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Report

CRIOP: A scenario method for Crisis Intervention and Operability analysis

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ABSTRACT
CRIOP is a methodology used to verify and validate the ability of a control centre to safely and efficiently handle all modes of operations including start up, normal operations, maintenance and revision maintenance, process disturbances, safety critical situations and shut down. The methodology can be applied to central control rooms, emergency control-rooms, drillers' cabins, cranes, ship bridges and other types of cabins, both onshore and offshore. The key elements of CRIOP are checklists covering relevant areas in design of a Control Centre (CC) i.e. "work as imagined", scenario analysis of key scenarios exploring "work as done" and a learning arena where the workforce with operating experience, designers and management can meet and evaluate the optimal CC. A CRIOP analysis is initiated by a preparation and organisation phase, to identify stakeholders, gather necessary documentation, establish analysis group, and decide timing.

This version of CRIOP was developed based on user requirements, experiences of use in actual projects and best practices from 2003, 2004, 2008, 2011, 2024 and 2025.

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VERSION	DATE	VERSION DESCRIPTION
2025	2025.04	Updated based on research and requirements, New HF and HMI standards
2024	2024.08	Updated references
2011	2011.03	Updated with relevant regulations and CCTV standards

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Preface

The aim of this preface is to give a short background of the CRIOP methodology to the users and describe how and why the new version has been developed and validated. The main goal has been to develop a methodology based on user needs, requirements, and experience. Use of CRIOP is based on Action Research (AR) as described by Greenwood and Levin (2006), i.e. a participatory approach to improvements that involves collaboration between researchers and stakeholders to address real-world problems and create practical solutions. This is in line with the principles in HOP, Dekker& Conklin (2014).The first version of CRIOP was published in 1990. The scope included a scenario and general checklist for evaluation of Offshore Control Centres. The focus of the methodology was on the human aspects in terms of conditions for successful crisis handling.

The methodology was a result of the CRIOP project, “Crisis Intervention in Offshore Production”, taking place in the period 1985-90, with support from Norsk Hydro, Saga and Elf. Some of the key events since the development of CRIOP in the 1990’s has been:

- 1990 and onward: CRIOP was used at Norsk Hydro (On Oseberg C, Troll B, Njord, Visund, Troll C, Oseberg Sør, Oseberg D, Grane).
- 1997: CRIOP was recommended as a preferred methodology in NORSOK S002, Rev 3.
- 2000-2002: NPD (Norwegian Petroleum Directorate) includes Man Machine Interfaces (MMI) and Human Factors (HF), ISO 11064 (Ergonomic design of control centres) in HSE regulations; includes requirements for systematic end user involvement, alarms, validation and verification, competence and reduction of human errors and MMI in Control Rooms.
- 2003-2004: CRIOP updated based on practice, remote operation and Integrated Operation. Questions related to Drillers Cabin have been incorporated.
- 2008-2013: CRIOP updated based on experience, new HSE regulation and use of CCTV, Aas et al. (2009).
- 2024: All references updated and CRIOP has been used at Yggdrasil and Askepott.
- 2025: CRIOP updated based on user requirements (from interviews and workshops); requirements from HMI standards covering packages; multifacility control; experiences of remote operations; experiences from brownfield; inclusion of meaningful human control; and use of automation/AI (EU AI regulation). New CRIOP used at remote operated platform (Neptun Deep) and an autonomous ferry in operation in Stockholm (Estelle). New CRIOP has also been used in remote management of an autonomous freight vehicle fleet (concept phase).

Norsk Hydro was a driving force to update and use CRIOP, key actors’ of 2013 version were:

Norsk Hydro:	**J. Monsen**, Chairman in SC; U. Kjellén, H. Aasved, A. Tiltnes
Statoil (Equinor):	T. Salbo, **T. I. Throndsen** (Responsible from Statoil/Equinor)
Scandpower:	O. Silkoset, H. Haukenes, J. Ramberg
SINTEF:	L. Bodsberg, S. O. Johnsen, K. Øien
NPD:	E. Bjerkebæk, T. Eskedal
IFE:	L. Å. Seim
NUTEC:	A. Tidemann, S. Halvorsen
HFS:	A. Balfour
SENSE	Olav Revheim, Jarle Dyrdal

Research activities have been performed in 2021 through 2025 to update CRIOP to support best practice in safety, efficiency and usability. We have performed workshops, discussed with actors in standardisation groups, and performed interviews with human factors experts from industry, research, consulting and research: Equinor, DnV, Kongsberg, IFE, Eggs, Halogen, We are Nice, Eldor, AkerBP, Vysus, NTNU – Samf.forsk, NTNU Design/Ålesund, Safetec and USN.

The work has been financed by NRF (Research Council), NTNU, The HFC forum and Equinor.

There is still a challenge to implement Human Factors in development and operations (through tools such as CRIOP). According to Bergh et al. (2024), *"Results from the analysis support research findings within the field of human factors and technology development, pointing out that there is a lack of focus on human factors in both development projects and in operations" (p.1).* There are still serious deficiencies in alarm handling in control rooms and in drillers cabin, Havtil (2022a). However –advantageous results (and design prizes) have been achieved when using Human Factors methods such as ISO 11064/9241-210 and human factors engineering (i.e. task analysis/ eye-tracking/ simulation and observations). Best practice examples are the development of the Unified Bridge system, Bjørneseth (2021) and next generation Air Defence, Helgar (2023).

CRIOP is planned to be revised iteratively each year, with updates made to the electronic version available online at *http://www.CRIOP.sintef.no.*

A key issue is to adapt CRIOP to the relevant case and project. Project management together with involved Human Factors experts should select relevant questions based on the project scope, phase and challenges. Relevant questions may vary; however, we have suggested a short-list of 10 key CRIOP questions in section 1.4.
(Selection of questions can be done through LLM/AI as described in the following or by a planned web tool to select questions by phase, industry and scope – based on user requirements.)

Use of Large Language Models (LLMs) to select relevant CRIOP questions adapted to phase and industry
Large Language Models (LLMs) can assist in selecting (few) relevant questions and issues from CRIOP, in generating scenarios, exploration of edge cases and in safety analysis adapted to scope (such as phase or industry). However, their outputs must always be reviewed and validated by human oversight, Weidinger et al. (2022). LLMs offer potential benefits in hazard analysis but also come with limitations, Charalampidou et al. (2024). New tools and frameworks, such as Retrieval-Augmented Generation (RAG) systems—examples include NotebookLM and ChatGPT—are developing rapidly. This remains an emerging field where further research is needed. To maximize the benefits of LLMs, several factors must be considered:

- Definition (and conceptual design in the coding phase), Liu et al. (2024),
- Prompt engineering strategies (such as using step-by-step prompting to explore reasoning and improve the quality of answers), Sammour et al. (2024).

Pilot testing have shown that using AI tools, combined with human validation, can improve both efficiency and the quality of hazard and scenario analysis.

1. Introduction – background, what is CRIOP?

1. Background – Need for Human Factors (HF)

The aim of this section is to describe the need for Human Factors (HF) and arguments for checking Human Factors issues through the CRIOP methodology.

In the US, the National Institute for Occupational Safety and Health (NIOSH) Prevention through Design (PtD) initiative recognizes that *"one of the best ways to prevent and control occupational injuries, illnesses, and fatalities is to 'design out' or minimize hazards and risks early in the design process''* Behm et al. (2014). In several accident analysis, design flaws have been identified as key root causes, such as the Chernobyl disaster, Insag-7(1992), the Boeing Max crash, Endsley (2019) and USS John McCain accident, NTSB (2019).

In many instances we operate with legacy systems/systems in operations (brownfield), that often accumulates issues including outdated designs, missing alarm management, ad-hoc modifications (maybe without MoC -management of change), missing integration of new small systems and evolving operational practices (work as done) that can introduce "error-traps". To avoid drift into failures, it is suggested to evaluate control facilities and their procedures and organisational factors periodically supported by CRIOP. Key areas should be to evaluate alarms, safety critical tasks, risk evaluations and trends, Nazaruk (2022). In addition, gather data and explore work as done through talking to people and observing adaptations, Shorrock (2021) and Nazaruk (2022).

CRIOP tries to use best practices from human factors research to design-out and minimize hazards and risks as early as possible. CRIOP can help to avoid drift into danger, by periodically review ergonomics, workload, fatigue, alarms, work as done and usability, improving safety, efficiency and usability. CRIOP builds upon principles in HOP, Dekker& Conklin (2014), that needs to be supported by relevant accident models as used by Havtil, Winge et al. (2023).

1.1. Aim, definitions, and framework

The aim of HF is safety, performance (quality and efficiency) and satisfaction (i.e. usability), Lee et al. (2017). Basic HF knowledge is documented in Lee et al. (2017) and Stanton et al. (2013).

A common definition of HF is from IEA (2000): *"Ergonomics or Human Factors is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance."*

Often used HF concepts are design and usability, cognition, human-machine interface (displays, controls, and alarms), human-automation interaction, physical workload, mental workload, teamwork, and training/simulations, Laumann et al. (2018).

HF is often defined and supported by rules and regulations. In Norway, the facilities regulations (FR) §20 Ergonomic design says, *"Work areas and work equipment shall be designed and deployed in such a way that the employees are not subjected to adverse physical or mental strain…"*. In EU, the new Machinery Regulation (EU) 2023/1230 is expected to contain the same elements in 2027.

1.2. Consequences of missing focus of HF

Poor HF is often identified after an accident, while good HF is identified in successful recoveries (or not at all). The significant consequences (harm, costs, etc.) of poor HF are the strong arguments for incorporating HF into design and operations. Some relevant incidents are listed in the following Table 1.1, from general to specific.

Table **1.1** Incidents and HF causes

Incident	**Loss**	**HF causes**
Boeing Max Disasters (in 2018 and 2019)	346 deaths; two crashes, Huge Loss and grounding of the Boeing Max airplane	**From the Accident Analysis Endsley (2019) presented to the US congress:** The crashes were due to several failures, mainly related to design i.e. one was in poor human-system integration, the automation system was activated without pilot input and without clear indication, a classic case of automation surprise in combination with additional poor design, missing training, and lack of pilot awareness.
Deepwater Horizon (in 2010)	11 deaths; Loss more than 60 000 Mill USD; Environmental consequences - Oil spills in Gulf of Mexico	**From Deepwater Horizon Accident Analysis CSB (2016)- Volume 3** The new perspective highlighted in the 2016 report was the poor HF focus, i.e. Inadequate incorporation of human factors into safety management practices and hazard assessments. Ineffective organizational learning from previous incidents. Illustrate the current gaps in US regulations and guidance that do not incorporate recognized process safety concepts, including human factors.
USS J. McCain Collision (in 2017) USS Fitzgerald Collision; (in 2017);	10 fatalities at USS McCain; 7 fatalities at USS Fitzgerald; In both cases, the financial loss was significant	**Key terms from the two accident reports NTSB (2020, 2019)** For J. McCain -The design flaw in the Integrated Bridge and Navigation System, NTSB (2019). Common issues in both accidents: Fatigue. Lack of operational oversight of the destroyer by the US Navy, which resulted in insufficient training and inadequate bridge operating procedures. Bridge team's loss of situation awareness. The AIS-automatic identification system data transmission policy.
BOP Rowan Stavanger 14.9.2020	Some mechanical damage, no significant loss	**Key terms from the Havtil accident report PSA (2020)** Design of the locking mechanism - human-machine interface; Personnel competence and training; Procedures and governing documentation; Management of change (MOC); Roles, responsibilities and information sharing in the organization; Workload and inclusion of personnel on board: Contract requirements and cost pressures Maintaining the operator's responsibility for supervision.

1.3. The importance of HF and learning between the involved actors and management

Norway has achieved the world's best road safety in the last decades. One of the key reasons has been systematic risk-based approach, open knowledge sharing and systematic learning, Elvik (2021). The argument used by Elvik (2021) is that open democratic processed and sharing of information between actors, is a key foundation of safety supporting a broad democratic change process involving the regulator, organizations building infrastructure, people involved and in the design of technology.

Open sharing of HF causes in accidents (such as from Deepwater Horizon, USS Fitzgerald) can help to prioritize Human Factors in regulation, development, operations and in accident investigations. Also, a systematic, research-based approach can help improve learning from successes.

Action research in safety research and development, from Greenwood and Levin (2006), is a systematic way to learn between management, involved actors and the regulator. Action research is a participatory and reflective research approach aimed at solving real-world problems through iterative cycles of planning, action, observation, and reflection. It involves collaboration between researchers and practitioners to improve practices, processes, or understanding within a specific context. Prioritizing aspect with highest risk, mitigating actions are implemented and results are discussed in a learning environment. Significant improvements may be achieved.

Figure 1.1 is an example of the impact of action research on safety in offshore supply vessels used in the oil and gas industry, Antonsen et al., (2007). Following a rise in collisions, injuries, and one fatality in 2000, action research was initiated in collaboration with vessel crews, management, and regulatory authorities. A joint working group—referred to as the "Captains' Forum"—was established to maintain momentum in improving safety. This group addressed human factors, technological aspects, and organizational elements such as procedures and responsibilities, with the aim of continuous learning and safety enhancement. The initiative led to significant improvements in reducing the risk of major accidents (such as collisions) and personal injuries.
A similar improvement in safety has been achieved in offshore helicopter transport in Norway, through open dialogue, collaborative learning, and continuous development—an approach facilitated by the "Forum for Helicopter Safety", Bye et al. (2018).

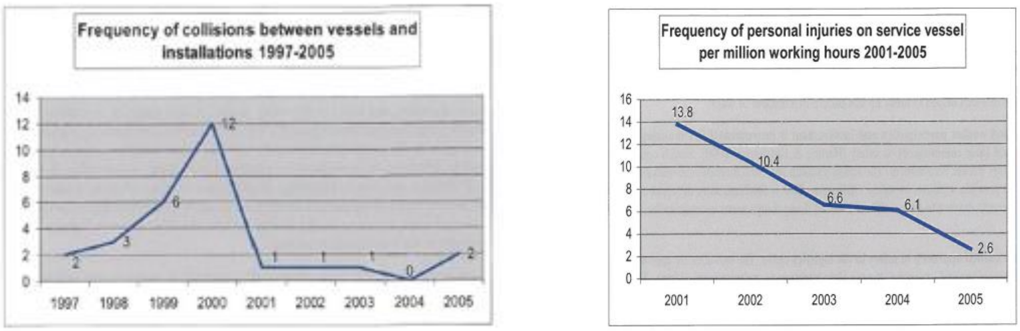


Figure 3: Development in the frequency of collisions between service vessels and installations in the period from 1997 to 2005.

Figure 4: Development in the frequency of personnel injuries on service vessels per million working hours in the period from 2001 to 2005.

Figure 1.1 Effects of action research on offshore supply ship safety (collision and personal injuries)

The science of HF has been a key area in Aviation. Aviation has such a low accident rate that they are characterized as ultra-safe Amalberti (2017). IATA -The International Air Transport Association managing 82 % of all air traffic had no hull losses in 2012 or 2017, supporting the view that aviation is a leader in safety. The aviation industry has initiated and integrated HF as a mean to support human control in their working environment from World War II, see Kirwan (2025). Key safety issues from aviation are the prioritization of HF and the open reporting culture prioritizing learning vs blame (i.e. Just Culture), as supported by HOP, Dekker & Conklin (2014). From successful recoveries, we have seen the effect of excellent HF design, such as observed in the US Airways Flight 1549 (Airbus A320) that struck a flock of birds shortly after take-off losing all engine power. The pilots managed to glide the plane to ditching on the Hudson River, NTSB (2010), without casualties. The airplane was designed to be able to land on water. The pilots had long experience, excellent HMI/cockpit layout and design – and they used 2 minutes to decide what to do, i.e. in our view an exceptional minimum time limit for decisions under duress.

1.4. Top 10 HF activities that should be checked in a CRIOP analysis

The CRIOP checklist contains many suggestions and best practice that must be selected based on context, scope and maturity. However, a high-level check can consist of 10 issues, that should be addressed in a normal development from project definition through development. Table 1.2 summarizes key activities and results, that should be evaluated and explored.

Table 1.2 Top 10 HF activities (CRIOP Questions) and results that should be checked by CRIOP

Activity *(Key CRIOP question)*	**Result**
1.*(G1)***Definition of the project** (or change) including MTO, clarifying and discussing the scope of work with users (identifying right problem and finding appropriate approach in line with hierarchy of Controls). (Checks that changes are administered through a Management of Change process-MOC).	**Project Definition: Define scope**, (sometimes defined as concept of operations) – ensure that scope includes MTO - man, technology and organization - not piecemeal**. Include HF experts from the start**. Assess the **technology readiness level (TRL) and Human Readiness level (HRL**- ANSI/HFES 400-2021 HRL) to ensure that technology and humans are ready. Check AI challenges, consult NAS (2021). Check issues in Fitts List**.** In Hierarchy of Controls discuss elimination...
2.*(G4)***Identify main risks** (and mitigate**)** and threats (Explore and analyse relevant incidents or accidents).	**List the main risks** and design mitigation to support safety, security, efficiency, and usability (Include HF risks).
3.*(G3)***Establishing a user-centred development process** (also for MOC) with HF experts from the start and relevant users (Ensure meaningful human control.)	Defining a standard process (such **as ISO 9241-210 or ISO 11064** or other relevant); Definition of responsible users and involve relevant HF experts.
4.*(G7)* **Analyse work-based task analysis TA (or safety critical task analysis** SCTA) and prototypes (simulations and eye-tracking if necessary) as a basis for system design, organization design (responsibilities), procedures, workplace layout (and HSE issues).	**Document tasks to be done** (Include "out of the loop" challenges) through TA (or SCTA when needed). Document Cognitive task analysis (**Explore workload** ex: NASA-TLX), Define responsibilities and organization. Document ergonomic requirements of work.
5.*(J1)***Define responsibilities of the work systems** (including distributed actors).	**Analyse and Define responsibilities** and see-to responsibilities of the Work system
6.*(C3)***Analyse flow of Situational Awareness** (**SA**), and Human Machine Interfaces (HMI) to support SA – "SA at a glance", especially in automation, AI-use task analysis.	**Documented flow of SA** among involved stakeholders Endsley (2000). Document **needed HMI** across systems and packages (Use IEC 63303 as a support) especially in critical situations. Check "Work as done" via Scenario analysis.
7.*(C9)***Ensure that alarms are designed** based on standards and managed to support SA, safety and to avoid incidents.	**Document alarm strategies** and operational procedures (including MOC) based on best practices such as EEMUA 191. Mitigate alarm findings from Havtil (2022a).
8.*(C1)***Analyse information and communication needs** and need to support common SA in the system.	**Documentation of information needs**, need to involve key actors, specify how to communicate in different settings.
9.*(G10)***Perform systematic usability testing** and robustness testing of components, and system as systems are designed/ built/ changed/ maintained. Control quality of changes through MoC process.	Document **system test plan, and defined situations of hazards (DFUs)** to be explored through testing. Check in operation: Usability assessed by the actual users, the procedures and quality of training.
10. *(T1)***Systematically train operators** based on tasks and unwanted incidents – ex by procedures such as Risk based training i.e. CRM.	Training plan based on needs and competencies, and system as it develops – check that training is continuously updated related to "situations of Defined Hazards – DFU".

These activities ensure that human factors are integrated throughout the lifecycle of the project, from design to operation. They support good design, ensuring that technology supports users, and that safety, efficiency, and usability are prioritized. By focusing on these top 10 activities and selecting relevant issues, projects using CRIOP can achieve safer and more reliable outcomes. For description of a successful HF project, using these elements, see Unified Bridge, Bjørneseth (2021).

1.5. What is CRIOP?

The aim of the rest of this section is to describe the goal and scope of CRIOP, document the importance of using CRIOP early, prioritizing on most effective HMS actions and suggest how to align work as imagined with work as done.

1.5.1. Goal and scope

Goal: CRIOP performs verification and validation of a control centre's ability to safely and efficiently manage all modes of operation.

CRIOP emphasize the importance of a user-centred approach and design thinking.

The methodology can be applied to central control rooms, driller's cabins, crane cabins, and other types of cabins, both onshore and offshore, as well as to emergency control rooms, ship bridges, control centres for autonomous ships, autonomous trailers or other control facilities.

In a CRIOP analysis It is important to evaluate the interaction between different control facilities (i.e. sub-sea, remote systems, including ROVs or drones as illustrated below in Figure 1.2.) and between control rooms (e.g. emergency and central control room).

The CRIOP methodology can be adapted for control centres or cabins such as the driving cabin of a train or the bridge of a boat. The present CRIOP methodology has a lot of good practice for offshore control centres and drillers cabin.

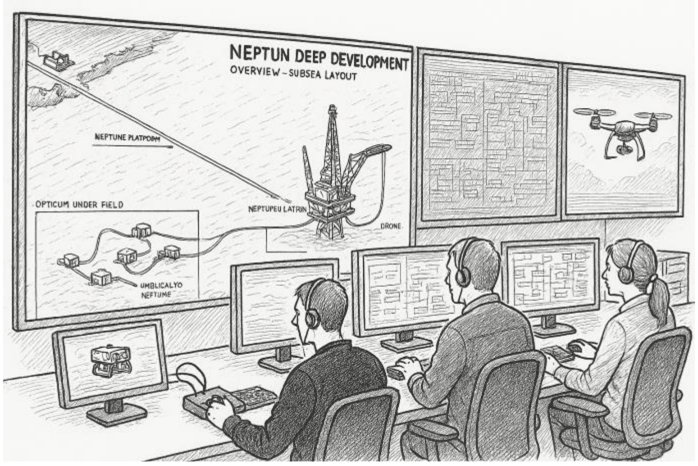


Figure 1.-2 The control centre can control multiple facilities

The control room can gather and control operations from many installations and objects such as oil rigs, sub-sea installation, drones and many other facilities. CRIOP focuses on the interaction between people (Man), technology(T) and organisations(O), i.e. MTO.

CRIOP consists of three main activities:

1. Introduction and context of use – i.e. definition of Scope (area and interfaces)
2. General Analysis checklists – exploring work as imagined (in design and operation)
3. Scenario Analysis – exploring work as done (in design and operation)

A short description of work as done is given in Shorrock (2021).

1.6. CRIOP: Key principles and its relation to the design process

One of the key issues in CRIOP is to verify that human factors (HF) are included in operation and management of abnormal situations in offshore control centres, as well as to validate solutions and outcomes based on human limitations and strengths. General principles in HF design are:

- Verifying and improving design through iteration (see Figure 1.3, adapted from ISO 11064)
- Conducting human factors analyses, such as function analysis and task analysis)
- Forming an interdisciplinary team and ensuring systematic end-user participation
- Documenting the process

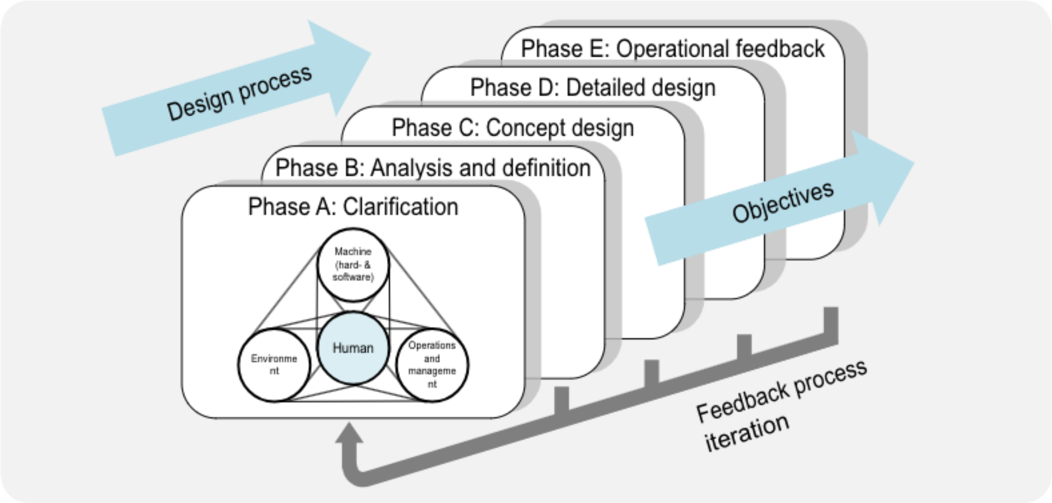


Figure 1.-3 Improve design through iteration (adapted from ISO 11064)

CRIOP should be applied multiple times throughout the design process, as indicated by the arrows in Figure 1.4. This includes its application from concept, design as well as in operation. Note that the potential for improvements and cost/benefit is naturally greatest during the early phases.

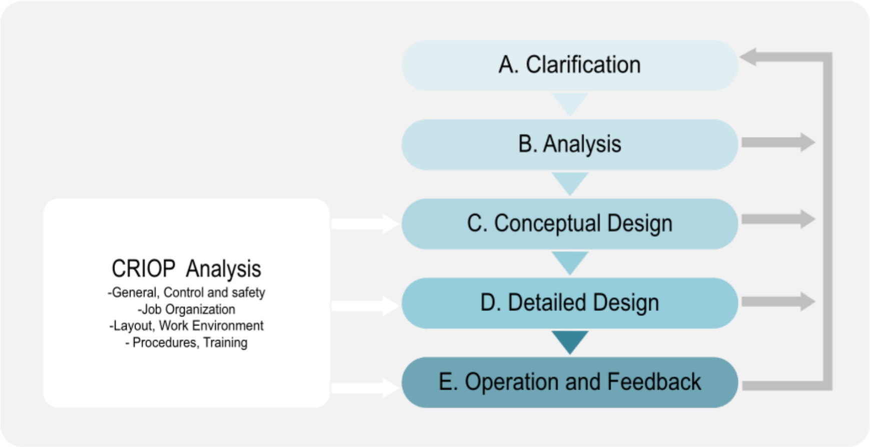


Figure 1.4 Integration CRIOP analysis as early as possible in ISO 11064 design process

Although not illustrated, the Build phase occurs between D) Detailed Design and E) Operation.

The scope of a CRIOP analysis typically requires between 2 to 5 meeting days for the workshop, in addition to time needed for preparing the analysis and writing the report. The total scope can vary and is usually within the range of 10 to 30 workdays.

1.7. Reducing costs and improving safety with CRIOP

The cost of changes increases significantly between each phase of the design process. Experience from different industries (software, construction) shows that the cost of a change increases exponentially as the project progresses through its phases, Boehm (1974), Szymberski (1997), Samset (2001); Behm (2005); Driscoll et al. (2008).

Both the cost/benefit considerations and the importance of designing for safety, as mentioned in Behm et al. (2014) and found in accident analysis, highlight the need for conducting a CRIOP analysis early in the design process. By conducting a CRIOP analysis early on, we can proactively design out risks and enhance safety, ensuring that hazards are identified and mitigated before they become costly and difficult to address. To illustrate this development of change cost, the cost of the same change could be:

- 10-100 USD in the analysis phase
- 100-1,000 USD in the design phase
- 1,000-10,000 USD in the build phase and
- 10K-100K USD in the operations phase (K=1,000)

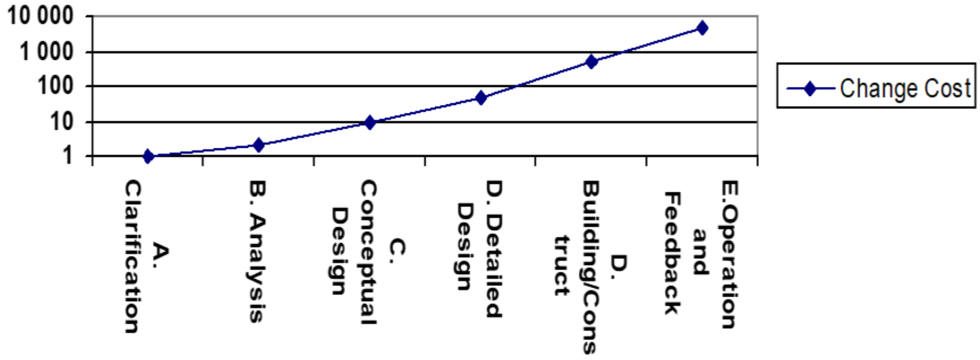


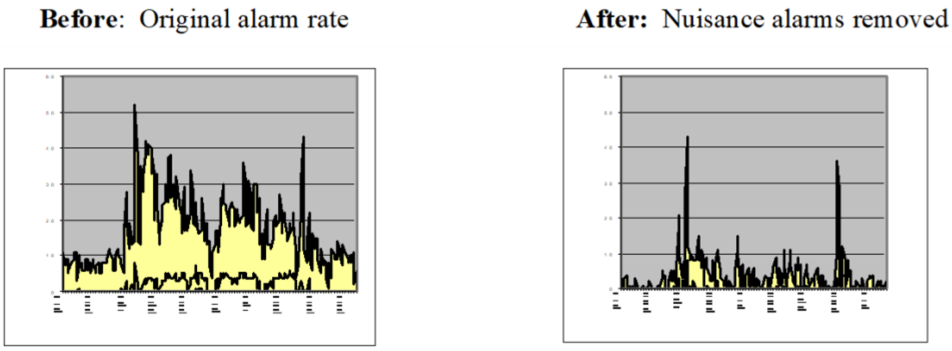
Figure 1.5- The cost of change dependent on phase (clarification through operation), Boehm (1974), Szymberski (1997), Samset (2001), Behm (2005); Driscoll et al. (2008).

1.7.1. Improving safety with CRIOP

One of the key functions of control rooms is to enable operators to perform tasks that support barriers against major hazards. Despite this purpose, and even with the petroleum industry's strong emphasis on safety and environmental protection, several issues persist that, both individually and collectively, reduce the effectiveness of the operator. As noted by the regulator Havtil, examples include:
The control room operator faces multiple challenges, including managing too many alarms at once, performing several safety-critical tasks simultaneously, and operating stations, communication devices, and display equipment that are located far from each other. The operator's workload is uneven and can be relatively high at times, and there is often a lack of a comprehensive overview of events or incidents, HFAM (2003).
Alarm management has been a persistent issue since 1988, as highlighted in the Piper Alpha disaster, Briwa (2022), affecting both control centres and ship bridges. Studies by Surry (1974), Rosness (2001), Bjerkebæk

(2004), Walker (2014), Havtil (2022a), and Briwa (2022), along with findings from accident investigations, indicate that poor alarm design, low-quality human-machine interfaces (HMI), uneven workload distribution, and alarm overload are strongly interrelated. Excessive numbers of alarms, particularly during critical situations, can contribute to operator overload and significantly increase the likelihood of human errors and accidents.

NPD (2002f) has illustrated the effects of alarm reduction outlined in the YA-711, *Principles for design of alarm systems (*like EEMUA 191), as shown in Figure 1.6.



Before: Original alarm rate

After: Nuisance alarms removed

Figure 1.6 Original alarm rate versus alarm rate after removal of nuisance alarms

Despite the considerable focus on HSE, and the “safety barrier” philosophy that permeates the petroleum industry, incidents still occur. Experience shows that incidents occur when two or more safety barriers are compromised (such as in Piper Alpha/ Deepwater Horizon accidents), as illustrated in Figure 1.7. from Reason (1997). CRIOP helps build and strengthen proactive (and reactive) barriers. CRIOP used in design has prioritized proactive barriers.

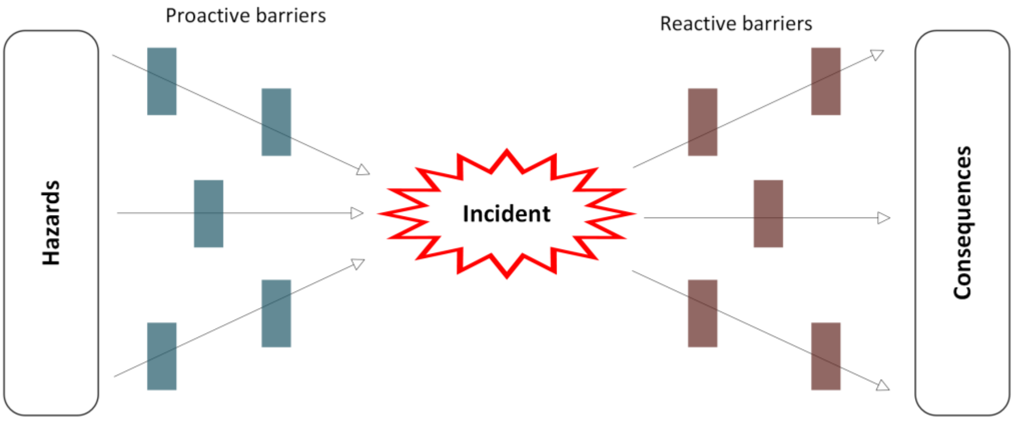


Figure 1.7 Incidents occur when multiple safety barriers are breached (inspired by Reason, 1997)

CRIOP is using bowtie to illustrate the risk management in the scenario analysis, and it offers several benefits. It provides a clear visual representation of risk management, helping stakeholders easily understand causes and consequences. The bow-tie model fosters better communication among teams and helps identify weaknesses in safety measures. By illustrating layered defences, it aligns with James Reason's Swiss Cheese Model, emphasizing that organizational issues can create "holes" leading to accidents. Exploring a bow tie encourages a proactive safety culture and promotes continuous improvement by allowing organizations to adapt their controls based on feedback. Overall, it enhances both safety and organizational resilience.

In addition to the typical issues found in control rooms and the interrelationships among them, several trends in the petroleum industry also impact the safe and efficient operation of control centre. As noted by the regulator, NPD (2003), Havtil (2022), areas of concern are:

- Rapid pace of changes makes the frame conditions more challenging.
- Increasing technological complexity due to the need for integration of data.
- Quality of Management of Change (MoC). MoC may be more challenging due to increased use of contractors. This can be due to missing clarity in responsibility or missing details in requirements such as the involvement of end users as a requirement.

In addition, there is Increased use of contractors, needing management of HSE risks, IOGP (2017).
A systematic methodology is needed to identify the common issues in today’s control rooms, to test the functionality of multiple safety barriers, and account for trends in the petroleum industry.
CRIOP seeks to address this need.

1.8. Selecting actions with the highest effect

Systematic analyses of accident investigations estimate that a large proportion of adverse events (approximately 40–60%) are due to poor design of routines and technology, Kinnersley et al. (2007), Moura et al. (2016). To address such issues, the Hierarchy of Controls (HoC) provides a structured safety framework, organizing interventions by effectiveness—from eliminating hazards at their source to relying on personal protective equipment (PPE) as a last resort.

The HoC aims to prioritize risk reduction strategies that address hazards early and minimize residual risk. While most effective when applied during the design phase, HoC principles should also be used during operation to mitigate error traps and enhance system defences. This risk-based design and mitigation approach is supported by several studies, including Dyreborg et al. (2022).

We have used the hierarchy of controls as defined by NIOSH (2024), and Manuele (2005), listing the most important issues first, Figure 1.8.

By using the hierarchy of controls, we can develop and implement measures with the greatest effect on risk. The most effective controls are “elimination”, “substitution” and “engineering controls”. They should be discussed when identifying mitigating actions.

Elimination: Elimination involves removing hazardous conditions entirely through changes in design, equipment, or work processes so that serious incidents cannot occur. Ideally, this should be achieved during the conceptual design phase through user-centred design. Examples include removing personnel from hazardous environments via remote operation. In the Chernobyl disaster, design flaws—such as a contra-intuitive reactor design and setup—could have been eliminated by adopting a safer reactor design (IAEA). Similarly, the Deepwater Horizon accident happened in an oil field that were known to be dangerous due to high pressure and fragility of rock, and other operators had halted drilling and moved their operation to less risky places. By halting operations in such a high-risk field, the accident could have been eliminated. In the Texas City refinery explosion, replacing open blowdown stacks with a closed flare system during design could have removed the underlying hazard. The Boeing 737 Max crisis illustrates how poor initial design choices, aiming to fit larger engines on an older airframe, necessitated complex mitigation systems, which eventually malfunctioned.

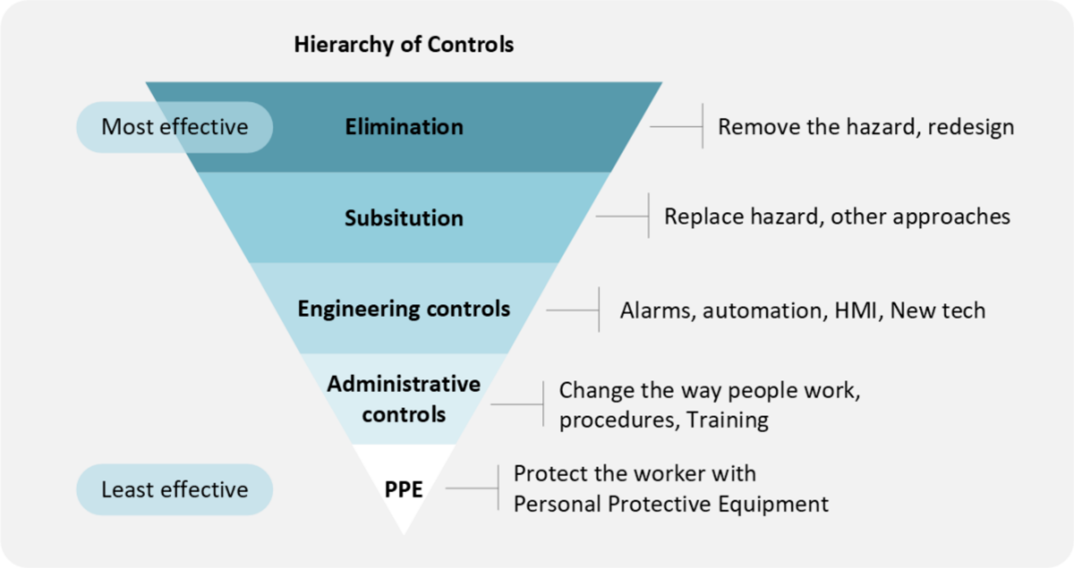


Figure 1.8 The hierarchy of controls as to a tool to prioritize efforts

Substitution: We replace material, activity, operation with safer variants, new technology or systems designed to be error tolerant. Automation can substitute human operations to reduce risks, avoid dangerous, difficult or dirty tasks. Examples: Bhopal gas tragedy, a less toxic chemical could have been substituted for methyl isocyanate (MIC). Fukushima nuclear disaster, by substituting older reactor designs with more modern, fail-safe designs they could have reduced the risk of meltdown. Automatic ground collision avoidance system at F16 has avoided four operational disasters by substituting human action with automation. The use of technology to substitute human operations should use a modern version of Fitts list, to ensure that technology increases safety vs old way of working.

Engineering Controls: Engineering controls (technical controls) involve designing systems that reduce risks independently of human actions (such as reduce the risks or possibilities for errors). These include error-tolerant designs, improved alarms, or HMI displays that enable “situation at a glance" awareness. Examples include Unified Bridge (UB) design, reducing cognitive load avoiding mistakes. Chernobyl: The control panel was poorly designed, with counterintuitive layouts, lack of real-time feedback, and misleading alarms. Deepwater Horizon: Poor Alarm & HMI Issues contributed to delayed response. Many critical alerts were suppressed, delaying the recognition of the blowout. Three Mile Island: Poor alarm & interface design delayed response, operators failed to recognize that a pressure relief valve was stuck open due to a misleading indicator on the control panel, which showed only the valve’s command status, not its actual position. Texas City refinery explosion, better pressure relief systems and blast walls might have mitigated the damage. Space Shuttle Challenger disaster, improved O-ring design and testing could have prevented the catastrophic failure. In each case, better system designs could have avoided the accident and/or mitigated the consequences.

Administrative Controls: Administrative controls modify how people work through measures such as training, job rotation, communication protocols, and procedural redesigns. These controls often become necessary when technical measures are insufficient. Examples include implementing Crew Resource Management (CRM) after the Tenerife Airport disaster to improve cockpit communication and teamwork. In Piper Alpha, inadequate procedures and poor communication heavily contributed to the tragedy, highlighting the importance of administrative interventions.

Personal Protective Equipment (PPE): PPE serves as the last line of defence when higher-level controls are not feasible. Examples include survival suits, gloves, or respirators. Following the 9/11 attacks, improved respiratory protection for first responders could have mitigated long-term health impacts. Similarly, during the Montara oil spill, proper use of PPE could have reduced workers' exposure to hazardous materials.

1.9. Aligning work as imagined with work as done

Work as Imagined (WAI) refers to how tasks, processes, and workflows are expected to be performed according to procedures, policies, or management assumptions. It is often based on ideal conditions and theoretical models. Work as Done (WAD) represents how tasks are performed in practice, considering constraints like quality of existing systems, time pressure, resource limitations, variability, training, and human adaptation. If there are large differences between WAI and WAD, the combined WAD , can lead to accidents, as suggested by figure 1.9.

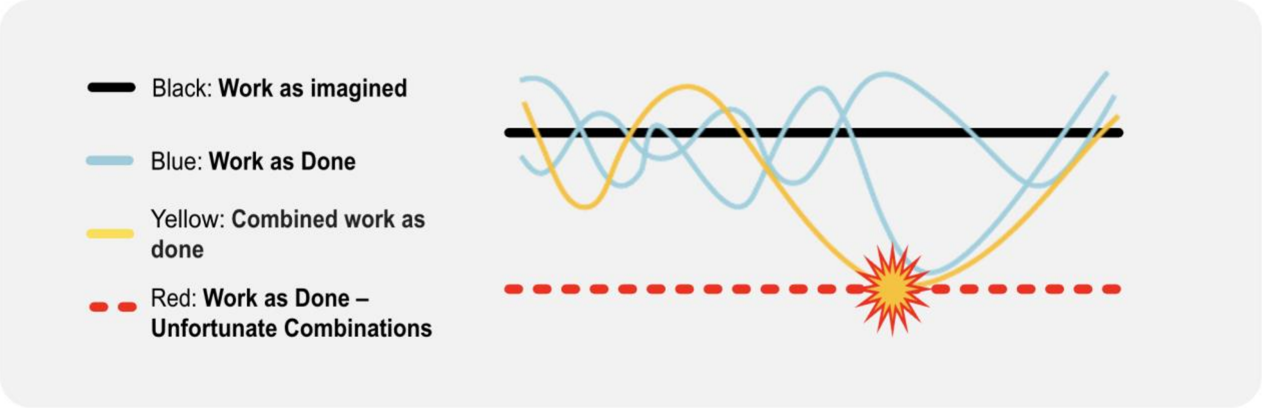


Figure 1.9 Gap between Work as Imagined vs combined Work as Done – influencing safety, Hollnagel (2017)

Our aim is to support people doing the actual work with a safe and supporting working environment. Good practice Human Factors Engineering (HFE) and use of CRIOP helps reduce the discrepancies between WAI and WAD by focusing on project definition, system design, usability, and human capabilities. Some key strategies and HFE practices to be used to align WAI with WAD and avoid accidents are:

- **Observational Studies & Field Research** – Conduct ethnographic studies, direct observations, and task analyses to understand real workflows especially in risky areas.
- **User-Centred Design** – Design tools, interfaces, and processes based on user needs and behaviours rather than idealized expectations, using ISO 9241-210/ ISO 11064 as a guide.
- **Functional analysis, Task Analysis & Cognitive Load Assessment** – Perform functional analysis, and TA (or Safety Critical Task Analysis) to evaluate workload, attention demands, and decision-making processes to design systems that support human performance. (e.g. trough function allocation and assessment of degree of automation).
- **Scenario analysis, Test, Simulation & Prototyping** – Analyse, explore, and test new systems in controlled but realistic environments before full implementation.
- **Training & Adaptive Systems** – Provide training that reflects real-world variability and design adaptive procedures that allow for flexibility without compromising safety.
- **Feedback Loops and exploration of scenarios** – Implement mechanisms for workers to report inefficiencies or deviations from procedures to improve systems continuously.

By integrating HFE principles, organizations can align expectations with reality, improve safety, efficiency, and worker well-being while maintaining system effectiveness.

