploy lifeboat
- test blowout preventer
- determine dispersant application
- monitor mud pit returns.

Step 4 – Determine sub-goals

The overall goal is broken into meaningful sub-goals. These sub-goals should together represent the total steps required to achieve the overall goal. For example, in Figure 3 the sub-goals identified in boxes 1-7 include *inspect engine*, *inspect exhaust system*, *inspect pump drive gearbox*, and so on.

Step 5 – Sub-goal decomposition

Each sub-goal identified in step 4 is then broken down into further sub-goals and operations. This process of decomposition continues until an operation is reached. The bottom level of each nested hierarchy within a HTA must always contain an operation, while each superordinate level contains a goal. Operations say what needs to be done. Operations describe a physical or mental action (a transitive verb[2]) performed by the actor in order to achieve the associated goal. For example, in Figure 3 sub-goal 7, *inspect slew bearing and bolts,* is broken down into four sub-goals, *check bolts*, *sample bearing grease*, and so on. The sub-goals also contain operations, such as *clean grease from lip area*, *fill sample container with grease*, *label sample*, and so on.

[1] For guidance on identifying critical tasks, refer to the ***Energy Institute (2011)*** publication.
[2] A verb used with a direct object, as *drink* in the sentence *"she drinks water"*, where *water* is the direct object (Macquarie Dictionary)

Step 6 – Plans analysis

Once the nested hierarchy is complete with all goals and operations described, plans are added to dictate how the goals are achieved. Plans specify the order in which the different goals and operations are to be performed, and can be contingent upon certain variables. Plans exist in many forms, including:

- linear, e.g. "do 1 then 2 then 3"
- non-linear, e.g. "do 1, 2, and 3 in any order"
- simultaneous, e.g. "do 1 and 2 at the same time"
- branching, e.g. "if x is present do 1 then 2, if x is absent do 3"
- cyclical, e.g. "do 1 then 2 then 3, repeat until x"
- selection, e.g. "do 1 then 2 or 3".

For example, in Figure 3 *Plan 0* is a linear plan, while *Plan 7.1.2* is a branching plan.

3.3 Tabular task analysis

Tabular task analysis (TTA) uses the bottom-level task steps derived from a HTA and analyses different aspects of each step such as potential errors, controls used, feedback, triggering events, etc. The content and focus of the TTA is highly modifiable and is easily tailored to the purpose of the analysis. The steps below describe the process of completing a TTA using data obtained from a HTA, referencing the example provided in Table 1**.**

Example TTA

Table 1 provides an example of how the HTA data from Figure 3 can be converted into a TTA and used for error analysis. Again, this example contains extracts for illustrative purposes and does not represent a comprehensive analysis of the task in question.

Table 1 – Tabular task analysis example

Operation number	Operation description	Possible errors	Error classification/s
1.2.1	Visual inspect mounts for wear	Failure to identify wear on mounts	Slip – reduced intentionality, interruption
1.2.3	Position new mount	Reinstates worn engine mounts, Incorrect new mount set-up	Slip – double-capture, reduced intentionality, interruption Memory lapse
1.2.4	Set torque wrench to OEM settings	Incorrect torque setting on wrench	Slip – perceptual confusion, interference
1.2.5	Test torque for mount bolt	Wrench not correctly applied on mount bolts	Slip – perceptual confusion
1.2.7	Re-tension/torque mount bolts	Bolt not tightened to torque setting	Rule-based mistake – signs and non-signs, rule strength

Step 1 – Convert HTA into tabular format

Each operation described in the corresponding HTA is transcribed into the left column of the TTA table.

Step 2 – Choose task analysis categories

Categories are selected based upon the nature of and reason for the analysis. Selected categories are entered into the top row of the table. As the purpose of this TTA is error analysis, the categories are selected to facilitate error identification and analysis.

Step 3 – Complete TTA table

Each cell in the table is completed using a range of data sources such as those accessed for the initial HTA (see Step 2 – Data collection).

3.4 Risk assessment

NOPSEMA information paper IP1509 describes the steps that should follow the completed task analysis. Broadly, the outputs from the completed task analysis should be subject to risk assessment to determine whether existing control measures provide sufficient protection against error risk, or whether additional controls are required to reduce hazardous event risk to ALARP.

For example, in Table 1 a potential error associated with Operation 1.2.3 is 'incorrect new mount set-up'. The risk associated with this error should be calculated (i.e. the probability of the error occurring and the maximum consequence should the error occur), and existing control measures identified including error prevention, error identification, and error recovery. Where risk is not reduced to a level that is ALARP, additional control measures should be implemented. Error prevention controls may include error tolerant mount design, while error identification controls may include testing, photographs of correct set-up, independent checking by a third party, and control panel alerts and alarms.

4 Managing change

The introduction of a new risk assessment methodology represents an organisational change and so should be managed appropriately to ensure that the process is fit-for-purpose and accepted by the organisation. The following steps provide an outline of a suggested strategy for those organisations choosing to implement critical task analysis.

Compile Information

Gather relevant information about hazardous events and compile it in a manner that is easy to present to a variety of people. Focus on major accident events, significant environmental damage, and hazardous events with severe potential consequences.

Engage interested stakeholders

Discuss the compiled information with people on the facility and in the office likely to be affected by the introduction of CTA. Identify those individuals who are interested, willing and able to get involved. Where possible, engage influential individuals – subject matter experts, health and safety representatives, trade specialists, peer leaders, and relevant supervisors or managers. Aim for a variety of job levels, disciplines, tenure, and organisational exposure.

Plan the change process

Assign stakeholder group members to engage with different groups across the organisation about the introduction of CTA. Engagement activities should focus on those groups likely to be impacted by CTA. Engagement activities should aim to ensure that participants understand the need for change, have an opportunity to contribute to the development of the process, and feel that their concerns and ideas are heard, considered, and actioned where appropriate.

Pilot the process

Identify a critical task to pilot the CTA process. The pilot should apply the principles of action research – plan, action, and then fact-find about the results of the action. Fact-finding should include technical outcomes relating to overall risk reduction, as well as perceptions of the process and outcomes.

Iterate

Where necessary, modify the process based on the results from the pilot, then select the next critical task for analysis. Continue to iterate the approach until a satisfactory CTA process is established.

Formalise

Capture the final iteration of the CTA process in supporting documentation such as procedures and work instructions. Develop a plan to continue CTA across all critical tasks. Modify existing standards, procedures, plans and other relevant documentation where necessary to incorporate CTA into risk assessment processes.

Further information on organisational change management can be found in the NOPSEMA information paper: *IP1039 Human factors: Change management*

5 References

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Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009

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