1.10. Definitions and abbreviations

The following definitions apply to this document:

Affordances:	Affordances, as defined by Norman (2013) refer to the perceived and actual properties of an object or interface that determine how it can or should be used. Identifying affordances is a critical part of human-centred design (HCD) and involves a mix of task analysis, user observation & testing and, and design principles (conventions, cues). Key methods to identify affordances are Task Analysis (Breaking down user tasks to see what actions are needed). User Observation/interviews & testing (Watching how users expect an interface to work). Cultural & Learned Conventions (Leveraging familiar design patterns, e.g. a red button affords stopping) Physical & Visual Cues (Shape, colour, texture, and placement suggest usage)
AI – Artificial Intelligence:	EU AI Act: 'AI system' means a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments;
Alarm:	IEC 62682: An alarm is an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response.
Best practice:	Processes, practices, or systems identified in public and private organisations that perform exceptionally well and are widely recognized for improving organisational performance in area such as effectiveness, efficiency, safety, ecology, and/or innovativeness.
Control centre (CC):	A combination of control rooms, control suites and local control stations which are functionally related; and all on the same site. (ISO 11064)
Control room (CCR):	A core functional entity, and its associated physical structure where Control Room Operators (CROs) are stationed to carry out centralised control, monitoring and administrative responsibilities. (ISO 11064) In this document, the term “control room” encompasses all types of control rooms, including central control rooms, emergency control rooms, drillers' cabins, off loaders’ cabins, and crane cabins. Control rooms can be either located onshore or offshore.
Control suite:	A group of functionally related rooms co-located with the control room, including the control suite itself, which houses the supporting functions to the control room, such as related offices, equipment, rooms, rest areas, and training rooms (ISO 11064).
Display:	Device for presenting information that can change with the aim of making things visible, audible or discriminable by tactile or proprioceptive perception. (ISO 11064) A display (HMI, a whiteboard, etc.) is something on which information is

	displayed; a screen is a type of display; a monitor is a free-standing screen that needs to be plugged into a device.
Emergency control room:	A control room provided to relieve the CC and its staff from personnel traffic in a distress situation, usually located close to the CC.
Emergency preparedness:	All technical, operational, and organisational measures that prevent a dangerous situation from escalating into an accidental event or to mitigate the harmful effects of accidental events that have already occurred.
Error traps:	Error traps (No:Feilfeller) are conditions that complicate safe work practices and increase the likelihood of mistakes. Examples are: *Task-related error traps:* Unfamiliar tasks, Unpredictable tasks, Complex tasks, Limited time; *Organisational error traps:* Unclear roles and responsibilities, Task conflicts, Communication issues, Staffing and resources, Work organization; *Individual error traps:* Insufficient training/skillset, Lack of experience, Lack of rest, Stress ; *Technical error traps:* Equipment malfunctions, Deficiencies in documentation, Unclear instructions, Poor accessibility, Noise, lighting conditions, temperature, and/or air quality. (Error Traps can be seen as the trigger zones where PSFs and flawed system design combine to create high risk for error.)
Ergonomics (Physical):	Ergonomics see definition for HF. *Physical ergonomics* is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. (Relevant topics include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, physical safety and health.) From IEA (2000). (In some environments and countries, Ergonomics is used for Physical Ergonomics.)
MTO:	MTO, the Man-Technology-Organization is a system perspective to promote safety in industrial processes based on an understanding of the interactions between M-(man), T-(technology), and O-(organisation). Key ideas of the system perspective are to analyse accidents or performance issues as emerging from the interactions between MTO components. A failure in one area (like a poorly designed interface) can be worsened by issues in the other two (like insufficient training or unclear procedures).
Meaningful Human Control:	*Meaningful human control is the ability of a system (with technology, organization, and humans) to be controlled by humans to avoid accidents impacting HMSS, subject to human abilities and limitations (in the context of the science of Human Factors).* MHC is dependent on design (scoping, human factors methods, workload, SA, time to react ~ 10 minutes), operational practices, and the ability to learn and improve based on investigations and continuous learning. By performing realistic user testing and scenario analysis of defined situations of hazard, we can check the possibility of MHC. Johnsen et al. (2025).
Method/ **Methodology:**	**Methodology:** A system of methods, rules and practices used in a particular discipline. (Example: ISO 11064). **Method:** Procedures and techniques characteristic of a particular field of knowledge. (Example Task analysis, user testing.) Methods provide an organized structure for employing techniques. **Techniques:** are the building blocks, the practical procedures carried out as an example in Human Factors Engineering. (Example: Safety Critical Task analysis, Workload Analysis). See Stanton et al. (2013) for examples of techniques.

HMI:	**Human Machine Interface**. HMI is the system, device, or platform through which a human operator interacts with a machine, process, or complex system. It encompasses all elements that enable perception, control, and feedback between the human and the technical system, including displays, alarms, control panels, keyboards, handles, knobs, mouse, GUI (Graphical User Interface) , lamps, buzzers, touchscreens, auditory signals, and visual cues. The primary purpose of an HMI is to support safe, efficient, and accurate human interaction by presenting information clearly, facilitating user input, and enhancing situational awareness. Effective HMI design considers human capabilities and limitations, aiming to minimize cognitive load, reduce the risk of human error, and optimize decision-making under varying operational conditions, (Inspired by ISO 9241-210).
Highly Managed Alarms:	**HMA – see Key Alarms**
Human factors (HF):	**Cognitive, Physical an Organizational ergonomics**. IEA (2000): *“Human Factors is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.”* *HF consist of: **Cognitive ergonomics** -concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. **Physical ergonomics** is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. **Organizational ergonomics** is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes.*
Human Error:	Human error refers to unintentional actions or decisions that deviate from expected procedures, often influenced by systemic factors such as design shortcomings, unclear guidelines or environmental stressors. There is no scientific support to say that a large percentage of accidents are due to Human Error, Wrobel (2021). Here “Human Error” is not seen as a cause, but as unfulfilled expectation after the facts, and a starting point for trying to understand events and actual root causes. Rather than assigning fault, effective analysis and CRIOP seeks to understand and mitigate the underlying conditions and SA that made the error possible, Endsley (2000), van Winsen & Dekker (2016) and Dekker & Conklin (2014). Poor design is often a root cause for Human Error, Norman (2013), Kinnersley et al. (2007), Moura et al. (2016).
HF Competency:	To perform a CRIOP analysis, some basic HF competencies and knowledge are needed. Basic HF knowledge that is needed are as an example documented in Lee et al. (2017) and Stanton et al. (2013). Important areas are Cognitive, Physical and Organizational ergonomics, IEA (2000): Key practical areas, Laumann et al. (2018) are design and usability, cognition, human machine interface (displays, controls, and alarms), human-automation interaction, physical workload, mental workload, teamwork, and training/simulations.
Key alarms: **Highly Managed:**	Key alarms (Highly Managed Alarms) are a selection of high priority alarms, such as important safety-related and safety critical alarms. Examples are: Fire and Gas alarms, Emergency Power system status information and failure alarms, Fire Pumps status information and failure alarms, Fire Protection System status

	information and failure alarms, and Flare & relief system. Key alarms should be defined. Key alarms should be displayed clearly to ensure they remain accessible and usable even during alarm overloads (EEMUA 191/ ISO 62682).
PSF Performance shaping factors:	PSFs are conditions or influences that can affect human performance—either positively or negatively. Examples: Fatigue, stress, time pressure, training, experience, procedures, HMI- Interface design, work environment. PSFs are broad, contextual factors. They are used to understand why a human might perform well or poorly in each situation.
Verification:	To satisfy stated requirements through confirmation by examination and the provision of objective evidence that the requirements have been fulfilled (ISO 8402, IEC 61508). The requirements can be statutory, company-defined, or related to standards and/or contractual obligations.
Validation:	To satisfy implied needs, i.e., ensuring that the control room is usable. Confirmation by examination and provision of objective evidence to demonstrate that the particular requirements for a specific intended use are fulfilled (ISO 8402, IEC 61508).
Weak Point:	Weak points are identified vulnerabilities in the human-system interaction where performance breakdowns are likely or have occurred. These can arise from PSFs, error traps, or other system limitations. Examples: A point in an emergency procedure where users often hesitate or Alarms that are often ignored due to poor salience or false alarms. Weak points are usually the result of analysis, identified through scenario evaluation, simulations, or incident reviews. They are used to target improvements.
Working environment:	The totality of all physical, chemical, biological, and psychological factors at work that may affect the employees' health and wellbeing through acute trauma or lasting exposure. The influences from lasting exposure may be positive and negative (NORSOK S-002 rev 4).

The following abbreviations apply to this document:

AID	Ministry of Labour and Social Inclusion; *Norwegian abbreviation (No)*Arbeids- og inkluderingsdepartementet
AR	Activities Regulations (*No:* Aktivitetsforskriften) from Havtil (2011)
CAP	Critical Alarm Panel, a hardwired action panel used to control emergency functions
CC	Control Centre
CCR	Central Control Room
CR	Control Room
CRIOP	CRisis Intervention and OPerability analysis
CRM	Crew Resource Management (Risk Based Training)
CRO	Control Room Operator
DC	Drillers' Cabin

DSHA/ DFU	Defined Situations of Hazards and Accidents (*No:* DFU – Definerte fare og ulykkessituasjoner)
ESD	Emergency Shutdown (system)
FA	Facilities Regulations (*No:* Innretningsforskriften) from Havtil (2011)
FPSO	Floating Production Storage and Offloading
FR	Framework Regulations (*No:* Rammeforskriften) from Havtil (2011)
GA	General Analysis
GUI	Graphical User Interface - icons, buttons, and visual indicators, not text based
Havtil	Norwegian Ocean Industry Authority (*No:* Havindustritilsynet)
HF	Human Factors
HFAM	Human Factors Assessment Method
HMI	Human Machine Interface
HMA	Highly Managed Alarm (ISO 62682/EEMUA)
HRO	High Reliability Organisation
HSE	Health, Safety, and Environment
HTA	Hierarchical Task Analysis
HVAC	Heating, Ventilating, and Air-Conditioning
ICT	Information and Communication Technology (also IT is used) integrated with OT
IEC	International Electro technical Committee standard
ISO	International Standards Organisation
IO	Integrated Operations
LSD	Large Screen Display
LCD	Liquid Crystal Display
MR	Management Regulations from Havtil (*No:* Styringsforskriften) 2011
MTO	Man, Technology and Organization (i.e. the system perspective)
MMI	Man, Machine Interface
NLIA	Norwegian Labour Inspection Authority, (*No:* Arbeidstilsynet)
NOG	Norwegian Oil and Gas industry – Now Offshore Norway
NORSOK	No: Norsk Sokkels Konkurranseposisjon (Supporting best practices)
NPD	Norwegian Petroleum Directorate – now two organizations Havtil and Sodir- Norwegian Offshore Directorate (*No:* Sokkeldirektoratet)
NUREG	Document published by the staff of the Nuclear Regulatory Commission
OT	Operational Technology - OT is controlling physical processes and equipment.

P & ID	Piping and Instrumentation Diagram
PSA	Former name of Petroleum Safety Authority Norway, now Havtil
ROC	Remote Operational Centre
SAS	Safety and Automation System (See also SCADA)
SCADA	Supervisory Control and Data Acquisition (Often used to denote SAS)
SCTA	Safety Critical Task Analysis (A targeted, in-depth analysis for tasks where human error must be managed because consequences are serious)
SEPA	Safety and Emergency Preparedness Analysis
SIS	Safety Instrumented Systems
Sodir	Norwegian Offshore Directorate (*No:* Sokkeldirektoratet)
STEP	Sequentially Timed Events Plotting
TA	Task analyses
TOR	Technical and Operational Regulations(*No:* Teknisk og operasjonell forskrift) 2011
VDU	Visual Display Unit

1.11. The system perspective and readiness (maturity)

Systems that are designed, implemented and operated consist of technology, humans and organisations. To ensure safety and efficiency, systems must be technologically feasible (TRL), usable and safe for humans (HRL), and practically adoptable within real-world organizations (ORL). New technology is the driving force, the challenge we have seen is missing HRL and the missing ORL due to poor understanding, knowledge and prioritization of Human Factors (and techniques).

- **Human Readiness Level (HRL)** evaluates how well human factors, user needs, and human-system interaction have been integrated into a system. Supported by ANSI/HFES 400-2021, it ranges from basic awareness (HRL 1) to validated operational performance (HRL 9), with strong emphasis on usability, situational awareness, and training. (CRIOP is in line with HRL.)
- **Technology Readiness Level (TRL)** describes the maturity of a technology, from initial concept (TRL 1) to full operational deployment (TRL 9). It is often used in engineering and innovation to track technical feasibility. (HF may be checked through the CRIOP checklists e.g. user testing).
- **Organizational Readiness Level (ORL)** measures how prepared an organization is to adopt, support, and sustain a new system or change. It spans from initial awareness (ORL 1) to strategic renewal (ORL 9), incorporating leadership engagement, cultural alignment, and system learning. HOP, Dekker& Conklin (2014), supports development of readiness through a just culture, system thinking, and creates a philosophical foundation for learning and change. Action research, Greenwood & Levin (2006), builds on HOP, support readiness development, based on a collaboration model, a democratic participatory approach with co-generation of knowledge and change. (CRIOP checks the HF part of ORL, relevant HF methods/ techniques).

2. CRIOP in Short

2. CRIOP in short

The aim of this section is to provide a brief and illustrative overview of the essential steps in CRIOP. This section summarises the information presented in Sections 3 to 5.

A CRIOP analysis begins with a **preparation and organisation phase**, which involves identifying responsible stakeholders, gathering necessary documentation, establishing an analysis group, determining the scope, identifying relevant questions and scenarios, and deciding when the CRIOP should be performed. A half day meeting with the HF responsible (a HF expert) and the project manager is often sufficient to identify key stakeholders, key issues, relevant CRIOP questions, and timeline. Figure 2.1 provides a flowchart illustrating the relationships between the different phases of the CRIOP methodology.

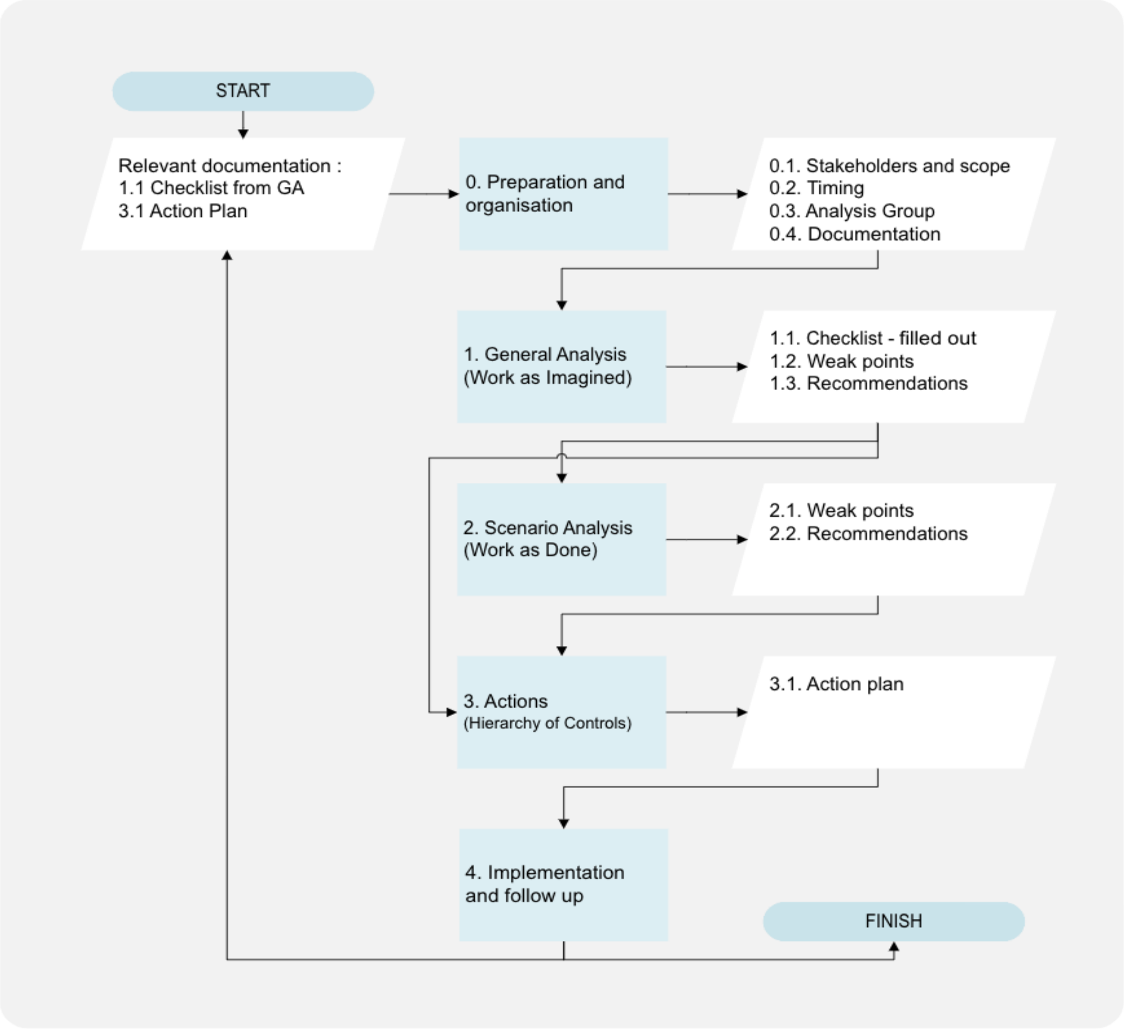


Figure 2.1 The main steps in the CRIOP methodology

The CRIOP analysis then proceeds with two main phases:

I. **General Analysis (GA) - Work as Imagined** (in design and operation): This phase uses checklists to verify that the control centre meets the specified requirements based on best industry practices. It is a standard design review of the CC, involving the analysis group.

II. **Scenario Analysis – Work as Done** (in design and operation): Key scenarios are analysed by the analysis group, i.e. relevant and experienced team (i.e. users/ experienced operators) to validate that the control centre meets implied needs (Analysis group should involve sharp end operators having practical experience). Unlike the summary level of traditional technical risk analysis, scenario analysis examines potential future incidents, helping to identify issues to be addressed, such as remedial actions that could prevent a scenario from escalating. The activity documents “work as done” by involving experienced operators from the workforce.

CRIOP specifies that workers, management, and the design team should meet to discuss key scenarios and the checklists in an environment that support open and free exchange of experience. Operational experiences should be discussed with the design team and management, and any issues identified should be collaboratively addressed with management.

The goal is to achieve double-loop organisational learning, Argyris& Schøn (1974), rather than single-loop learning, by taking actions to adjust ‘governing variables’ discussed in the CRIOP analysis such as control centre design, procedures, or work organisation, as illustrated in Figure 2.2. The group process should emphasize a collaborative approach and create opportunities to modify these governing variables.

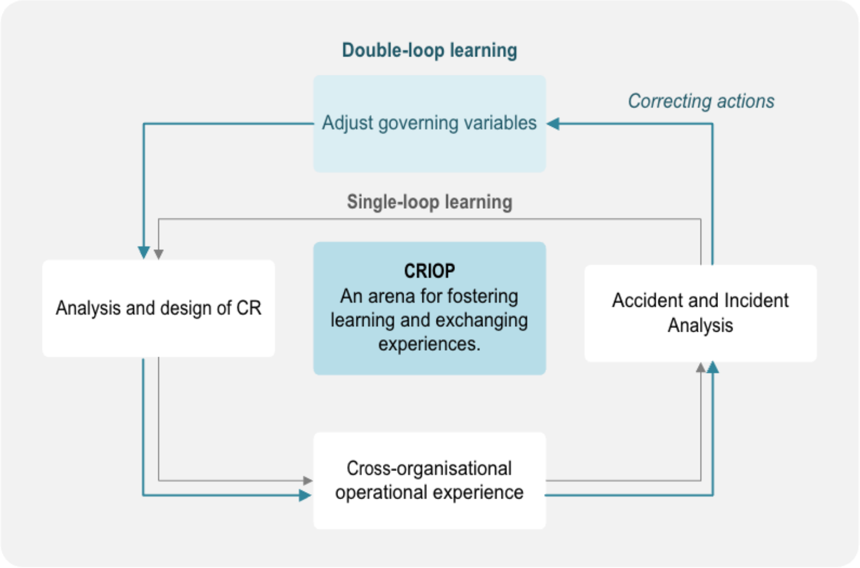


Figure 2.2 CRIOP as an arena for organisational learning, Argyris & Schøn (1974).

A website has been established at http://www.CRIOP.sintef.no providing the latest version of CRIOP, a brief PowerPoint presentation of the methodology, and information on industry networks related to CRIOP analysis. The web www.hfc.sintef.no can help with references to theory, references to relevant projects and contact information. Users can post comments and suggestions for improvements on the CRIOP methodology by emailing CRIOP@SINTEF.NO; however, a short meeting could be useful to understand the need for change.

2.1. Definitions and abbreviations

The *General Analysis (GA)* addresses factors affecting the working environment within a control centre and the ability to manage normal operations and abnormal situations that *are not tied to a specific sequence of events.*

The General Analysis includes a checklist with yes/no questions that provide a static assessment of the control centre. The General Analysis plays a key role in familiarising the analyst with the control centre concept under review and should be conducted prior to the more detailed Scenario Analysis.

The checklist in CRIOP has been structured to cover seven areas:

• General Questions	(Abbreviated G)
• Control and safety systems	(Abbreviated C)
• Job organisation	(Abbreviated J)
• Layout	(Abbreviated L)
• Working environment	(Abbreviated W)
• Procedures and work descriptions	(Abbreviated P)
• Training and competence	(Abbreviated T)

An example of a question related to control and safety systems is as follows:

> **C14.2 Can communication equipment be reached from the operator's workplace?**
>
> *Control room operators should be able to communicate with other personnel while working at the VDUs. Check radio, VHF, telephones, public address system (PA), and intercom.*

Each question must be addressed, with comments and recommendations documented according to the standard layout of the checklist, as shown in Table 2.1.

Questions applicable to Drillers Cabin (DC) are highlighted by “DC: Applicable to the DC” in the Comments column. If the questions are very specific to ship bridges/ROC of autonomous ships this will be noted in the Comments column.

Table 2.-1 CRIOP Checklists, example

POINT	Description	YES	NO	N.A	REFERENCES	COMMENTS/REF. TO DOCUMENTS	RESP.
C14.2	Can communication equipment be reached from the operator's workplace?				NUREG0700 (2020), rev. 3, 10.1-1.	DC: Applicable to the DC	

At the end of the General Analysis, findings, recommendations, and Weak Points are documented, and a responsible person is identified to implement the necessary actions.

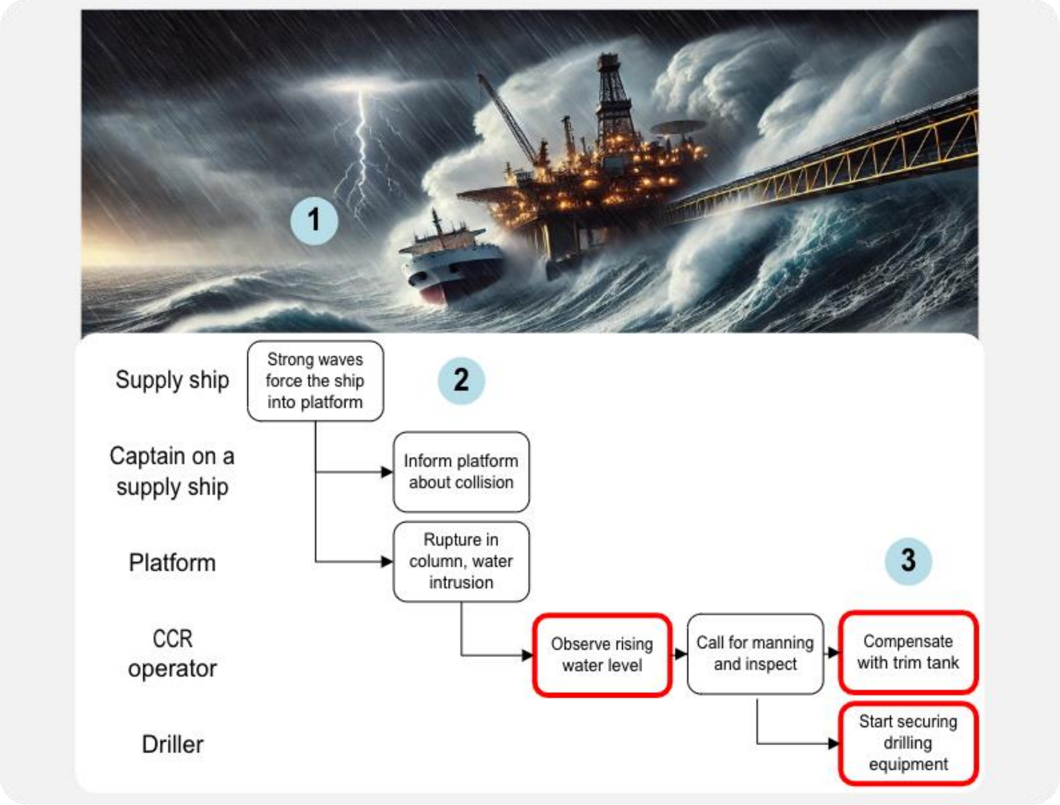
2.2. Scenario Analysis

The Scenario Analysis, in contrast, takes a different approach, and assessing control room actions in response to possible scenarios. This ‘dynamic’ assessment focuses on the interaction of key factors in the control room, such as presentation of information and time available for response.

The Scenario Analysis is conducted in a group with participants from the CR and includes four main activities, as shown in Figure 2.3:

- Selection of a realistic scenario,
- Description of the scenario using a STEP diagram,
- Identification of critical decisions, and
- Analysis of the decisions and evaluation of potential barriers (see Figure 5.5).

Scenarios should be based on experiences, hazards, or risks identified by the participants (workforce) to promote understanding and involvement.



1. Selection of a scenario

2. Description of the scenario

3. Identification of critical decisions

4. Analysis of decisions and barriers

Figure 2.-1 The main steps in a Scenario Analysis

The scenarios are illustrated using a STEP-diagram, see Hendrick and Benner (1987).

The Scenario Analysis focuses on factors that impact control room operators' Situational Awareness, i.e. ability to *observe and identify* deviations, *interpret* situation, *plan and make decisions,* and *take actions and execute* in response to abnormal situations and subsequent events in the process, Endsley et al. (2012). Through systematic scenario analysis, the analyst identifies possible weak points in handling these situations, which form the basis for recommendations.

Although the Scenario Analysis is based on a specific sequence of events, the method also considers alternative sequences, i.e., “what could have happened if” scenarios. This approach allows the analysis to cover a broader range of events than the selected scenario alone might suggest. Scenario Analysis provides more detailed findings at a granular level compared to General Analysis, and the two analyses complement each other.

2.3. Actions, implementation, and follow up

At the conclusion of the CRIOP analysis, the findings, recommendations, and weak points from both the General Analysis and Scenario Analysis are documented.

In coordination with management, an action plan is developed, including budgets, target dates, and designated individuals responsible for implementing the actions. It is suggested to discuss the “hierarchy of controls” and pinpoint actions with the highest effect (i.e. at the highest possible level(s) of the hierarchy of controls) and describe specific steps required to ensure proper implementation. To eliminate the risk of errors, the most effective strategy is to implement system level modifications and improvements, i.e. by eliminate/design out error-producing conditions or organizational factors, substitute dangerous environments/design with safer concepts or reduce risks through technical measures such as redesign or other means.

2.3.1. A Taxonomy for AI Hazard Analysis

Due to different stages of AI implementation, we have seen the need to suggest a structure to be used when learning from early deployment of AI systems. Key issues as mentioned by the EU act and Norwegian regulator (Havtil) is related to need for AI oversight, Bergh et al. (2024a). The EU AI act declares in article 1, that the purpose among other issues is to “…promote the uptake of human-centric and trustworthy artificial intelligence (AI)”. Some key issues from the EU AI act are AI Oversight, AI design, AI maintenance and AI testing, also described by Cummings (2024).

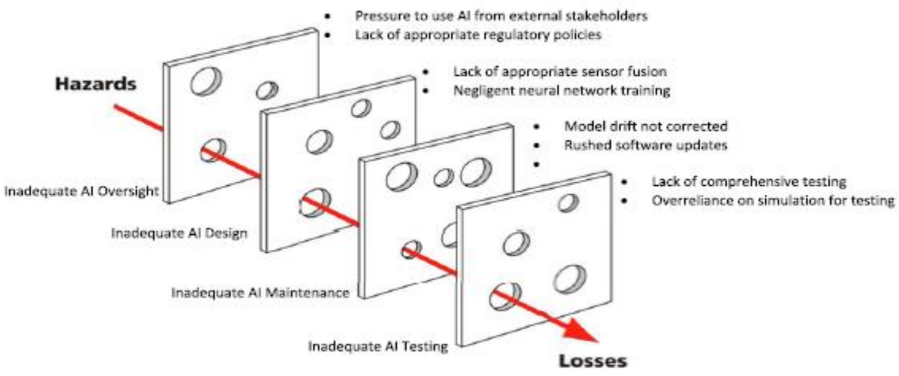


Figure 2.2 Taxonomy for Artificial Intelligence Hazard Analysis (TAIHA), Cummings (2024)

Figure 2.4 describes some of the hazards and issues that should be explored and analysed when implementing AI, Cummings (2024). Thus, according to Cummings (2024), key failures that may contribute to challenges in implementing AI are:

1. **Inadequate Oversight:** That is lack of proper organizational and regulatory oversight for AI systems, leading to unsafe deployments and ethical violations. (Example: Cruise's self-driving cars in San Francisco operated without adequate safety culture or regulatory checks, resulting in accidents and permit suspension)
2. **Inadequate AI Design:** That is flawed design decisions in AI systems, such as poor sensor fusion or failure to account for real-world complexities, leading to operational failures. (Example: Cruise's AI failed to recognize an articulated bus, causing a collision due to inadequate sensor integration and design.)
3. **Inadequate AI Maintenance:** That is failure to regularly update or retrain AI models, leading to performance degradation (model drift) and inability to adapt to new environments. (Example: Cruise's neural networks were not retrained for articulated buses, a common entity in San Francisco, resulting in accidents.)
4. **Inadequate AI Testing:** That is Insufficient or poorly designed testing protocols, relying too heavily on simulations and failing to catch real-world edge cases or software bugs. (Example: Cruise's testing did not identify the failure to recognize articulated buses, highlighting gaps in real-world testing and simulation coverage.)

3. Preparations and organisation of a CRIOP

3. How to prepare and organise the CRIOP analysis

The purpose of this section is to outline how to prepare and organise the CRIOP analysis and to specify when CRIOP should be applied in relation to the design and operation of the control centre (CC).

The initial activities in a CRIOP analysis include:

1. Describe scope and preconditions for study
2. Planning and deciding on the "timing" of the CRIOP analysis, timeline and budget
3. Collecting relevant documentation
4. Establishing the analysis group
5. Conducting a workload assessment
6. Addressing practical considerations (facilitating the group process)

3.1. Describe scope and preconditions for study

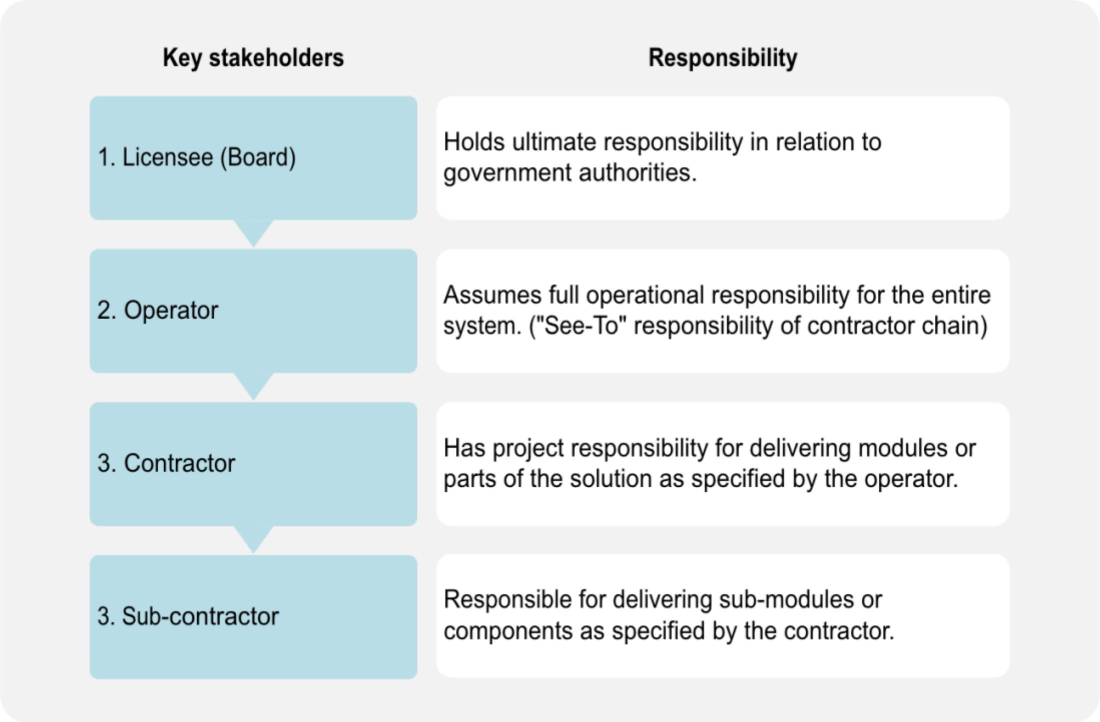
Key actions to be undertaken include:

- *Describe scope:* What systems and interfaces are to be analysed, and what are the context, key users and key management involved. Identify the user needs and key requirements
- *Identify key stakeholders:* Identify and document the important stakeholders in the project. This should be represented through an organisational chart that outlines the analysis, stakeholders, and responsible parties. Users from the sharp end (i.e. CCR operators, or captain of a ship) must be involved, and HF experts must be involved from the start.
- *Confirm design methodologies:* Ensure an appropriate design method, such as ISO 9241-210 or ISO 11064, is in use. CRIOP is a methodology for reviewing control centre design as it progresses through development and operation phases. The use of CRIOP assumes that a structured design processes, ISO 11064 and/or ISO 9241-210, have been or will be applied.
- *Select CRIOP elements based on key requirements:* Determine which elements of the CRIOP methodology should be used based on user requirements and status (challenges) of the project. Consider any previous analyses, relevant checklists, and scenarios. In the projected "scope of work", the relevant parts of CRIOP should be selected before beginning the actual work. This selection process should involve personnel with CRIOP experience. It is essential to choose the relevant parts of CRIOP to be applied, depending on the timing of the CRIOP, as well as the complexity and size of the equipment being analysed. (Adaption is important to reduce the workload). If possible, plan to pre-populate some of the checklists in advance of the GA meeting.
- *Estimate the scope of the analysis*: A typical CRIOP workshop requires between two to five days, additional workdays needed to prepare and summarize findings. Confirm the project budget, detailing the necessary effort in terms of person-days and resources required. However, a minor modification (MoC) requires a different approach than the analysis of a large, new control centre. (See chapter 3.2).

- *Guidelines for conflict resolution*: Conflict resolution guidelines should be established, as conflicting interests may arise in a CRIOP analysis. Documenting how open points and disagreements are addressed between stakeholders is essential. Conflicts of interest may occur due to budgets or due to a too narrow scope (ex. avoiding structural safety issues). Responsibilities for the CRIOP analysis must be clearly defined, and procedures for documenting safety challenges due to a too narrow scope or change orders affecting the budget and timeline must be clearly outlined.

3.1.1. Project organisation and responsibility preconditions for study

The responsibility from primary stakeholders is outlined in Figure 3.1.



Key stakeholders	Responsibility
1. Licensee (Board)	Holds ultimate responsibility in relation to government authorities.
2. Operator	Assumes full operational responsibility for the entire system. ("See-To" responsibility of contractor chain)
3. Contractor	Has project responsibility for delivering modules or parts of the solution as specified by the operator.
3. Sub-contractor	Responsible for delivering sub-modules or components as specified by the contractor.

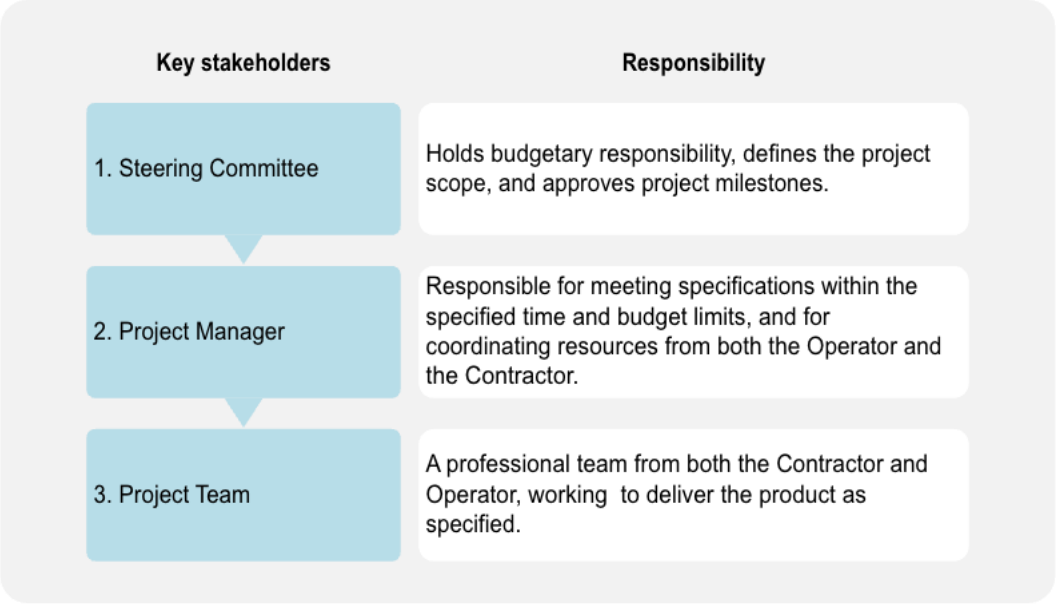
Figure 3.-1 Stakeholders in establishing a new CC or modifying a CC

Before the CRIOP analysis, responsibility in the analysis should be clarified, there are two options:

- The operator: Engages the necessary operating staff, such as control room operators.
- The contractor: Responsible for designing and building the CC according to the operator's specifications, within an agreed-upon timeline and budget.

The involvement of experienced control room operators in the CRIOP analysis can influence both the design and budget of the CC. Structuring the CRIOP as a project with reporting to a dedicated project steering committee, where both the operator and contractor are represented, enables a collaborative approach. This setup allows for necessary adjustments to be made within the project's scope, carefully considering time and budget constraints.

In general, a project is organised as described in Figure 3.2.



Key stakeholders	Responsibility
1. Steering Committee	Holds budgetary responsibility, defines the project scope, and approves project milestones.
2. Project Manager	Responsible for meeting specifications within the specified time and budget limits, and for coordinating resources from both the Operator and the Contractor.
3. Project Team	A professional team from both the Contractor and Operator, working to deliver the product as specified.

Figure 3.-2 Key project roles in establishing or modifying a CC

3.2. Planning and timing of CRIOP in CC design and operation

The CRIOP methodology should be applied at the right times during design and operational phases of a control centre. The recommendations to perform the CRIOP analysis are as follows:

I. Analysis or Conceptual design (I); using checklist 1, 2, 3 and 4* if appropriate and perform a Scenario Analysis. (*1.General Questions, 2.Control and safety systems, 3.Job organisation, 4.Layout)

II. Detailed design (II); complete checklist 1, 2 ,3 and 4 using checklist 5, 6 and 7* if appropriate and perform a Scenario Analysis. (*5.Working environment, 6.Procedures and work descriptions, 7.Training and competence).

III. Post-operation review (III); completing the checklist 1, 2, 3, 4, 5, 6 (and 7 if appropriate) and perform a Scenario Analysis.

The questions in the checklists have been structured in such a way that high level questions from 5, 6 and 7 also can be explored during phase “C. Conceptual design”.

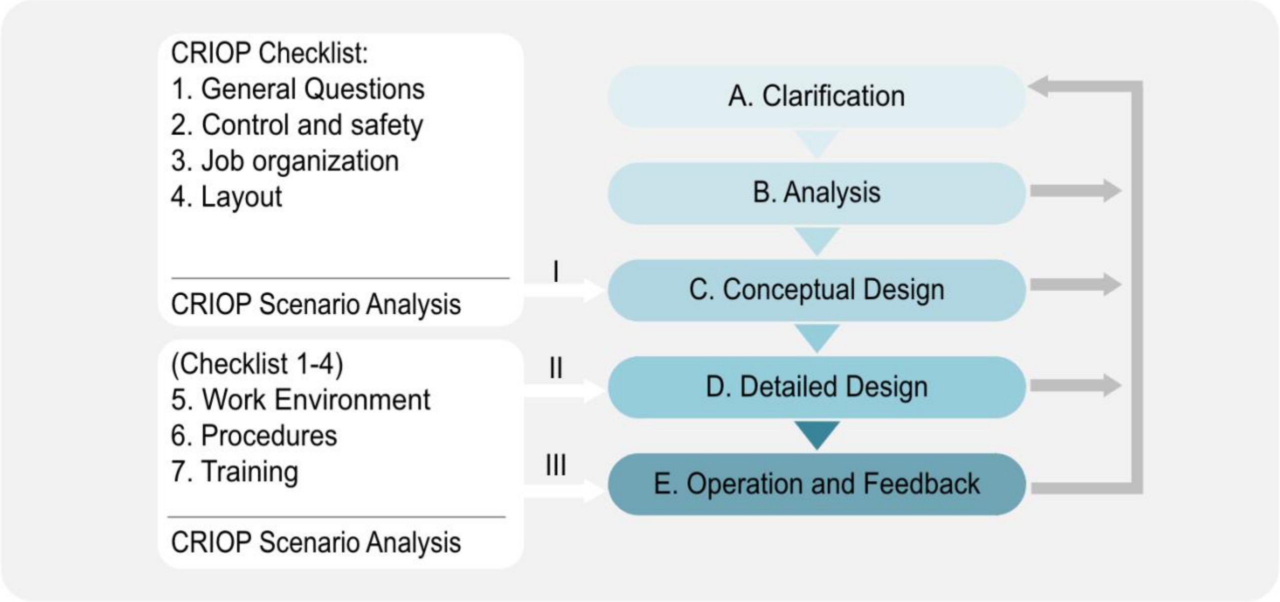


Figure 3.-3 Examples of use of CRIOP based on ISO 11064 phases

The phases involved in establishing a new CC or modifying an existing CC are described in ISO 11064. The typical five steps, A to E, as illustrated in Figure 3.3, consist of:

A.	**Clarification**	Clarify the purpose (goal), context, resources, and constraints when starting the design process, considering any existing situations that could be used as a reference
B.	**Analysis** and definition	Analyse the CC's functional and performance requirements, resulting in a preliminary allocation of functions between machine and humans, define tasks, job and work design.
C.	**Conceptual design**	Develop designs, displays and controls, communication interfaces and initial room layout/furnishing necessary to satisfy the needs identified in step B - analysis and design.
D.	**Detailed design and building/construction**	Perform detailed design of displays and controls, Layout/arrangement, i.e. the detailed design specifications necessary for constructing the control centre and content, operational interfaces, and environmental facilities. (As a last part execute the actual construction of the CC.).
E.	**Operation and operational feedback**	Manage the day-to-day operation of the CC. This phase should include a post-commission review to identify successes or shortcomings in the design, influencing subsequent design or maintenance. Exploration of work as done, adaptations, safety trends, possible critical issues based on safety critical task analysis, see Nazaruk (2022), Shorrock (2021).

Recommendations concerning the control room are easier to implement if the analysis is performed early in design, (i.e. phase B or C). Major changes to the control room layout, for instance, are rarely made after the installation startup, as they entail significant economic consequences. On the other hand, if the analysis is conducted too early, several questions may be inapplicable because certain design issues may not yet be resolved. Therefore, the timing of the CRIOP analysis is crucial, and evaluating it should be given high priority.

Depending on project scope, other HF activities and verification and validation activities, it may be considered appropriate to conduct only one CRIOP during the design phase. However, the recommendation is to apply the CRIOP methodology at three main points in the CC design processes, as illustrated in Figure 3.3, and described below:

C. Conceptual design

Develop a comprehensive design of a control centre that meets the allocated functional requirements, tasks requirements, job descriptions, and organisational plans established in phase B. This conceptual design should include the physical attributes of the control centre and the proposed operator interface (displays, controls, and communication). Use CRIOP checklists: 1.General Questions, 2.Control and safety systems, 3.Job organisation, 4.Layout and Scenario Analysis. (The relevant ISO 11064 activity defining the CRIOP analysis is point 8-Review and approve the conceptual design.)

Note: If possible, parts of the analysis may be beneficial carried out in Phase B: Analysis and definition. (The relevant ISO 11064 activity defining the CRIOP analysis is point 6; Verify and validate the obtained results).

D. Detailed Design

Develop the detailed design specifications necessary for the construction and/or procurement of the control centre, its content, operational interfaces, and environmental facilities. Use **CRIOP checklists**: 1 to 4, and 5.Working environment, 6.Procedures and work descriptions, 7.Training and competence), and perform a **Scenario Analysis**. (The ISO 11064 activity is point D.10-Verify and validate the detailed design proposal.) Complete checklists: 1.General Questions, 2.Control and safety systems, 3.Job organisation, 4.Layout

E. Operation and Feedback

(Operational feedback in ISO 11064). During the day-to-day operation of the CC, include a post commission review to identify design successes and shortcomings to improve future design or maintenance. A CRIOP analysis is recommended after one year of operational experience, identifying error traps. At this point, use the full set of CRIOP checklists to identify safety critical areas that needs to be improved especially check alarms, workload and issues of SA, and conduct a Scenario Analysis of areas of risks where work as done has changed from work as imagined. (The ISO activity is E.11- Collect operational experiences).

Issues or points that cannot be addressed (in the different phases due to the project timeline) should not be ignored; instead, they should be noted and deferred for resolution during the next verification and validation phase. It is essential that responsibility for these deferred issues is assigned to a designated person who will ensure they are followed up appropriately. Deciding when to conduct a CRIOP involves a trade-off between the quality of the design work and the cost of implementing changes identified during the CRIOP. The later a change is identified, the more costly it becomes. We recommend conducting a CRIOP as early as possible and applying industry "best practices."

3.2.1. Use of CRIOP in a modification project

During a modification project, the CRIOP analysis should be conducted in the same way as a standard CRIOP analysis, as shown in Figure 3.3. A project definition or an assessment of the status, part of Management of Change- MoC, should be performed to identify key areas of interest and potential challenges.

In a modification, it is crucial to focus on the changes (and the MoC) being made to the installation. Relevant CRIOP questions for the General Analysis should be identified during the preparation phase. In the Scenario Analysis, it is important to examine scenarios that explore these changes. The scope of the CRIOP analysis should span from 2 to 4 days, allowing time to fully understand the modification and explore relevant scenarios. As mentioned in CRIOP G14 - Is experience from other relevant projects (or MoC) used? The project team should be exposed to "best practice" from new installations to gain insights into new possibilities.

3.3. Collect necessary documentation

Essential documentation should be provided to the analysis group in advance (See documentation checklist in Table 3.2). This is an important step for ensuring an efficient evaluation process. Note that the documentation checklist presented in the methodology is comprehensive, however, only certain sources may be necessary for a specific analysis. The checklist serves as an overview of *potentially relevant* documentation rather than a set of strict requirements. The most critical documents are highlighted in bold in Table 3.2. The documentation requested should correspond to the relevant phases in the design process.

Table 3.-1 CRIOP documentation checklist- key documents in bold

Area	Documentation	Yes/No
1. **Project description** and project plans	**Project definition** and **project plan**, including context, scope (interfaces to other installations), and goals with emphasis on planned changes.	
Installation layout	**Plant plan** or installation plan, Overall layout of Control Suite; **HF analysis for Control Suite Design;** Module plans where scenarios are expected to occur.	
2. **Goals and strategies for HSE**	Established goals and strategies for enhancing HSE, as described in MR section 4, risk reduction. HF policies (Documents related to HF in design/Risk assessment) and standards/guidelines of HMI/ Alarms/ Design/ Communication	
3. **Results from other analysis**	**Task analysis/Safety Critical Task analysis (job, task, and timeline analysis) and workload assessment. Security issues. HAZOP** or HAZID, working environment analysis, and predictions Situation analysis	
CRIOP studies	**CRIOP analysis reports from earlier phases**	
4. **Process characteristics**	**Process flow sheet (process overview);** Safety, risk and emergency preparedness analyses (QRA, HAZOP)	

	ICT architecture and system description Piping and instrumentation diagrams (P&IDs); Shutdown logic matrix (cause & effects); Detailed equipment drawings	
5. Alarm strategy	**Description of alarm strategy or philosophy and design**	
6. Control room layout	**Control room or section layout plans;** Control room ceiling, lighting, colour plans, and architectural descriptions	
7. Control room equipment	**Description of process control system equipment and safety shutdown system equipment** Printout samples (alarm listings/VDU displays); List of acronyms, abbreviations, and coding conventions; Description of controls, desks, VDUs, large screens, and furniture	
8. Organisation	Organizational philosophy, organizational goals and strategy. Description of installation (plant or platform) emergency organization and operating and emergency procedures, training material (concerning abnormal situations). Job rotation plan, Incidents/accident reports (from existing and similar control rooms). Suggested improvements (work environment) Description of control room organisation Training materials (focused on abnormal situations)	

3.4. Establish the analysis group

The analysis group should include or be led by the facilitator (CRIOP lead), an individual experienced in human factors issues. This leader, ideally a neutral and trusted third party, should be well-versed in Human Factors and the CRIOP methodology and responsible for guiding discussions, managing time schedules, and ensuring impartiality throughout the process. To achieve the best outcomes, the two (three) control room operators should come from diverse backgrounds with varying experiences. A typical analysis group should consist of the following personnel:

- CRIOP lead - A facilitator with a strong understanding of human factors, preferably a human factors specialist and a CRIOP scribe with a solid grasp of human factors to accurately document issues and points from the analysis. (Both supporting analysis).
- Two (ideally three) control room operators; at least one should be a senior operator with extensive experience
- An instrument engineer
- A process engineer
- HF expert (analyst) from the operator or contractor working with HF analysis
- Additional experts as identified from the CRIOP Checklist

Additionally, the following personnel may be required for specific topics during the analysis:

- Training personnel
- Safety personnel
- Specialised disciplines, such as electrical, HVAC, ergonomics, telecom, OT/IT, SAS experts

- Personnel responsible for designing procedures and work instructions

Key responsible personnel from the supplier or operator company or owner’s engineering or operations organisation may also be represented in the CRIOP dependent on scope and responsibility.

3.5. Workload assessment (WA)

Evaluating operator workload should be done in normal operations and during abnormal situations. Excessive workload can distract operators, preventing them from managing situations effectively. WA should be done before the CRIOP analysis is done to support the analysis.

The figure below attempts to illustrate that a task analysis (here called HTA – Hierarchical Task Analysis) is a starting point for spreading tasks over time and then arriving at a time distribution of the workload. The task analysis involves systematizing all tasks (functions) to be performed and describing the tasks in a hierarchy (HTA) that shows the order and relationships between tasks. After the tasks have been identified and structured, for critical tasks, the tasks will be placed over time and then the mental workload (and physical workload) will be assessed at the different times. Based on such a workload analysis, it is possible to say something about which tasks will be performed and which staffing is necessary to perform them.

This documentation should be used as a foundation for assessing the operator’s workload during crisis or high-stress scenarios. It should be prepared by experienced human factor personnel. A brief example is provided below, as illustrated in Figure 3.4.

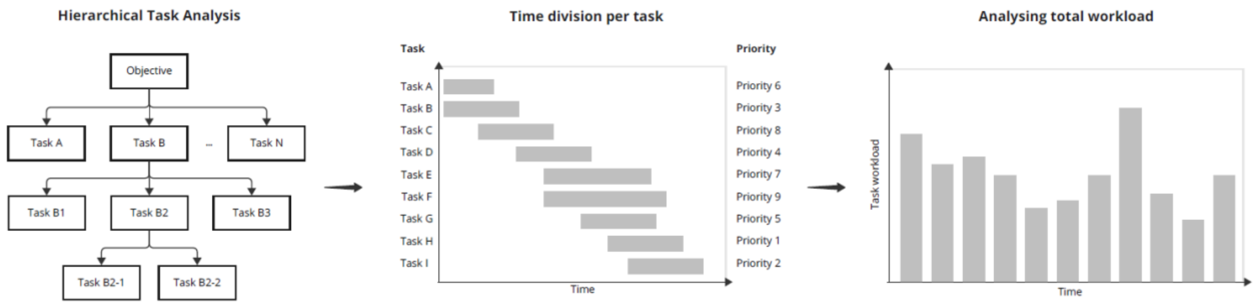


Figure: 3.4 The flow of Work-load analysis based on task analysis and time-line planning

3.5.1. Timing of the workload assessment for normal operations

A general workload assessment for normal operations should be conducted in accordance with ISO 11064, which recommends performing “Job and work organisation design” as a part of phase B: Analysis.

3.6. Facilitating the group process during a CRIOP analysis

Effective control room design and operation depend on collaboration among personnel with different backgrounds. A CRIOP analysis focuses on the interactions between man, technology and organisation (MTO). The goal is to support operators by enabling them to maintain the required level of safety across various operational modes and crisis situations. The CRIOP analysis brings together experts from different fields. To maximize the use of each participant's knowledge and experience, it is essential to employ a CRIOP lead skilled in group dynamics and knowledgeable in human factors.

The facilitation of the group process can be divided into four main steps or phases, with specific focus areas for the CRIOP leader in each phase:

A. Preparation of the CRIOP workshop
B. Briefing
C. The CRIOP analysis /CRIOP workshop
D. Debriefing

A. Preparation of the CRIOP workshop

Introductory information

Participants should receive relevant information prior to the analysis, including an introduction to CRIOP, the specific scope and purpose, participant backgrounds, and a brief description of relevant scenarios (if a Scenario Analysis will be performed).

Practical issues - Physical layout of the room used in the CRIOP workshop, sustenance and time

The physical layout is important for a successful CRIOP analysis. Key elements are:

- *Room size:* Should accommodate 8-12 people, with ample space and equipment for presenting scenario-related events (usually on grey paper: Kraft paper – Economy, 40 g/m^2, 1000 mm x 200 m), and posting large flipchart (A1) on the wall – summarizing key findings and involving the participants in the prioritization. Provide sufficient space for participants to bring supporting materials, such as laptops, documents, or reference books.
- *Equipment and seating:* Ensure all necessary equipment (e.g., flip chart, projector) is present and functional before the analysis begins. Arrange seating to give all participants a clear visual and audible view of the presentations.
- *Room Climate:* Maintain good ventilation and adequate lighting conditions.
- *Sustenance:* Coffee, water, fruit, energy food – ample supply
- *Time/duration: Sessions are intensive* - Time of each session should be 50 minutes followed by 10 minutes break; Lunch/mid-day break should be 1 hour

B. Briefing

The briefing phase introduces the structure and content of the group process. The CRIOP leader will go over key factors for a successful analysis outcome, such as:

Introduction:	The CRIOP leader welcome all participants, set the agenda, outlines the background and focus of the analysis, and explains the purpose.
Presentation:	Each participant, along with the CRIOP leader, introduces themselves, sharing their name, background, and role in the CRIOP analysis.

Setting Rules:	The CRIOP leader establishes guidelines for interaction and dialogue, emphasising a structured, open, non-judgemental, and exploratory approach.
Setting the Agenda:	The CRIOP leader presents the time schedule and key focus areas for the analysis, which participants agree upon.
Questions:	Participants are encouraged to ask questions or provide comments about the structure or content of the CRIOP analysis.
Analysis initialisation:	The CRIOP leader clearly marks the transition from the briefing to the start of analysis.

C. The CRIOP Analysis

The CRIOP analysis aims to facilitate the sharing and integration of the participant's knowledge. Key elements to maximise joint efforts include:

Dialogue:	The CRIOP leader should encourage a non-judgemental exploration of participant knowledge through 'active questioning', uncovering the premises and assumptions underlying the statements.
Second stories:	The CRIOP leader should prompt detailed descriptions of events sequences, focusing on how operators solve and interpret problems in everyday situations.
Involvement:	The CRIOP leader should ensure balanced engagement among participants, preventing any one individual from dominating or remaining overly passive.
Joint focus:	The CRIOP leader should facilitate the synthesis of knowledge, translating individual insights into terms accessible to all participants to establish a joint group focus.
Summary:	The CRIOP leader should provide clear, understandable summaries of key themes and findings throughout the analysis, ensuring the project team agrees on recommended actions.
Maintain focus:	The CRIOP leader should remind the participants of the analysis's aim and focus, and confine discussions to relevant topics when necessary.
Conflict resolution:	The CRIOP leader should facilitate conflict resolution if disagreements hinder group performance.

D. Debriefing

Key elements for the closure and debriefing of the CRIOP analysis include:

Preparing for termination:	The CRIOP leader should announce the termination of the analysis 30-45 minutes in advance, allowing participants time to prepare for final conclusions.

Final conclusions:	The CRIOP leader should present summaries of major conclusions and findings, inviting participants to comment.
Closing the session:	The CRIOP leader should clearly mark the closure of the analysis before transitioning to evaluations and verbal debriefing.
Q&A and evaluation:	Participants should have the opportunity to comment on the analysis, including its value, group dynamics, and the CRIOP leader's role.
Contact:	Participants should be informed of how to contact the CRIOP leader for further comments after the CRIOP session.
Orientation:	The CRIOP leader briefly explain how the analysis information will be handled and how participants can access to the final report.

The main challenge is to create a productive, effective group process, allowing each participant to contribute with their knowledge to the joint exploration of the system. This is achieved by establishing a shared focus and interaction rules and applying them flexible during the analysis. The final stages of the CRIOP analysis should provide a smooth closure, with major issues resolved and summarised, allowing participants to reach a consensus on the findings. The CRIOP analysis concludes with an evaluation of the meeting.

3.7. Suggested Agenda for the CRIOP workshop

Prior to the CRIOP workshop, it is essential to have a “Kick-off meeting” clarify the purpose, scope and participation in the workshop. It is recommended that the checklists have been discussed with the responsible team/group and pre-filled, so that the workshop can be more efficient and prioritize on answers with “No” – i.e. deviations from suggested practice.

The workshop should be scheduled for four consecutive days. The project team should pre-identify and describe 2 to 4 key scenarios for elaboration in the Scenario Analysis.

The workshop participants should remain consistent throughout the analysis to support continuity in the group process, agreements of findings and recommendations. If necessary, the group could add scenarios that has been identified during the discussion of checklists.

The prioritization of findings should be done in a group process, each participant should participate in the prioritization process and help identify recommendations with responsibilities and timeline. (Ex. Each participant uses post it-notes or voting to get the team assessment).

For a CRIOP Analysis with a scope of approximately four days, we recommend using the following agenda and structure. (Issues from the General Analysis could be elaborated in day 3). At the end of the workshop all the participants should evaluate the CRIOP workshop.

Table 3.2 Suggested workshop agenda for CRIOP analysis

Preparation: Kick-off meeting (Half a day meeting with HF experts and project management)
1-Definition of scope of the analysis; 2-Key issues in the projects (challenges, strengths); 3-Areas where a scenario analysis is needed; 4-Key questions from checklist; 5-Relevant documentation; 6-Time schedule/participation; 7- Review of the project offer and contract.

General Analysis (2 Days)	**Scenario Analysis and summary (2 Days)**
Day-1: Introduction of Participants	Day-3: Summary
Day-1: Description of Scope and Challenges	Day-3: Continue with Checklists not covered earlier
Day-1: Walkthrough of Checklist 1 to 4	Day-3: Start Walkthrough of Scenarios 1, 2…
Day-1: Agree on prioritization of findings and description of recommendations with responsibilities	Day-3: Agree on prioritization of findings and description of recommendations with responsibilities
Day-2: Walkthrough of Checklist 5, 6, 7	Day-4: Walkthrough of Scenarios 3,4…
Day-2: Agree on prioritization of findings and description of recommendations with responsibilities	Day-4: Agree on prioritization of findings and description of recommendations with responsibilities
(Day-2: If needed -Round-table evaluation of GA process from all participants)	Day-4: Round-table evaluation of CRIOP workshop process from all participants

3.8. Summary of preparation and organisational activities

Table 3.1 provides a summary of activities and results from the preparation and organisation activities.

Table 3.-3 Activities and results from preparation activities

Activities	Results/milestones
3.1 Describe scope and precondition for study.	• Document scope and key stakeholders (What systems and interfaces are to be analysed, and what are the context, key users and key management involved). What is status of prior analyses, especially HF issues. (Scope must be agreed with HF and Safety, i.e. relevant questions identifying deviations should be answered not avoided.) • Identify methods (ISO 9241-210, ISO 11064, CRIOP). ○ (Identify standards: EEMUA 191/ISO 62682, IEC 63303) • Arrange Kick-off meeting (1/2 day) with HF experts and project management- activities: 1-Definition of scope of the analysis; 2-Key issues in the projects (challenges, strengths); 3-Areas where a scenario analysis is needed; 4-Key questions from checklist; 5-Relevant documentation; 6-Time schedule/participation; 7- Review of the project offer and contract. • Document scope of work, timeline and budget • Establish guidelines for conflict resolution

3.2 Planning and deciding on the "timing" of the CRIOP analysis	• Document workplan and tasks, document when the CRIOP analysis should be performed in relation to the design and operation of the control centre. • Allocate and document necessary resources.
3.3 Establishing the analysis group	• Establish and document the participants in the analysis group (include users from the sharp end and HF experts)
3.4 Collecting relevant documentation	**Document the status (see Table 3.2)**, including: • Control room layout, alarm strategy, screen prints (screen layout), process characteristics, and installation layout. **Document potential changes and development plans**, including: • Strategies and major changes that could impact the control centre, along with an analysis of their consequences.
3.5 Conducting a workload assessment	• Perform and document a workload assessment (this should be completed prior to the CRIOP analysis).
3.6 Addressing practical Considerations before CRIOP workshop	• Collect and distribute introductory information and relevant documentation to participants before the analysis • Arrange appropriate physical conditions for the meeting room (e.g., sufficient space, equipment for graphical presentations, adequate workplace for each participant, and a comfortable room climate) • Conduct a briefing and debriefing

4. General Analysis – Checklists to be used in Design and Operation

4. General Analysis – checklists for design and operation

This section describes the principles behind the CRIOP checklists, guidelines for their usage and, presents the checklists themselves.

While various checklists for control exist across regulations, standards and guidelines, there is a lack of a comprehensive, balanced checklist. CRIOP addresses this gap by integrating relevant materials into a “best practice” checklist, having selected key issues. Issues are prioritized based on the following sequence:

1. Relevant requirements from Norwegian and EU regulation. The objective has been to ensure that local (Havtil) and EU acts and regulations are considered when performing a CRIOP analysis.
2. Key international standards, methods and guidelines (ISO/IEC), i.e. Human Centred Design ISO 9241-210, Ergonomics Design of CC ISO 11064, NUREG 0700, HMI 63303 and Alarms IEC 61508. (NUREG 0700 contains ca 700 pages. Key issues from NUREG and other standards were selected based on empirical studies.) The most important standards are listed in figure 4.1. These standards define the foundation of best practices. Selection based on Leva et al. (2015), Briwa et al. (2022), and Johnsen et al. (2020).
3. NORSOK standards (NORSOK S-002 and NORSOK I-002). NORSOK standards are internationally accepted as best practices and are often referenced outside Norway. (Havtil regulations supersede NORSOK standards as shown in this list.)
4. Best industry practice, such as alarm standards EEMUA 191 and HFE-Human Factors Engineering practices and techniques are often not sufficiently described in the ISO standards. Key HFE practices and techniques are Task analysis, Safety Critical Task analysis, interviews, observational studies, eye tracking, prototyping, workload analysis and user testing, Stanton et al. (2013), Leva et al. (2015).
5. User requirements, as described in scope and preconditions for the CRIOP analysis.

Relationships between the checklists and key methods/standards are illustrated in Figure 4.1.

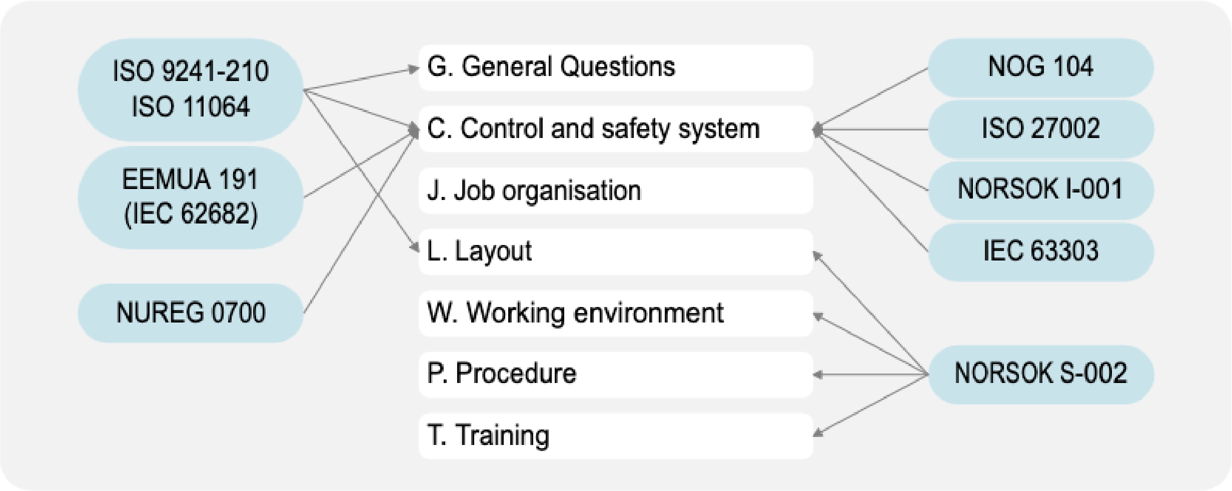


Figure 4.-1 The relationships between CRIOP checklists G to T and key methods/standards

OT/IT challenges related to increased integration is based on ICT and SAS standards, including ISO/IEC 27002, IEC 62443/ANSI/ISA-99. Offshore Norge has published the NOG 104 (2016), also known as OLF 104 ISBR, as a best practice, referencing IEC 62443 and relevant standards. This guideline has also been implemented into the checklists, enhancing alignment with industry standards. A list of guidelines would also include NIST SP 800-82, *"Guide to Industrial Control Systems*". Ergonomics principles in the design of work systems, ISO 6385 (2016) is seen as a general framework that promotes a human-centred approach to designing work systems, recognizing that well-designed systems must account for how people actually perceive, think, and act.

Relevant standards related to robotics and automation are ISO/TR 9241-810 (2020) Robotic, intelligent and autonomous systems; ISO 10218:2025 Robots and robotic devices —Safety requirements for industrial robots; (and if relevant ISO 13482:2014 Robots and robotic devices — Safety requirements for personal care robot) see Johnsen et al. (2020) for more details.

The general checklist is presented in Section 4.3, following this introduction.

4.1. Planning

The General Analysis plays a key role in familiarizing the analyst with the specific control centre concept. Table 4.1 provides recommendations for participants, along with suggested session durations. The table list for each topic, the suggested duration in hours and the number of questions (#), NB: Questions should have been prepared and answered prior to meeting, using time on questions with NO as answer, to ensure effective walkthrough of questions.

Table 4.-1 Participants in General Analysis

Topic	**Duration. (# number Questions)**	**Participants from areas of expertise**
General questions	4 hrs. (# 37)	Management, operations, HF-engineer
Control and safety systems	6 hrs. (# 71)	Operations, instrument, safety, process, ergonomics, manufacturer, working environment engineer /HF-engineer; ICT security, process (SAS) expert
Job organisation	2 hr. (# 21)	Operations, HF-engineer
Layout	3 hrs. (# 29)	Operations, instrument, architect, working environment engineer /HF-engineer.
Working environment	3 hrs. (# 32)	HVAC, electrical/lighting, architect, safety, working environment, noise/vibration control.
Procedures	2 hr. (# 19)	Operations, HF-engineer
Training	2 hr. (# 27)	Operations, HF-engineer
SUM	**22 hr. (# 236)**	
	The estimated effort is based on a selection of key relevant questions	

Participation from experienced control room operators and line management (operations) is essential throughout the analysis. The duration of analysis may vary from estimates with -50% to +200%, depending on the complexity of the scope and the composition of the analysis group.

4.2. Checklist

The checklists support the identification of issues and potential *solutions* related to human factors in the control room. Explanations to the questions are also given. Each question includes explanations and is phrased so that the "correct" answer is "yes." The "comments" field can document *how* an issue is implemented when relevant.

Each checklist field consists of:

- ***Point:*** Structured question number with syntax: <area>.<level>.

  A single-digit level number indicates a high-level question, with additional digits denoting more detailed sub-questions (e.g., L2 is a high-level question, with sub-questions L2.1 through L2.4).

- ***Description or question:***

  Example: *C 10.2 Are warnings provided if out-of-range values are entered?*

- ***Rationale or evaluation criteria: (under each question)***

  Example: *Entry of out-of-range or extreme values (e.g. % changes in relation to a set value) may cause deviations in the process or damage equipment. Check that keyboard entries are distinct from potentially hazardous commands. Display entered data, check it, and request confirmation if needed.*

- ***Questions in the checklist should be answered:***

  Yes (Y): Used when the activity is completed or planned; planned actions should be noted in the "Comments" field and agreed upon by the CRIOP project group.

  No (N): The reason for a "No" response must be explained and documented.

  Not Applicable (NA): The reason for "NA" response must also be explained and documented thoroughly.

- ***References:***

  References and background of the Question. Example: NORSOK I-002, NUREG0700. References specific to the Drillers Cabin are prefixed with "DC". Questions applicable to Drillers Cabin (DC) are marked with "DC: Applicable to the DC" in the Comments column. *(This column can also be used to prioritise the importance of the issues, with suggested prioritisation: H – High, M - Medium, L - Low.)*

- ***Comments/REF:***

  Can be used to document *how* an "No" issue or identified challenge in the project is resolved or suggested to be implemented when appropriate; with references to key documentation.

- ***Responsibility (Resp.):***

  At the end of the General Analysis the findings, recommendations and identified weak points should be documented, with a responsible person designated to follow through on actions.

4.3. Documentation of results

The documentation of results from the General Analysis should include:

- References to relevant questions in the general checklist
- A description of identified weak points/ challenges identified
- Suggestions for remedial measures and recommendations based on the identified weak points
- The responsible person for addressing the weak point and implementing the recommendation (Resp.)
- Prioritization (Prio), a collaborative weighting of identified issues done by the participant voting or a prioritization in High, Medium, Low

An example is shown in Table 4.2.

Table 4.2- Documentation of results – Example (General Analysis)

Ref **Prio**	**Question/ *Weak points***	**Comments/ Recommendation**	**Resp.**
L4.7 (High) 20 votes	**Can the operator maintain a natural posture while seated at the workplace?** *The operator's legs touch the lower part of the desk at the VDU workstations.*	Redesign seating at the VDUs (desk/chairs).	Equinor/HMS/NN
W5.4 (Med) 10 votes	**Are vibrations in the control room within acceptable limits?** *The control room is planned below vibrating equipment.*	Increase distance or implement measures to reduce vibrations.	Equinor/HMS/NN
C9.2.1 (Med) 10 votes	**Are suppression mechanisms used to reduce the number of consequence alarms?** *Unnecessary alarms are not suppressed.*	Excessive unimportant alarms divert the operators' attention from critical alarms, limiting time for analyse. Implement suppression mechanisms.	Equinor/HMS/NN

C10.2 (Med) 10 votes	**Are warnings provided if out-of-range values are entered?** *There is no warning function for out-of-range values, risking entry errors (e.g. 44000 instead of 4400).*	Enable warnings for out-of-range entries.	Equinor/HMS/NN

4.4. Prioritization done in collaboration

Key findings and the subsequent recommendations should be listed and weighted (or prioritized) based on ratings from the participants in the workshop. Involving each participants helps identify key issues and helps ensuring that issues are resolved.

Weighting can be done by giving each participant five votes (post-it notes that can be placed on the identified issues/ or collecting viewpoints in meeting). The findings with the most votes can then be used in prioritization. Each attendee got five votes with a weight of 1, 2, 3, 4 or 5 that was used by the participants to prioritize the issues. (The weight 5 was used to identify the most important issue.)

Weighting/prioritization can also be done based on identifying issues as High importance/ Medium Importance or Low importance.

The findings should have references to the relevant checklists (and later scenario analysis) or regulation. Responsibilities and due dates are specified in prioritized actions and must be followed up and tracked.

Example:

Findings (F) **Actions (AC)**	**Description** **(References to CRIOP items, Prioritized issues Mx, and Scenario findings Sx)**
F1	**Need to define IO and operation philosophy and responsibilities more precisely and communicate goals.**
AC1.1 **(Weight 31)**	**Describe IO/Operational philosophy more precisely and communicate goals.** (CRIOP checklist: G12, G12.1, G12.3, L1, C1, T1.1, J1, J1.2, J1.5.1, J1.6). Description of operation philosophy should be based on best practices and experiences in the industry. As an example - the room layout can be impacted by operational philosophy, and thus the operational philosophy needs to be documented. (Task analysis/ workload analysis is also dependent on the operational philosophy.) It could be useful to include description of the "Job rotation philosophy". (Ref CRIOP: J1.5.1). *Responsibility: NN; Due Date: 13/11.*

4.5. Latest update (2025) of CRIOP

The latest update of CRIOP contains a few new questions, and some questions are removed. We have renamed e-Operation questions as “General”. A summary of the background for new questions is documented in the following Table 4.4. Main additions are due to user requirements such as need for Multi Facility Control, new HMI standards, SA flow, alarm management, need for focus on security due to new threats of integration, increase in Autonomy/AI, need to reduce Error Traps, need for meaningful human control as automation increases and need for cost reductions.

Table 4.4- Summary background/reason for new questions in 2025

Background/Requirement	New questions
Requirement/ research from Equinor (dialogue partner) of Multi facility control.FR § 9 Qualification, FR § 10 - possibility for human error is limited.	G13-Are multiple facilities controlled?
Standard for HMI, IEC 63303 enhances safety by improving HMI design to prevent accidents. It highlights need for MoC. It ensures standardization across multiple facilities and different vendor packages, making training easier, reducing errors, and improving efficiency. It supports digital transformation, aligning HMIs with AI, IoT, and remote operations. By optimizing usability, it helps reduce human errors and downtime. The standard promotes regulatory compliance, future-proofing operations and alignment with industry´s best practices.	C2.3 Is the project following relevant HMI standards? C2.4 Are approved Management of Change (MOC) procedures being used during the life cycle? (C3.5, C3.6)
IEC 63303 emphasizes the importance of situational awareness (SA) in HMI design. The standard ensure that operators have optimal knowledge of the processes they oversee, enhancing ability to detect, diagnose, and respond to abnormal situations.	C3 Has flow of Situational Awareness been designed to support “situation at a glance” (and C3.1, C3.2, C3.5, C3.6).
FA § 34a Control and monitoring system- Inadequate follow-up of alarm management (many standing alarms). Missing monitoring of alarms to improve operational conditions in the CR, Havtil (2022a).	C9.1.1 Is there a reporting system and procedures to document and manage the alarm rate over time?
Significant attacks 2017-2021 on Hydro (2019), Amedia (2021), Nortura (2021), Maersk (2017); and incidents -Equinor in Riksrevisjonen (2019) noted possibility of "Weakening/loss of safety functions and barriers" - "risk of refinery failure, weakening/loss of safety functions/barriers, reputational loss and production loss in the order of NOK 15–20 million."	G19 – Security issues added based on NOROG 104, example G19.3 B) “Are the IT/OT network segmented appropriately based on the policy? “
EU AI act (Art 14) mandates that high-risk AI systems be designed with mechanisms (stop buttons or intervention) to allow operators to oversee and interrupt operations, when necessary.	C6- Are the logic of AI transparent enough for operators to understand what the system is doing and why? C6.1 Can the operator easily take over control from the automated system?
MR § 19 Collection, processing and use of data/ Federation of Norwegian Industry (2025); Needs to be checked during MoC/ Brownfield.	G8-Are error traps and “work as done” explored systematically?
FR § 10 - Installations, systems and equipment shall be designed in the most robust and simple manner possible and such that the possibility for human error is limited.	G4- Have Human Factors risks been integrated and mitigated in the project?
FR § 9 Qualification and use of new technology and new methods.	G6-Have operational tasks been designed based on the strengths and weaknesses of the technology and human operator?
MR §18 (ISO 11064- Part 1 Principle 1: Human-Centred design approach). FR § 9 Qualification and use of new technology and new methods, FR § 21 (Information presentation) EU/AI act (art 14)- human oversight.	G9-Does the system support Meaningful Human Control?
Need for cost reductions of control systems – (CC, ROC) standardization should be assessed to support the Norwegian shelf’s competitive position.	C2.2- Is standardization through open innovation considered?

New questions (total 20) and marked by asterix* are: G4, G6, G8, G9, G11, G13, G19.1, G19.3, G19.5, C2.2, C2.3, C2.4, C3, C3.1, C3.5, C3.6, C6, C6.1, C6.2, C9.1.1, T2. **The following questions are removed from 2024 version (or integrated into others) (total 12):** E6, E7.3, E9, E17, E11.4, E14, E14.1 (E14&E14.1 integrated in new), E15, E18; J3.1.1; P1.3.2; T2.4.1. **Different opinions** related to removal of questions are indicated by a minus sign, and may be removed later, i.e. C4.3^{-}

Checklist G: General Questions

Checklist G: General questions

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G1	**Has a project definition (a concept analysis/ or MoC) been done to ensure that the right problems (and best solutions) are evaluated to ensure a safe and prudent approach?** *A too narrow scope may ignore safety critical issues. Thus, it is important to discuss the scope including MTO. Human factors, organizational issues. Technology/ Human maturity and updated Fitts List should be checked to ensure a prudent approach. A Double Diamond approach can be used as described by* Tschimmel (2012). *Operational design domain can be used to document framework conditions, see* EU (2022/1426). Hierarchy of controls can be used to support elimination or substitution, see Federation of Norwegian Industries (2025). *Changes should be defined, and the MoC should be planned and include training, information and procedures.*				CRIOP (2024) 3.4, E7.3, J1.1 ISO 11064- part 1. Begnum (2021). Tschimmel (2012). FR §9, §10, §11; FA §6 IEA/ILO (2021). EU (2022/1426). ANSI/HFES 400-2021. Federation of Norwegian Industries (2025). De Winter et al. (2014). DC: (MoC) should be done for changes/ maintenance / software updates. There is often a lack of overview of systems in the driller cabin, MoC must be planned, standardization must be checked.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G2	**Are (all) the important stakeholders identified, analysed (roles identified), and involved in the project?** *The different stakeholders should be identified and involved in the project in the right way to support the change project. A guiding coalition consisting of the influential stakeholders and management should be established. (This could be telecom, energy, security…)* *The Steering Group should be selected from the guiding coalition. Participants from all the "virtual organization" involved in the project should be involved, including third parties such as vendors and suppliers if they are supposed to design solutions or operational support after implementation.*				ISO 11064 (Series) ISO 9241-210 (2019) Kotter (1996) Pinto (1996)		
G2.1	**Is a communication plan established to inform the relevant stakeholders?** *To ensure an optimal change process it is important to ensure common understanding, participation, and involvement among the different stakeholders. The communication plan should inform about the benefits of the change among the relevant stakeholders. The communication plan must ensure that relevant information is gathered and distributed.*				MR §15 Kotter (1996)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G3	**Has a relevant HF method/process been selected to guide and ensure iterative user-based approach?** *User-centred design is a key methodology to ensure safety, efficiency, and usability. The methodology should ensure that human, organisational, and technology issues are being addressed. A Work process approach may help.* *(For Guidance Haptic interactions ISO9241-810)*				ISO 9241-210(2019); 11064 (Series). IEC 63303 (2024) or ISA 101.01 (2015). FR §13, MR §13, FA §10, §20. IEA/ILO (2021). CRIOP (2024) 3.1, E9 ISO 9241-810 (2020); ISO 10218 (2025)		
G4*	**Have Human Factors risks been integrated and mitigated in the project management from the start?** *Are HF risks (and possibilities for Human Error) been identified, assessed, and prevented into the project's overall risk management framework as early as possible? Designing for safety and security is a key issue. A risk-based approach supports world leading safety, Elvik (2021). (Safety for industrial robots, see ISO 10218).*				FR §10, §27, MR §4. Behm et al. (2014). ISO/IEC 27000-series. Salomonsen (2019). ISO 10218(2025), Johnsen et al. (2020)		
G5	**Is Human Factors knowledge and expertise used and prioritized in the project (or in MoC) from the start?** *Is there a responsible for HF in the project? Key competence for the HF expert is knowledge and understanding of Human ergonomics, Cognitive and Organizational issues to support safety, efficiency, and usability (and reduce change costs at a later stage).*				FR §13. FA §10 §20. TOR §7, §21, §23. Lee (2017). Stanton (2013). CRIOP (2024) 3.3		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G6*	**Have operational tasks been designed based on the strengths and weaknesses of the technology and human operator(s)?** *Fitt's list can be adapted, de Winter (2014), as an example to ensure that technology and users support each other and support teamwork. The Boeing Max disasters are examples of poor human/technology matching, Endsley (2019).*				ISO 9241-210 (2019) FR §9, §10 TOR §9 de Winter (2014) National Academics (2022) Sætren (2016)		
G7	**Has an appropriate HF-based technique been used to identify, design, and allocate tasks as a basis for design?** *Has a task analysis (TA) been done to share tasks between humans and machines and identify areas of concern for human errors, (e.g. SCTA – Safety Critical Task Analysis). Check the need for Cognitive Task Analysis to provide input to workload, design, and training.*				CRIOP (2024)1.2, 3,4. MR §18. TOR §21. Energy Institute (2020). Helgar (2023).		
G8*	**Are error traps and "work as done" explored systematically and truthfully (not only "work as imagined").** *Check that HF-based design is done to support error tolerance, and to avoid error traps such as poor HMI, poor task training, limited time, unclear roles, unclear task description, poor user testing, and poor user understanding. Work as done usually deviates a great deal from work as intended. Identify critical tasks, explore issues that makes work difficult, and areas of high*				MR §18. Nazaruk (2022). Dekker, Conklin (2014). IEA/ILO (2021). Thun (2021). Federation of Norwegian Industries (2025).		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	risks. Use Scenario testing to explore ability to handle surprises. *Check that all collaborate to create an environment where it is safe to give honest feedback? (A safe psychological environment where individuals are open about 'work as done', not being afraid of punishment?). Thun (2021)*						
G9*	**Does the system support Meaningful Human Control i.e. ensuring sufficient time, mindset, organization, and systems/information to act before incidents occur?** • *Is human oversight of safety-critical (AI) systems designed and implemented if necessary?* • *Is design based on a TA (or SCTA) and user centred design ensuring clarity in responsibility, rapid detection and comprehension through HMI?* • *Has workload been assessed to ensure operators have sufficient time to acquire SA and handle safety-critical tasks – especially situations of defined hazards?* • *Has training and user testing of safety critical situations and key scenarios been approved by the users.*				FR §9, §21, MR §18 EU/AI act (art 14)- system oversight Bergh et al. (2024a)		
G10	**Has the system been tested and accepted by the relevant users, systematically step by step including unit testing, user testing, and whole system testing?**				CRIOP (2024) E15 FR §9, §19; AR §24; TOR §45 ISO 9241-11 Usability ISO/IEC 25000 series		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	• *Are all tasks, systems and procedures user-tested, and are the system user-tested in a systematic manner through prototyping, mock-ups and FAT? (This should be documented.)* *_Experiences from large projects are that testing accounts for 1/3 of project effort, programming/building takes another 1/3, and establishing procedures, training, and organisational issues requires the last 1/3 of the time._				• ISO/IEC 25010 effectiveness, efficiency, satisfaction and context of use • ISO/IEC 25022 quality in use, measures of effectiveness, efficiency and satisfaction • ISO/IEC 25023 measures for product quality • ISO/IEC TS 25011 service quality model for services or support IT		
G10.1	**Is equipment for remote operations tested and approved by the responsible user prior to production?** *The IT system, the relevant procedures and the training must be tested. The recently trained users should perform the testing. The testing should also involve the backup solutions. Simulators could also be used to test the solutions.*				HSE (2003), CRIOP (2024) E15 Kotter (1996)		
G10.2	**Has the video equipment (screens and cameras including CCTV) been tested and approved by the end users?** *The video equipment should be tested and approved by the users. Important issues are:* ○ *Usability/ Simplicity of use* ○ *User guides and user training* ○ *Stability, fitness related to use, quality in use related to coverage, resolution and brightness.*				HSE (2003)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	○ *ATEX; and robustness and simplicity in maintenance.*						
G11*	**Does the operational concept in review going to use remote operations or new (non-traditional) ways of working?** *Then the remaining questions are relevant*						
G12	**Is the degree of remote operations or remote support defined and precisely described?** *To avoid misunderstandings, it is important to define the concept and the degree of remote operations. This will ensure a better implementation process and a better result. Clarity in responsibility, procedures, and communication protocol must be in place, among all the different actors and participants, including suppliers involved in outsourcing. Three examples of different degrees of remote operations are listed:* 1. *Remote Support: The operation is done offshore, but remote support is being given by onshore experts via teleconferencing, video, phone, or radio.* 2. *Remote Monitoring: The operation is done offshore, but some sort of remote monitoring is being performed.* 3. *Remote Control: The operation is managed and operated remotely.*				FR §10, §11 Kotter (1996) Johnsen (2005a)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G12.1	**A. Is a clear vision and goal for remote operations defined in cooperation with key stakeholders?** **B. Are the vision and goals of remote operations aligned with the organization’s underlying values, philosophy, and procedures?** **C. Do key stakeholders understand the rationale behind the vision and goals?** *To avoid complacency and misunderstanding it is important to establish a compelling vision and goal of remote operation in cooperation with key stakeholders. The goal and vision of remote operations must be aligned with the organisation’s underlying values and philosophy, or certain aspects may need to be adjusted. (I.e. Remotely operated equipment may not have the lowest upfront cost, but it could be the most cost-effective option when considering the total cost of ownership, which might challenge purchase procedures.)*				FR §12, §13 Kotter (1996)		
G12.2	**Has a cost/benefit analysis of remote solution been documented in cooperation with the key stakeholders?** *The analysis should be broad (including MTO), to document all costs. A*				Kotter (1996): Nystrøm (2019), Adressa (2023).		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	consequence analysis should be documented and presented to the key stakeholders. An assessment of remote operations should be conducted after 2-5 years of experience. Costs may increase, particularly if scope is fragmented.						
G12.3	**A. Are remote operations specified and developed in cooperation with the key users and stakeholders?** **B. Is the functional requirement for remote operations developed based on user requirements?** *To ensure participation from both management and employees, the development of remote operations should be done both top-down and bottom-up. Key stakeholders should participate in the change process. Requirements should be specified together with the key stakeholders and adjusted based on feedback from experience. Relevant stakeholders could be users, management, and third-party providers.*				FR §13 Pinto (1996). ISO 11064 (Series) ISO 9241-210 (2019)		
G12.4	**Are sufficient competent resources allocated to the project to meet the deadlines?** *Management must allocate key resources from the line to new ways of*				HSE (2003) Kotter (1996)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	working to ensure the success of the project. Competence from different suppliers could be beneficial. Since new ways of working could make fundamental changes – it is important to involve competent resources.						
G13*	**Are multiple facilities controlled?** **A. Has the scope and level of multi-facility control been identified (i.e. heterogenous, homogenous)?** **B. Has a verification (or simulation) of what is compatible to combine been performed?** **C. Has the human factors challenges been identified through a systematic process and planning identifying challenges of:** ○ Maintain situation awareness across facilities. ○ Handle simultaneous disturbances at multiple facilities. ○ Workload and ability to prioritize. ○ Manage differences between facilities (confusion/ Human Error). ○ Unfamiliarity with construction and physical properties. ○ Misconceptions about responsibilities. ○ Social needs of the operator, leading to less contact, and how to avoid isolation. **D. Have the HF challenges been mitigated and accepted by the users?**				Hurlen (2022). FR §9, §10, §11, §13; MR §13; FA §10; §20 IEA/ILO (2021)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G13.1 *	Have the appropriate HF challenges of drone operations been identified and mitigated and accepted by the users? (If drones are controlled and managed from the CC) • *IF the CC operator is going to operate drones (air, surface, underwater, etc.) HMI, layout and workload must be addressed as mentioned in G13. Operator error rate of drone-operations is high – Waraich (2013)*				FR §9 Waraich (2013) Bakken et al (2020)		
G14	**Is experience from other relevant projects being used?** *Experience from relevant projects within and outside the company should be gathered to avoid pitfalls and ensure good organizational learning.* *Check background of onshore installations being returned to offshore, to support knowledge and good practice.* *Safety/SIL experience is important to share.)*				Kotter (1996) Nyström et al. (2019))		
G15	**For new ways of working/ remote operation:** **A) Are the changes in the work processes specified and documented?** **B) Are the changes in work processes analysed in a Human Factor considering Man, Technology, and Organisation?** *Changes in all the work processes must be analysed with respect to overall organisational implications. The work process must be analysed from a Human Factor perspective (e.g.*				FR§ 9; MR §13 ANSI/HFES 400-2021 HRL DNV-RP-A203 (2021) HSE (2003) NIST (2023) SP 800-82 Johnsen (2006) Henderson (2002)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	using TA or SCTA). Successful realisation of new work processes will have some prerequisites related to technology and human factors: Technology can be new tools, upgrades of existing control systems, improved user interface etc. Human factors can be new tasks, workload, roles, new skills, and new competence. Key issues related to readiness are documented in TRL and HRL standards.						
G15.1	**Is a preliminary operational risk analysis ("pre- HAZOP") performed?** *A preliminary operational risk analysis (pre-HAZOP) should be performed to identify relevant risks when new ways of working are implemented. Integration of IT/OT/systems can introduce new vulnerabilities and increase reliance on technology.*				MR §13, §17 HSE (2003) NIST (2023) SP 800-82 Johnsen (2006) Henderson (2002)		
G16	**A) Are all interfaces clearly defined and are all organizational areas of responsibility clearly defined and described?** **B)* Are "See-To" responsibilities clearly defined and described for SCT- safety critical tasks (ex. through work processes)?** *Who has the "See-To" responsibility of work-processes and workload, (EU Framework directive 89/391)?* *An example of interface could be responsibility between operator and supplier related to a*				HSE (2003) Henderson (2002) IOGP (2017) 423 Safetec (2023 *EU Framework directive 89/391* IEA/ILO (2021)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	firewall, or an IT network. Related to an interface, the following responsibilities should be defined: ○ *Who is actually operating the interface and has responsibilities to follow the SLA.* ○ *Responsible user (the responsible user decides functional requirements, specifies the contract and specifies the SLA – Service Level Agreement).* ○ *User (asked about user satisfaction, informed about modifications and updates).*						
G16.1	**A. Is an SLA (Service Level Agreement) for the necessary systems established?** **B. Does the SLA define responsibilities, service levels, availability requirements, security requirements within the chain of suppliers, exception handling, and reporting requirements?** *The SLA usually specifies the operational period such as 24 hours/7 days a week, availability requirements such as 99, 9%, and reporting requirements.*				ISO/IEC 27002 (2022)		
G17	**A) Are the requirements to establish common situational knowledge and awareness between the participants in remote operations established?** **B) Do the requirements reflect the following common ground knowledge**				Kotter (1996), Orasanu et al. (1997), Stanton, et al. (2017).		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Common situational knowledge could be a key issue during an emergency, but also during regular operation. Key resources are involved from dispersed geographical locations and must acquire common situational knowledge to be able to function as a team to solve an emergency and possible operational problem. The requirements should cover: *1) Knowledge and assumptions about the current situation, termed "situational knowledge"* *2) Professional knowledge about each participant's roles and responsibilities?* *3) Professional knowledge and understanding about standard operating procedures, termed "procedural knowledge"?* 4) *Cultural knowledge, e.g. beliefs and norms based on company specific policies and norms?*						
G18	**A. Has a risk assessment of the operations been performed both prior to and after implementation of remote operations?** **B. Is the risk analysis approved by responsible senior management?** *A risk assessment should be performed before and after implementation of remote operations (or new ways of working) to identify major hazards in the production process.*				MR §17 HSE (2003) ISO/IEC 27002 (2022) NOG 104 (2016); Hopkins (2000)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G18.1	**A. Are new risk-based barriers established as remote operations are implemented?** **B. Are the barriers sufficient?** *Examples of barriers in this context are:* *Organisational barriers such as personnel redundancy, training or procedures – i.e. training on unwanted incidents. Mitigation of less workload and boredom?* *Technical and physical barriers such as Physical firewalls, isolating danger from humans, firewall, doors with entrance restrictions – alarms better quality.*				ISO/IEC 27002 (2022) Johnsen (2006) Havtil (2017) Barrier Memorandum IFE (2020)		
G19*	**A. Is the principle of safety/security by design established?** **B. Are suppliers/technology selected based on safety/security by design?**				CISA (2023a) NIOSH “Prevention through Design Program” (2024)		
G19.1*	**A. Has the scope of IT/OT systems been clearly documented?** **B. Has an assessment of the scope and criticality of these IT/OT systems been conducted?** **C. Is this assessment performed periodically?** *IT/OT integration is increasing to enhance operational efficiency and automation. However, the criticality of these systems may*				ISO/IEC 27002 (2022); NOG 104 (2016) CISA (2023), CRIOP (2024) E11.1		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	evolve over time due to several factors, including Increased user reliance, reduced manning (e.g., fewer personnel onboard), task relocation (e.g., transferring responsibilities from offshore to onshore teams). *A system that was initially non-critical may become safety-critical, either through expanded operational roles, becoming a single point of failure, or the emergence of new vulnerabilities (e.g., cybersecurity threats). It is essential that criticality assessments consider operational continuity and adhere to the CIA principles—Confidentiality, Integrity, and Availability—particularly when systems are involved in safety-critical operations.*						
G19.2	**A) Is the safety and security of the individual IT/OT systems regularly assessed?** **B) Is a safety and security policy established based on identified major risks?** **C) Is the policy enforced and adhered to by relevant stakeholders?** **D) Is a formal risk management process in place for IT/OT systems?** *The safety and security policy should be based on the principles outlined in ISO/IEC 27002. Several security weaknesses have been identified by authorities, such as CISA (2023) and the*				ISO/IEC 27002 (2022) IEC62443 series NOG 104 (2016) Riksrevisjonen (2019)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Norwegian Office of the Auditor General (Riksrevisjonen, 2019).						
G19.3*	**A) Does all the system have designated owners or responsible party?** **B) Does the "PåSe/ See-To" responsible actively follow up on system performance and the supply chain obligations?** **C) Is the IT/OT network segmented appropriately in accordance with the safety and security policy? (Are segmentation controls documented and maintained?)** **D) Are maintenance and system changes carried out in alignment with the safety and security policy, and risk management process?** **E) Is access to critical systems based on appropriate access control?** (such as role-based access, two factor authentication, time limited credentials for contractors?)				ISO/IEC 27002 (2022) NOG 104 (2016) IEC 62443 series		
G19.4	**Are all remote access points documented, analysed, and protected from unauthorised use?**				ISO/IEC 27002 (2022) IEC 62443 series NOG 104 (2016)		
G19.5*	**Has an assessment been carried out to ensure that security and safety measures do not interfere with each other?**				Ginther (2023)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Example: Could strict authentication requirements delay operator response in an emergency?						
G20	**Is a thorough scenario analysis performed involving accidents, incidents, and the effect of remote operations?** *Scenario analysis involving personnel from different geographic locations should be performed. Scenarios should address normal operation, operational deviations, complexity and defined emergency situations involving remote operations. The exploration of unwanted IT incidents involving actors from suppliers and other organisations should be performed. Documented incidents, Bowties or TA/SCTA could be a good starting point. (See the scenario analysis description in the CRIOP).*				HSE (2003) Jaatun (2007)		
G 21	**Are all necessary questions asked regarding the general questions (Remote, Security…?)**						

Checklist C: Control and safety systems

Checklist C: Control and safety systems

Facility	**Performed by / date**	**Approved by /date**

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C1	**Are information needs specified, analysed and documented based on functional and task analysis (i.e. following best HF practice)?** *The information required to perform the work processes must be specified. These needs should also account for aspects such as collaboration, remote control, monitoring, or other relevant factors. Additionally, the different methods for fulfilling these information needs should be documented, including:* ○ **Direct communication** – Face-to-face interaction, informal meetings (e.g., social corners), and direct perception. ○ **Interactive real-time communication** – HMI, telephone, videoconferencing, indirect perception via IT systems, and collaboration tools (e.g., MS Teams, chat). ○ **Asynchronous communication** – Logs, email, and other non-real-time methods.				Henderson (2002) DC: Applicable to the DC		
C2	**Are the displays (and large screen displays) designed according to ergonomic principles, user requirements and best practice to suit the way they are to be used?**				FA §21 NORSOK S-002 (2018), 7.8.3. EN 614-1 (2006), 4.1.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	All displays that are present in the CC should be designed according to ergonomic principles (i.e. functional description, task oriented) and best practice to ensure that they reduce cognitive load, support attention/SA, decision-making, and teamwork (i.e. shared mental models). (Large screen displays are considered to have a size of 4m-6m and upward, where the user is seated distance 3.5-4m). Check usability, efficiency from user side.				DC: Applicable to the DC		
C2.1	A. **Are the displays designed in such a way that they support operators' tasks? (i.e. based on systematic task analysis)** B. **Is navigation between different displays quick and easy? (Based on task analysis)** *This concerns Graphics/HMI. Examples are "one key commands", "pop-up" or direct access. Changing between different displays should be easy to carry out and should require little memorisation. Navigation in alarm displays should be quick and easy.*				NORSOK S-002 (2018), 7.8.3. NORSOK I-002 (2021) 8.2.2.1. EEMUA 191 (2013), 4.1.2, 2.7.1 & 4.2 NUREG0700 (2020), 2.5. DC: Applicable to the DC		
C2.2*	**Are open innovation principles, such as Open Remote or Open Bridge, considered from the start of the project?** *OpenRemote and OpenBridge are human-centred design frameworks that*				OpenBridge (2025); OpenRemote (2025); (Standard for OpenCrane in development, OpenBridge used in HMI for Cranes.)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	support open innovation. They provide tools and methods to improve the design, approval, and implementation of workplaces and equipment. *Current Control Centres (CC) and Data Centres (DC) often rely on multiple, supplier-specific systems, leading to cluttered environments, increased human error, inefficiency, and training needs. The lack of standardization also raises development costs and slows innovation, as suppliers must create and maintain various system versions. While open standards help, a coherent system architecture and user-centred design are still essential.*				DC: Applicable to the DC		
C2.3*	**A. Is the project (and are suppliers) following relevant HMI standards (such as requirements from IEC 63303 or other relevant standards?** **B. Is the HMI system developed and managed through an appropriate life cycle model?** *Does the system standards include HMI philosophy, HMI style guide and HMI toolkits.*				EEMUA 191 ISO 11064 IEC 63303-(ISA 101.01-2015) DC: Applicable to the DC		
C2.4*	**Are approved Management of Change (MOC) procedures being used during the life cycle (design and operation) of the HMI?**				IEC 63303 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Are tasks, systems, equipment, or HMI that are not in use anymore, removed?						
C3*	**Has flow of Situational Awareness (SA) been designed to support "situation at a glance" as evaluated by the users?** ○ *Does the system provide operators with adequate situational awareness across all conditions—including alarm handling, non-routine, and emergency situations?* ○ *Is the design aligned with Endsley's three levels of SA:1- Perception – detecting critical elements in the environment; 2-Comprehension – understanding their meaning and relevance; 3-Projection – anticipating future states and events?*				IEC 63303, Cpt 6.- Situation Awareness *(Inadequate situation awareness has been identified as one of the primary factors in accidents attributed to human error.)* Endsley (2000) Hollifield (2008) DC: Applicable to the DC		
C3.1*	**Can SA and decision making be appropriately supported during high workload?** - *Are the impacts of function allocation on human workload, situational awareness, and need for decision-making described and evaluated?*				IEC 63303 NORSOK S-002 (2018), 7.8.3. NORSOK I-002 (2021) 8.2.2.1. EEMUA 191 (2013), 4.1.2, 2.7.1 & 4.2 NUREG0700 (2020), 2.5. DC: Applicable to the DC		
C3.2	A. **Does the system present information to support rapid detection and comprehension?** B. **Does the system provide tools and methods to help operators maintain and enhance their**				IEC 63303 (2024) CRIOP (2024) C1.2 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	situational awareness during operations? *Does the system include tools and methods to help operators maintain and enhance their SA during operations?*						
C3.3	**Is graphical coding effectively used to support quick understanding and pattern recognition?** **A. Is visual coding applied to highlight deviations clearly?** **B. Are graphs used to reveal trends and changes over time?** **C. Is graphical emphasis placed on primary information to guide attention?** *Using graphical coding—either alongside or instead of numerical data—can help reduce cognitive load and enable users to identify issues “at a glance”*				ISO 11064-5 (2008), Annex A, A2.4.4. DC: NORSOK I-002 (2021), 9.2.4		
C3.4	**Does the visual salience (eye-catching) of screen objects correspond to their importance?** *The visual salience of graphical objects and information should follow this general rule:* ○ *Primary information (alarms and key information): high* ○ *Other dynamic information: medium*				ISO 11064-5 (2008), table 2. DNV-OS-D202 (2023), 3.3 DC: NORSOK I-002 (2021), 9.2.4.3. DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	○ *Static information: low* *Note that the importance might change in different operational contexts (e.g. suppressed, not suppressed alarms).*						
C3.5*	**Are user interfaces designed to support human capabilities, weaknesses, or possibility for Human Errors?** ○ *If a user enters data in wrong format or outside enforced limits, is the data rejected, with the operator being alerted to the error visually and/or audibly, provided with a clear reason, and then allowed to re-enter the data?* ○ *Is confirmation required for commands that are considered critical actions, such as shutdowns?* ○ *Error Tolerance: The system shall take account of the fact that the operator will make errors and minimize the effect of these.*				IEC 63303		
C3.6*	**Are user trained in all operational contexts, including but not limited to:** A) *Interaction with the control system under all modes of operation* B) *Use of the alarm system*				IEC 63303 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	C) *Recognition of abnormal situations* D) *Responding to process or control upsets* E) *Retrieval of historical data* F) *Adjusting setpoints* G) *Adjusting parameters* H) *Starting up or shutting down a continuous process?*						
C4	**Does the HMI have a consistent "look and feel" with consistent design concepts for information display and user interaction?** *Ensuring consistency in the graphical user interface (GUI) and user interactions across multiple devices, particularly when supplied by different vendors, is crucial for minimizing human error. (Including different vendor packages)*				IEC 63303 DC: Applicable to the DC		
C4.1	**Do operator interaction principles for all screen work (systems) follow commonly used interaction principles?** *It is important that the interaction principles used follow general conventions to the highest possible extent. For instance, should there be consistency with work performed on PC which is familiar to the personnel. This will minimise effort and time spent and will reduce guessing.*				ISO 9241-810 (2020). DC: Applicable only to DCs where screen work is much used. "One key commands" may be used as screen interaction tool		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C4.2	**Is display information presented using consistent and unambiguous symbols?** *Symbols should require little interpretation and memorization and should be consistent within the control room.*				FA §21 EN 614-1 (2006), 4.4.3. EN 894-1 (1997), 4.4.3. NUREG0700 (2020), rev. 3, 1.3.4.5. IEC 62288 (2021) OpenRemote/OpenBridge(2025) DC: Applicable to the DC		
C4.3-	**Is the time to complete a visual display with 100 dynamic points less than 2 seconds?** *The time to complete a display should be short, to avoid annoyance to operators. Note that response time may increase when system load is high. Check how modifications will affect response time.*				FA §34a NORSOK I-002 (2021), 9.4.2. EEMUA 191 (2013), 5.2.3. DC: Applicable to the DC		
C5	**Are the main objectives for large screen displays properly identified and documented?** *Large screen displays should be used when crew performance may be enhanced by access to a common view of plant information or a means of sharing information between personnel. Check that it provides:* ○ *key information and overall plant status information to relevant users.* ○ *high level information to reduce mental workload or enhance team performance.*				NORSOK I-002 (2021), 9.2.4.3. NORSOK S-002 (2018), 7.8.3. ISO 11064-5 (2008), table 2 NUREG0700 (2020), rev. 3, 2.5.1.3 & table 2.5 DC: Not Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	○ *permanently visible safety related information, as key alarms.*						
C5.1	**Are the users of the large screen displays identified?** *Different personnel may need different information. Consider e.g.~~:~~ CC operators, technicians, additional personnel needed in a disturbance, system engineers, test personnel, emergency preparedness team members, supervisors/management and maintenance.*				EEMUA 191 (2013), 3.7.2 NUREG0700 (2020), rev. 3, section 2 DC: Not Applicable to the DC		
C5.2	**Are the different operational contexts for which the large screen display is aiding operators** **A) identified and** **B) primary information related to these situations defined?** *The operational context could be e.g. alarm management or overview of the process condition. These contexts have very different information needs. This is important since primary information related to different operational context will wary. To prevent the displays from being crowded and thereby reducing readability and operator awareness, the operational context should be adhered to.*				NUREG0700 (2020), rev. 3, section 2. DC: Not Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C5.3	**Is the information presented on large screen displays effectively utilising their benefits?** *When the information on large screen display needs to be regularly viewed by CC operators, the design of the visual display and the layout of the CC should ensure that all necessary information is visible from the CC operator's normal working position, both the vertically and horizontally.* (Large screens are used to monitor and view, different from workplace displays to enter data).				ISO 11064-3 (1999), 4.5.1. ISO 11064-5 (2008), table 2 DC: Not Applicable to the DC		
C6*	**Are the logic and actions of the automation/ autonomy transparent enough for operators to understand what the system is doing and why?** • *Are there consistent and clear feedback mechanisms for actions performed by automated systems, allowing operators to track progress and verify correct operation?* • *Can errors in automated systems be quickly identified and understood by operators?*				EU AI Act (Article 13 and 14) for high-risk systems DC: Applicable to the DC		
C6.1*	**Can the operator easily take over control from the automated system in the event of an emergency or system failure?**				EU AI act (Art 14) mandates that high-risk AI systems be designed with mechanisms (stop buttons or intervention) to allow operators to oversee and interrupt operations, when necessary.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	- *Can operators easily override automated actions or decisions when deemed inappropriate?* - *Are operators kept in control and engaged by using lower levels of automation and periods of manual control to ensure they remain an active part of the decision-making process?* Operators should not normally override actions of safety systems. They should train to take over (train in simulator).				DC: Applicable to the DC		
C6.2*	**Are there mechanisms in place to utilise feedback from operators and incident data for the continuous improvement of system interfaces; and (AI if relevant) decision algorithms?**				EU AI act (Art. 9, Art 17). DC: Applicable to the DC		
C6.3*	**Is the system designed to "fail gracefully", allowing for gradual deterioration while keeping the human in control for effective recovery?** *The ability to fail gracefully (and go to a safe state) is an ability of a resilient system to continue to operate even during partly failures* Hollnagel et al. (2008) *an important ability in critical systems, operating systems, etc.*				EU AI Act (Article 14, 15) for high-risk AI systems Hollnagel et al. (2008)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C7	**Is the alarm system clearly defined by means of the physical components and software components which constitute the alarm system?** *Responsibility must be clear – who get the alarm, who answers the alarm, and what are the actions?* *The scope of the alarm system could include parts of several systems examples are the marine systems, fire & gas, process control system (PCS), ESD and PSD system, and other relevant field instrumentation.*				EEMUA 191 (2024), 1,1., 1,2., 2.1. & 3.7. IEC 62682 (2023), 6.2.1 DC: Normal alarms in the DC are drilling parameters (pressure, volumes) drilling equipment (height of top drive), pipe handling equipment (racking arms), anti-collision/ zone management/ block control, fire and gas (HC, H2S), well control (BOP), ESD and PSD alarms.		
C7.1	**Are alarms, including third party packages integrated following human factors standards/ principles?** *The use of "common alarms" must be analysed when integrating (third party) packages. Operational similarity across different packages must be ensured to support consistent human factors interfaces.*				FA §34a NORSOK I-002 (2021), 9.2.4.4.2. DC: Applicable to the DC		
C8	**Is an alarm rationalization study performed?** *It is important to reduce the amount of alarm information, review alarm needs.*				NORSOK I-002 (2021), 9.2.4.4. IEC 62682 (2023) EEMUA (2024). DC: Applicable to the DC		
C8.1	**A) Are alarms assigned different priorities and** **B) is this documented?**				EEMUA 191 (2024), 2.5.1, 2.5.1.3 & 3.5 ISO 11064-5 (2008), 6.2.2.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The rationale behind this prioritisation should be documented. It is important to be able to identify the different priorities and to easily identify high priority alarms.				NUREG0700 (2020), rev. 3, 4.1.3-1, 4.1.8-1, 4.2.9-3 & 4.2.9-7 DC: Applicable to the DC		
C8.2	**Are key alarms (highly managed alarms/a selection of high priority alarms) identified and presented in a manner that supports rapid detection under all alarm conditions?** The alarm processing system should clearly highlight alarms that demand immediate operator action or signal a threat to safety-critical functions. These alarms should be presented in a way that supports quick detection and understanding—such as through spatially dedicated, always-visible displays (SDCV).				EEMUA 191 (2024), 2.5.1 & 3.5 ISO 11064-5 (2008), 6.3.4. NUREG0700 (2020), rev. 3, 4.2.7-1. *DC: This question is applicable only to some DCs where there are multiple alarms*		
C9	**Is the alarm system designed in accordance with human factors principles (i.e. physical and cognitive ergonomics) and best practice?** *The alarm system should be designed based on recognised HF principles to ensure usability and safe operation. (Especially related to mental workload)*				FA §34a EEMUA 191 (2024), 2.1 (including table 2) IEC 62682 (2023) DC: Visual alarm signals should be in front of the driller.		
C9.1	**Is the design of the alarm system based on**				EEMUA 191 (2024), 2.1, table 2 & 3. IEC 62682 (2023), 6.2.1.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A) an alarm philosophy and **B) an alarm specification?** *The alarm system should be designed based on an alarm philosophy, which states aims of the alarm system including how to approach HF issues. The alarm system should also be based on an alarm specification, in which the components of the alarm system are specified. Check:* *i) that there are routines to improve the usefulness and usability of the system such as performance requirements,* *ii) the role of the operator, how this changes according to operating state, and what support the operator has,* *iii) how the design accounts for human limitations,* *iv) the use of alarm priorities: their purpose, how they are defined, and the rationale behind the definitions,* v) *the use of alarm acknowledgment, including its purpose, how operators should be trained in its use, standards,*				DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	and alarm generation and structuring principles.						
C9.1.1	**Is there a reporting system and procedures to document and manage the alarm rate over time?** *E.g. to improve the alarm system*				EEMUA 191 (2024), 2.1, table 2 & 3. IEC 62682 (2023), 6.2.1. Havtil (2022a), follow up. FA §34a DC: Applicable to the DC		
C9.2	**Are human factors, capabilities and limitations explicitly taken account for when designing the alarm system?** *Some of the key factors to be taken account of include:* *A. The goal should be fewer than one critical alarm per ten minutes, with up to two per ten minutes being manageable. (EEMUA)* *B. Standing alarms should be minimum (Suggestion from EEMUA: fewer than 10 in normal operations)* *C. Alarm flooding should be reduced (Suggestion from EEMUA: fewer than 10 in ten minutes after upset)* *This should be documented. The design should ensure that the alarm system remains usable in all process conditions, by ensuring that unacceptable demands are not placed on operators by exceeding their cognitive capabilities.*				FA §34a NORSOK I-002 (2021), 9.2.4.4.2. EEMUA 191 (2013) IEC 62682 (2023) DC: Applicable to the DC Note: Fixing standing alarms should be quite easy.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C9.2.1	**Are suppression mechanisms used to reduce the number of consequence alarms?** *This is especially important during equipment/ process shutdown. Too many unimportant alarms divert the operators' attention from important alarms, and the operators may not have sufficient time to check all alarms and analyse the situation. Operators may thus miss critical alarms. (Shelving can be evaluated)*				FA §34a EEMUA 191 (2013), 5.5.2 & 5.5.3. NUREG0700 (2020), rev. 3, 4.1.2-2. DC: May not be applicable to the DC, as there is a limited number of alarms		
C9.2.2	**Are spurious alarms avoided?** *Spurious alarms (i.e. misleading or false) are following on false alarms because of shutdown actions. A high number of false alarms may cause operators to become insensitive to safety alarms and subsequently fail to respond to abnormal situations. They may try to "beat" the safety system by inhibiting safety functions or interpret false alarms as being "real" alarms.* ○ *Check the frequency of alarms caused by testing of the sensors.* ○ *Is there a system for planned testing and correlation on sensors?*				NUREG0700 (2020), revision 3, 4.1.2-3 & 4.4 (including table 4.1) EEMUA 191 (2024) DC: Are spurious alarms logged to reduce false alarms?		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C9.2.3	**Are performance requirements to the entire alarm system** **A) defined and** **B) used?** *Performance measures include usefulness i.e. how many of the alarms are useful for the operator and implies that the operators must do an action. This is a key performance indicator (KPI). The entire alarm system could include marine, utility, communications, F&G and process systems.*				EEMUA 191 (2013), 6.2, 6.3 & 6.4. IEC 62682 (2023), 16.5.2 DC: Applicable to the DC		
C9.3	**Is the alarm priority context sensitive?** *Check if alarms are designed so that they are worthy of operator attention in all the plant states and operating conditions in which they are displayed. (See Key Alarms or HMA). e.g. when the context is the possibility of a marine collision, these alarms should be highlighted instead of process alarms.*				EEMUA 191 (2013), 2.5.2. DC: Applicable to the DC		
C9.4	**A. Does each alarm state have a unique presentation?** **B. Is there consistency between how different alarm states are presented in the process displays**				NORSOK I-002 (2021), 9.2.4.4.3. NUREG0700 (2020), rev. 3, 4.2.9.3. DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	versus other display formats e.g. lists, large screen displays, panels, and matrices? *Operators must be able to rapidly distinguish between states as e.g. new, accepted, cleared, or suppressed alarms.*						
C9.5	**Are alarms integrated in the process displays?** *Operators cannot know the physical location of all alarm sensors by heart and should therefore have means of identifying the location of infrequent alarms. Information about the geographical arrangements of detectors and fire areas shall be available in the CC.*				NORSOK I-002 (2021), 9.2.4.4. NUREG0700 (2020), revision 3, 4.2.9-1 – 4.2.9-5. DC: Is the location of an activated sensor (pressure, gas, fire, height etc.) presented visually in the drilling displays?		
C9.6	**Are new alarms presented in a manner that supports rapid detection and comprehension?**				IEC 62682 (2023), 5.5.2. EEMUA 191 (2013), 2.4.1. DC: Applicable to the DC		
C9.6.1	**Can all key alarms be read even when multiple alarms are triggered simultaneously?** *A full overview over key alarms should be provided, e.g. on a dedicated display for all alarms.*				EEMUA 191 (2013), 2.5.1 & 6.5.2. NUREG0700 (2020), rev. 3, 4.2.2-1, 4.2.2-2 & 4.2.8.1. *DC: This question is applicable only to some DCs where there are multiple alarms*		
C9.6.2	**Are new alarms presented both audibly and visually?**				IEC 62682 (2023), 11.3.2. EEMUA 191 (2013), 4.1.1, 4.3 & Appendix 16		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Audible alarm annunciation should be used when new alarms arrive. Special visual annunciation should be used for new alarms.				DC: Applicable to the DC		
C9.6.3	**Are auditory and visual alert signals** **A) unambiguous and** **B) perceivable from all relevant workplaces in the CC under all operating conditions?** *The purpose of auditory and visual alert signals is to attract the operators' attention to a deviation. The use of flashing (or blinking) should be limited. E.g., in alarm messages, only a small symbol should be flashing. Text should never flash. Instead of flashing, other effects could be used that are less disturbing to the eye (i.e. raised face / 3D-effects that highlight new alarms). Operators should be able to easily distinguish between system alarms, process alarms and events. Note to point B) – in some cases there could be just one operator alone in the CC, can he perceive all alarms?*				IEC 62682 (2023), 11.4.2. EEMUA 191 (2013), 4.3. IEC 62682 (2023), 11.3.2. NUREG0700 (2020), rev. 3, 4.2.6.1-1, 4.2.6.1-2, 4.2.6.2-1 & 4.2.6.3-3 DC: Applicable to the DC		
C9.6.4	**Do auditory and visual alert signals have appropriate intensity?**				NUREG0700 (2020), rev. 3. 4.2.6.3-21 & 4.2.6.2-3 Barrett (2021)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Alarm signals should not startle, annoy, or distract operators, or interfere with verbal communication. Auditory signals should be 2-3 dB (A) (max 10 dB) above the ambient noise but should not exceed 95 dB (A). Signal levels of 115 dB (A) may be used if indicating extreme danger. The signals should differ from each other by a minimum of 6 dBA. Visual signals, such as flashlights or flashing symbols, should have a flash rate of 3-5 flashes per second with equal on and off times.				ISO 7731:2003 DC: Applicable to the DC		
C9.6.5	**Is alarm information presented using consistent and unambiguous colours?** *Colours used to prioritise alarms should not be used for other purposes.*				EEMUA 191 (2013), 4.2 & 4.1.1. NUREG0700 (2020), rev. 3, 4.2.6.1-2 & 4.2.6.2-6. DC: Applicable to the DC		
C9.6.6	**Are alarm texts informative and easy to understand?** *Alarm texts should be easy to understand, requiring minimal interpretation and memorization. They should include only the information essential for operators. Acronyms and abbreviations should be standardized and known to the operator. Operators should be*				EEMUA 191 (2013), 1.2. IEC 62682 (2023), 10.5.2. ISO 11064-5 (2008), 6.3.8. NUREG0700 (2020), rev. 3, 4.1.2-11 & 4.2.5-1. DC: The question is applicable to some DCs, where alarms are presented in alarm lists or similar		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	involved in the development of alarm texts.						
C9.7	**Can the operator:** **A) Silence auditory signals from any workstation?** **B) Acknowledge alarms only from locations where the alarm message can be read?** *It should be possible to silence an auditory alert signal from any set of alarm system controls in the main operating area. An alarm acknowledgement function should change the visual coding of alarm from an unacknowledged to an acknowledged state. Acknowledgement should only be possible from locations where the alarm message can be read.*				NORSOK I-002 (2021), 9.2.4.4.3 NUREG0700 (2020), rev. 3, 4.3.3-2, 4.3.3-1 & 4.3.2-1. DC: Applicable to the DC		
C9.8	**Does the operator have access to alarm inputs?** *The operator should have the ability to view inputs to the alarm processing system (e.g. sensor data). Operators may need to view sensor data that results from alarm system processing under certain circumstances, such as if the pattern of alarm messages appears to be contradicting, or if operators suspect*				NUREG0700 (2020), rev. 3, 4.1.2.11. DC: Applicable to the DC for some alarms.		

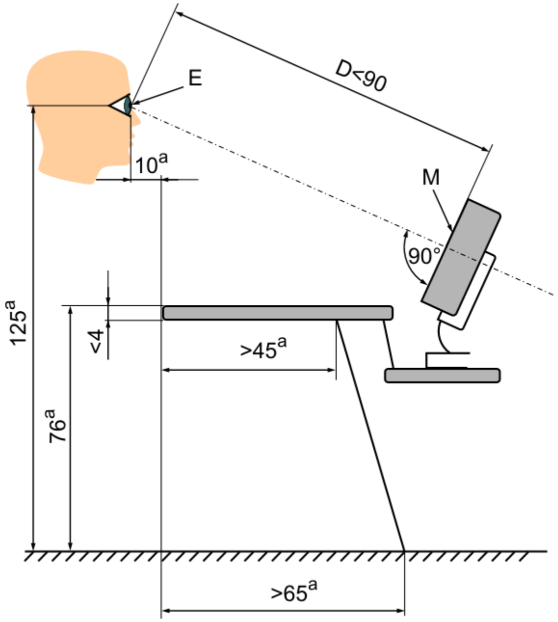
POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	that there is a problem with the processing system. The alarm system should provide functions that enable users to evaluate the meaning or validity of the alarm messages.						
C9.8.1	**Are the time indications of alarms sufficiently accurate to represent the correct sequence of events, especially during an alarm flood?** *Accurate time indications of alarms assist operators in determining the order of alarms and thereby the cause of deviations. This is especially important in distributed systems.*				NORSOK I-002 (2021), 8.1.6.2 DC: Applicable to the DC		
C9.8.2	**Is the warning alarm related to trip limit, set in such a manner that the operator can react before the trip limit is reached?** *This can be done by monitoring parameter trends.*				IEC 62682 (2023), 5.4.6 & 9.4. Smidt Olsen & Wendel, 1998, App.2 *DC: For instance, height of the top drive. Is mud logging involved in setting the trip limits and the alarm settings?*		
C9.9	**Are relevant availability requirements defined for the alarm system?**				NORSOK I-002 (2021), 9.1.2. EEMUA 191 (2013), 5.2.2 & 2.3.4. IEC 61511-1 (2016), 11.4. IEC 62682 (2023), 11.11.2		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The components constituting the alarm system should be fault-tolerant, ensuring that safety-critical information is always available to the operators, during normal operations and in emergencies. Factors to consider include redundant CPUs, I/O and bus systems, UPS as backup for electrical/electronic equipment, and redundant displays.				IEC 61508 series DC: Is independent backup of safety critical systems in the drilling module available (H2S, HC, pressure, flow rates)?		
C10	**Are control actions fault-tolerant and simple to execute?** *Errors in manual actions are more likely to occur in stressful situations, such as accurately placing a light pen on displays or entering words longer than seven characters.*				NUREG0700 (2020), rev. 3, 2.8-1 (table 2.6), 7.3.5-2 & 7.3.1. DC: Applicable to the DC		
C10.1	**Are operational systems, instruments, and controls that are used together located next to each other?** *Related controls and displays should be easily identified as being associated such as metering system, marine system, and F&G system.*				NUREG0700 (2020), rev. 3, 11.2.2.1.1.-2, 11.2.2.2.-3, 11.2.3.1.1-3 & 11.2.3.2-1. DC: Applicable to the DC		
C10.2	**Are warnings provided when out-of-range values are entered?** *Entering out-of-range/extreme values (e.g., values expressed as a*				NORSOK I-002 (2021), 6.1.4. ISO 11064-5 (2008), Annex A, A2.4.6 EEMUA 201 (2019), ed. 3, 4.8.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	percentage (%) change in relation to a given value) may cause process deviations and damage equipment. Check keyboard entry commands for potentially dangerous similarities. Data being entered should be displayed, reviewed, and confirmed before execution.				NUREG0700 (2020), rev. 3, 14.2-1, 7.3.7-3, 7.3.5-4 & 2.4.2-1. DC: Applicable to the DC		
C11	**Is the emergency shutdown system status available, clearly readable and unobstructed from the operator's workplace?** *Check: by-pass of emergency shutdown system actions (inhibitions) and fire and gas detections.*				FA §8 & 33 NORSOK I-002 (2021), 6.1.2.2, NUREG0700 (2020), rev. 3, 14.2.1, 6.1.2-6. DC: Applicable to the DC		
C11.1	**Is the shutdown logic available on displays (cause and effects)?**				FA §33, NORSOK S-001 (2021), 11.2, 11.4.4 & 16.2; Not Applicable to the DC		
C11.2	**Does the operator receive the correct chronological order of events after shutdown activation?** *It is important that the operator is alerted when a shutdown function is released and the cause of the shutdown (first out alarm). (Check if this is important or just useful.)*				FA §33 DC: Few levels, seldom applicable to the DC		
C11.3	**Is it possible to use the control system and emergency shutdown system even when the CC is heeling (or listing)?**				FA §62 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Heeling or listing is when an object leans over to either side (due to wind or water intake). Allowed static heeling for a moveable installation due to wind is 17 degrees.						
C12	**In the case of fire or gas detection, are follow-on actions performed automatically?** *E.g. PA messages to go out automatically or deluge performed automatically. (No hot work)*				FA §32 DC: Not Applicable to the DC		
C12.1	**Is the operator timely informed about deviations when performing the shutdown function?** *To be able to intervene, operators must be able to detect any failures in shutdown actions. A separate deviation list could be presented to the operator. Check: process control system, process shutdown system, emergency shutdown system, fire and gas detection, and depressurizing system.*				FA §33 NUREG0700 (2020), rev. 3, 4.1.2-1 & 14.1.3. DC: Not Applicable to the DC		
C13	**Can safety systems be started manually from the CC?** *Examples hardwired De-pressurisation, fire pumps etc., through panels.*				FA §33, §34, §35 *DC: Partly applies to the DC. Emergency shutdown in the drilling area may include ESD valves in different levels, stop of all moving items (top drive, racking arms etc.), BOP, fire pumps, deluge etc.*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C13.1	**Are emergency controls on panels easily accessible?** *Emergency controls on panels should be located between 76 cm and 125 cm above the floor when seated (see Figure C1) and between 90 cm and 150 cm (shoulder height) when standing for easy operation.*				NORSOK S-002 (2018), 6.2.1. *DC: Are emergency shutdown buttons easily accessible?*		



Legend

a	Examples, the values of the anticipated user population shall be applied
D	Viewing distance
M	Monitor (20" LCD)
E	Design eye point

All figures in cm

Figure C1: Example for a seated and standing control console (Measures in cm as given in original figure, for seated posture) suggested from ISO 11064-4.

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C13.2	**Are critical actions/shutdown actions protected from accidental activation?** *Controls may be recessed, shielded, or otherwise surrounded*				NUREG0700 (2020), rev. 3, 3.1.1.1-3, 13.6-1, 7.3.1-6, 3.1.3-3 & 2.7.6-6. DC: Applicable to the DC		

	by physical barriers to protect shutdown actions for accidental activation. Controls should be operable form the location where the user is most likely to need to interact with the system. Check: keyboard, mouse, trackball, and light pen.						
C13.3	**Is any bypass of the emergency shutdown system recorded in a logbook (or logging system)** *Information concerning bypass of automatic shutdown actions must be accessible to all involved personnel, who, when, why are important to document. The logbook might be electronic. It is important to easily extract a short list of outstanding bypasses.*				AR §26 DC: Applicable to the DC when safety systems and emergency shutdown systems are bypassed		
C14	**Are the main objectives, tasks and requirements for the communication equipment properly identified and specified?** *Equipment may be telephones (hotline, emergency, and mobile phone), Internet Channels (MS Teams, Zoom, Discord…) Satellite phones, VHF and UHF radios, videophones, and smart boards. Things to consider: (requirement)description, criticality/ risks, prioritisation,*				ISO 11064-3 (1999), 4.4.1. DC: Applicable to the DC		

	communication procedures/format, quality of communication, localisation, how to mute, numbers, ringing tones, visual marking, user configuration, caller displays, set over, Bluetooth, and hands-free. Check comm. procedures.						
C14.1	**Is communication equipment distinguished both visually and audibly?** *Similar communication equipment should be marked to avoid confusion concerning "which is which". High priority telephones should be distinguished both audibly and visually from other telephones. This should be based on a communication specification – which prioritizes communication equipment.*				NORSOK S-001 (2021), 18.4.3. NUREG0700 (2020), rev. 3, 10.2.2-7. *DC: Intercom, telephone and radio communication equipment should be easily distinguishable.*		
C14.2	**Can communication equipment be reached from the operator's workplace?** *CC operators should be able to communicate with other personnel while working at the displays. Check radio, VHF, telephones, public address system (PA), intercom...*				NUREG0700 (2020), rev. 3, 10.1-1. DC: Applicable to the DC		

C14.3	A. **Is backup communication equipment or alternative means of communication provided?** B. **Is the communication equipment connected to emergency power supply?** *Alternative means of communication should be available in the case of equipment failure or danger or accidents. There must be an emergency power supply.*				FA §38 NUREG0700 (2020), rev. 3, 10.2.7-1. DC: Applicable to the DC		
C14.4	**Are dedicated communication lines provided between the emergency CC and the CC?** *Communication between operators and the emergency CC must be possible in spite of extensive heavy communication during abnormal situations.*				NUREG0700 (2020), rev. 3, 12.2.1.2.4-2 DC: May be Applicable to the DC		
C15	**Is the design of the Closed-Circuit Television (CCTV) system based on established standards or "good practice"?** *CCTV equipment is utilised to get an overview of critical equipment, critical situations, or to support communication. When used to get an overview of equipment or situations – there has been established standards or good practice*				EN 62676-4 (2015). Home Office (2025) UK DC: Applicable to the DC		

	guidelines such as EN 62676-4 (2015) or Home Office (2025) Recommended standards. Such standards should be used as a support when designing and implementing CCTV.						
C15.1	**Are the viewing distance, resolution of the CCTV screens, and size of the objects to be considered in accordance with ergonomic standards?** *The viewing distance, as well as the size of the objects and elements, must be legible for the users.*						
C15.2	**Does the CCTV support situational awareness of the user in all conditions?** *The CCTV should support awareness of place (i.e. indication of placement and view) and situation (i.e. normal observation or deviation/alarm). Check possibility of navigation of cameras and screen resolution.*						
C15.3	**Has the criticality of the CCTV been assessed?** Check need for use of CCTV in an emergency.						
C16	**Are all necessary questions asked related to Control and Safety Systems?**				DC: Applicable to the DC		

C17 DC	**Has the communication in the driller's cabin been considered with respect to:** **A) Communication between the driller's cabin and other control cabins in the drilling module?** **B) Activation of communication equipment whilst operating drilling equipment?** **C) Communication between driller cabin and drill floor personnel?** It is important that the communication between the driller's cabin and other control cabins in the drilling module is easy to perform. The communication equipment should be designed based upon an analysis of the communication needs. The communication equipment should be designed to protect against inadvertent operation.				Other relevant cabins are mud logging, derrick man's cabin etc. Check need for communication via other means such as hand-signs.		

Checklist J: Job organisation

Checklist J: Job organisation

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
J1	**Is it documented that the job and work organisation consider relevant information such as:** **A) Task analysis covering all modes of system operation and administrative task?** **B) Workload analysis?** **C) Workstation design?** **D) Job satisfaction?** **E) Lessons learnt from incidents?** *Analyses should cover all modes of system operation—including start-up, normal running, shutdown, emergency scenarios, and maintenance periods (e.g., partial shutdowns). The results of these analyses should inform both the system design and staffing plans.* *In addition to addressing clear ergonomic needs of the installation, the design should also account for less obvious psychological factors that impact operator performance and well-being. These may include Motivation, Sense of self-fulfilment, Cultural and social considerations. To support this, it's important to: Identify factors that influence job satisfaction (e.g., workload, autonomy, feedback, work environment). Determine how to measure these factors—using tools such as employee surveys, interviews, performance metrics, and observational studies.*				HFAM (2003) ISO 11064-1 (2000), 4.6 DC: Applicable to the DC		
J1.1	**Are tasks adequately allocated between operator and system?**				ISO 11064-1 (2000), 7.3. EN 614-1 (2006), 5.2.1 (table 1)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Check: Are high speed, high accuracy or highly repetitive tasks done automatically? Document the criteria used in this allocation. Function allocation should support cooperation between operator and machine. See Fitts List, De Winter et al. (2014).				De Winter et al. (2014). DC: Applicable to the DC		
J1.1.1	**A. Is the operator fully aware of what he or she is expected to do at all times? (i.e. will the design provide the operator with information necessary to execute the tasks in a safe and efficient manner).** **B. Are operators given reasons for what they are expected to do under all circumstances?** *The operator should be fully notified about targets, priorities and consequences of failure. Criteria for taking over manual control from automatic equipment should be clear and unambiguous. A job assignment criteria checklist should be developed to help assign the tasks to a particular job. In addition, the operator should be given reasons for what s/he is expected to do, as operators are less likely to engage in alternate behaviours if they are well*				HFAM (2003). ISO 11064-1 (2000), 7.4 & 7.5. DC: *Is there a system for safety job analysis, pre-job meetings and information meetings at departure to drilling location? Are the drillers involved in preparing and checking the procedures?*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	aware of the cause of a required behaviour.						
J1.1.2	**Are there no conflicts or incompatibilities in operator tasks and performance criteria?** *The operator should not be expected to resolve conflicts between production regularity and safety. Operators must not be "rewarded" for unsafe acts or for maintaining production when they should have shut down.* *Are there clear criteria for e.g. shutdown and do the operators have authority to shut down without consulting a supervisor?*				HFAM (2003) DC: Applicable to the DC		
J1.2	**Is the allocation of responsibility and authority clear, complete, non-overlapping, known to and accepted by the operators and their collaborators?** *Each operator should be informed about his or her responsibilities, as this will ensure that all tasks are conducted as required. This is also very important related to collaboration related to remote operations or remote support.*				ISO 11064-1 (2000), 7.5 *DC: Is the driller's and assistant driller's responsibilities clearly stated and known to supervisors, drillers, deck personnel and relevant operators in the drilling module?*		
J1.3	**Are jobs organized so that all operators have a roughly equal workload?**				HFAM (NPD 2003)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A workload analysis should be carried out to ensure that all operators have an optimal and roughly equal workload.				*DC: Applicable to DCs where there is more than one operator*		
J1.4	**Are periods of high and low mental workload within acceptable limits?** *Good operator performance during high workload periods can only be maintained for short periods of time, not to exceed 45 minutes. Describe tasks and periods with high mental or physical workload.* *Operator ability to detect visual signals is significantly reduced after periods of boredom (half an hour). Use NASA TLX and/or simulator study to assess CRO workload in critical situations*				AR §33, §35 ISO 10075-2 (2000), 4.5. EN 894-1 (1997), Appendix A For NASA-TLX see Stanton et al. (2013) or NASA TLX (1986) DC: Applicable to the DC		
J1.5	**Are the shifts designed according to rules, regulations, and standards?** *Examples are HSC Rules and regulations (In Norway: Arbeidsmiljøloven).*				FR §37-§44 DC: Applicable to the DC		
J1.5.1	**Is job rotation practiced?** *Job rotation implies that operators alternate between the control room and the field. Job rotation reduces boredom and may improve operator motivation and alertness. In addition, operators learn the process systems and installation layout better by having experience from the field. Job rotation reduces boundaries*				ISO 11064-1 (2000), Annex B, B.4. DC: May not be applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	between organizational units, fostering cooperation and information flow among these units (but only if proper training is provided).						
J1.5.2	**Are breaks planned/coordinated with control centre tasks?** *The workload must be planned so that operators can take breaks during quiet periods.*				ISO 11064-1 (2000), 7.5 DC: Applicable to the DC		
J1.6	**Is the job and work organisation designed to handle abnormal situations?**				FA §73-§77; ISO 11064-1 (2000) NORSOK Z-013 (2024) DC: Applicable to the DC		
J1.6.1	**Are the changes in responsibilities during an emergency/abnormal operation clearly defined and established through practice?** *Responsibilities and operator task in the CC change from normal situations to abnormal operations. These changes must be known to and accepted by all personnel.*				ISO 11064-1 (2000), 7.2 *DC: Are the driller's responsibilities versus the company man's or tool pusher's responsibilities in case of a well control situation clearly defined and known by relevant personnel?*		
J1.6.2	**Is relevant and competent assistance to the CC operators from other personnel available during abnormal situations?** *The job organisation shall allow operators to exchange or share information in such cases where*				ISO 11064-1 (2000), 7.5 NUREG0700 (2020), rev. 3, 6.1.4-1, 12.1.1.2-2, 12.1.1.6-2. *DC: Are other personnel with required certificates and courses available during abnormal situations? Are there*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	teamwork is required to carry out a task. Check: field operators, supervisors, management, instrument, maintenance, and electrical. This should be part of emergency operation procedures (EOP) and should describe who does what and when. (Check Remote support).				*dedicated personnel for this on each shift?*		
J2	**Is the job organisation designed to provide effective information transfer?**				ISO 11064-2 (2000), 5.1. DC: Applicable to the DC		
J2.1	**Does the work permit system ensure that operators and supervisors are continuously aware of all critical and hazardous work in progress?** *A large number of work permits often make it difficult to have an overview over work in progress. Possible measures are:* *A) transfer of information between shifts, different departments and installations (example flotels).* *B) Ensure that work permits are issued for critical or hazardous operations* *C) Establish a maximum number of work permits operators are allowed to issue.* *D) Improve control by reducing administration of work permits/ persons involved.*				MR §17 AR §30, §31, §32 DC: Applicable to the DC related to drill floor, drilling cabin, etc.		
J2.2	**Are procedures for communication in operation drawn up and followed?**				ISO 11064-1 (2000), 7.5 SfS (2023)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Is there clear prioritisation of communication channels when there are several – i.e. radio, telephone, Teams, Chats. *Ensure that common situational awareness is supported, and that affirmative communication is taking place. Check: restrictions concerning unnecessary use of radio, acknowledgement of important messages, use of different radio frequencies/channels, communication equipment checks, and use of standard abbreviations and acronyms familiar to all involved parties to avoid misunderstanding. See also SfS (2023).*				*DC: Is there a dedicated drilling channel?*		
J2.3	**Are there clear procedures for the handover of information and responsibility between different CC shifts and between different personnel categories?** *Frequent changes of personnel are a common source of misunderstandings and communication breaches in offshore organisations. Procedures and checklists for handover must be drawn up and practiced to ensure that important information is transferred. In addition, the transfer of information between different personnel categories should be considered, as personnel may*				AR §32 ISO 11064-2 (2000), 4.5. *DC: Are proper handovers between drillers and assistant drillers performed?*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	operate with different mindsets and different verbal expressions.						
J3	**Is the information from incidents used for modifications in the current and future designs?** *Experience from incidents should be used to ensure that problems are not repeated in the current system or future designs (of MTO). Experience from process disturbances is a useful source of information when improving work processes, upgrading installations, or designing a new control centre. Experience also helps operators mentally prepare for similar situations as well as preventing mistakes from being repeated.* *Is there a system to ensure distribution of information regarding incidents, modifications to relevant personnel?*				FR §13 ISO 11064-1 (2000), 10.1 & 10.2 *DC: Is there a system to ensure distribution of information to relevant personnel such as drillers, derrick man etc?*		
J3.1	**Is there a reporting system for incidents and near misses in use?** *There should be a focus on the reporting system. The system should be actively used for recording near misses, incidents and accidents. The system should be capable of providing a list of all incidents. (Check possibilities of automated reporting).*				MR §19, §20 FR §13 ISO 11064-1 (2000), 10.2 DC: Applicable to the DC		
J3.1.1	**Are the recommended changes following an incident implemented within an acceptable time frame?**				MR §19, §20, §21, §22 FR §13 ISO 11064-1 (2000), Annex B, B.3.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	All actions regarding equipment, procedures, training etc. following incidents must be followed up within the organisation. It is important to inform personnel about the resulting changes and their timely execution as this may increase awareness and also motivate for further reporting.				DC: Applicable to the DC		
J4	**Are all necessary questions asked related to Job Organisation?**				DC: Applicable to the DC		

Checklist L: Layout

Checklist L: Layout

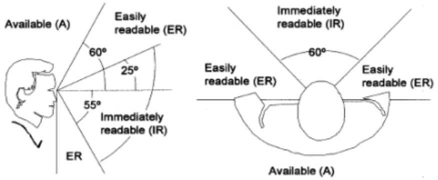
Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L1	**Does the room location, room volume and room layout of the CC consider relevant design issues?** *The CC should be designed in accordance with analyses and considerations that will ensure proper room location, -volume and -layout such as:* ○ *Function analysis* ○ *Task analysis including full range of process conditions and administrative tasks.* ○ *Cooperation with remote installations* ○ *Experience exchange*				FA §20, §21 TOR §20, §21 NORSOK S-002 (2018) ISO 11064: Part 1-5 (Series) DC: NORSOK D-001, ed. 3 (2023)		
L2	**Does the room location and room layout of the CC consider safety and security?** *When placing and designing the CC, consideration should be given to safety and security issues. In general, the CC should be placed in a safe location that also ensures security. Specific considerations must be made for each individual CC and its respective environment.*				Safety: FA §7 ISO 17776 (2016), 5.2.4. DC: NORSOK Z-013 (2024) Security: ISO 11064-2 (2000), 4.4 & A.1. ISO 27001 (2023), Annex A, table A1. DC: Location of cabin is on the drill floor and shall be designed to withstand specific events/accidental loads. Security considerations are relevant for DC.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L2.1	**Are entrance restrictions to the CC implemented during abnormal situations?** *Irrelevant personnel in the control room distract operators during stressing situations.*				DC: Applicable to the DC		
L2.2	**Are there at least two escape routes from the CC?** *There should be at least two easily accessible escape routes from the CC.*				FA §44 DC: NORSOK S-001 (2021), 22.4.1		
L2.3	**Does location and layout prevent the control room from being used as a natural passage for personnel?** *Personnel should not be tempted to use the CC as a short cut between different areas of the installation as this may disturb the operators.*				ISO 11064-2 (2000), 5.2. DC: Applicable to the DC		
L2.4	**Does the layout and location of the CC and emergency control centre allow for quick and easy information exchange between the two centres and yet avoid unnecessary noise and disturbance?** *Operators should not be distracted by activities in the emergency control centre. Check: In case of major incidents, a separate facility, generally fitted with special*				ISO 11064-2 (2000), 4.4 & 5.1. DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	communication equipment, might be necessary. Consider whether the CC fulfils this role.						
L3	**Are internal traffic routes in the CC designed?** *An analysis of internal traffic routes should be performed to show how people move in the CC, and whether functions have been placed in an optimal manner with regard to this.*				ISO 11064-2 (2000), 5.2. DC: Applicable to the DC		
L3.1	**Can personnel work at and move past the workstations without accidentally altering the controls?** ○ *For main walkways:* – *Vertical - 2700 mm (2300 mm is recommended)* – *Horizontal – 1000 mm* ○ *For access ways:* – *Vertical – 2100 mm (2300mm in door openings and above each step in a fixed stepladder)* – *Horizontal – 600 mm. Minimum width 800 mm for access to permanently and intermittently manned workplaces.* ○ *Distance between panels/ cabinets/ walls/ equipment should be greater than 915 mm for desk to opposing surface, or*				NORSOK S-002 (2018), section 8 ISO 11064-3 (1999), 4.3. NUREG0700 (2020), rev. 3, 13.6-1. DC: Applicable to the DC, however the numbers are not		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	1250 mm between single row panels where one person works at a time, 2500 mm for opposing rows where two or more persons work simultaneously.						
L3.2	**Are tripping hazards, protruding objects, and slippery liquids avoided?** *Check: Different floor levels, cables, waste bins, clothes, thresholds and table edges.*				NORSOK S002 (2018), Annex F DC: Applicable to the DC		
L3.3	**Are frequently used walkways within the CC unobstructed?** *Check: Walkway between operator's workplace and instrument on panels. All work areas shall have a layout that provides safe access for operation and maintenance. Protruding objects shall be avoided in walkways, access ways, and transportation ways.*				NORSOK S-002 (2018), 8.1 & table 2. ISO 11064-3 (1999), 4.3.1. DC: Applicable to the DC		
L4	**Is the workplace of the operator designed according to ergonomic principles and best practice?** *Consult ISO 11064, relevant NORSOK standards as mentioned in these checklists.*				NORSOK S-002 (2018) EN 547-1/2/3 (1996) EN 614-1 (2006) EN 1005- (2001-2007) ISO 11064-1 (2000) ISO 11064-2 (2000), 4 & 5		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L4.1	**Do the operators have an adequate view of the visual display from their workplace (seated and standing)?** *Viewing distance to the visual display should be located sufficiently close that a user can read it clearly and without parallax from a normal operating posture, between 500mm and 1000 mm. It should not be necessary to turn head more than 30/35 degrees left or right to see important displays (95 degrees for less important / not frequently used displays). Check: Process control system, safety system, utility system and supervisory system, and possible obstructions from personnel during emergencies.* *NB: Requirements from DNV-OS-D202 are used (figure L2) The requirements from EN894-2 are stricter with regards to angles.*				FA §20 DNV-OS-D202 (see figure 1) (2023) EN 894-2 (1997), 4.1.1. ISO 11064-4 (2013), 5.1.2. NUREG0700 (2020), rev. 3, 11.2.1.1.-5 & 11.3.5.1-1  **Figure L2** DC: NORSOK S-002 (2018), 2.1.1.		
L4.2	**Do the operators have an adequate, unobstructed view of panels from their normal workplace?** *For monitoring, the distance between panels and the operator's workplace should be minimum 2 meters, and operators should not*				FA §20, §21 NORSOK D-001 (2023), 6.7.2. ISO 11064-4 (2013) DC: Applicable to the DC. *The access to BOP and choke panels must be free from obstructions and there should be an adequate and unobstructed view to these.*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	have to turn their heads more than 60 degrees. Console height in front of operators should be no greater than approximately 1150 mm. Check: personnel possibly obstructing view of process mimics, fire and gas panels, equipment status overviews, inhibition overviews and CCTV during emergencies. (The measurement requirements should not be applied when utilising a cockpit design solution. Distances and degrees of view to panels and consoles do not apply to the DC.) Check also placement and viewing distance to PC. (if applicable).						
L4.3	**Is sufficient room provided at the operators' workplaces for use of written documentation without interfering with controls and visual displays?** *The desk at the workplace should be at least 410 mm deep and 760 mm wide.* *Desks must allow support for elbow in front, keyboard, A3 sheets and books. Provision should be made so that the procedures, manuals, and*				NUREG0700 (2020), rev. 3, 11.2.1-7, 11.2.1-8, 11.3.4.1.-4 & 11.3.4.1-5 ISO 11064-2 (2000), 4.5, Annex A.1 DC: Applicable to the DC *Nearby, at hand, close to the driller's chair there should be room for pipe tallies and procedures.*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	other reference materials can be consulted easily while task sequences are performed at the consoles. Check: documentation tasks, administrative tasks.						
L4.4	**Is other important and frequently used information easily available to the operators?** *The information should be stored and structured to provide easy and quick access.* *Check: work permits, printers, procedure manuals, P & IDs.*				NORSOK D-001 (2023), 7.5.6.1. ISO 11064-2 (2000), 5.8. ISO 11064-3 (1999), 4.4.1. DC: Applicable to the DC		
L4.5	**If back-up displays are provided, are they located so that the operators can communicate easily when using them?**				DC: Applicable to the DC		
L4.6	**Does the seating arrangement allow for easy co-operation, voice communication and reach between operators?** *Operators should not need to turn their heads more than 90 degrees to communicate.*				EEMUA 201 (2019), ed. 3, 3.6. ISO 11064-2 (2000), 5.1. *DC: Many DCs have foot pedals or similar to communicate whilst operating. It must be ensured that these are easy to use and are protected from inadvertent operation (which may block information flow).*		
L4.7	**Can the operator have a natural posture while seated or standing at their workplace?**				FA §20 ISO 11064-4 (2013), 5.1.2 figure 2 & 3. NORSOK C-002 (2015), 20.5.4.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The desk and chair at the operator's workplace shall be easy adjustable from seated and standing position. Note that a thick desk plate may cause an unwanted working posture. Desk thickness shall be <40 mm. Office desks and computer tables for all permanently manned areas shall be electrically user adjustable from a single point, from minimum 660 mm to 800 mm. It is important that the desk is adjustable. Figure C1 shows important measures for the workplace as suggested from ISO 11064-4.				EN 614-1 (2006), 4.3. DC: Measures in figure do not apply to DC		
L4.8	**Can the operator get in and out of the chair at the workplace freely?** *Minimum requirements for operator manoeuvring space are approximately 760 mm laterally ("sideways") and 920 mm from the edge of the desk to any opposing surface ("backwards"). Ref. Figure L1. inspired by NUREG0700*				EN 614-1 (2006), 4.3.2 NUREG0700 (2020), rev. 3, 12.1.1.2. DC: Applicable to the DC, but not the measurements shown in Figure L1. It should be possible to rotate the Driller's chair for easy access		

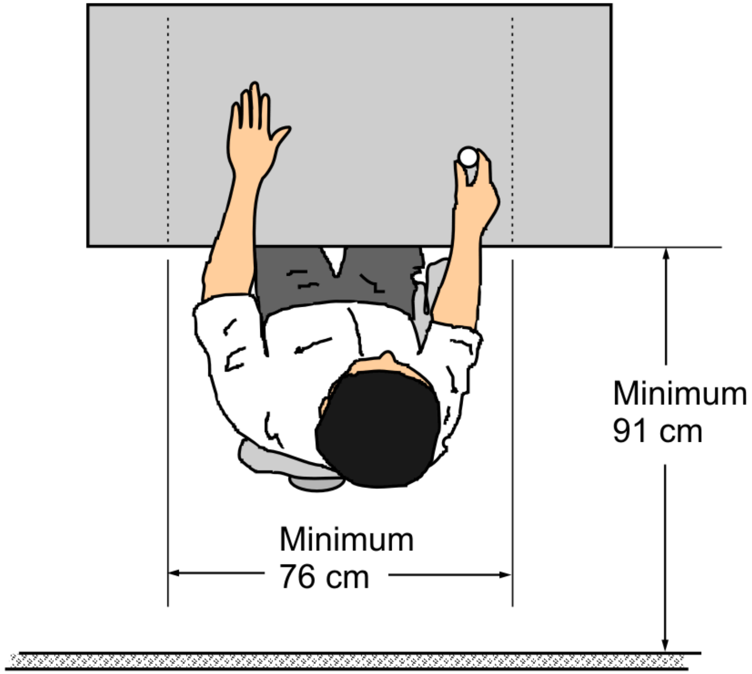


Figure L1: Spacing of equipment to accommodate seated users (In cm as suggested in original figure)

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L4.9	**Is a separate workplace or uncluttered area provided for paperwork?** A useful approach is to specify a task zone for each work task: These task zones should then be allocated to workstation. Check: documentation tasks, administrative tasks. The area should accommodate A3 folders.				ISO 11064-2 (2000), 4.5 ISO 11064-2 (2000), Annex A.1. DC: Applicable to the DC. Check that sufficient space is available for doing necessary paperwork (e.g. drilling reports).		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L4.10	**Is the placement and use of the control functions (joysticks, touch pad, buttons etc) of the operator station designed according to ergonomic principles and best practice?**				FA §21, EN 614-1 (2006), 4.4.3. EN 894-3 (2000), 8.3. ISO 9241-5 (1998), 4.1. ISO 9241-400 (2007), 4.2.5.5. DNV-OS-D202 (2023), Chapter 2, 5 2.1.1, DC: Applicable to the DC		
L5	**Is the CC designed to be used for use by other personnel?** *Supervisor, shift leader, maintenance operators, field operators etc.*				ISO 11064-2 (2000), 4.4. *DC: Only relevant personnel should have access to the DC to avoid disturbance. Barriers should be established to avoid disturbances by other personnel. Restricted access to the DC and drill floor should be stated in procedures.*		
L5.1	**Can other personnel (maintenance, instrument, etc.) obtain necessary information without disturbing the operators?** *Check: work permits, information for fault diagnosis, information requests, location in safe area, entrance, toilet/ wardrobe/ coffee facilities/ rest area/ dining room, noisy areas, room for printers/ faxes/ computers*				ISO 11064-2 (2000), 5.6. DC: Applicable to the DC		
L5.2	**Is the supervisor provided with a separate workplace?** *Information and work permit requests are frequently directed to the supervisor. Operators should not be distracted by these activities.*				ISO 11064-3 (1999), 4.4.3 ISO 11064-2 (2000), Annex A.1. DC: No permanent workplace – but a separate all-purpose workplace can be available.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The supervisor's workplace should be a natural meeting point when entering the room.						
L5.2.1	**A) Does the supervisor's workplace allow easy visual and voice contact with operators?** **B) If the supervisor is not located in the control room, are dedicated communication lines provided?** *Communication between operators and supervisors must be possible in spite of heavy communication during abnormal situations.*				ISO 11064-3 (1999), 4.4.2. ISO 11064-2 (2000), 5.1. NUREG0700 (2020), rev. 3, 12.1.1.6.-2. DC: Applicable to the DC		
L5.2.2	**Does the supervisor's workplace allow him to obtain important information in the control room?** Check: process mimics, fire and gas panels, equipment status overviews, inhibition panel and work permits.				ISO 11064-3 (1999), 4.4.2. NUREG0700 (2020), rev. 3, 12.1.1.6-1		
L6	**Are the social needs of the operator considered?**				ISO 11064-1 (2000), 9.2 ISO 11064-3 (1999), 4.3.5 DC: *There should be coffee and rest facilities in the vicinity of (not within) the*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Such as a social corner/pantry/meeting table and a lockable space within or nearby the control room for personal effects A social corner provides change and rest for the operators. Note, however, that a social corner may also cause people to gather and may divert the operators' attention. The social area should be sheltered from visitors. (Check also need for exercise equipment).				*driller's cabin to facilitate rest and coffee breaks. Also, drillers should be provided with a locker for personal effects, not necessarily in the DC.*		
L7	**Are all necessary questions asked related to Layout?**				DC: Applicable to the DC		
L8	**Does the driller have an adequate unobstructed view of the drilling area on drill floor, derrick, hoisting structure, mast and V-door?** *The driller's cabin should be designed so the view to the drilling area from the DC is free of obstructions to for instance the top drive, racking arms, catwalk, iron roughneck, personnel etc. It is often seen that the view is obstructed by beams that support the driller's cabin structure. Cameras with monitors can be used as compensating measure for the derrick, pipe handling equipment and mast if necessary.*				NORSOK D-001 (2023), 6.9.1 & 6.7.2. ISO 11064-2 (2000), 4.4		

Checklist W: Working environment

Checklist W: Working environment

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
W1	**Does the design of the CC consider ergonomic criteria related to a safe and comfortable working environment?** *The CC should be designed in accordance with ergonomic principles and best practice to ensure optimal user interface and a workplace that will protect against physical and mental strain.*				ISO 11064-4 (2013) DC: NORSOK S-002 (2018) NORSOK D-001 (2023)		
W2	**Are construction material and surfaces considered with respect to work environment and health hazards?**				FA §12, NORSOK S-002 (2018), 7.7.1 NORSOK C-002 (2015), 20.3 ISO 11064-6 (2005), DC: Applicable to the DC		
W2.1	**Are indoor building materials and inventories selected with respect to** A. **clean building concept?** B. **low emission of pollution and odour?** C. **easy cleaning of surfaces?** D. **ergonomic factors?** *Low emitting materials should be chosen. The manufacturer should give declarations on material emissions and cleaning methods.*				FA §12 NLIA (2013), “Workplace regulations”, Chapter 2 & 7. FHI (2015) NORSOK S-002 (2018), 7.7. NORSOK C-001 (2015), 7.1.6. DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
W2.2	**Are colours and surfaces in the CC chosen to minimise contrast and reflection?** *The following features are recommended: White ceiling, dark floor, reflection factor on walls between 0.5-0.8.* *Glare in visual display units from reflecting surfaces shall be avoided. Surfaces, which diffuse light such as flat paint, non-gloss paper and textured finishes reduce reflected glare.*				NORSOK S-002 (2018), 7.6. EEMUA 201 (2019), ed. 3, 2.4.4 & Annex A2.6. ISO 11064-6 (2005), 5.3. DC: Applicable to the DC		
W2.3	**Are measures taken to prevent static electricity?** *Static electricity can cause failure/loss of visual displays when displays are touched. Materials in chairs, floor and footwear should be chosen to reduce static electricity.*				NORSOK C-002 (2015), 4.6. ISO 9241-6 (1999), 8.1. DC: Applicable to the DC		
W2.4	**Are measures taken to prevent electromagnetic disturbances of CC equipment?** *Electromagnetic disturbances may cause interference to electrical signals and damage electronic equipment in the CC. Relevant measures include shielding of equipment and appropriate selection*				IEC TR 61000-5-1 (2023), 4.1 & 4.2 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	of parts. Examples of potential sources: Lightning, radio/radar transmitters, switches, thermostats and mobile phones.						
W3	**Are thermal environment, air distribution and air composition designed according to working environment requirements and best practice?**				FA §14 NLIA (2013), "Workplace regulations", chapter 2 & 7 ISO 11064-6 (2005), 5.2 DC: NORSOK S-002 (2018), 7.7 & 8.2		
W3.1	**Is the operative air temperature between 20°C and 24°C under all weather conditions?** *It is recommended that the air temperature be kept below 22°C at any time and especially in wintertime. Too high or too low temperature may cause inattention and is a risk factor during work requiring mental tasks. Individual temperature adjustments should be possible.*				FA §14 NORSOK S-002 (2018), 7.7 & 8.2 NLIA (2013), "Workplace regulations", chapter 2 & 7 DC: For DC, temperature range between 19° - 26° C		
W3.2	**Is the difference in temperature between floor level and head level less than 3 - 4°C?** *A difference in temperature between feet and head of more than 3 - 4 °C will be uncomfortable, and likewise daily or periodic temperature variations of more*				FA §14 NORSOK S-002 (2018), 7.7.1. NLIA (2013), "Workplace regulation", chapter 2 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	than about 4°C. Check heat from screens and data equipment.						
W3.3	**Is the ventilation need calculated as the sum of the following:** **A. air flow requirements for personnel,** **B. emissions from materials and** **C. emissions from work or process?** *Balanced ventilation is required, and displacement ventilation is preferred to dilution ventilation. Pollution from personnel calls for an air flow rate of 7 - 10 l/s per person. Emissions from normal building materials without strong odour calls for an air flow rate of 2 l/s per m2. Extra airflow should be added for e.g. heat generating equipment.*				FA §14 NORSOK S-002 (2018), 7.7.1 NLIA (2013), “Workplace Regulations”, chapter 2 & 7 DC: Applicable to the DC		
W3.4^{-}	**Is the air intake located in open air:** **A. at a safe distance from exhaust outlets and vent pipes and** **B. in a shaded place so the air is as cool as possible in the summer?**				NORSOK S-002 (2018), 7.5.4 NLIA (2013), “Workplace regulation” DC: Applicable to the DC		
W3.5	**Is smoke and gas detection equipment located at the air intake (and air outlet)?**				NORSOK S-002 (2018), 7.5.3. DC: Applicable to the DC		
W3.6	**Is easy and safe access provided for operators for**				NORSOK S-002 (2018), 6.2.9. ISO 11064-4 (2013), 4.4.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A. **Internal inspection and cleaning of ducts?** B. **Change of air filters?**				DC: Applicable to the DC		
W3.7	**Is the air ventilation velocity less than 0.15 meters per second measured at the operator's workplace?** *Low air velocity is necessary to avoid air draught.*				NLIA (2013), "Workplace regulation" DC: Applicable to the DC		
W3.8	**Are dust sources avoided?** *Dust content in the air has a considerable effect on personnel well-being. Check dust sources such as materials, carpeting and textiles. Carpets should be avoided. Materials containing synthetic mineral fibres shall be fully sealed.*				FA §12 NORSOK C-001 (2015), section 13 NORSOK C-002 (2015) ISO 11064-6 (2005), 5.2 DC: Applicable to the DC		
W4	**Is lighting designed according to ergonomic principles and best practice?**				NORSOK S-002 (2018), 7.6. EN 12464-1 (2021), 5.1. ISO 11064-6 (2005), 5.3.1. DC: Applicable to the DC (Possible to turn down lightning to see driller deck?)		
W4.1	**Is access to daylight provided?** *Permanently manned workplaces should have access to daylight. Ref: Technical and operational regulations §27 "The Workplace Regulation (§2-10. Outside view -The workplaces shall have windows to the outside/ access to daylight.)"*				ISO 11064-6 (2005), 5.3. NLIA (2013), "Workplace Regulation" TOR §27 *Jamrozik et al. (2019).*		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Access to daylight and view in an office improves cognitive performance and satisfaction and reduces eyestrain Jamrozik, et al. (2019).				DC: Access to daylight is not required but is considered favourable for the working environment		
W4.1.1	**Are windows exposed to sunlight equipped with effective shades?** *In choosing shading, one should evaluate* *A. achievable reduction of heat input* *B. ease of use and regulation* *C. durability and ease of cleaning* *D. that the light is not distorted by the reflective coating* *E. that the view is not permanently blocked to any great extent* *F. individual adjustments*				NLIA (2013), “Workplace regulations”, chapter 2. EN 12424-1 (2021), 5.5.2. DC: Applicable to the DC		
W4.1.2	**Are glare and reflections from windows avoided on visual displays?** *Location of windows in relation to displays may cause direct glare or*				NORSOK C-001 (2015), 7.19.1 ISO 11064-2 (2000), 5.4 & 4.6 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	reflections on displays and discomfort to operators. Displays should be perpendicular to windows.						
W4.2	**Is the lighting level in the CC 500 lux and adjustable in intensity and direction?** *Adjustable lighting offers the following advantages:* A. *Gives personal control over the environment* B. *Gives varying light level according to different tasks to be carried out.* C. *Caters for different physiological lighting needs between day and night.* D. *Make sure that adjustable directional lighting does not cause reflections*				NORSOK S-002 (2018), 8.2 EU (2017). DC:400 lux for DC		
W4.2.1	**Are glare and reflection from lighting avoided?** *Direct glare and reflections on displays cause discomfort and problems reading displays. The choice of fittings influences reflections significantly. Indirect lighting should be considered used. Fittings should be to the side*				NORSOK C-001 (2015), 7.19.1. EEMUA 201 (2019), ed. 3, 2.4.1. ISO 11064-6 (2005), 5.3 & Annex A.4 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	rather than behind workstations, perpendicular to displays. Adjustable/flexible fittings are recommended. Displays should be tiltable and antireflection coating or a matt finish should be used. Also check possibilities of glare from emergency lighting.						
W4.2.2	**Is lighting with high colour temperature (e.g. light tubes with white light) used in the control room?** *Different levels of lighting require different light colour if the lighting is to be comfortable. High colour temperature, white light, should be used in areas with high lighting levels like the control room. (Intervals 5000K to 17000K). However, this must be based on tasks and user dialogue. Mills et al. (2007).*				NORSOK S-002 (2018), 7.6. EN 12464-1 (2021), 6.2.4 Mills et al. (2007) DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
W4.3	**Is additional lighting provided in areas where greater intensity is needed?** *Lighting intensity at workplace for paperwork should be min. 500 Lux.*				NORSOK S-002 (2018), 7.6 NORSOK C-001 (2015), 7.19.1 DC: Lighting must not disturb view to the drill floor, derrick etc.		
W4.4	**Is emergency illumination between 15 and 50 lux?** *1 lux is the requirement of EN 1838 for escape routes 0.5 lux for open areas. Areas of high physical risk, or the control rooms of dangerous plant and production lines, need emergency lighting to enable them to be shut down safely, 15 Lux are mentioned by EN 1838. BS5266 Part 1: 1999 defines that emergency lighting should provide 10% of the normal lighting level at the hazard, with a minimum of 15 Lux.* *If work is ongoing in CR, full lightning should be provided, supported by UPS.*				NORSOK S-001 (2021) EN 1838 (2013) IEC 61892-2 (2019), 11.4 BS 5266 (2016) NUREG0700 (2020), rev. 3, 12.1.2.4 DC: Applicable to the DC		
W5	**Are acoustic environment and vibrations designed according to working environment regulation and best practice?**				ISO 11064 (1999-2013) DC: NORSOK S-002 (2018)		
W5.1	**Is the total noise level below 45 dB (A-absolute)?** *The noise level limit refers to background noise including HVAC as well as noise sources in continuous use within the room. Good*				FA §23 TOR §6, §7 NORSOK S-002 (2018), 8.2 (table 3). DC: Total noise level: 65 dB (+ 5 dB for mobile Offshore Units). Noise from the		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	communication requires a noise level less than 45dB. For mobile offshore units the maximum noise limit is 5 dB higher during operation. Noise contribution from the HVAC system should be max. 40 dB (A). Check: control room equipment, ventilation system/ fans, printers, equipment in adjacent rooms and process equipment.				HVAC system should be maximum 60 dB (A).		
W5.1.1	**Is the average octave band sound absorption coefficient not less than 0.2 in the frequency range 250 Hz to 2 kHz?**				NORSOK S-002 (2018), 8.2 (table 3)		
W5.1.2	**Is the minimum airborne sound insulation index (R'w) 45 dB in the CC?** *Minimum permissible airborne sound insulation index (R'w) for horizontal, vertical and diagonal sound transmission between adjacent rooms should be 45 dB for control rooms.*				NORSOK S-002 (2018), 7.3 (table 1) NORSOK S-002 (2018), 8.2 (table 3) DC: Applicable to the DC		
W5.2	**Is it ensured that speech communication is not masked by noise sources especially under the**				ISO 9921 (2003) DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	noisiest conditions, e.g., emergency preparedness, and emergencies? *Has ISO 9921 "Ergonomics – Assessment of speech communication" been used regarding the specification and location of communication equipment?*						
W5.3	**Are noisy office machines like printers, copy machines, servers, air conditioners, and air fans placed in a separate, unmanned area?** *Such machines should not be in the CC due to noise and dust emission. If location in a separate room close to the CC is not practicable, location in special cabinets in the CC may be considered.*				NORSOK S-002 (2018), 7.3 ISO 11064-2 (2000), 4.4 DC: Applicable to the DC		
W5.4	**Are vibrations in the control room within acceptable limits?** *Vibrations cause discomfort and fatigue to personnel and may damage control room equipment. Limits for vibration are stated as acceleration (m/s^2) as a function of frequency (Hz). (On a personal level 2.5 m/s^2).* *For vibration limits, reference is made to NORSOK S-002, REV 4,*				AR §39 FR §24 TOR §26 NORSOK S-002 (2018), 8.2 (table 3) NS 4931 (1985, Same as ISO 6897:1984) ISO 2631-1 (1997), 8.1 & 9.1 ISO 5349-1 (and -2) (2001), Annex B-D DC: DC is considered as Category 2 room (Drilling areas).		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Annex A. Control rooms are considered as Category 1 rooms.						
W6	**Are all necessary questions asked related to Working Environment?**				DC: Applicable to the DC		

Checklist P: Procedure and work descriptions

Checklist P: Procedures and work descriptions

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
P1	**Is a consistent approach used to develop, use and maintain procedures and work descriptions?** A. *Has a philosophy and goal/vision for development of procedures and work descriptions been established?* B. *Have principles been established to distinguish between mandatory procedures and guidelines (work descriptions)?* *Is there coherence between philosophy, goals, rules, procedures, work descriptions and working practice?*				Vatn (1997) CCPS (1996) CCPS (2022) DC: Applicable to the DC		
P1.1	**Are procedures developed in a structured manner, based on functional analysis and task analysis?** *The structured approach should consist of the following steps:* A. *Identify core tasks, identify hazards and working environment issues and identify supporting tasks related to these.*				MR §13, Chapter V AR §24 Vatn (1997) CCPS (1996) CCPS (2022) DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	B. Plan the sequence of the core tasks and supporting tasks. C. *Perform a hierarchic breakdown of the tasks.* *D. Perform tabular task analysis of critical and difficult task steps. This should include human – machine interaction and possible erroneous actions.* *E. Perform structured walk through of the procedures/ work descriptions.*						
P1.1.1	**Are procedures clearly marked with titles/labels?** *Titles and labels should allow the operator to choose the required procedure quickly. Check: typographical, colour and shape coding of procedures. It is important that the use of the latest version is verified, and that the version is clearly stated in the procedure.*				AR §24 DC: Applicable to the DC		
P1.1.2	**Are the criteria and conditions for use of procedures clear and unambiguous?** *The procedures should be used as a measure to prevent*				AR §24 UKAEA (1985) p.12 DC: Are all conditions stated before first step in the procedure such as all pipes are drifted and measured, pipe tally is supplied to the driller, 5200 m 5 ½" drill pipe in		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	errors and accidents. Are all conditions required to perform the operation stated before first step in the procedure is performed.				derrick, pressure test prior to drill out cement etc.?		
P1.1.3	**Do the procedures include information about why a certain method of working is necessary?** *Operator understanding is complimented if procedures provide knowledge about actions in the process, rather than a set of rules for the operator to follow blindly. The procedures should also contain information about operating envelopes.*				UKAEA (1985) p.12 Rasmussen (1997) CCPS (1996) NUREG0700 (2020), rev. 3, 8.1.1-2 DC: Do the procedures contain a short start-up list in case of temporary stops in the operation, crew change, breaks, personnel off hazard areas on the drill floor, racking arm removed, all involved personnel ready to proceed etc.?		
P1.1.4	**Can the instructions in procedures be easily understood and followed, particularly by a person who seldom use them?** *The wording in the operation procedures should be kept short and consistent. Procedures in a step-by-step columnar format reduce the number of words necessary*				HSE (2009) UKAEA (1985) p.14 CCPS (2022) NUREG0700 (2020), rev. 3, 8.1.2-1 DC: The procedures should keep the selection of methods and conditions separated from the actual action steps in the procedure		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	to describe actions, as opposed to a narrative format. Drawings, figures, checkoff provisions and feedback from control room systems should be provided.						
P1.1.5	**Do the procedures and work descriptions support fault tolerant work practices?** *Fault tolerant work practices allow human errors to be detected and be recovered.*				Skjerve (2004) NUREG0700 (2020), rev. 3, Appendix B, B.3 DC: In case a step can cause a result to turn out differently, the events with their actions steps should be clearly separated. For instance, "if running tool is not released, add additional 5 tons (Total maximum 50 tons) and proceed"		
P1.2	**Do operators participate in the development and testing of procedures?** *Operator participation in the development and testing ensure that procedures are practical and in accordance with "real life" on the installation, thus ensuring personnel acceptance.*				FR §13 DC: Applicable to the DC		
P1.2.1	**Are the procedures and operators' skills complementary?** *Where the operators are skilled and experienced, and a standard sequence is not necessary, the procedures*				UKAEA (1985) p.13 CCPS (2022) NUREG0700 (2020), rev. 3, 8.2.1-1 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	should be in the form of reminder checklists with guidance on priorities, rather than detailed instructions.						
P1.3	**Is a system for checking and modification of procedures established and in use?** *There must be rules and authorisation to cover these areas. It should be easy to modify procedures when needed. Modification of paper-based procedures can be eliminated or minimized by computer-based procedure designs where practical.*				HSE (2023b) NUREG0700 (2020), rev. 3, Appendix B, B.3 CRIOP (2024) 1.3.2 DC: Applicable to the DC		
P1.3.1	**Are the procedures available digitally/on-line, and in latest version?**				DC: May not be applicable to the DC because of missing on-line terminals.		
P1.3.2	**Are procedures checked routinely, compared with operator action, learning from incidents, and revised as appropriate?** *The updating of procedures is often not carried out systematically in the organisation, causing information to be out of date. Check: the company's*				HSE (2023a) HSE (2023b) UKAEA (1985) p.12 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	system for updating procedures and that all the written procedures are used and really necessary.						
P1.4	**Do the procedures and work description support handling of abnormal situations?** A. *Do the procedures and work description describe how to handle the most common abnormal situations?* B. *Do the procedures and work descriptions support improvisations in critical and unforeseen situations?*				AR §24 Skjerve (2004) DC: Applicable to the DC		
P1.4.1	**Are emergency procedures distinguished from other procedures?** *The emergency procedures should be available as a hard copy, clearly marked and highlighted by coloured paper and coloured tabs, in the CC.*				CCPS (1996) Edmonds (2016) DC: The emergency procedures used during a serious condition must be separate, clearly marked documents. Procedures used in a less serious situation can be part of the normal operation procedure, clearly distinguished such as last chapter. Reference from the normal operation procedure steps to the emergency procedure should be made		
P1.4.2	**Are emergency procedures provided in sufficient number in the CC?** *Each CC operator should have access to a complete set of procedures in the*				HSE (2023a) UKAEA (1985) p.12 Edmonds (2016) DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	control room, to be used if power supply is failing. It could be easier to access the procedures in a binder while the displays must be used to other purposes.						
P1.4.3	**Are written bypass procedures provided for manual actions when automatic actions are unavailable?** *Is there guidance when the automatic action fails? Can the CC be manually operated?*				IEC 61511-1 (2016), 16.2.2 DC: Applicable to the DC		
P1.4.4	**Is there a work process or procedure for bypass of safety functions?** *Bypass of safety functions are vital to installation safety and must only be carried out after authorization. Bypass should be authorized by responsible CC personnel, and bypass switched should be protected by key locks or passwords.*				FA §8 AR §26 IEC 61511-1 (2016), 11.7.1.2 & 11.7.1.3 DC: Applicable to the DC – example collision avoidance systems.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
P1.4.5	**In the driller's cabin, and elsewhere, when necessary, there shall be posted:** 1) initial well shut-in procedure and well control action plan 2) kill sheets for the well being drilled 3) emergency disconnect sequence(s) and emergency disconnect procedures (MODU specific) 4) well specific operating guidelines (MODU specific) 5) well control manual 6) well control bridging document 7) contingency procedures for use of BOP secondary control system(s), ROV/acoustic (MODU specific).				NORSOK D-001, 2023, 7.5.6.1 DC: Applicable to the DC		
P2	**Are all necessary questions asked related to Procedures?**				DC: Applicable to the DC		

Checklist T: Training and competence

Checklist T: Training and competence

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
T1	**Is the requirement to a training program documented?** *The requirements should cover what (all operating conditions) and who (who participates in the team?). This can for instance be presented in a competence matrix. A task analysis should be the basis.*				MR §14 AR §21, §22, §23 TOR §52 DC: Applicable to the DC		
T1.1	**A. Is a systematic method used to document all CC tasks across all operating conditions including abnormal conditions and remote support?** **B. Is a systematic method used to document associated training needs?** **C. Have operational barrier elements been identified, and are they covered by training?** *Training needs should be identified through a systematic process covering function and task analyses. This process must be carried out when the overall design of the CC is ready, and the amount of remote*				MR §5, §16, §17, §18 AR §21, §23 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	support has been decided. *Associated training needs should include identification and training of operational barrier elements.* *Training needs also have implications for manning of the CC.*						
T1.2	**Have all involved team members been included in the training program (also personnel involved in remote support)?** *All the involved team members must be identified and included in the training program. In an environment with remote support, team members could be involved from both offshore and onshore. The team members should be involved in all operating conditions including abnormal conditions and remote support.*				DC: Applicable to the DC		
T1.3	**A. *Have the required qualification and competencies been specified for the actual tasks?** **B. Does the operator have the required qualification and competence to perform the task?** *Competence criteria should be defined for jobs that are of significance to safety. Can be presented in a competence matrix.*				MR §14, §16, §17, §18 FR §12 CRIOP (2024) T1.1, T1.3 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	How is the qualification objectively documented?						
T1.4	**A. Are learning objectives identified?** **B. Are learning objectives incorporated into the training programme?** *Learning objectives should include the team and be based on the task analysis conditions and standards of performance including HSE issues and include these in the training programme.*				AR §21, §23 HFAM (NPD 2003) EEMUA 201 (2019), ed. 3, 6.3 DC: Is there a programme for training of the drillers, and are the learning objectives identified and incorporated in the programme? Are the drillers frequently and systematically trained?		
T1.4.1	**Are operators trained in all operational conditions including abnormal situations?** *This should include start up, shut down, abnormal situations and normal operations. During startup, many problems arise that do not occur when the process is in a stable running state. Shutdowns and abnormal situations are frequent in this period and this experience is an important contribution to operator competence.*				AR §23 HSE (1999), ed. 2, p.17 ISO 11064-1 (2000), 10.2 DC: Are the driller, tool pusher, company man etc. trained to work as a team in abnormal situations?		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
T1.4.2	**Is training given in the use of all job aids?** *Check: Procedures, work permits, logs and emergency equipment, and communication equipment.*				HSE (1999), ed. 2, p.25 & p.36 DC: Applicable to the DC		
T1.4.3	**Do operators receive instruction and systematic training in all realistic operational usage of the alarm system?**				EEMUA 191 (2013), 3.8 ISO 11064-5 (2008), 6.1.4 DC: Applicable to the DC		
T1.4.4	**Are operators trained in the use and objectives of mimics and large screen displays?**				IFE (2003), question 8, appendix 2 NUREG0700 (2020), rev. 3, 6.1.2-8 DC: Applicable to the DC – related to mimics		
T1.4.5	**Are operating teams trained to communicate effectively?** *Check: Technology. Team members onshore, offshore, expert teams giving remote support and supporting staff from suppliers and other remote staff, check communication protocol training and technology used*				AR §21, §22 FA §19 SfS (2023) DC: Applicable to the DC		
T1.4.6	**Are operating teams trained together in the allocation/ transfer of responsibility?** *Check: Team members onshore, offshore, expert*				IOGP-502 (2014), section 5 Energy Institute (2014), EI Report, 3.3.5 HSE (2003)		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	teams giving remote support and supporting staff from suppliers and other remote staff.				DC: Is an onshore emergency /support team established? Are the "on location team" and the onshore emergency team trained to work together as a team in abnormal situations?		
T1.4.7	**A. Are necessary competence requirements related to remote operations identified?** **B. Is necessary training involving remote operations done?** *Training must be performed based on the new technology, procedures and new roles and responsibilities. Risk related to Information security should be explored and communicated to increase awareness among the operators in the Central Control Rooms and operators in the Collaboration rooms.*				HSE (2003), CRIOP (2024) E14, 14.1 DC: Applicable to the DC		
T1.4.8	**Are operators trained in diagnostic skills which will help them act in unfamiliar situations?**				AR §21, §23 DC: Applicable to the DC		
T1.4.9	**Are operators trained in correcting their own errors?**				MR §23 DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
T2*	**Is a system for evaluating, checking and modification of training program available?** Check handling of MoC, small software updates. (MoC must include training).				ISO 11064-1 (2000), 9.7, 10.2 DC: Applicable to the DC, especially related to small software updates, new equipment, new small systems…		
T2.1	**Are experience and the information from incidents used in the re-training of operators?** *Experience and the information from incidents should be spread systematically to all operators involved and relevant personnel through the company training department.*				ISO 11064-1 (2000), 10.2 CRIOP (2024) T4 DC: Applicable to the DC		
T2.2	**Do changes in requirements for task performance result in changes in training and training materials?** *Multiskilling, job-rotation, new equipment, new technology and minor alterations to the CC may change the work situation for the operator. These changes should be documented analyse and new associated training needs should be included in existing training programmes.*				AR §21, §22, §23 MR §23 HFAM (NPD 2003) CRIOP (2024) T4.1 DC: Applicable to the DC		
T3	**Is there an attitude of non-penalization and organisational learning when an operator makes an error?**				FR §23 ISO 11064-1 (2000), 4.6 & 4.7 HSE (1999), ed. 2, p.18		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Is there a "no-blame" or "Just" culture in the organization? Learning from both individual and shared experiences or errors is essential. To support this, a system for reporting and sharing incidents, near misses, and lessons learned should be in place. Creating an optimal work environment requires a non-punitive approach to reporting—where raising concerns or deviations leads to positive changes, not punishment. This mindset not only improves day-to-day operations but also positively influences the development of future projects and fosters a strong, open reporting culture throughout the organization. EU Regulation 376/2014				See also Norsk Industri (2025)- HOP; Federation of Norwegian Industries (2025) EU 376/2014 DC: Applicable to the DC		
T4	**Are simulators or other training methods used for teaching manual operations and fault handling?** *To ensure adequate training covering fault handling and exception handling simulators, scenario workshops or training based on virtual reality should be used.*				AR §23 DC: Applicable to the DC		
T4.1	**Does the simulator or other training methods allow for training of emergency scenarios that the operator seldom experiences in reality?**				AR §22 AR §21, §23 EEMUA 201 (2019), ed. 3, 6.3.		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Process simulators can benefit in training operators, enabling them to practice routine and emergency procedures in a safe environment, and enabling competency to be measured. Others means should also be evaluated.				DC: Applicable to the DC		
T4.2	**Does the simulator or other training methods accurately mimic relevant process characteristics?** *The simulation used should be an accurate representation of the system, with less or more detail (depending on whether the simulation if low fidelity or more expensive high fidelity).*				AR §21, §22, §23 EEMUA 201 (2019), ed. 3, 6.3 DC: Does the simulator or other training methods mimic relevant drilling and well operations, including well control operations?		
T5	**Is the effectiveness of different training methods evaluated for the different types of tasks to be performed?** *Examples of tasks are day-to-day vs. emergency operations. Different training methods have different outcomes depending on task. To select the most suitable training method, it is necessary to compare outcomes from different methods (Hands-on, inhouse, vendor, etc.).*				HFAM (NPD 2003) DC: Applicable to the DC		
T5.1	**Is on-the-job training practiced and followed up?**				AR §23 NORSOK D-010 (2021), rev. 4, 4.9.1		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The operators' basic training is supplemented with practical experience through on-the-job training.				DC: Applicable to the DC		
T5.2	**Are the learning outcomes of the training programmes evaluated?** *Transfer of training is critical to operator performance. The only way to assess how well training transfer into task performance is to conduct an evaluation of what the operator has learned.*				HFAM (NPD, 2003) DC: Applicable to the DC		
T5.3	**Is upgrade training and re-training provided at regular time intervals?** *Operators take time to adjust from a free period to work in the control room, and to: "get the picture" of the process again. Ultimately, this may imply that the production organisation is more vulnerable to process disturbances when a new shift takes over.*				AR §22 AR §23 CRIOP (2023) T2.4.1 DC: Applicable to the DC		
T6	**Is a risk-based training concept like Crew Resource Management (CRM):** **A) Evaluated?** **B) implemented?** *CRM training focuses on key non-technical skills such as: communication, stress management, situational awareness,*				IOGP-502 (2014), section 5 The Energy Institute (2014), EI Report, Section 3 HSE (2003) DC: Applicable to the DC		

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	teamwork, decision making, leadership and personal limitations. Research has shown that CRM training helps reduce accidents by preventing, detecting, and mitigating errors. Both the International Association of Oil & Gas Producers (IOGP) and the UK Health and Safety Executive (HSE) recommend CRM training for the oil and gas industry. Additional guidance is available on their respective websites. (NB: High workload should not be mitigated by learning to cope with continuous stress, but should be mitigated by resolving root causes)						
T7	**Are all necessary questions asked related to competence and training?**				DC: Applicable to the DC		

5. Scenario Analysis

5. Scenario Analysis

The aim of this section is to describe how to conduct Scenario Analysis, when it might be appropriate to perform it and give a framework of types of scenarios to be developed for analysis.

The Scenario Analysis is a step-by-step method to identify and address potential weaknesses in system performance, especially under critical or abnormal conditions, and consist of the following steps:

- **Organize and Select Scenarios**, identify realistic and hazardous situations (examples appendix A, B). AI/Large language models can help identify relevant scenarios and edge cases (and reduce effort).
- **Develop and explore Scenarios** using STEP to map out the sequence of events among actors in each scenario.
- **Identify Weak Points/Error traps and check SA** in design, procedures, or performance that could lead to failures. Weak points are the result of analysis to be mitigated, the error traps are possible trigger zones where performance shaping factors and poor design create high risks for errors
    - Check how Situational Awareness is influenced by Performance Shaping Factors (PSFs) like stress, fatigue, interface design, or organizational issues
- **Conduct Safety Barrier Analysis** – identify proactive and reactive barriers
- **Develop and prioritize recommendations**, improvements to design, training, procedures, or safety systems to reduce risk and enhance performance.

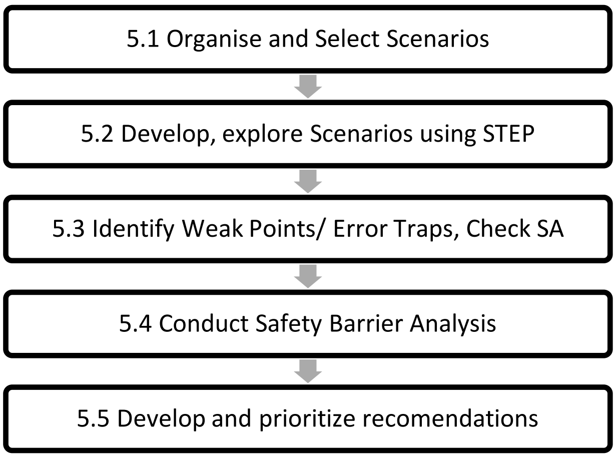


Figure 5.1: Flowchart describing the main steps in the Scenario Analysis

The Scenario Analysis comprises a detailed assessment of the control room operator's responses to abnormal situations. The Scenario Analysis should be carried out after the General Analysis. In this way, the group will be more familiar with the challenges in the project. The Scenario Analysis is highly detailed, and a good knowledge of the process and information presentation in the control room is required. Emphasis is made on the operator's Situational Awareness, how the operator perceives, understand, and anticipate the environment to make effective decisions. SA consists of:

1. **Perception** – Detecting relevant elements in the environment (e.g., alarms, readings, signals).
2. **Comprehension** – Understanding what those elements mean in context.
3. **Projection** – Anticipating what will happen next based on that understanding.

5.1. Organise and select scenario

5.1.1. Participants and duration

Participants in the Scenario Analysis are described in “3.4 Establish the analysis group”.
The most important participants during the Scenario Analysis are operations and instrument personnel. Process personnel could be required for outlining the main steps of the scenarios.
Note that the method has important pedagogical effects on the personnel who participate. By participating actively in the design of scenarios and subsequent evaluations, the personnel's awareness to handling abnormal situations seems to be heightened

The analysis group should aim at completing the analysis of one to three scenarios in approximately one workday, see Table 5.1 below. The first scenario may take longer to complete, depending on the participants' knowledge of the method and the control room, and availability of information and key personnel. Subsequent scenarios will be completed in shorter time, because certain topics will already have been thoroughly discussed.

Table 5.-1: Approximate duration of activities in the Scenario Analysis

Activities	**Duration**
Construction/adaptation of scenarios	1 hr to ½ hrs
STEP presentation of events	1 hr to ½ hrs
Identification of weak points/Recommendations	2 hrs to 1 hr

The duration could vary within a range of -50% up to +200% depending on the complexity of the scenarios and the participants in the analysis group.

The Scenario Analysis will be an important arena for organisational learning by actively using the findings to not only correct weak points directly but also change the “governing values/variables” in the organisation. This means that findings in the analysis should activate change in governing procedures, documentation and design material. The Scenario Analysis should be carried out as a discussion of problems related to the events described in the scenarios. It is important that discussions are open and free. One should therefore not limit discussions to the scenarios but allow discussions to drift around other topics. In this way, the participants trigger each other, and many findings are identified which are not directly related to the tasks in the scenarios.

Documentation to assist, should include (see Table 3.2 for more information):

- Safety Critical Task analysis
- HAZOP or Hazard analysis
- Key challenges in the project
- Organisational structure, supply chains

5.1.2. Selection of scenarios

The basis for the Scenario Analysis is accident or incident scenarios that the control room must be able to handle. The analysis aims at evaluating how well the control room personnel can handle the scenarios with the available/planned control room equipment, organisation, layout, etc.

Scenarios for the purpose of the analysis may be obtained from different sources:

- Incidents that have occurred on *the installation*
- Incidents that have occurred on *other installations*
- Hypothetical incidents *constructed* by the analysis group, e.g. based on HazOp-analyses, or suggested by AI/Large language models (experiences is rapidly developing, and suggestions should be found from relevant scientific documentation)
- Scenarios based on defined situations of hazards and accidents offshore, Ptil (2009).

The term scenario is in the following used for all the above categories.
It is underlined that even if one uses incidents from the installation in question or other installations, the scenario should always be developed during the analysis and the final scenario must be a result of continuing interaction between the participants.

As an introduction to the method for building scenarios, Appendix A presents prototypical *examples* of scenarios that have occurred in the North Sea. These are only scenario examples and should not be used directly in the analysis. To make the prototypical scenarios relevant for the installation in question, these must be adapted. This is done through a process of extending the prototypical STEP diagrams by incorporating installation specific information and behaviours (actors and events).

Scenarios can also be selected based on the safety critical task analysis, the HAZOP analysis or identified challenges in the project.

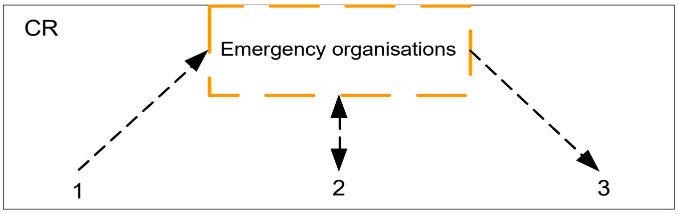
Scenarios based on incidents on other installations cannot be applied directly to the installation. It is important that the scenarios are made specific for the installation in question. This should be done by only using *ideas* from earlier incidents and then develop the scenarios for the first time during the Scenario Analysis. One can say that the scenarios must be *adapted* to the specific conditions on the installation being analysed.

5.1.3. Some initial criteria for selecting scenarios

Scenarios should initially, take into consideration the following characteristics:

- **Failure of barriers** I.e., accident scenarios involve failures in several safety barriers.
- **Feasibility** i.e., scenarios must be physically possible in the process in question.
- **Acceptance** i.e., scenarios must be accepted as possible by the participants in the analysis.
- **Hazard potential** i.e., the scenarios should have a potential to cause major accidents or installation damage. Environmental pollution should be evaluated.
- **Operator involvement and stress** I.e., the scenarios must involve control room operators and cause stress. Consider situation when one of the CCR operators is missing, and/or a peak workload.

- **Real situations** It is an advantage if some scenarios are based on situations that have occurred on installations in the North Sea as far as possible. This implies that one cannot argue that the scenarios are “unrealistic”, “impossible” or “cannot happen here”. Also, real scenarios illustrate relevant time constraints in handling the situation. However, “black swan” scenarios/ new scenarios must also be included.
- **Different scenarios** I.e., the scenarios should not be too similar, so that different aspects of the control room may be addressed.
- **Width and depth** I.e., at least one “width scenario” and one “depth scenario” should be carried out. Width means involvement of several persons, parties and other factors where multiple conditions are analysed over time all the way to an emergency. Depth means covering special functions isolated, i.e., not involving emergency team and external groups.
- **Resilience** I.e., scenarios exploring resilience should be discussed, ensuring that critical tasks are resilient. Key issues that could be explored are **redundancy** (having several alternate and independent ways of performing a function), **controlled degradation** (allow flexible responses, support of improvisation), **flexibility** (having different ways of performing a function), **ability to manage margins close to performance boundaries** (getting signals and information proactively close to boundaries), **reduction of complexity** (reduce complex connections, reduce feedback loops), **reduce tight couplings** (flexibility in sequencing, allow slack).
- **“Human error”** Human error should be vital for the outcome of the scenario. It should be of great importance whether the operators make errors or executes the correct actions. The scenario should “provoke” the participants in such a way that they don’t feel comfortable with the selected solutions. In this way focus is always on making improvements.
- **Specificity** The chosen scenario must be specific for the installation in question. This is to ensure that one exposes weak points on the control room in question.
- **Complexity** To make sure the operators are stressed the chosen scenarios should be sufficiently complex. Simultaneously operations/incidents, extensive communication and fallacy of multiple safety barriers are key words.
- **Emergency preparedness** At least one scenario should be pursued to emergency preparedness, where the crisis team and the emergency organisation take control of the situation, se Figure 5.2 below.



Responsibilities between CR and emergency organisation to be checked and discussed in a CRIOP analysis:

1. Handover from CR to the Emergency organisation
2. Responsibilities and tasks of CR during the Emergency
3. Handover from Emergency Organisation to CR

Figure 5.2: Handover between control room and emergency organisation during a crisis

5.1.4. Scenarios based on incidents on the installation

If the control room in question has been in operation for a period, *incidents that have previously occurred on the installation* may be used as a basis for scenarios. Detailed information concerning the incidents may be obtained from the company reporting system or accident reports. However, one must avoid a narrow view and imagine the possibility of a combination of events. See also Nazaruk, M (2022), "Find out where and how your next accident may happen with learning from normal work".

5.1.5. Scenarios based on incidents on other installations

Another source of scenarios is *incidents that have occurred on other production installations* in the North Sea. In this way, the Piper Alpha accident, for example, may be applied to the installation in question, i.e., "*Could Piper Alpha have happened on our installation/how can we prevent the Piper Alpha accident on our installation?"* Sources of information concerning incidents are company reporting systems or accident reports. Note that the incidents must adapt to process equipment on the installation in question. Issues could be loss of containment, loss of power / utility, plant trip, personal safety event (missing person).

5.1.6. Hypothetical incidents constructed by the analysis group

Finally, scenarios may be constructed based on *hypothetical situations,* i.e., not necessarily on situations that have occurred. The approach to constructing hypothetical scenarios is to consider *malfunction or bypass of safety barriers*. This implies that the method does not attempt to identify scenarios that have been overlooked in e.g. a HAZOP analysis, but rather to analyse how well the operators will be able to handle failures in safety barriers.
HazOp analyses of the installation in question may provide a basis for constructing hypothetical incidents or use of AI/large language models.

5.1.7. Guidelines for adaptation of scenarios

Constructing/adapting scenarios are a very important step of the method, because it provides the basis for the subsequent identification of weak points. Be prepared to spend some time on this step. It is particularly important to emphasize that the objective of constructing scenarios is not to imply that they are probable on the installation, but rather to establish a concrete basis for discussion of operator tasks. The activity consists of

- **Input:** Scenario examples or incidents on other installations.
- **Process:** Adaptation of scenarios is a group process with involvement of control room operators.
- **Output:** Main features of the scenario, adapted to process equipment on the installation in question

The Process may consist of the following steps:

1. Consider the original scenario and the process equipment on the installation in question. Decide whether the equipment involved in the original scenario is the same as or like equipment on the installation in question.
2. If there are no major differences in the equipment, use the main features of the original scenario as a basis for constructing a similar scenario on the installation in question (adapted scenario). Use "local" terminology on the installation in question.

3. If there are major equipment differences, adaptation of the scenario is necessary. List the main features of the original scenario (e.g. equipment failures, operator actions, leaks, misunderstandings).
4. Construct a similar (adapted) scenario on the installation in question by using the main features of the original scenario. Note that this may involve other equipment (e.g. oil pump instead of condensate pump, leak from manual valve instead of pressure safety valve), but the main features of the original scenario should be preserved (e.g. equipment failures, operator actions, misunderstandings).
5. Draw a simplified equipment diagram of the equipment involved in the adapted scenario.

It is vital to the progress of the analysis that all personnel involved *accept* the scenario as *possible* (but not necessarily probable). Remember that personnel who are unfamiliar with the method need time to adapt to the scenario approach. Once convinced, personnel have little problems constructing adequate scenarios for the analysis.
The above emphasizes the benefits of using real scenarios as a basis for the analysis. In this way, one cannot argue that the scenario is impossible.

Example of adaptation of scenarios - The main equipment involved in the scenario example is:

- Condensate separator
- Condensate pumps downstream from separator
- Blind flanges on pressure safety valves

The installation in question does not have condensate pumps, and this makes an adaptation of the scenario necessary. A similar accident (a hydrocarbon leak from a pump) preserving the main features of the original scenario can be constructed on the installation in question involving the following equipment:

- *Oil separator* (instead of condensate separator)
- *Oil booster pumps* downstream from separator (instead of condensate pumps)
- *Oil leak from blind flange on manual valve* (instead of condensate leak from blind flanges on pressure safety valves)

The main features of the adapted scenario are shown in Table 5-2.

Table 5.-2: Main features of original and adapted scenarios – Example

Original scenario	Adapted Scenario
Equipment trip due to vibrations on condensate pump	Equipment trip due to vibrations on oil pump
Maintenance work on pressure safety valve	Maintenance work on manual valve
Inadequate communication between shifts	Inadequate communication between shifts
Operator reacts to an initially normal situation by switching condensate pumps	Operator reacts to an initially normal situation by switching oil pumps
Hydrocarbon leak from blind flange on PSV	Hydrocarbon leak from blind flange on valve
Operator misses information due to high workload	Operator misses information due to high workload

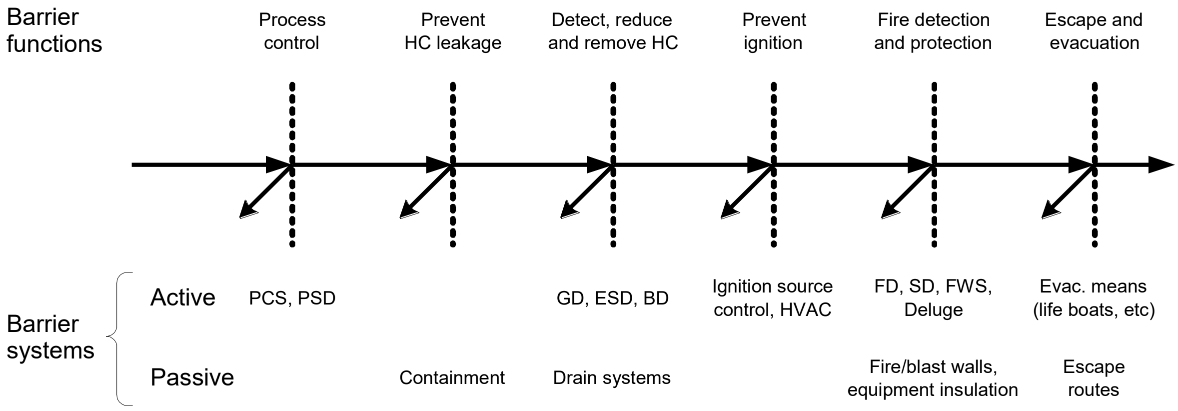
At first glance, it seems that the original scenario has been changed substantially to be feasible on the installation in question. However, the *main features* of the adapted scenario are similar to the original, see Table 5-2.

5.1.8. Prototypical scenarios from the oil and gas industry

Several prototypical STEP scenarios have been developed to support the analysis. The scenarios are:

1. Gas leak
2. Utility systems start-up after blackout
3. Subsea start-up
4. Emergency shutdown
5. Blackout
6. Sudden listing

See Appendix A for descriptions of the scenarios. The prototypical scenarios describe different types of emergencies in which the CRO plays an important role. During the Scenario Analysis these scenarios should be combined with failures in barrier functions or systems as showed in Figure 5.6.



HC - Hydro Carbons; PCS - Process Control System; PSD - Process Shutdown; GD - Gas Detector; ESD - Emergency Shutdown; BD - Blowdown; HVAC - Heating, Ventilation and Air Conditioning; FD - Fire Detector; SD - Smoke Detector, FWS - Fire Water System

Figure 5-6: Barrier functions and barrier systems that may fail

The prototypical scenarios and the examples of possible failures in barrier functions and systems are just meant as a helping start for the scenario development. By combining the scenarios mentioned, with different failures and consequences, i.e., personnel injuries, all kinds of operator aids can be tested in all the prototypical scenarios.

5.2. Explore Scenarios

The Scenario Analysis proceeds through two stages:

- Exploration of two or three scenarios in STEP (Sequentially Timed Events Plotting) diagrams for the analysis based on the prototypical scenarios provided (appendix A)
- Conduct the analysis by asking questions relating to sensemaking for each event involving CRO personnel. Use the checklist of performance shaping factors/error traps and ask additional questions to elaborate on answers received

5.2.1. Presentation of events – using STEP

The STEP method was originally developed for detailed analysis of incidents and accidents. (What happened and why did it happen, Hendrick and Benner (1987).) The STEP method provides a common framework for the analysis group in the form of a graphic presentation of the events during the scenario. The method is conducted in the following manner:

1. **Actors: The actors who are involved in the event are identified.** The term actor denominates a person or object that affects the event "by his or her own force". The actors do not only react in a passive manner to outside influence, but they are also actively involved in the events leading up to the accidents by e.g. their own actions, decisions or omissions. The actors are drawn under each other in a column on the left side of the STEP diagram.
2. **Events: Identify the events that influenced the accident.** The events are described by "whom", "what" and "how", and are placed in the diagram according to the order in which they occurred. There should only be one event in each rectangle. A mental event, that is what the actor perceives, interprets or actions she or he intends to conduct should be included in the diagram.
3. **Time: Place events in the correct place on the time-actor sheet**. If the exact time of an event is not known, attempts should be made to identify the correct order of events. In some situations, it is better to identify the sequence of events first. This is not a problem if the investigator remembers to identify all the involved actors afterwards.

Identify the relationship between the events, what caused each of them, and show this in the diagram by drawing arrows to illustrate the causal links. For each event the previous events leading to this event are assessed. This is done using a logic test. The logic test consists of a necessary and a sufficient test. The logic tests address whether one event is sufficient to cause the following event. If not, then other events that are necessary to cause the following events are identified. Finally, the connection between the events is shown using arrows. This will also ensure that the events are in correct order regarding the timeline.

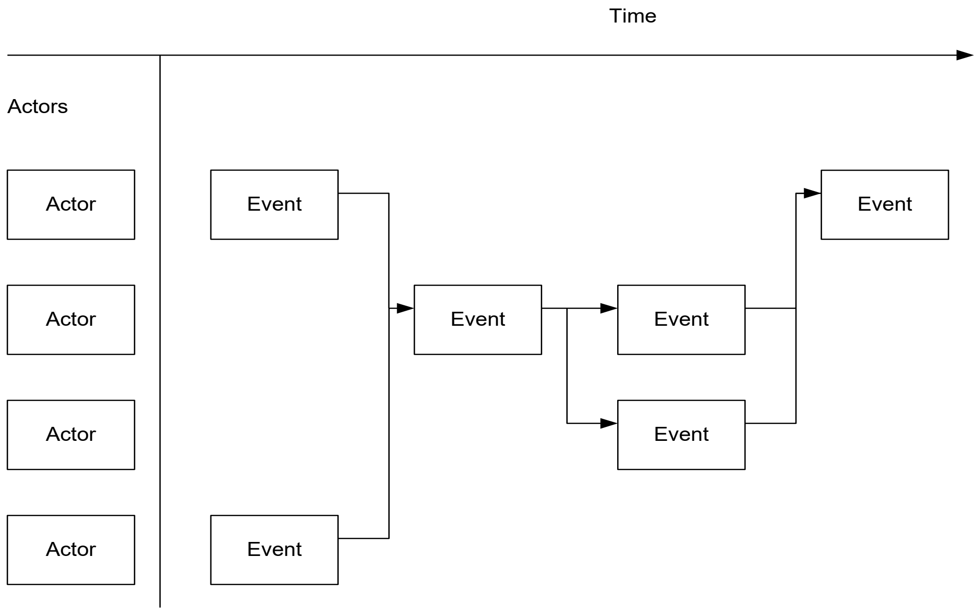


Figure 5.3: Schematic STEP diagram

It is practical to use yellow post-it notes and large pieces of paper when the incident is constructed. The text is written on the post-it notes, which are placed in the presumed correct position and moved when needed. The connecting lines should be drawn with pencil, so that they can be altered easily.

5.3. Check SA - Situational awareness

The Scenario Analysis is designed to verify that the CRO (Control Room Operator) can perform the task at hand considering cognitive abilities, human-machine interaction and other Performance Shaping factors.
The analysis is human-centred, focusing on the CRO’s interaction with the system including communication with other personnel. Emphasis is on ***how the systems support the operator’s situation awareness and decision making in different situations***.

To achieve this goal the analysis must have a framework for analysing the cognitive functions. The framework selected is Endsley´s SA model, Endsley (2000), where three elements are identified, Figure 5-4.:

- Perception of elements in current situation
- Comprehension of current situation
- Projection of future status

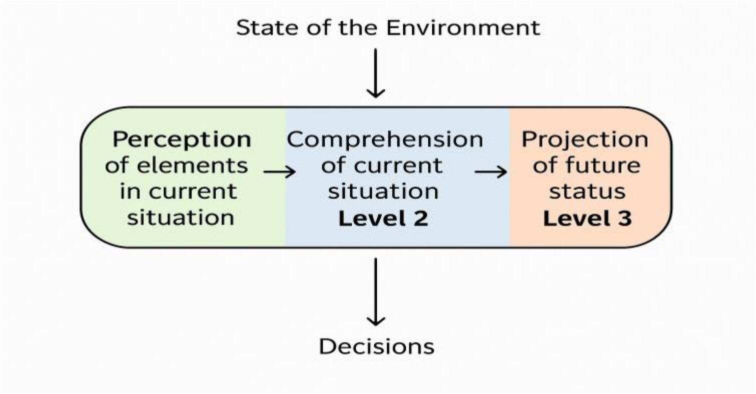


Figure 5.4 Flow of SA-Situational Awareness (Endsley, 2000). The figure shows the three elements in the SA model. A person perceives and comprehend a signal, project future state and decide.

Other models can also be used as a basis for reflection, such as Hollnagel Simple model of Cognition, Hollnagel (1998).

5.3.1. Endsley’s Three Levels of Situational Awareness

1. Perception of Elements (Level 1)

This is the foundation of SA. It involves detecting and identifying key elements in the environment—such as instruments, alarms, objects, people, or events.

Example: An operator sees a warning light flashing on a control panel.

2. Comprehension of the Current Situation (Level 2)

At this level, a person understands what the perceived elements mean in context. It’s about integrating data to assess the situation’s significance and implications.

Example: The operator understands that the flashing light indicates a pressure drop, which could impact system stability.

3. Projection of Future Status (Level 3)

This involves using the current understanding to predict future states or developments. It helps in anticipating problems and making proactive decisions.

Example: The operator anticipates that if the pressure continues to drop, it may trigger an automatic shutdown and prepares to intervene.

5.3.2. Performance shaping factors / Weak Points/ Error Traps

In addition to the cognitive functions described in the SA, several performance shaping factors may play an influential role in the CRO’s ability to handle emergencies. (Performance shaping factors and poor design can impact Error traps).

These factors should be considered when they appear of relevance to the questions at hand. The performance shaping factors have been selected to represent some limited common root causes found in incidents and accidents across various industries. The performance shaping factors to be considered are:

- Competence and training
- Procedures

- Human Machine interface (HMI)
- Teamwork
- Goal conflicts, multitasking
- Time of day
- Time available, Fatigue
- Work environment
- Emergency response
- Interventions
- Fatigue

5.3.3. Exploration of Weak points

In general, a **weak point** is any factor that increases the likelihood of **operator error, delayed action, or reduced system control**, particularly due to design flaws or system shortcomings—not operator fault.

The exploration can start when the scenarios are documented. The analysis proceeds as follows: For each event involving a CRO, questions are asked regarding:

1. Perception
2. Comprehension
3. Future state

The questions are asked to identify how the systems support the situation awareness of the operator and his/her ability to take decisions and execute actions.

The questions from the performance shaping factor checklist are selected for their relevance, e.g.:

- If the event relates to the CRO **perception**; questions regarding human-machine interface may be appropriate, or
- If the event relates to the CRO **comprehension and making future decisions**; questions regarding training, procedures and time available may be appropriate etc.

A weak point is any situation, condition, or system design issue that negatively affects the operator’s (e.g., CRO's) ability to perform effectively, particularly in terms of decision-making and maintaining situational awareness. More specifically, a weak point may arise from:

- **Information System Limitations**: Incomplete, delayed, or poorly presented data, Cluttered or confusing interfaces, Lack of integration between systems
- **Situational Awareness Gaps**: When the CRO is unable to perceive, comprehend, or project the state of the system due to how information is displayed or organized, Overload, distraction, or conflicting cues that reduce awareness
- **Insufficient Decision Support**: Lack of clear, timely, or actionable information to support fast, informed decisions, Missing feedback loops or unclear system responses,
- **Potential Human Error Sources/Error traps**: (Human error refers to unintentional actions or decisions that deviate from expected procedures, often influenced by systemic factors such as design shortcomings, unclear guidelines or environmental stress). Elements that increase the chance of human error are listed in the following sections: Complex procedures, high workload, stress, fatigue, poor alarm management or misleading cues.

5.3.4. Checklist - Perception (information)

Question	Specific situations or design that increases possibility of errors	Consider these factors as background of Error traps
1. Who receives the information?		▪ Competence and training ▪ Procedures ▪ Human-Machine interface ▪ Teamwork ▪ Number of goals ▪ Time of day ▪ Time available ▪ Work environment ▪ Emergency response ▪ Interventions ▪ Fatigue
2. Is the information easily perceived in all relevant contexts?		
3. Is the content of the information relevant?		
4. Can the information be misunderstood?		
5. Where is the information presented?		
6. Are more sources of information available at the same time?		
7. Can these sources be contradicting the main source of information?		
8. Are there rules/procedures that define which sources to trust?		
9. Is the information timely presented?		
10. What happens if the information is not presented?		
11. Are there problems with attention or perception in relation to information presentation?		
12. Are there other factors that influence observation / identification?		

5.3.5. Checklist - Comprehension

Question	Specific situations or design that increases errors	Consider these factors as background of Error traps
13. Can the information be misinterpreted?		▪ Competence and training ▪ Procedures ▪ Human-Machine interface ▪ Teamwork ▪ Number of goals ▪ Time of day ▪ Time available ▪ Work environment ▪ Emergency response ▪ Interventions ▪ Fatigue
14. Does the order in which information is received have any effect on the interpretation?		
15. Are necessary informational elements presented required for a correct interpretation?		
16. If two sources contradict one another, which is considered to be most trustworthy?		
17. How is the reliability of the information assessed?		
18. Are there other factors that influence interpretation?		

5.3.6. Checklist - Projection of future

Question	Specific situations or design that increases errors	Consider these factors as possible Error traps
19. What planning is required?		▪ Competence and training ▪ Procedures ▪ Human-Machine interface ▪ Teamwork ▪ Number of goals ▪ Time of day ▪ Time available ▪ Work environment ▪ Emergency response ▪ Interventions
20. Which decisions must be taken?		
21. Are there any alternatives?		
22. If information is missing, how will this impact on the decision?		
23. Which erroneous decisions can be made? For example, use of wrong rule, use of rule in wrong situation, no use of rule, memory errors?		
24. Are there other factors that influence planning / decision making?		

25. Is the action necessary?		▪ Competence and training ▪ Procedures ▪ Human-Machine interface ▪ Teamwork ▪ Number of goals ▪ Time of day ▪ Time available ▪ Work environment ▪ Emergency response ▪ Interventions
26. Are there alternative actions?		
27. What will happen if the action is not conducted?		
28. What will happen if the action is conducted incorrectly or out of sequence?		
29. What is the expected result in relation to the execution of the action?		
30. Is sufficient means available for execution of the action?		
31. Is it possible to take short-cuts?		
32. If the consequences are different than expected, what corrections can be done?		
33. Are the execution and/or communication verified i.e., can the result of the action be verified?		
34. Can personal motivation affect the actions?		
35. Are there other factors that influence action / execution?		▪ Fatigue

5.3.7. Checklist for issues related to possible error traps

Performance Shaping Factors	**Questions to be considered (for possible Error Traps)**
Competence and training	37) Has the CRO received training on this specific task? (Check unfamiliar, unpredictable). 38) Was the training adequate (theory vs. practice)? 39) If training is not provided for this task, why not? 40) Does the CRO understand the risks involved in the task? 41) Does the CRO's understand their role as human barriers?
Procedures	42) Are there procedures written for the task? 43) Are the procedures accessible? 44) Is it possible to follow the procedures? (Check complex procedures.) 45) Is the sequence of actions in the procedures, correct?
Human-Machine interface	46) Is the operator interaction means sufficient and easy to use? 47) Is necessary information timely available and understandable? 48) Can the CRO see, and use required equipment according to emergency response? 49) Is there a risk of making errors?
Teamwork	50) Are the persons involved to solve the task, trained for it? 51) Is communication central to task success? 52) Is there sufficient communication equipment available? 53) Is the quality of the communication equipment adequate? 54) If communication does not happen or happens too late, what are the consequences? 55) Can communication be misunderstood? 56) Is reception of information confirmed?
Number of goals (Multitasking)	57) Do goal conflicts exist? 58) Does the CRO have guidelines for task prioritisation? (Multitasking is a source of Errors)
Time of day	59) Will it have any impact if the event happens at another time? 60) Is the shift work pattern designed so that it minimises the risk of human error?
Time available	61) Does the CRO have sufficient time available to carry out the task? 62) Is the CRO workload acceptable?

Work environment	63) Does the physical environment allow the CRO to perform the task in the best possible way? 64) Does the psychosocial environment allow the CRO to perform the task in the best possible way?
Emergency response	65) Are roles and responsibilities clear? 66) Are roles and responsibilities clear if a team member fails to show up? 67) Are decisions dependent on onshore personnel? 68) Are the ER plans adequate? 69) Does the CRO receive sufficient support to perform the task?
Interventions	70) Is it difficult to identify and correct errors? 71) What type of information does the CRO receive regarding own errors? 72) Is there sufficient time available to correct errors?
Fatigue	73) Has workload been assessed in relation to tasks, complexity, time of day, length of work period and possible support?

5.3.8. Identification of weak points

The objective is

- To identify weak points in the control centre's ability to handle abnormal situations.

The identification of weak points comprises an identification of possible conditions or safety problems in the achievement of operator tasks, such as high workload or insufficient information. The identification of weak points is based on the *operator action tasks* that are included in the STEP presentation of events. Although only operator *actions* are included in this description, such tasks also involve *identification, interpretation* and *planning* of the situation. Answering the questions in the Scenario Checklist covers problems in operator identification, interpretation and planning.

The scenario represented in the STEP presentation of events is only *one of many possible scenarios.* To investigate operator actions other than the ones described, for each operator action the analyst should ask:

- How could a harmful outcome be produced by changes in operator actions?

In other words, the analyst should look for *other unwanted operator actions* that are feasible at that point in the scenario, due to insufficient information, time pressure, misunderstandings, etc.
For the purpose of the analysis, operator actions in the following will therefore include:

- Operator action tasks identified in the STEP presentation of events.
- Alternative operator actions that are identified.

5.3.9. Guidelines for Identification of weak points

The following process is suggested to identify weak points:

Input STEP presentation of events in the scenario, Scenario Checklist.

Process:

- Consider each operator action task which is identified in the STEP presentation of events.
- Identify weak points in the perception, comprehension and future by answering the questions in the Scenario Checklist. Use the checklist for Performance Shaping factors if more detailed information is needed.
- Before you proceed to a new operator action task, consider other unwanted operator actions that are feasible at each point in the scenario ("alternative operator actions").

Output Weak points in handling the scenario

5.4. Conduct safety barrier analysis based on STEP-scenario

The safety philosophy is generally that *multiple* technical safety devices are installed to prevent escalation of deviations into adverse consequences, However, barriers can be put out of function intentionally or unintentionally, due to errors, variability in work as done or slack in operating procedures on the installation, as well as insufficient component reliability.

When constructing scenarios for the analysis, the following hypothesis must be kept in mind:

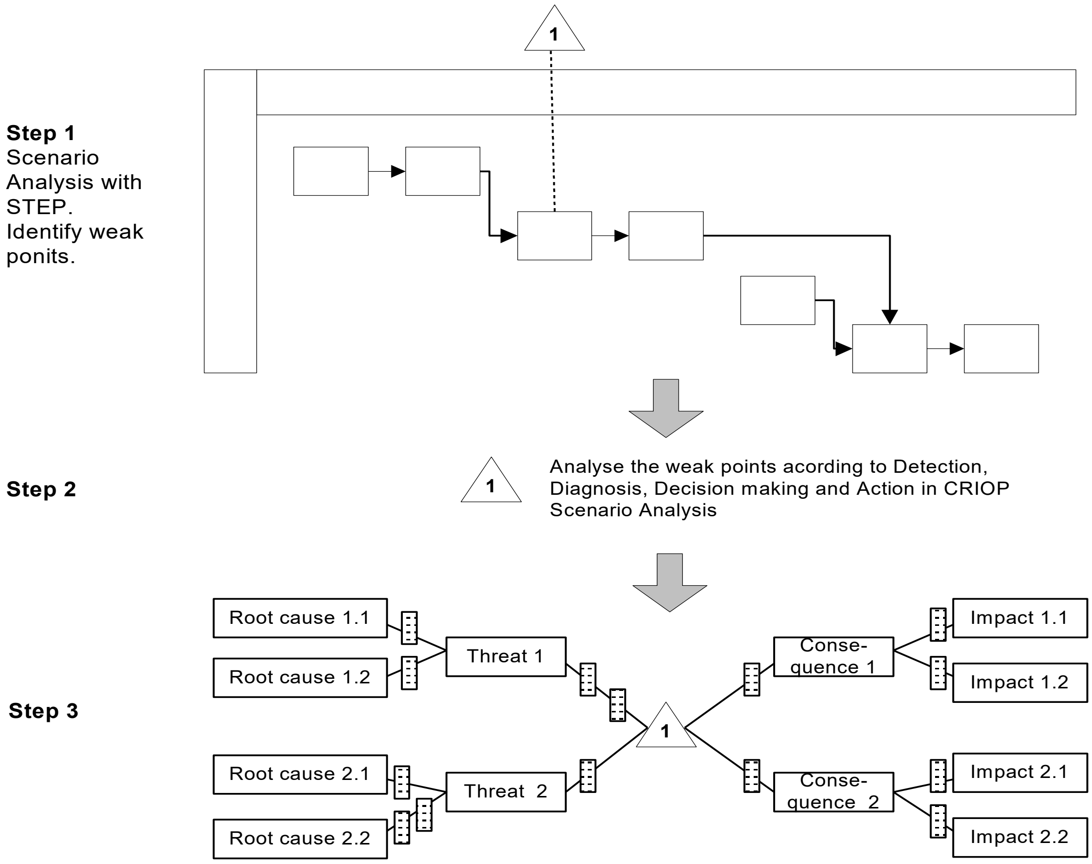
Accident scenarios involve failures in several safety barriers

Experience shows that major incidents typically are caused by a combination of instrument failures, incorrect operator actions and inadequate organisational communication systems. Therefore, safety barriers often include technological, human or organisational elements.

5.4.1. Combining the barrier analysis with STEP

To understand the root causes and consequences of weak points and safety problems found in the Scenario Analysis, the analysis team should evaluate the existing and missing safety barriers. One way of evaluating the safety barriers and their relationship with the weak point is to carry out the three steps shown in Figure 5.5 below. (See also MR Section 5.)

Figure 5.1: Evaluating the weak points in combination with safety barrier analysis (from Fartum, 2003)



Explanation of STEP 3

-Evaluate the threats which can lead to a a weak point
-Identify the root causes leading to the treath
-Identify the Consequences and Impacts of the weak point (use the results from Step 2)
- Identify the existing and missing barriers to hinder root causes and threats
- Identify the existing and missing barriers to reduce negative consequences and impacts
- Summarise weak points, root causes, safety barriers and impacts in a table showing their relations to one another

NB! The triangle represents the weak pointt. The shaded vertical blocs represents safety barriers.

5.5. Developing Recommendations Based on Performance Shaping Factors, Error Traps, and Weak Points

In accident analysis and system design, identifying Performance Shaping Factors (PSFs), error traps, and weak points is essential. However, the critical next step is transforming these insights into concrete recommendations that improve system safety, operator performance, and overall resilience. This chapter outlines a systematic approach for achieving that goal.

5.5.1. Analysing Root Causes

Each identified weak point should be traced back to its root causes:

- **Performance Shaping Factors (PSFs):** Determine which human, environmental, organizational, or task-related factors negatively influence operator performance.
- **Error Traps:** Identify specific situations or design flaws that increase the probability of human error.

A root cause analysis method, such as a Cause-Effect (Fishbone) diagram, can help map the underlying reasons for each weak point clearly. The Cause-Effect Diagram (also known as the Fishbone Diagram) is a visual tool used to systematically identify and present the possible causes of a specific problem or event. The "head" of the fish represents the main problem, while the "bones" branching off represent different categories of root causes, such as known from MTO, i.e. People, Processes, Equipment, Environment, Materials, and Management. Each category can be further broken down into more specific contributing factors. When adapted to the concept of **Situational Awareness (SA)** as described by Mica Endsley, a Fishbone Diagram can be used to explore causes of SA breakdowns at different levels:

- **Perception Issues:** Failures in detecting critical elements in the environment.
- **Comprehension Issues:** Failures in understanding the meaning of perceived information.
- **Projection Issues:** Failures in predicting future system states based on current understanding.

By categorizing causes along these three levels of SA, organizations can systematically diagnose and address weaknesses in how operators perceive, comprehend, and anticipate operational situations.

Another useful method for root cause analysis is **Fault Tree Analysis (FTA)**. FTA is a top-down, deductive approach used to analyse the pathways within a system that can lead to a specific undesirable event (the "top event"). The process begins with the top event and systematically explores all possible causes, breaking them down into intermediate and basic events using logical gates (e.g., AND, OR). FTA provides a structured, visual representation of how combinations of failures and errors can contribute to an accident, helping to identify critical areas for intervention and the need for additional controls or barriers.

5.5.2. Prioritizing Weak Points

Once the weak points and their causes are identified, they should be prioritized based on risk assessment principles—often the user assessment can give a good indication – but the assessment could also be based on evaluating the likelihood of occurrence and the potential severity of consequences. Addressing high-risk weak points first ensures that resources are directed toward the most critical vulnerabilities.

5.5.3. Matching Mitigation Strategies to Causes

Different types of weak points require tailored solutions:

Type of Issue	Example Solution
Poor interface design (error trap)	Redesign displays for clarity and hierarchy
Operator fatigue (PSF)	Improve shift scheduling and implement fatigue management programs
Confusing procedures (PSF + error trap)	Simplify and test procedures for usability
Missing feedback (error trap)	Enhance system status displays and feedback mechanisms
Alarm mismanagement (error trap)	Implement alarm rationalization and prioritization practices

The goal is to align mitigation strategies directly with the causes of errors or vulnerabilities.

5.5.4. Applying a "Defences in Depth" Strategy

Effective recommendations should build multiple layers of defence. Rather than relying solely on training or procedural changes, comprehensive mitigation might involve:

- **Technical Solutions:** Redesigning user interfaces, alarm systems, or control layouts.
- **Organizational Measures:** Enhancing communication protocols, improving staffing models, or adjusting workload distribution.
- **Training and Competence Development:** Regular skill refreshment, scenario-based exercises, and cognitive training.
- **Cultural Interventions:** Promoting a "no-blame" reporting culture to uncover latent issues early.

Combining different types of interventions makes the system more resilient to various types of failure.

5.5.5. Defining Clear, Actionable Recommendations

Recommendations should be:

- **Specific:** Clearly describe the action to be taken.
- **Practical:** Feasible within the given operational, technical, and financial constraints.
- **Measurable:** Allow verification that the action was implemented and had the intended effect.

Example:

"Redesign the alarm interface so that critical alarms are displayed in a dedicated section of the operator console using standardized colour coding (ISO 11064-7), accompanied by unique audible signals." This specificity ensures that recommended changes are not only suggested but also realistically achievable and assessable.

5.5.6. Conclusion

By systematically analysing weak points, prioritizing risks, matching mitigation strategies to causes, applying multiple layers of defence, and defining clear actions, organizations can significantly enhance both human performance and system safety. Transitioning from analysis to recommendation is not only the natural next step—it is essential for creating safer, more reliable, and more effective work systems.

5.5.7. Documentation of Recommendations

Using the identified weak points, the final step of the Scenario Analysis is to Identify measures that should be taken to improve the identified weak points. The documentation of results from the Scenario Analysis should include:

- Copy of the STEP diagram, with documentation of actors, steps and weak points
- A description of operator tasks
- A description of identified weak points
- Reference to questions in the scenario checklists, if relevant
- Suggestions for remedial measures based on the identified weak points

An example is shown in Table 5-3.

Note that many of the findings represent *possible* safety problems that may be used as a basis for recommendations when preparing operators in the handling of abnormal situations.
The weak points do not necessarily require design changes, but in many cases the purpose is rather to prepare and call the operators' attention to possible safety problems.

The identified recommendations should be assessed regarding need for implementation and cost of implementation, although CRIOP does not suggest a systematic procedure for this.
Table 5-3: Documentation of results - example

Weak points from Scenario #1 (Sc1)	**Recommendations (Importance)**	**Resp.**
W1: Alarm texts may be difficult to understand because they are: ▪ Too general, not self-explanatory, do not indicate the nature of the problem ▪ Too short and abbreviated, due to insufficient space provided.	R1:More space should be reserved for alarm texts. **(Importance: High)**	Equ/A. Smith
W2: The oil pump cannot be started from the control room. A field operator must assist the control room operator. (This may increase risks for the field operator)	R2:Means should be provided for operators to start oil pumps from the control room. **(Importance: High)**	Equ/A. Smith
W3: The changing of pumps causes many alarms to appear in the control room, making it difficult to identify additional alarms.	R3:Alarm suppressing mechanisms should be used. **(Importance: Medium)**	Equ/A. Smith

W4: Information concerning the removed valve may be found in the work permit system, but the operator cannot check this within the time available.	R4:In cases where two related/ dependent components are involved, a work permit system should be introduced to prevent start-up before both components have been checked (e.g. using two dependent key locks). (**Importance: Low)**	Equ/A. Smith

5.5.8. Prioritization of weak points/findings

Key findings and the subsequent recommendations should be listed and weighted (or prioritized) based on ratings from the participants in the workshop. Involving each participants helps identify key issues and helps ensuring that issues are resolved. Weighting can be done by giving each participant votes and the findings with the most votes can then be used in prioritization. Weighting/prioritization can also be done based on identifying issues as High importance/ Medium Importance or Low importance. The findings should have references to the relevant checklists (and later scenario analysis) or regulation. Responsibilities and due dates are specified in prioritized actions and must be followed up and tracked.

6. Actions, Implementation, and Follow-up of a CRIOP Analysis

6. Actions, Implementation and Follow up of a CRIOP Analysis

The aim of this section is to describe the result from a CRIOP analysis and how it should be used and followed up.

The report from the CRIOP analysis should be discussed with all the main stakeholders to ensure understanding and commitment to the proposed actions. Both the identified strengths and weaknesses should be mentioned as a result of the analysis, to ensure that we build on the strengths and mitigate the weak points. The competence related to Human Factors is usually varying, and some stakeholders may be negative to some of the identified weaknesses, thus it may be important to highlight both the risks of poor HF and benefits of taking care of HF.

The report from the CRIOP analysis should contain a short summary, containing both positive and negative issues from the CRIOP analysis to ensure that the results from the CRIOP analysis is being distributed and read by the stakeholders and participants. (Examples of earlier CRIOP reports that are open and can be used as examples are available.) The report should be given to the responsible management that initiated the analysis. The report should contain:

1 Introduction and System Description
2 Management Summary of key findings and recommendations
3 Background, list of participants (&responsibilities) and limitations of the performed work
4 Activities performed as a part of the CRIOP verification and validation
5 Findings from the CRIOP workshop (CRIOP Checklists and Scenario)
    a. Documented weak points and recommendations from the General Analysis
    b. Documented weak points and recommendations from the Scenario Analysis
6 A Appendix A: All CRIOP Checklists filled at the CRIOP workshop
7 B Appendix B: Document of Scenario analysis performed at the CRIOP workshop

The weak points and recommendations from the report should be the responsibility of the relevant stakeholders (usually participants in the analysis) with clear responsibility and time schedule regarding follow-up. An action plan should be established, documenting points that are resolved and not resolved. An action is based on a recommendation but may be adjusted taking into consideration budgetary limits, available resources and target date. Short- and long-term actions must be described. The responsible person for each recommendation should as soon as possible plan for actions and deadline for following through (see example in Table 6.1).

Table 6-1: Action Plans as a result of a CRIOP Analysis

Findings/ Weak point			**Recommendations and Actions**		
ID	**Description of the findings**	**Checklist reference**	**ID**	**Description**	**Responsibility (Due date)**
F1	No clear alarm philosophy	#C9, C9.1	CRIOP2	Establish alarm philosophy in accordance with EEMUA 191	Safety lead (Q1, 2025)
F2	No access to daylight is provided in the CC (No available budget)	#W4.1	CRIOP2	Discuss budget and possible mitigating actions	Safety lead (Q1, 2025)

Findings/ Weak point			Recommendations and Actions		
ID	**Description of the findings**	**Checklist reference**	**ID**	**Description**	**Responsibility (Due date)**
F3	Safety Critical Task Analysis (SCTA) pending and need to be finalized	#G7, G9, G15	CRIOP1	Finalize SCTA. Ensure that human factors issues raised are considered and paid attention to in the remaining SCTA workshops.	Safety lead (Q1, 2025)

The management responsible in the initiating organisations should consider changes in the relevant governing variables for each action which is carried out, i.e., changing safety or design procedures.

The findings from this CRIOP analysis should be checked out in the next CRIOP analysis. It should be documented if all findings from previous CRIOP's been followed up in a responsible manner – or not.

7. References (APA-7 standard)

Aas, A. L., Johnsen, S. O., & Skramstad, T. (2009). CRIOP: a human factors verification and validation methodology that works in an industrial setting. In Computer Safety, Reliability, and Security: 28th International Conference, SAFECOMP 2009, Hamburg, Germany, September 15-18, 2009. Proceedings 28 (pp. 243-256). Springer Berlin Heidelberg.

Adressa 28/11-2023- «Moving Ivar Aasen CCR offshore" Flytter 16 arbeidsplasser"

Amalberti, R. (2017). The paradoxes of almost totally safe transportation systems. In Human Error in Aviation (pp. 101-118). Routledge.

ANSI/HFES HRL (2021). Human Readiness Level Scale in the System Development Process.(ANSI/HFES 400- 2021)

ANSI/ISA-99.00.01 series (versions from 2004 to 2007) (See http://www.isa.org/) replaced by the IEC 62443 series of standards, Security for industrial automation and control systems, The following are the published ISA-62443 standards and technical reports:

- ISA-TR99.00.01-2007, Security technologies for industrial automation and control systems
- ISA-62443-1-1-2007, Security for industrial automation and control systems, Part 1-1: Terminology, concepts, and models
- ISA-62443-2-1-2009, Security for industrial automation and control systems, Part 2-1: Establishing an industrial automation and control systems security program
- ISA-TR62443-2-3-2015, Security for industrial automation and control systems, Part 2-3: Patch management in the IACS environment
- ANSI/ISA-62443-2-4-2018 / IEC 62443-2-4:2015+AMD1:2017 CSV, Security for industrial automation and control systems, Part 2-4: Security program requirements for IACS service providers (IEC 62443-2-4:2015+AMD1:2017 CSV, IDT)
- ANSI/ISA-62443-3-2-2020, Security for industrial automation and control systems, Part 3-2: Security risk assessment for system design
- ANSI/ISA-62443-3-3-2013, Security for industrial automation and control systems, Part 3-3: System security requirements and security levels
- ANSI/ISA-62443-4-1-2018, Security for industrial automation and control systems, Part 4-1: Secure product development lifecycle requirements
- ANSI/ISA-62443-4-2-2018, Security for industrial automation and control systems, Part 4-2: Technical security requirements for IACS components

AIBN (2019) – Delrapport 1 om kollisjonen mellom fregatten KNM Helge Ingstad og tankbåten Sola TS utenfor Stureterminalen i Hjeltefjorden, Hordaland, 8. november 2018 (https://havarikommisjonen.no/Sjofart/Avgitte-rapporter/2019-08).

Alsos, O. A., Johnsen, S. O., & Bjørneseth, F. B. (2023). Menneskelige, tekniske og organisasjonsmessige forhold knyttet til Helge Ingstad ulykken. Rapport NTNU.

Amedia (2021) https://www.csidb.net/csidb/incidents/29b9c893-abeb-485d-9c5d-9f71ac9f96b5/

Arbeidsmiljøloven. (2005). *Lov om arbeidsmiljø, arbeidstid og stillingsvern.* (LOV-2005-06-17-62). Lovdata. https://lovdata.no/dokument/NL/lov/2005-06-17-62

Argyris, C. & Schön, D.A. (1974). "*Theory in practice: increasing professional effectiveness.*" Jossey-Bass, San Francisco.

ANSI/HFES (2021). Human Readiness Level Scale in the System Development Process. (ANSI/HFES 400-2021).

Antonsen S., Ramstad L. and Kongsvik T., (2007) "Unlocking the organization: Action research as a means of improving organizational safety", Safety Science Monitor, vol. 11(1).

Bakken, T., Johnsen, S. O., Holmstrøm, S., Merz, M., Transeth, A. A., Grøtli, E. I., ... & Storvold, R. (2020). Bruk av droner i nordområdene. SINTEF report. Retrieved from https://www.havtil.no/contentassets/b9a0b633fd7c4db08f28cef052c81d9d/rapport-om-bruk-av-droner-i-nordomradene.pdf

Barrett (2021) - https://www.sintef.no/globalassets/project/hfc/documents/12-alarm-sounds-based-on-human-factors-ppt-as-pdf.pdf

Begnum, M. E. N. (2021). 11 "User-Centred Agile Development to support sensemaking" in Sensemaking in Safety Critical and Complex Situations Human Factors and Design, 173.

Behm, M., Culvenor J., and Dixon, G. "Development of safe design thinking among engineering students." Safety Science 63 (2014): 1-7.

Behm, M. (2005). Linking construction fatalities to the design for construction safety concept. Safety science, 43(8), 589-611.

Bergh, L. I. V., Teigen, K. S., & Dørum, F. (2024). Human performance and automated operations: a regulatory perspective. Ergonomics, 67(6), 744–758. https://doi.org/10.1080/00140139.2024.2321457

Bergh, L. I. V., & Teigen, K. S. (2024a). AI safety: A regulatory perspective. In 2024 4th International Conference on Applied Artificial Intelligence (ICAPAI) (pp. 1-6). IEEE.

Bjørneseth, F. B. (2021). Unified Bridge–Design Concepts and Results. Sensemaking in Safety Critical and Complex Situations, 135-153.

Bjørkli, C.A., 2003. CRIOP 2003: *Note on the issue of group processes in CRIOP Scenario Analysis.* Internal SINTEF note for the CRIOP 2003 project.

Boehm. (1976). Software engineering. *IEEE Transactions on Computers*, *C–25*(12), 1226–1241. https://doi.org/10.1109/tc.1976.1674590

Briwa, H., Leva, M. C., & Turner, R. (2022). Alarm Management for human performance. Are we getting better? ESREL 2022.

British Standards (BS). (2016). *Emergency Lighting – Code of practice for the emergency lighting of premises*. (Standard No. 5266-1). Retrieved from https://knowledge.bsigroup.com/products/emergency-lighting-code-of-practice-for-the-emergency-lighting-of-premises?version=standard

Bye, R. J., Johnsen, S. O., & Lillehammer, G. (2018). Addressing differences in safety influencing factors—a comparison of offshore and onshore helicopter operations. Safety, 4(1), 4.

Charalampidou, S., Zeleskidis, A., & Dokas, I. M. (2024). Hazard analysis in the era of AI: Assessing the usefulness of ChatGPT4 in STPA hazard analysis. Safety Science, 178, 106608.

CCPS. (1996). *Guidelines for writing effective operating and maintenance procedures*. Center for Chemical Process Safety, American Institute of Chemical Engineers.

CCPS. (2022). *Human factors handbook for process plant operations: Improving process safety and system performance*. Center for Chemical Proecess Safety, American Institute of Chemical Engineers.

CISA (2023a) "Secure-by-Design - Shifting the Balance of Cybersecurity Risk: Principles and Approaches for Secure by Design Software"

CISA (2023) 2023 Top Routinely Exploited Vulnerabilities see https://www.cisa.gov/news-events/cybersecurity-advisories/aa24-317a

CSB (2016) U.S. Chemical Safety and Hazard Investigation Board Investigation Report Volume 3 Report No. 2010-10-I-Os of 4/12/2016 Drilling Rig Explosion And Fire At The Macondo Well

Cummings, M. L. (2024). A Taxonomy for AI Hazard Analysis. *Journal of Cognitive Engineering and Decision Making*,

Dekker, S. (2017). *The field guide to understanding 'human error'*. CRC press.

Dekker, S., & Conklin, T. (2014). "Safety differently." London: CRC Press.

De Winter, J. C., & Dodou, D. (2014). Why the Fitts list has persisted throughout the history of function allocation. Cognition, Technology & Work.

Det Norske Veritas (DNV). (2022). *Electrical Installations*. (Standard No. DNV-OS-D201). Retrieved from https://standards.dnv.com/explorer/document/E9C8B8A389924393B537CF4FFD0DB330/7

Det Norske Veritas. (2023). Automation, Safety and Telecommunication Systems. (Standard No. DNV-OS-D202). Retrieved from https://standards.dnv.com/explorer/document/A7923794B3F74FCD97E1E55452691EFE/6

DNV-RP-A203 (2021) Technology qualification Recommended practice

Dyreborg, J., et al., (2022). Safety interventions for the prevention of accidents at work: A systematic review. Campbell systematic reviews, 18(2), e1234.

Driscoll, T. R., Harrison, J. E., Bradley, C., & Newson, R. S. (2008). The role of design issues in work-related fatal injury in Australia. Journal of Safety Research, 39(2), 209-214.

ECAA (2019) Aircraft Accident Investigation Preliminary Report Ethiopian Airlines Group B737-8 (MAX) Registered ET-AVJ 28 NM South East of Addis Ababa, Bole International Airport March 10, 2019 (https://leehamnews.com/wp-content/uploads/2019/04/Preliminary-Report-B737-800MAX-ET-AVJ.pdf)

Edmonds, J. (2016). *Human factors in the chemical and process industries: Making it work in practice*. Elsevier.

Elvik, R. (2021). Democracy, governance, and road safety. Accident Analysis & Prevention, 154, 106067.

EEMUA 191: The Engineering Equipment and Materials Users Association (EEMUA). (2013). Alarm systems: A guide to Design, Management and Procurement. (Standard No. 191). Retrieved from https://online.standard.no/nb/eemua-publication-191

EEMUA 191: The Engineering Equipment and Materials Users Association (EEMUA). (2024). Alarm systems: A guide to Design, Management and Procurement. (Standard No. 191). Retrieved from https://online.standard.no/nb/eemua-publication-191

EEMUA 201: The Engineering Equipment and Materials Users Association (EEMUA). (2019). Control Rooms: A guide to their specification, design, commissioning, and operations. (Standard No. 201). Retrieved from https://online.standard.no/nb/eemua-publication-201

Endsley, M.R. & Jones, D: (2012) Designing for Situation Awareness. CRC Press, Taylor & Francis Group, Boca Raton, Florida.

Endsley, M.R., 2019. Human Factors & Aviation Safety, Testimony to the United States House of Representatives Hearing on Boeing 737-Max8 Crashes — December 11, 2019

Endsley, M.R. and Garland, D.J. (2000) Situation awareness analysis and measurement, CRC press.

Energy Institute. (2020). Guidance on human factors safety critical task analysis. Energy Institute.

Energy Institute (EI). (2014). Guidance on Crew Resource Management (CRM) and non-technical skills training programmes. (EI Report, 1st. ed.). Retrieved from https://publishing.energyinst.org/topics/human-and-organisational-factors/training-and-competence-including-supervision/guidance-on-crew-resource-management-crm-and-non-technical-skills-training-programmes2

Equinor (2024) Presentation at the drilling conference in Kristiansand

European Standards (EN). (1996). *Safety of machinery – Human Body Measurements – Part 1: Principles for determining the dimensions required for openings for whole body access into machinery.* (Standard No. 547-1). Retrieved from: https://online.standard.no/nb/ns-en-547-1-1996a1-2008

European Standards (EN). (1996). *Safety of machinery – Human Body Measurements – Part 2: Principles for determining the dimensions required for access openings.* (Standard No. 547-2). Retrieved from https://online.standard.no/nb/ns-en-547-2-1996a1-2008.

European Standards (EN). (1996). *Safety of machinery – Human Body Measurements – Part 3: Anthropometric data.* (Standard No. 547-3). Retrieved from https://online.standard.no/nb/ns-en-547-3-1996a1-2008

European Standards (EN). (2006). *Safety of machinery – ergonomic design principles – Part 1: Terminology and general principles.* (Standard No. 614-1). Retrieved from https://online.standard.no/nb/ns-en-614-1-2006a1-2009

European Standards (EN). (1997). *Safety of machinery – Ergonomic requirements for the design of displays and control actuators – Part 1: General principles for human interaction with displays and control actuators.* (Standard No. 894-1). Retrieved from https://online.standard.no/nb/ns-en-894-1-1997a1-2008

European Standards (EN). (1997). *Safety of machinery – Ergonomic requirements for the design of displays and control actuators – Part 2: displays.* (Standard No. 894-2). Retrieved from https://online.standard.no/nb/ns-en-894-2-1997a1-2008

European Standards (EN). (2000). *Safety of machinery – Ergonomic requirements for the design of displays and control actuators – Part 3: Control Actuators.* (Standard No. 894-3). Retrieved from https://online.standard.no/nb/ns-en-894-3-2000a1-2008

European Standards (EN). (2001). *Safety of machinery – Human Physical Performance – Part 1: Terms and definitions.* (Standard No. 1005-1). Retrieved from https://online.standard.no/nb/ns-en-1005-1-2001a1-2008

European Standards (EN). (2003). *Safety of machinery – Human Physical Performance – Part 2: Manual handling of machinery and components parts of machinery.* (Standard No. 1005-2). Retrieved from https://online.standard.no/nb/ns-en-1005-2-2003a1-2008

European Standards (EN). (2002). *Safety of machinery – Human Physical Performance – Part 3: Recommended force limits for machinery operations.* (Standard No. 1005-3). Retrieved from https://online.standard.no/nb/ns-en-1005-3-2002a1-2008

European Standards (EN). (2005). *Safety of machinery – Human Physical Performance – Part 4 – Evaluation of working postures and movements in relation to machinery.* (Standard No. 1005-4). Retrieved from https://online.standard.no/nb/ns-en-1005-4-2005a1-2008

European Standards (EN). (2007). *Safety of machinery – Human Physical Performance – Part 5 – Risk assessment for repetitive handling at high frequency.* (Standard No. 1005-5). Retrieved from https://online.standard.no/nb/ns-en-1005-5-2007

European Standards (EN). (2013). *Emergency lighting regulations.* (Standard No. 1838). Retrieved from https://online.standard.no/nb/ns-en-1838-2013

European Standards (EN). (2021). *Light and lighting – lighting of work places – Part 1: Indoor work places.* (Standard No. 12464-1). Retrieved from https://online.standard.no/nb/ns-en-12464-1-2021

European Standards (EN). (2015). Video surveillance systems for use in security applications - Part 4: Application guidelines. (Standard No. 62676-4). Retrieved from https://online.standard.no/nb/nek-en-62676-4-2015

EU Regulation 376/2014 reporting, analysis and follow-up of occurrences in civil aviation

EU Regulation 2022/1426 on the Type Approval of Automated Driving Systems

EU/AI Act 2024/1689

EU (2017) Guidelines for Indoor Lighting in the Public and Private Service Sector

EU Council Directive 89/391/EEC of 12 June 1989 "on the introduction of measures to encourage improvements in the safety and health of workers at work" (usually known as the Framework Directive).

Fartum, H. (2003). *Krisehåndtering i kontrollsenter* (Hovedoppgave). Norges teknisk-naturvitenskapelige universitet (NTNU).

Federation of Norwegian Industries (2025) "Safety, leadership, and learning – A practical guide to HOP"

Flin, R. H. (1997). Crew resource management for teams in the offshore oil industry. *Team Performance Management: An International Journal*, *3*(2), 121–129. https://doi.org/10.1108/13527599710190876

Folkehelseinstituttet (FHI). (2015). *Anbefalte faglige normer for inneklima.* https://www.fhi.no/anbefalte-faglige-normer-for-inneklima-pdf.pdf

Forskrift om flyttbare produksjonsinnretninger (1994). *Forskrift for flyttbare innretninger med produksjonstekniske installasjoner og utstyr.* (FOR-1994-02-10). Lovdata. https://lovdata.no/dokument/SF/forskrift/1994-02-10-123

Forskrift om støy på arbeidsplassen (2006). Forskrift om vern mot støy på arbeidsplassen. (FOR-2006-04-26). Lovdata. https://lovdata.no/dokument/LTI/forskrift/2006-04-26-456

FOR 1991-12-20 nr 878 Stabilitetsforskriften (1991). Forskrift om stabilitet, vanntett oppdeling og vanntette/værtette lukningsmidler på flyttbare innretninger (FOR-1991-12-20). Lovdata. https://lovdata.no/dokument/SF/forskrift/1991-12-20-878

Frick, E., Tardini, S., & Cantoni, L. (2013). LEGO SERIOUS PLAY-A state of the art of its applications in Europe. White Paper, Università della Svizzera italiana, Lugano, Switzerland.

Ginter, A. (2023). Engineering-Grade OT Security: A manager's guide. Canada: Abterra Technologies Incorporated.

Greenwood, D. J., & Levin, M. (2006). Introduction to action research: Social research for social change. SAGE publications

Havtil (2017) Barrier Memorandum

Havtil (2022) https://www.havtil.no/en/explore-technical-subjects2/technical-competence/news/2022/new-technology-must-take-people-into-account/

Havtil (2022a) Ansvar, kompetanse og vedlikehold avalarmhåndteringssystemer i kontrollrom/ (Responsibility, competence and maintenance of alarm handling systems in control rooms) Activity: 992923

Hale, A.R., & Glendon, A.I. (1987). "*Individual behaviour in the Control of Danger.*" Elsevier Science Publishing Company Inc., New York.

Health and Safety Executive (HSE). (2003). *Organisational change and major accident hazards*. (Chemical Information Sheet No. CHIS7). Retrieved from. http://www.hse.gov.uk/pubns/CHIS7.pdf.

Health and Safety Executive (HSE). (2009). *Procedures audit tool*. Retrieved from https://www.hse.gov.uk/humanfactors/assets/docs/procedures-audit-tool.pdf.

Health and Safety Executive (HSE). (2023a). *Core Topic 4: Reliability and usability of procedures.* Retrieved from https://www.hse.gov.uk/humanfactors/assets/docs/core4.pdf

Health and Safety Executive (HSE). (2023b). *Revitalising Procedures*. Retrieved from https://www.hse.gov.uk/humanfactors/assets/docs/procinfo.pdf

Health- and Safety Executive (HSE). (1999). *Reducing error and influencing behaviour – HSG 48 (2nd. Ed., HSG48)*. HSE Books. Sydbury.

Helgar, S. (2023). Når ISO ikke har alle svarene. Retrived from https://www.sintef.no/globalassets/project/hfc/documents/03-helgar-stein.pdf

Henderson J., Wright K., & Brazier. A. (2002). *Human factors aspects of remote operations in process plants*. HSE, ISBN 0-7176-2355-6.

Hendrick, K., & Benner, L. (1987). *Investigating accidents with STEP*. M. Dekker, New York.

HFAM (2003).- The Norwegian Offshore Directorate (NPD). HFAM Human Factors (HF) - Assessment Method - Human factors i kontrollrom. retrieved at https://www.sintef.no/globalassets/project/hfc/documents/englishhfam_final.pdf

Hollifield, et al. (2008). The high performance HMI handbook: Houston: Pas.

Hollnagel, E., Nemeth, C. P., & Dekker, S. (2008). Resilience Engineering Perspectives, Volume 1: Remaining sensitive to the possibility of failure (pp. XIV-332). Ashgate.

Home Office (2025) UK – retrieved at https://www.gov.uk/guidance/recommended-standards-for-the-cctv-industry" standards-for-public-space-cctv-control-roomsoperators

Hollnagel, Erik (2017). Safety-II in practice: Developing the resilience Potentials. Routledge.

Hollnagel, E. (1998). *Cognitive reliability and error analysis method*. Oxford UK, Elsevier.

Hollnagel, E. (1999). *Accident analysis and barrier functions*. IFE, Halden.

Hopkins, A. (2000). *Lessons from Longford –The Esso Gas Plant Explosion*. CCH Australia, Ltd.

Home Office UK. (2009). *CCTV Operational Requirements Manual*. (Publication No. 28/09). https://comfortzone-cctv.co.uk/wp-content/uploads/2019/04/Home-Office-CCTV-Operations-Manual-HOSDB-2009.pdf

Hurlen, L., Eitrheim, M., Rindahl, G., & Heps, V. (2022). Concepts for Operating Multiple Petroleum Facilities from a Single Control Center. ESREL

HSE (2015) Literature review: Barriers to the application of Human Factors/ Ergonomics in engineering design – retrieved from https://www.hse.gov.uk/research/rrpdf/rr1006.pdf

HSE (2003) Factoring the human into safety: Translating research into practice Crew Resource Management Training for Offshore Operations Volume 3 (of 3) https://www.hse.gov.uk/research/rrhtm/rr061.htm

Hydro (2019) - https://www.hydro.com/Document/Index?name=General%20cyber-attack%20presentation%20April%2012.pdf&id=28255

IEA (2000)- International Ergonomics Association, retrieved at 2025.01.20 from https://iea.cc/about/what-is-ergonomics/

IEA/ILO (2021) «Principles and Guidelines for Human Factors/Ergonomics - Design and Management of Work Systems" from IEA/ILO - SBN 978-92-2-035590-9

Insag-7 (1992) - INSAG-7: The Chernobyl Accident: Updating of INSAG-1". IAEA. 1992

International Electrotechnical Commission (IEC). (2010). *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*. (Standard No. 61508-1). Retrieved from https://online.standard.no/nb/nek-iec-61508-1-2010

International Electrotechnical Commission (IEC). (2016). *Functional Safety – safety instrumented systems for the process industry sector – part 1: Framework, definitions, systems, hardware and application programming requirements.* (Standard No. 61511-1). Retrieved from https://online.standard.no/nb/nek-iec-61511-1-2016a1-2017-csv

International Electrotechnical Commission (IEC). (2023). *Electromagnetic compatibility (EMC) – Part 5-1: Installation and mitigation guidelines – General considerations.* (Technical Report - Standard No. 61000-5-1). Retrieved from https://online.standard.no/nb/nek-iec-tr-61000-5-1-2023

International Electrotechnical Commission (IEC). (2019). *Mobile and fixed offshore units – Electrical installations – Part 2: System design.* (Standard No. 61892-2). Retrieved from https://online.standard.no/nb/nek-iec-61892-2-2019

International Electrotechnical Commission (IEC). (2023). *Management of alarm systems for the process industries.* (Standard No. 62682). Retrieved from https://online.standard.no/nb/nek-en-iec-62682-2023

IEC 63303:2024 - International Electrotechnical Commission Human machine interface for process automation systems

Institute for Energy Technology (IFE). (2003). *Group-view displays (IFE report* HR/F-2003/1208). IFE.

IFE "Operating autonomous ships remotely from land-based operation centres: The current state-of-the-art" (2020)

Ingstad, O. & Bodsberg, L. (1990). *CRIOP: A Scenario-method for Evaluation of the Offshore Control Center* (SINTEF rapport STF A89028). SINTEF Teknologiledelse.

Ingstad, O., Rosness, R. & Sten, T. (1989). *Evaluation of the CRIOP-method* (SINTEF rapport STF A89055). SINTEF Teknologiledelse.

International Organization of Oil and Gas Production (IOGP). (2014). *Guidelines for implementing Well Operations Crew Resource Management training* (IOGP Report 502). Retrieved from https://www.iogp.org/bookstore/product/guidelines-for-implementing-well-operations-crew-resource-management-training/

IOGP (2017) Report 423 – HSE management – guidelines for working together in a contract environment

IOGP (2024) Report 656 – Assessment of eye tracking technology in well control operations – onshore

ISA-101.01-2015, Human Machine Interfaces for Process Automation Systems

ISO Standards, see: http://www.iso.ch/iso

- International Organization for Standardization. (1997). *Evaluation of human exposure to whole body vibrations* (Standard No. 2631-1). Retrieved from https://online.standard.no/nb/ns-iso-2631-1-1997
- International Organization for Standardization. (2001). *Guidelines for measurement and assessment of human body exposure to hand transmitted vibration*. (Standard No. 5349-1). Retrieved from https://online.standard.no/nb/ns-en-iso-5349-1-2001
- International Organization for Standardization. (2016). *Ergonomics principles in the design of work systems* (Standard 6385).
- International Organization for Standardization. (2003). ISO 7731:2003 - Danger signals for public and work areas
- International Organization for Standardization. (1999). *Ergonomic requirements for office work with visual display terminals (VDTs) – Guidance on the work environment* (Standard No. 9241-6). Retrieved from https://online.standard.no/nb/ns-en-iso-9241-5-1999
- International Organization for Standardization. (1999). *Ergonomic requirements for office work with visual display terminals (VDTs) – Workstation layout and postural requirements*. (Standard No. 9241-5). Retrieved from https://online.standard.no/nb/iso-9241-6-1999
- International Organization for Standardization. (2018). Usability; Ergonomics of human-system interaction Part 11: Usability: Definitions and concepts (Standard No. 9241-11). Retrieved from https://online.standard.no/nb/iso-9241-6-1999
- International Organization for Standardization. (2019). ISO 9241-210:2019 *Ergonomics of human-system interaction Part 210: Human-centred design for interactive systems*

- International Organization for Standardization. (2007). *Ergonomics of human-system interaction: Principles and requirements for physical input devices.* (Standard No. 9241-400).
- International Organization for Standardization. (2020). ISO/TR 9241-810 Ergonomics of human-system interaction — Part 810: Robotic, intelligent and autonomous systems
- International Organization for Standardization. (2003). *Assessment of speech communication.* (Standard No. 9921). Retrieved from https://online.standard.no/nb/iso-9921-2003-2
- International Organization for Standardization. (2000). *Ergonomic principles related to mental workload – design principles.* (Standard No. 10075-2). Retrieved from https://online.standard.no/nb/ns-en-iso-10075-2-2000
- International Organization for Standardization. (2025). ISO 10218-1:2025 Robotics — Safety requirements — Part 1: Industrial robots; ISO 10218-2:2025 Robotics — Safety requirements — Part 2: Industrial robot applications and robot cells
- International Organization for Standardization. (2000). *Principles for design of control centres* (Standard No. 11064-1). Retrieved from https://online.standard.no/nb/iso-11064-1-2000
- International Organization for Standardization. (2000). *Principles for arrangements of control suites.* (Standard No. 11064-2). Retrieved from https://online.standard.no/nb/iso-11064-2-2000
- International Organization for Standardization. (1999). *Control room layout.* (Standard No. 11064-3). Retrieved from https://online.standard.no/nb/iso-11064-3-1999
- International Organization for Standardization. (2013). *Layout and dimensions of workstations.* (Standard No. 11064-4). Retrieved from https://online.standard.no/nb/ns-en-iso-11064-4-2013
- International Organization for Standardization. (2008). *Displays and controls (*Standard No. 11064-5). Retrieved from https://online.standard.no/nb/iso-11064-5-2008-2
- International Organization for Standardization. (2005). *Environmental requirements of control centres.* (Standard No. 11064-6). Retrieved from https://online.standard.no/nb/iso-11064-6-2005-3
- International Organization for Standardization. (2006). *Principles for the evaluation of control centres.* (Standard No. 11064-7). Retrieved from https://online.standard.no/nb/iso-11064-7-2006-3
- International Organization for Standardization. (2010). *Safety of machinery – General principles for design. (*Standard No. 12100). Retrieved from https://online.standard.no/nb/iso-12100-2010-3
- International Organization for Standardization. (2006). *Principles for the evaluation of control centres.* (Standard No. 11064-7). Retrieved from https://online.standard.no/nb/iso-11064-7-2006-3
- International Organization for Standardization. (2016). *Offshore production installations – Major accident hazard management during the design of new installations.* (Standard No. 17776). Retrieved from https://online.standard.no/nb/iso-17776-2016
- International Organization for Standardization/International Electrotechnical Commission. (2022). *Information security, cyber security and privacy protection – information security management systems - requirements.* (Standard No. 27001). Retrieved from https://online.standard.no/nb/nek-isoiec-27001-2022

- International Organization for Standardization/International Electrotechnical Commission. (2022). *Information security, cybersecurity and privacy protection - Information security controls*. (Standard No. 27002). Retrieved from https://online.standard.no/nb/nek-isoiec-27002-2022

ISO/IEC 25000:2014 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guide to SQuaRE

ISO/IEC 27002:2022 Information security, cybersecurity and privacy protection — Information security controls

Jamrozik, A., Clements, N., Hasan, S. S., Zhao, J., Zhang, R., Campanella, C., ... & Bauer, B. (2019). Access to daylight and view in an office improves cognitive performance and satisfaction and reduces eyestrain: A controlled crossover study. Building and Environment, 165, 106379..

Janis, I.L. (1982). *Groupthink: Psychological Studies of Policy Decisions and Fiascoes.* Houghton Mifflin, Boston.

Jaatun M. G., Johnsen S. O., Line M. B., Longva O. H., Tøndel I. A., Albrechtsen E. & Wærø I. (2007*). Incident Response Management in the oil and gas industry* (SINTEF rapport A4086). SINTEF. ISBN: 978821-40-40-746.

Johnsen, S. O., Hansen, C. W., Nordby, Y., & Dahl, M. B. (2006). Measurement and improvement of information security culture. *Measurement and Control*, *39*(2), 52–56. https://doi.org/10.1177/002029400603900203

Johnsen, S.O. (2005a). *CRIOP 2003, oppdatert forslag til prosjektdefinisjon*. Powerpoint presentasjon med oppsummering fra CRIOP-møte 26-27/10 2005.

Johnsen, S.O., Lundteigen, M.A., Fartum, H. & Monsen, J. (2005b). Identification and reduction of risks in remote operations of offshore Oil and Gas installations. In Kolowrocki, K. (ed.). *Advances in safety and reliability. Proceedings from the European Safety and Reliability Conference -ESREL 2005* (Vol.1, p. 957-964). Leiden, Balkema.

Johnsen S.O., Askildsen A. & Hunnes K. (2005). Challenges in remote control and remote co-operation of offshore oil and gas installations in the North Sea. In Kolowrocki, K (ed.). *Advances in safety and reliability; proceedings of the European Safety and Reliability Conference, (ESREL 2005) (p. 965-971).* Tri City (Gdynia, Sopot, Gdansk), Poland, 27-30 June, 2005. Taylor & Francis Group. ISBN 0415383404.

Johnsen S.O, Holen S., Aalberg A.L., Bjørkevoll K.S., Evjemo T.E., Johansen G., Myklebust T., Okstad E., Pavlov A., Porathe T., "Automatisering og autonome systemer: -Menneskesentrert design" (2020) SINTEF Rpt:2020:01442

Johnsen, S. O., & Aminoff, H. (2024). Use of ANSI/HFES Human Readiness Level to ensure safety in automation. Human Factors in Design, Engineering, and Computing, 159(159).

Johnsen, S. O., and S. Winge. "Human Factors and safety in automated and remote operations in oil and gas: A." (2023), ESREL.

Johnsen, S.O. & Park J. "Meaningful human control with increased digitalization, automation, and remote oversight" ESREL 2025 – European Conference on Safety and Reliability (ESREL) 15-19 JUNE 2025

Kirwan, B. & Ainsworth, L.K. (Eds.). (1992). *A guide to task analysis.* Taylor & Francis, London.

Kinnersley, S., & Roelen, A. (2007). The contribution of design to accidents. Safety Science, 45(1-2).

Kirwan, B. "Human Factors Requirements for Human-AI Teaming in Aviation." (2025).

Kjellén, U. (2000). *Prevention of accidents through experience feedback.* Taylor & Francis, New York.

Kotter, J. P. (1996). *Leading Change*. Harvard Business School Press.

Laumann, K., Rasmussen, M., & Boring, R. L. (2018). A literature study to explore empirically: what is the scientific discipline of human factors and what makes it distinct from other related fields. In *Proceedings of the AHFE 2017 International Conference on Human Error, Reliability, Resilience, and Performance, July 17–21, 2017, Los Angeles, California, USA 8* (pp. 63-73). Springer International Publishing.

Leva, M. C., Naghdali, F., & Alunni, C. C. (2015). Human factors engineering in system design: a roadmap for improvement. Procedia Cirp, 38, 94-99.

Lee J.D., Wickens C. D., Liu. Y, Boyle, L. "Designing for People: An Introduction to Human Factors Engineering" – (2017) CreateSpace), ISBN-10: 1539808009

Liu, M., Wang, J., Lin, T., Ma, Q., Fang, Z., & Wu, Y. (2024). An empirical study of the code generation of safety-critical software using llms. *Applied Sciences*, *14*(3), 1046.

Maersk (2017) - https://sosintel.co.uk/case-study-maersks-response-to-notpetya-how-cybersecurity-best-practices-mitigated-a-major-cyberattack/

Mearns (2001) Mearns, K., Flin, R., & O'Connor, P. (2001). Sharing worlds of risk: Improving communication with Crew Resource Management. *Journal of Risk Research, 4*(4), 377-392. https://doi.org/10.1080/13669870110063225

Meshkati, N. (2006). Safety and human factors considerations in control rooms of oil and gas pipeline systems: conceptual issues and practical observations. International journal of occupational safety and ergonomics, 12(1), 79-93.

Miranda, A.T. (2019) Misconceptions of human factors concepts, Theoretical Issues in Ergonomics Science, 20:1, 73-83,

Mills, P. R., Tomkins, S. C., & Schlangen, L. J. (2007). The effect of high correlated colour temperature office lighting on employee wellbeing and work performance. Journal of circadian rhythms, 5, 1-9.

Moura, R., Beer, M., Patelli, E., Lewis, J., & Knoll, F. (2016). Learning from major accidents to improve system design. Safety science, 84, 37-45.

NAS - National Academies of Science (2021) Human-AI Teaming: State of the Art and Research Needs (2021).

NASA TLX (1986) https://ntrs.nasa.gov/api/citations/20000021488/downloads/20000021488.pdf

Nazaruk, M. (2022). Find out where and how your next accident may happen with learning from normal work. Retrieved from https://www.sintef.no/globalassets/project/hfc/documents/nazaruk-2022-learning-from-normal-work.pdf

National Institute of Standards and Technology (NIST). (2007). SP 800-82. *Guide to Industrial Control Systems (ICS) Security*. (Standard No. SP 800-82). Retrieved from http://csrc.nist.gov/publications/drafts/800-82/2nd-Draft-SP800-82-clean.pdf

Nazaruk, M (2022), “Find out where and how your next accident may happen with learning from normal work” - https://www.sintef.no/globalassets/project/hfc/documents/nazaruk-2022-learning-from-normal-work.pdf

Norman, D. (2013). The design of everyday things: Revised and expanded edition. Basic books.

Nortura (2021) - https://www.linkedin.com/pulse/when-cyberattacks-hit-close-home-case-nortura-peter-ottis/

NIOSH “Prevention through Design Program” (2024) - https://www.cdc.gov/niosh/research-programs/portfolio/ptd.html

NI- Norsk Industri (2025) A practical guide to HOP from www.norskindustri.no/siteassets/dokumenter/hms/hop/hop-veileder-engelsk-2024-3005.pdf

NOG 104 (2016); Norwegian Oil and Gas’ Guideline No. 104 OLF Retningslinjer 104 ISBR (2016)

NORSOK Standards, see: http://www.standard.no/standard/index.db2?id=1780

- Norsk Sokkels Konkurranseposisjon. (2015). *Living Quarters Area.* (Standard No. C-001, rev. 4). Retrieved from https://online.standard.no/nb/norsok-c-001-2022
- Norsk Sokkels Konkurranseposisjon. (2015). *Architectural components and equipment.* (Standard No. C-002, rev. 3). Retrieved from https://online.standard.no/nb/norsok-c-002-2015
- Norsk Sokkels Konkurranseposisjon. (2023). *Drilling Facilities.* (Standard No. D-001, rev. 3). Retrieved from https://online.standard.no/nb/norsok-d-001-2023
- Norsk Sokkels Konkurranseposisjon. (2021). *Technical Safety.* (Standard No. S-001, rev. 4). Retrieved from https://online.standard.no/nb/norsok-s-001-2020ac-2021
- Norsk Sokkels Konkurranseposisjon. (2018). *Arbeidsmiljø.* (Standard No. S-002, rev. 5). Retrieved from https://online.standard.no/nb/norsok-s-002n-2018ac-2021-2
- Norsk Sokkels Konkurranseposisjon. (2021). *Industrial Automation and Control Systems.* (Standard No. I-002, rev. 2). Retrieved from https://online.standard.no/nb/norsok-i-002-2021
- Norsk Sokkels Konkurranseposisjon. (2001). *Electrical Systems.* (Standard No. E-001, rev. 4). Retrieved from https://online.standard.no/nb/norsok-e-001-2016
- Norsk Sokkels Konkurranseposisjon. (2024). *Risk and Emergency Preparedness.* (Standard No. Z-013, rev. 8). Retrieved from https://online.standard.no/nb/norsok-z-013-2024

Norwegian Labour Inspection Authority (NLIA). (2003). *Order 516 - Climate and Air Quality in the Workplace*. Retrieved from http://www.arbeidstilsynet.no/om/engelsk.html

NLIA- The Workplace Regulations. (2013). *The Workplace Regulations* (FOR-2011-12-06-1356). Arbeidstilsynet (NLIA). http://www.arbeidstilsynet.no/en/laws-and-regulations/regulations/the-workplace-regulations

NTSB (2010) National Transportation Safety Board. 2010. Aircraft Accident Report NTSB/AAR-10 /03. Washington, DC.

NTSB (2017) Highway Accident Report "Collision between a car Operating With Automated Vehicle Control Systems and a tractor-Semitrailer Truck" Fra https://www.ntsb.gov/investigations/AccidentReports/Pages/HWY16FH018-preliminary.aspx

NTSB (2019b) ASR-19-01 Safety Recommendation Report: "Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance" https://ntsb.gov/investigations/AccidentReports/Pages/ASR1901.aspx

NTSB (2019) National Transportation Safety Board, 'Collision between US Navy Destroyer John S McCain and Tanker Alnic MC. Singapore Strait 5 Miles Northeast of Horsburgh Lighthouse August 21, 2017" Marine Accident Report: NTSB/MAR-19/01 PB2019-100970)', 2019.

NTSB (2020) National Transportation Safety Board "Collision between US Navy Destroyer Fitzgerald and Philippine-Flag Container Ship ACX Crystal Sagami Nada Bay off Izu Peninsula, Honshu Island, Japan June 17, 2017. Marine Accident Report NTSB/MAR-20/02 PB2020-101007

NPD /OD (Oljedirektoratet):

- Styringsforskriften (MR). (2011a). *Forskrift om styring og opplysningsplikt i petroleumsvirksomheten og på enkelte landanlegg* (FOR-2010-04-29-611). Lovdata. https://lovdata.no/nav/forskrift/2010-04-29-611
- Aktivitetsforskriften (AR). (2011a). *Forskrift om utføring av aktiviteter i petroleumsvirksomheten* (FOR-2010-04-29-613). Lovdata. https://lovdata.no/dokument/SF/forskrift/2010-04-29-613
- Rammeforskriften (FR). (2011c). *Forskrift om helse, miljø og sikkerhet i petroleumsvirksomheten* (FOR-2010-02-12-158). Lovdata. https://lovdata.no/dokument/SF/forskrift/2010-02-12-158
- Innretningsforskriften (FA). (2011d). *Forskrift om utforming og utrustning av innretninger i petroleumsvirksomheten* (FOR-2010-04-29-634). Lovdata. https://lovdata.no/dokument/SF/forskrift/2010-04-29-634
- Teknisk og operasjonell forskrift (TOR). (2011e). *Forskrift om tekniske og operasjonelle forhold på landanlegg i petroleumsvirksomheten med mer* (FOR-2010-04-29-612). Lovdata. https://lovdata.no/dokument/SF/forskrift/2010-04-29-612

NPD /OD (Oljedirektoratet):

- Prinsipper for utforming av alarmsystemer. (2002f). *Basis i en tilsynsserie gjennomført av OD. Powerpoint presentasjon fra OD.* (In Norwegian only)
- 2003. Utvikling i risikonivå – norsk sokkel. Sammendragsrapport. Fase 3 – 2002. Stavanger, 2003.

Nyström, S. Nielsen C.K., Nordström, D., (2019) "Reducing Costs Of Air Traffic Control" , Copenhagen Economics A/S, Stockholm 26 March (Found at https://copenhageneconomics.com/wp-content/uploads/2021/12/reducing-costs-of-air-traffic-control.pdf

NUREG- U.S. Nuclear Regulatory Comission (NUREG) (2020). *Human-System Interface Design Review Guidelines* (Standard No. NUREG-0700, Rev. 3). Retrieved from http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/index.html

O`Hara, J. M., Brown, W. S., Higgins, J. C., & Stubler, W. F. (1994). *Human Factors Engineering Guidance for the Review of Advanced Alarm Systems*. https://doi.org/10.2172/10189333

OpenBridge (2025) Design System https://www.openbridge.no/

OpenRemote (2025) https://www.oicl.no/projects/openremote

Offshore Norge (OLF). (2007). *Information Security Baseline Requirements for Process Control, Safety, and Support ICT Systems*. (OLF Guideline No. 104). Revised 2016 Retrieved from http://www.olf.no/hms/retningslinjer/?32546

Orasanu, J., Fischer, U., Davison, J. (1997). *Cross-cultural barriers to effective communication in Aviation.* In C.S. Gransrose & S. Oskamp (Eds) *Cross-cultural workgroups.* Beveley Hills: Sage.

Paridon, H. M., & Kaufmann, M. (2010). Multitasking in work-related situations and its relevance for occupational health and safety: Effects on performance, subjective strain and physiological parameters. Europe's Journal of Psychology, 6(4), 110-124.

Perrow, C. (1999). *Normal Accidents: Living with High-Risk Technologies*. Princeton University Press, Princeton, N.J.

Pinto, J. K. (1998). *Power & Politics in project management*. Project Management Institute.

Porathe, S. T. (2023). Alarm and hand-over concepts for human remote operators of autonomous ships. In Proceedings of ESREL 2023)

PSA (2019) Report "Investigation of collision between Sjoborg supply ship and Statfjord A on 7 June 2019"

PSA - Petroleumstilsynet (Ptil). (2009). *Trends in Risk Level in the Petroleum Activity*. Retrieved from www.ptil.no/getfile.php/PDF/RNNP%202009/Trends%20in%20risk%20levels%20-%20Summary%20Report%202009.pdf

PSA (2020) Report of the investigation of an incident with a ram door blown off a BOP during a connection test on Rowan Stavanger 14 September 2020

Rasmussen, J. (1997). Risk management in a dynamic society: A modelling problem. *Safety Science*, *27*(2–3), 183–213. https://doi.org/10.1016/s0925-7535(97)00052-0

Reason, J. (1995). A systems approach to organizational error. *Ergonomics*, *38*(8), 1708–1721. https://doi.org/10.1080/00140139508925221

Reason, J. T. (1997). *Managing the risks of organizational accidents*. Ashgate.

Riksrevisjonen (2019) Dokument 3:6 (2018–2019) / Undersøkelse av Petroleumstilsynets oppfølging av helse, miljø og sikkerhet

Rosness, R., Håkonsen, G., Steiro, T. & Tinmannsvik, R.K. (2000, June 15-16.). *The vulnerable robustness og High Reliability Organisations: A case study report from an offshore oil production platform.* Paper presented at the 18th ESREDA seminar Risk Management and Human Reliability in Social Context. Karlstad, Sweden.

Roussel, P.A. (1991). *Third Generation R&D*. Harvard Business School Press.

Sammour, F., Xu, J., Wang, X., Hu, M., & Zhang, Z. (2024). Responsible AI in Construction Safety: Systematic Evaluation of Large Language Models and Prompt Engineering. *arXiv preprint arXiv:2411.08320*.

Samset, K. 2001. Prosjektvurdering i tidligfasen. Fokus på konseptet (Front-end Assessment of Projects. Focus on the concept" , University textbook, Tapir Academic Press, ISBN 82-519-1679-8, Trondheim 2001; Side 39 - Figur 4.2

Safety forum -Sikkerhetsforum (2019) Learning from incidents/Rapport fra Sikkerhetsforum

Sandhåland, H., Oltedal, H., & Eid, J. (2015). Situation awareness in bridge operations study of collisions between attendant vessels and offshore facilities in the North Sea. Safety science, 79, 277-285.

Safetec (2023) “Endrede rammebetingelser og konsekvenser for sikkerhet og arbeidsmiljø i petroleumsvirksomheten”

Salomonsen, C. et al. (2019) «Sikker design i havbruk” SINTEF Rapport 2019:00574 ISBN 978-82-14-06326-4

SfS (2023) - SfS Anbefaling 051N/2023- “Sikker kommunikasjon” https://www.linkedin.com/advice/0/heres-how-you-can-enhance-safety-communication-oil-gas-h5jkf

Shorrock, S «Work as imagined& Work as done – Mind the Gap” - https://www.sintef.no/globalassets/project/hfc/documents/09-shorrock_-_waiwad_mind_the_gap.pdf

Smith, L., Folkard, S., & Poole, C. J. M. (1994). Increased injuries on night shift. The Lancet, 344(8930), 1137-1139

Stanton, N. A., Salmon, P. M., Rafferty, L. A., Walker, G. H., Baber, C., & Jenkins, D. P. (2013). Human factors methods: a practical guide for engineering and design. CRC Press.

Skjerve, A.B., Rosness, R., Aase, K., Hauge, S. & Hovden, J. (2004, June 14-18). *Human and Organizational Contributions to Safety Defences in Offshore Oil Production.* Paper presented at ESREL 2004. Berlin, Germany.

Smidt Olsen, A. & Wendel, E. (1998). *Metode for analyse av menneskets rolle i storulykker* (Fordypningsoppgave). Institutt for Industriell økonomi og teknologiledelse, studieretning Helse, Miljø og Sikkerhet, Norges teknisk-naturvitenskapelige universitet (NTNU).

Sten, T., Bodsberg, L., Grefstad, J.E., 1999. *A scenario method for evaluation of control centres at offshore oil and gas production intallations* I Schueller and Kafka (eds.). Proceedings of ESREL`99 - European Safety and Reliability Conference (pp. 1303–1308). Balkema, Rotterdam.

Stanton, N. A., Salmon, P. M., Rafferty, L. A., Walker, G. H., Baber, C., & Jenkins, D. P. (2013). *Human factors methods: a practical guide for engineering and design*. Ashgate.

Stanton, N. A., Salmon, P. M., Walker, G. H., Salas, E., & Hancock, P. A. (2017). State-of-science: situation awareness in individuals, teams, and systems. Ergonomics, 60(4), 449–466. https://doi.org/10.1080/00140139.2017.1278796

St. Meld. 7. (2001-2002). *Om helse, miljø og sikkerhet i petroleumsvirksomheten.* Det Kongelige Arbeids- og administrasjonsdepartement.https://www.regjeringen.no/contentassets/dfd4ef4df070442b802559d1bc810715/no/pdfa/stm200120020007000dddpdfa.pdf

Surry, J. (1974). *Industrial Accident Research. A Human Engineering Appraisal.* Labour Safety Council, Ontario Ministry of Labour, Toronto.

Szymberski, R. T. (1997). Construction project safety planning. Tappi Journal, 80(11), 69-74.

Sætren, G.B., Hogenboom, S., Laumann, K., (2016). A study of a technological development process: Human factors—the forgotten factors? Cognition, Technology & Work 18, 595– 611.

Tschimmel, K. (2012). Design Thinking as an effective Toolkit for Innovation. In ISPIM Conference Proceedings (p. 1). The International Society for Professional Innovation Management (ISPIM).

Thun S., Tinmannsvik R. «PRoIND - Proaktive indikatorer for psykososialt og organisatorisk arbeidsmiljø" (2021)

United Kingdom Atomic Energy Authority (UKAEA). (1985). *Guide to reducing Human Error in Process Operations – Short Version*. SRD Associates, United Kingdom.

US-CSB (2016) U.S Chemical Safety and Hazard Investigation Board. Drilling rig explosion and fire at the Macondo well. Investigation report volume 3, Report no. 2010-10- I-OS, 20 April 2016. Washington, DC

Vatn, G & Åm. (1997). *Prosedyreutvikling. Metode for analyse og beskrivelse av arbeidsoppgaver (SINTEF rapport* STF38 A9741). SINTEF.

van Winsen, R., & Dekker, S. W. (2016). Human factors and the ethics of explaining failure. In Human Factors and Ergonomics in Practice: Improving System Performance and Human Well-Being in the Real World (pp. 65-76). CRC Press.

Waraich, Q. R., Mazzuchi, T. A., Sarkani, S., & Rico, D. F. (2013). Minimizing human factors mishaps in unmanned aircraft systems. Ergonomics in design, 21(1), 25-32.

Weidinger, L., Uesato, J., Rauh, M., Griffin, C., Huang, P.S., Mellor, J., Glaese, A., Cheng, M., Balle, B., Kasirzadeh, A. and Biles, C., 2022,Taxonomy of risks posed by language models. In: Proceedings of the 2022 ACM Conference on Fairness, Accountability, and Transparency (pp. 214-229).

Winge, S., Kilskar, S. S., & Johnsen, S. O. (2023). A Guide for Identifying Human Factors in Accident Investigations. Proceeedings Esrel 2023

Wróbel, K. (2021). Searching for the origins of the myth: 80% human error impact on maritime safety. Reliability Engineering & System Safety, 216, 107942.

Yasseri, S., & Bahai, H. (2018). System readiness level estimation of oil and gas production systems. International Journal Of Coastal, Offshore and Environmental Engineering (ijcoe), 3(2), 31–44

Appendix

A – Scenarios, elements that can be used as a starting point for scenarios

Exploration of scenarios can also be done supported by tools such as Lego Serious Play, see Frick, et al. (2013). AI/LLM can help to identify scenarios and "edge cases" that can stress the system. Accident scenarios can be prepared and gathered based on recent relevant elements that has been highlighted, in combination with added conditions as described in performance shaping factors. In table A.1 we have listed elements and some consequences that can be explored further.

Table A.1: List of possible elements that can be explored in a scenario

Scenario elements	Possible elements (based on experience) that can be explored
General: Remote operation	Some issues related to remote: Boredom. Many different tasks, overload in some situations. Poor HMI quality of systems supporting remote operation, Poor Alarms. Loss off communication; Loss of "weak signals" and loss of perception from being close to the operation.
Incident due to drone	Surprise/ Incident (i.e. collision/ drone falling down) due to drone in air, at surface or under water – often poor quality of HMI – there is 100 time as many incidents from drone's vs human controlled systems.
General Security incident	Security incident due to increased integration between technical systems (OT) and IT systems – consequences and mitigation based on recent incidents – see Hydro (2019), Amedia (2021), Nortura (2021), Maersk (2017); and incidents -Equinor in Riksrevisjonen (2019).
General cognitive overload -too high Multitasking	Exploration of multitasking, how to prioritize and manage parallel activities, too many alarms Havtil (2022a). Humans cannot perform multitasking of safety critical tasks without increased risks. Paridon (2010).
General: Data line broken or down	Data communication broken. (Example: Line to a remote operational centre.) Discuss consequences, how to ensure proactive and reactive mitigation. Discuss need for redundancy and backup.
General: Standing alarm on ship bridge due to…	Standing alarm, complex situation, may shut down power and the ship may be without propulsion. See accident report Sjøborg- PSA (2019) or Viking Sky – Porathe (2023). Proactiv issues – Alarm Design; MoC – Update alarms/ check consequences of shut down in critical situations.
Case: Boeing 737 Max disaster	Single sensor failure, automation overrode human action, no safe state, poor design, poor training, explore accidents reports Endsley (2019), NTSB (2019b), ECAA (2019).
Case: KNM Helge Ingstad collision	Variations in Work as done, differences in SA between actors involved, poor design of bridge systems, poor alarms, fatigue, fatigue or reduced performance due to circadian rhythm, procedures for communicating in a high-risk situation AIBN (2019), Alsos et al (2024)
Case: Autonomous car collided - Joshua Brown	Not enough sensors in autonomous car (did not see crossing trailer – fatality with Tesla, Joshua Brown), not enough redundancy in control infrastructure (road) one fatality: Too much Trust in automation, Trustworthy supplier? NTSB (2017)
Case: Macondo Blowout	Poor HF, Poor Alarms, Poor Emergency procedures - US-CSB (2016), check that the CRO has authority to shut down quickly (i.e. ESD).

<u>List of defined hazards and accidents,</u> retrieved from Havtil MR §29 can be used to improve the scenarios as described in the appendix:

1.Situations where there is a danger that vessels or drifting objects can collide with facilities,
2.Well control incidents and well integrity incidents, - Well kicks/loss of well control,
3.Explosions and fires,
4.Major accidental hydrocarbon and chemical discharges of significance to safety and the working environment, (non-ignited hydrocarbon leaks, Ignited hydrocarbon leaks)
5.Accidental discharges of petroleum, drilling fluid and chemicals of significance to the external environment
6.Incidents where the use of radioactive sources is out of control, or acute discharges of radioactive substances have taken place,
7.Incidents caused by electricity or arising from work in or operation of electrical installations,
8.Falling objects, including all falling objects with falling energy above 40 Joules,
9.Situations which have led to loss of deck cargo, anchoring, mooring and towing equipment, and drilling and well equipment.
10.Situations where normal operation of control or security systems is disturbed by unplanned work (ICT event).

- Structural damage to platform/stability/anchoring/positioning failure
- Leaking from subsea production systems/pipelines/risers/flowlines/loading buoys/loading hoses
- Damage to subsea production equipment/pipeline systems/diving equipment caused by fishing gear
- Evacuation (precautionary/emergency evacuation)
- Helicopter crash/emergency landing on/near installation

Scenario 1 – Gas Leak (as a starting point – add additional faults/risks)

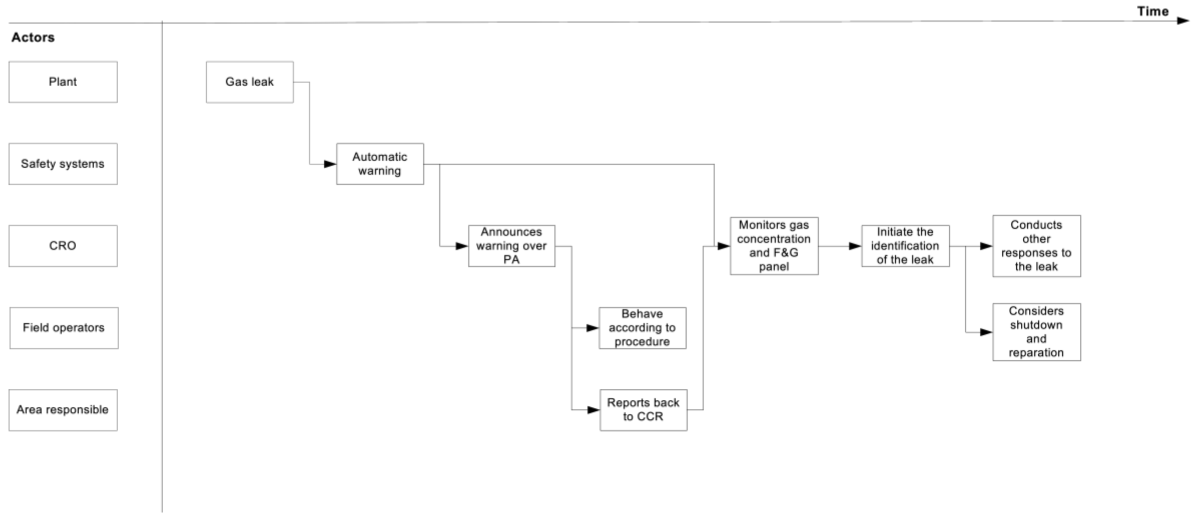
Scenario Description

A gas leak takes place in the process area. The gas leak is large enough to be detected by the gas detectors but does not lead to automatic shutdown.

Main Steps of the Scenario

- Automatic warning from F&G panel
- CRO announces the warning over PA
- Field operators behave according to procedure
- Area responsible reports back to CCR
- CRO monitors gas concentration (shown as % of LEL [Lower Explosion Limit])
- CRO monitors F&G panel
- CRO initiate identification of the leak
- Area responsible considers shutdown and reparation
- Emergency responsible initiate necessary further actions according to procedure

STEP



Scenario 2 – Utility Systems Start Up (add failures)

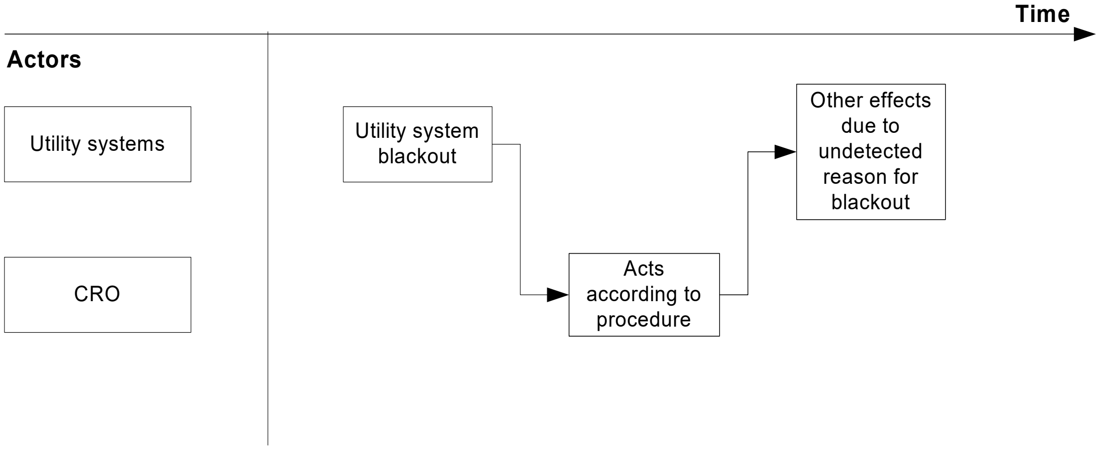
Scenario Description

After loss of utility systems, the CRO will act according to procedure for utility systems start up. The CRO may start this procedure without acknowledging the reason for failure. Most likely reason for failure is loss of power, due to e.g. valves failing or contaminated diesel. This problem may cause other effects later in the scenario.

Main Steps of the Scenario

- Loss of utility systems
- CRO acts according to procedure
- Effects due to undetected reason for failure of utility systems

STEP



Scenario 3 – Subsea Start-up

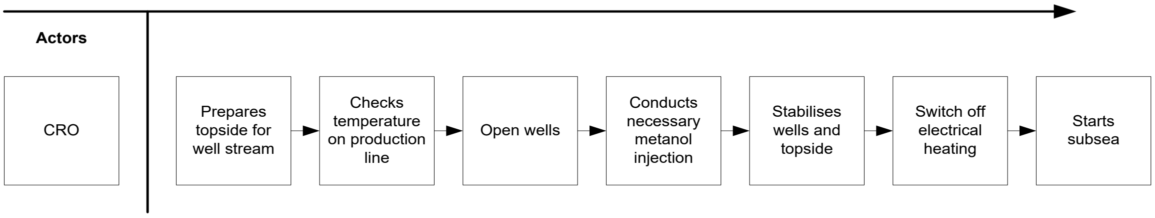
Scenario Description

After a revision due to maintenance the quality assurance has failed, and a leak point has been established. This leak point initiates a gas leakage which will be detected during the subsea start-up procedure. Follow procedure for subsea start -up in combination with scenario 1 - gas leak.

Main Steps of the Scenario

- CRO prepares topside for well stream
- CRO checks temperature on production line
- CRO opens wells
- CRO conducts necessary methanol injection
- CRO stabilises wells and topside
- CRO switches off electrical heating
- CRO starts subsea

STEP



Scenario 4 – Emergency Shutdown

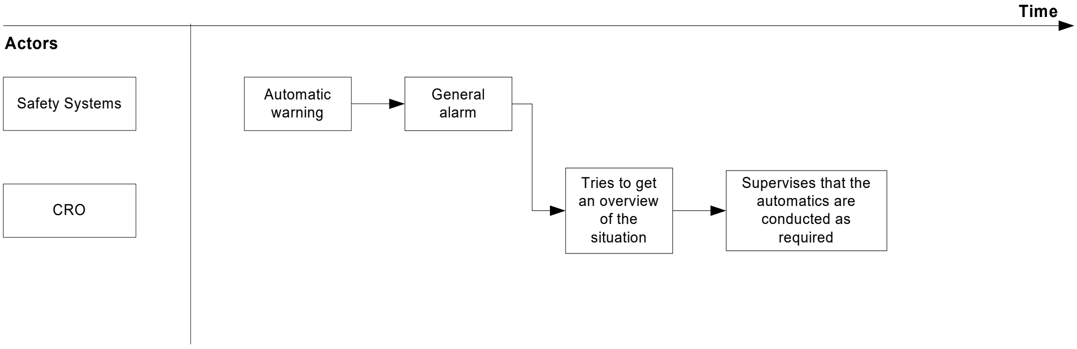
Scenario Description

There has been a manual release of the ESD button. This scenario should at least be combined with a fire or an explosion. Emergency preparedness (ref. FR Section 20, 21 and 22.) should be evaluated and the safety zone (ref. FR Section 51 - 61) should be assessed.

Main Steps of the Scenario

- Automatic warning
- General alarm
- CRO tries to get an overview of the situation
- CRO supervises that the automatics are conducted as required

STEP



Scenario 5 – Blackout

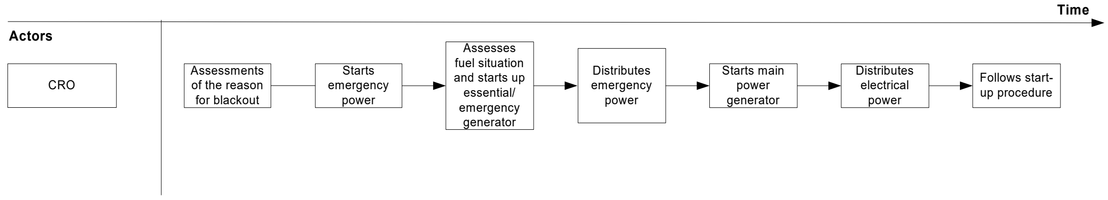
Scenario Description

The platform has been running for a longer period (1 year +) when there is a complete blackout. No systems are operational except the UPS system and its consumers, which normally have enough power to operate for a maximum of 30 minutes. The initial factor may cause other problems later in the scenario.

Main Steps of the Scenario

- Assessment of reason for blackout
- CRO starts emergency power
- CRO assesses fuel situation and starts up essential/emergency generator
- CRO distributes emergency power
- CRO starts main power generator
- CRO distribute electrical power
- Follow start-up procedure

STEP



Scenario 6 – Sudden Listing

Scenario Description

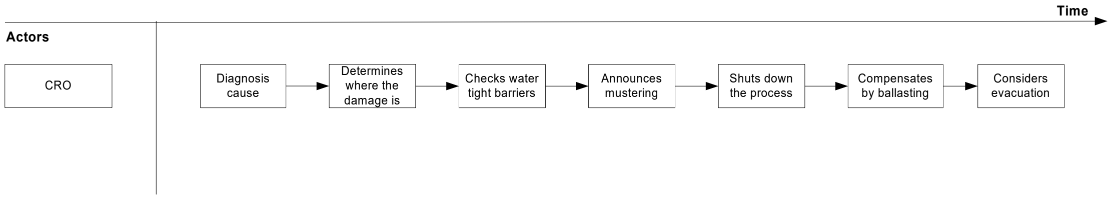
A ship has run into the side of the platform and caused two leaks: one above and one below the water line. The listing is caused by the leak below the water line. For fixed platforms the scenario can be limited to structural damage. Check that the floating construction can be quickly relocated in the event of an accident or incident.

Explore operation of facilities in general when there is heeling (or listing) up to 17 degrees. (Allowed static heeling for a moveable installation due to wind is 17 degrees). Check that the operator can use the control system and/or emergency shutdown system even when the control room is heeling (or listing). (This can also be done early by exploring a "mock-up" of the CCR). Ref FA section 62, FOR 1991-12-20 nr 878 section 20, 21 and FOR 1994-02-10 nr 123 section 17, 30, 31,32.

Main Steps of the Scenario

- CRO diagnoses cause
- CRO determines where the damage is
- CRO checks watertight barriers
- CRO announces mustering
- CRO shuts down the process
- CRO compensates by ballasting
- CRO considers evacuation

STEP



Scenario 7 – ICT and SAS systems breakdown and loss of communication

Scenario Description

The ICT system and main part of the SAS system have a common failure. The common failure could be loss of power, loss of communication or stop of several critical systems.

The failure could be due to someone connecting faulty or misconfigured ICT equipment to the network or equipment infected with a virus. The faulty equipment could be a PC with an error flooding the network with unanticipated traffic.

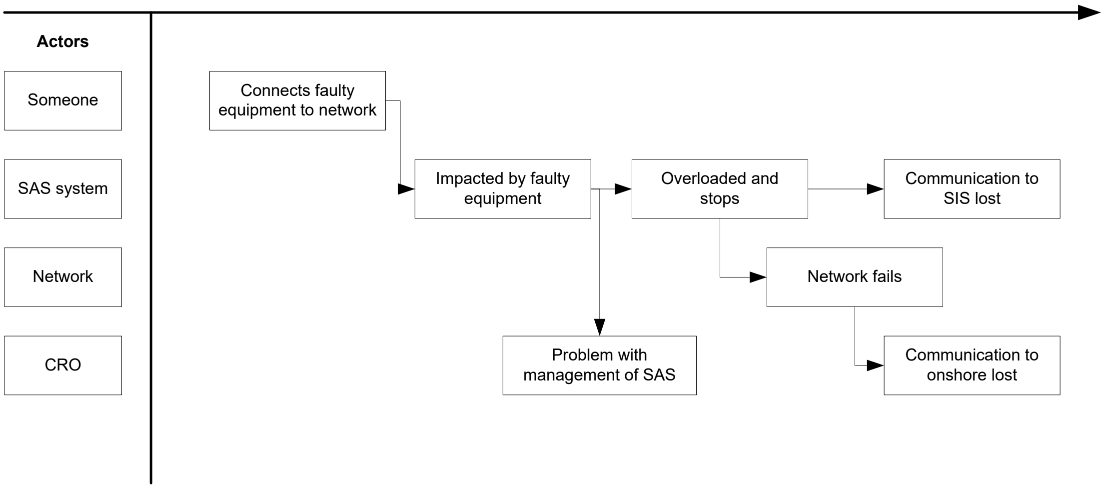
The result could be network overload (denial of service), or virus being spread from the infected equipment, impacting several systems and/or infrastructure such as the communication network. The scenario could impact and stop the safety and automation system (SAS) or impact safety instrumented systems (SIS). Communication based on high-speed data network between onshore and offshore could be lost, influencing ICT systems, video communication and telephony. The loss of CCTV (Closed Circuit Television) should be explored related to criticality i.e., is CCTV critical or important or does it give additional useful information.

The CRO may lose control of part of the process, and some part of the system may degrade to an unsafe condition. The breakdown could influence common situational awareness among the different actors involved and lead to serious errors.

Main Steps of the Scenario

- Someone connecting faulty equipment (e.g. PC) into the network
- SAS system is impacted, and parts of the system stops
- CRO has problems with management of the SAS system
- SAS system stops, problem with communication to SIS
- Network fails and high-speed data network between onshore and offshore is closed down, or data network cable has been cut
- Communication onshore (ICT, CCTV, telephony) lost

STEP



Scenario example

Scenario Description

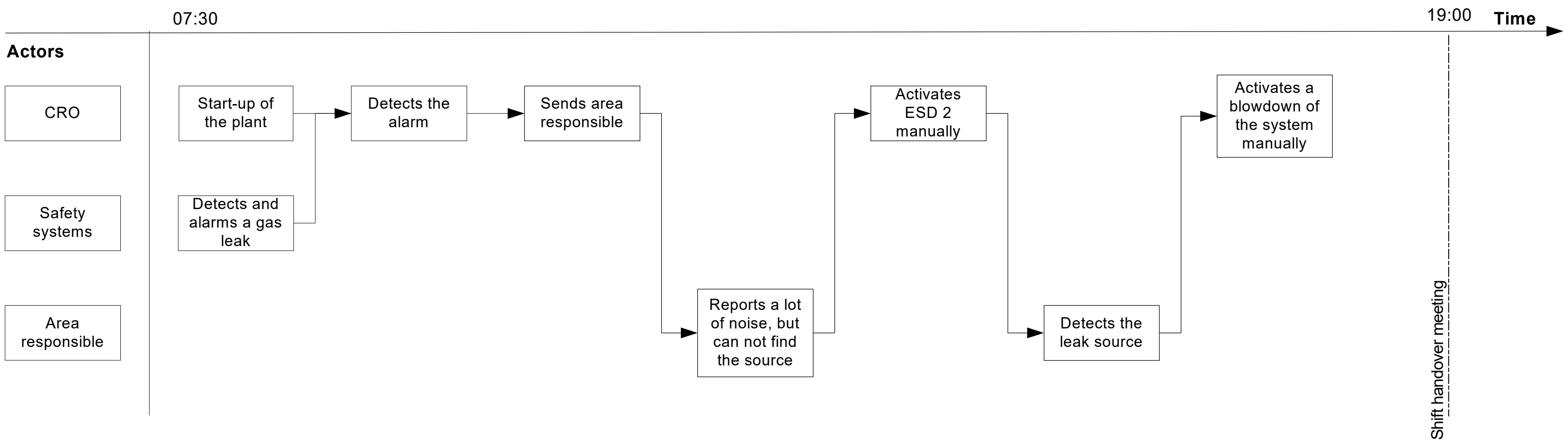
During a start-up after revision, a gas leak is detected by a line detector (25% LEL) in area 1A. The area responsible reports back to CCR that she or he can hear and see the gas, but due to noise and gas the area responsible is not able to detect the leak source. Since the leakage is located in the outer part of the platform, no more detectors are activated. However, CCR decides to activate the ESD 2 manually. After a while area responsible detects the leak source, and a blow down of the system is manually activated from CCR. During the day the source of the leakage is repaired, tested and found to be in order. Early evening the same day, the platform is ready for a second attempt of the revision start-up. During this second start-up, a condensation leakage in a flange is detected by a field operator. She or he reports back to CCR about a big leak in area 1B. No gas detectors have been activated and CRO believes the leakage to be located in the same area as the first gas leak detected earlier that morning. Due to this, CRO performs no actions but sends area responsible to area 1B to get a confirmation of the condensate leak. Area responsible confirms the leakage and CCR closes the emergency shutdown valve upstream the leakage and overrides the gas detectors in the area to avoid an emergency shutdown. While the area responsible is isolating the leakage, there is a discussion if the ignition sources should be disconnected, however CCR chooses not to do this since the leakage is under control and decreasing.

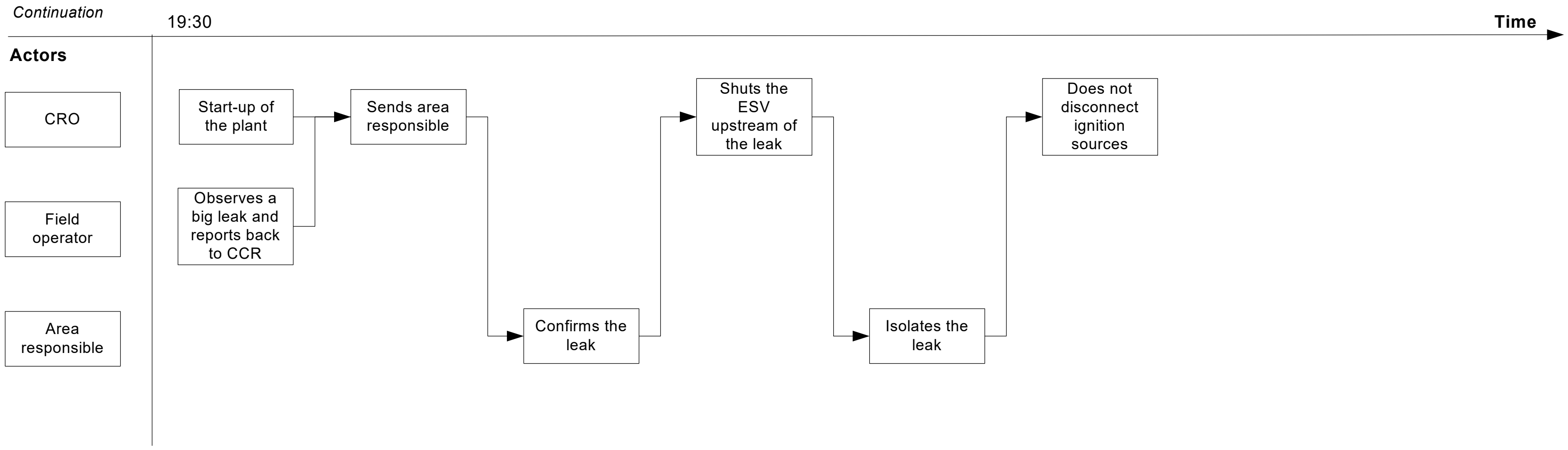
Main Steps of the Scenario

- CRO is busy with a start-up of the plant
- Gas detector alarms CRO (25% LEL)
- Area responsible reports back to CCR
- CRO activates ESD 2 manually
- Area responsible detects the leak source
- CRO manually activates a blowdown of the system
- Shift hand over meeting in the CCR

- CRO is handling a second start-up of the plant
- Field operator observes a big leak and reports to CCR
- CRO believes there must be a misunderstanding and sends area responsible to get a confirmation
- Area responsible confirms the leak
- CRO closes the emergency valve upstream of the leak
- Area responsible isolates the leak

4. CRO chooses not to disconnect ignition source


07:30
19:00
Time
Actors
CRO
Safety systems
Area responsible
Start-up of the plant
Detects and alarms a gas leak
Detects the alarm
Sends area responsible
Reports a lot of noise, but can not find the source
Activates ESD 2 manually
Detects the leak source
Activates a blowdown of the system manually
Shift handover meeting


Continuation
19:30
Time
Actors
CRO
Field operator
Area responsible
Start-up of the plant
Observes a big leak and reports back to CCR
Sends area responsible
Confirms the leak
Shuts the ESV upstream of the leak
Isolates the leak
Does not disconnect ignition sources

Appendix B – Scenarios for the remote control of autonomous ferries

List of defined hazards and accidents identified by Thieme et al. (2023), can be used to refine the scenarios described in the appendix:
Defined situations of hazard and accident situations aboard include:

1. Fire in the engine room, passenger salon, or battery room.
2. Collision with other vessels or floating objects or grounding.
3. Passenger falling overboard, or person floating in the water (MOB Man overboard).
4. Evacuation due to fire, loss of stability, collision, grounding, or engine failure.
5. Ferry loses stability or capsizes, due to overload or loss of watertightness.
6. Passenger emergencies caused by injuries, medical conditions, or vandalism.

Defined situations of hazard and accident situations at the ROC include:

7. Loss of connection to the ferry.

Scenario B1 – Fire onboard

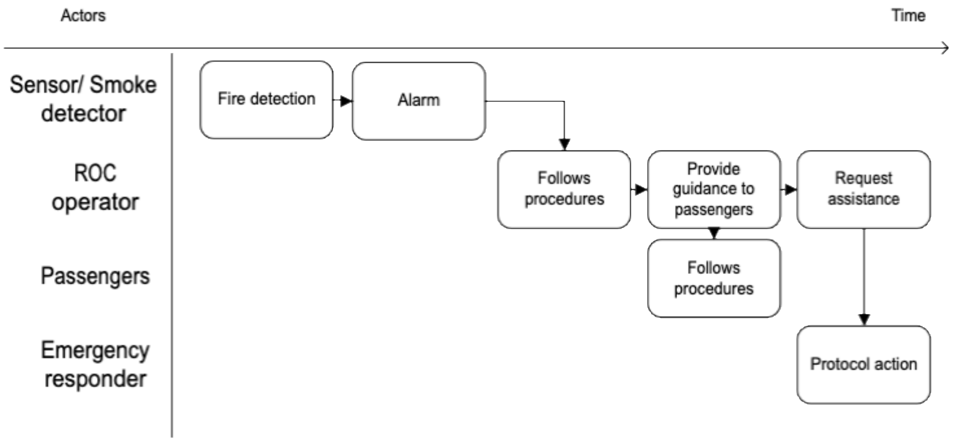
Scenario Description

A fire breaks out on the autonomous ferry due to an electrical fault, battery overheating, or fuel leakage. The fire is detected by onboard sensors and reported to the remote operations centre. Meanwhile, the passengers require appropriate guidance and evacuation instructions to ensure their safety. Two-way communication may be necessary to acknowledge that there are people to help them in the ROC. The ROC is responsible for notifying the local emergency services to request immediate assistance to the passengers and the ferry.

Main Steps of the Scenario

1. Sensor/smoke detector detects a fire and sends an alert to the ROC.
2. ROC operators follow established procedures.
3. ROC operators communicate with passengers and provide guidance.
4. ROC operators promptly request assistance from local emergency services.
5. Emergency responders initiate necessary actions according to protocol.
    - Passengers follow the guidance from the ROC and emergency responders to evacuate safely.

STEP:



Scenario B2 – Collision

Scenario Description

A collision occurs when a fast-moving, unaware boat crashes into the aft of the autonomous ferry. The ferry's sensors may have difficulty detecting the approaching vessel due to blind spots or sudden manoeuvring.

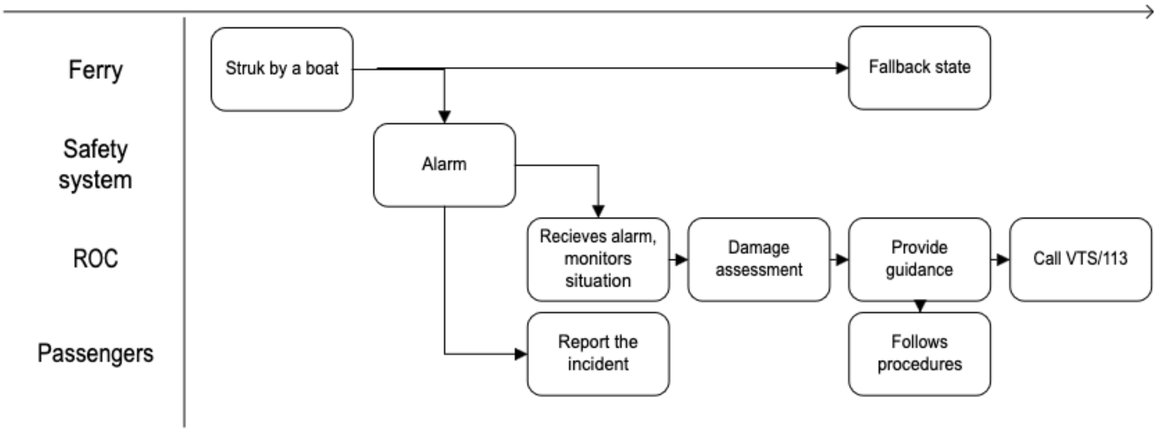
The ROC receives a collision alarm, and the passengers or nearby civilians may also witness the event. Passengers must be informed and provided with safety instructions through appropriate communication equipment.

The ROC and onboard systems assess the damage using CCTV, sensors, and self-diagnostic tools. Based on the situation, the ROC contacts Vessel Traffic Services (VTS) or emergency services for assistance. The ferry must then transition to a safe state to prevent further risks to passengers and operations.

Main Steps of the Scenario

1. The ferry is struck from the aft by a fast-moving boat (collision detected via impact sensors, alarms, or visual confirmation).
2. ROC receives the collision alarm and monitors the situation through CCTV and sensors.
3. The passengers or bystanders may report the incident if they witnessed the collision.
4. Passengers are informed via public announcement (PA), instructing them to remain calm and follow safety procedures.
5. Damage assessment is conducted using CCTV, sensors, and onboard diagnostics.
6. ROC contacts VTS/113 to report the incident and request emergency assistance.
7. The ferry is guided to a safe state (adjust speed, maintain stability, and prepare for evacuation if necessary).

STEP:



Scenario B3 – Passenger overboard/ person floating in the water

Scenario Description

The ferry's onboard sensors or CCTV may detect the incident and trigger an alert to the ROC. Alternatively, other passengers may witness the situation and report it to the ROC using two-way communication equipment.

Passengers are guided to use onboard life-saving equipment, such as lifebuoys and throw ropes, while maintaining safety protocols.

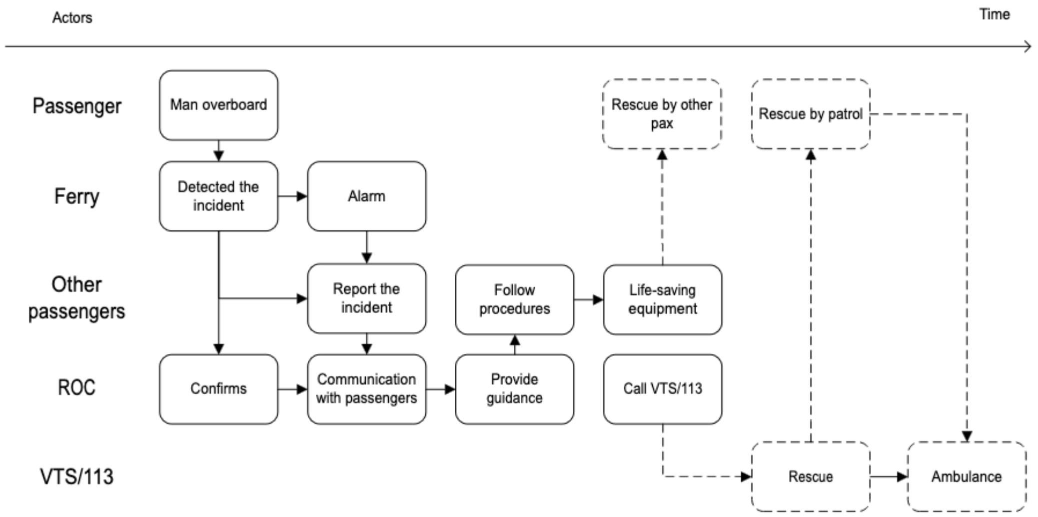
The ROC assesses the situation through CCTV and sensor data and immediately requests assistance from local emergency services. Depending on the circumstances:

- A patrol or rescue boat arrives to assist the person in the water.
- If passengers successfully retrieve the individual, they provide first aid while an ambulance waits at the nearest dock.

Main Steps of the Scenario

1. A passenger falls overboard, or the ferry detects a person
2. The ferry automatically alerts the ROC, or passengers report it via two-way communication.
3. The ROC confirms the incident using CCTV and sensor data.
4. Passengers are guided to deploy onboard life-saving equipment (e.g., lifebuoys, throw ropes).
5. The ROC contacts local emergency services (VTS, coast guard, 113) for assistance.
6. If patrol boats are nearby, they proceed to the scene for rescue.
7. An ambulance is notified and waits at the nearest dock for further medical assistance.

STEP:



Scenario B4 – Evacuation

Scenario Description

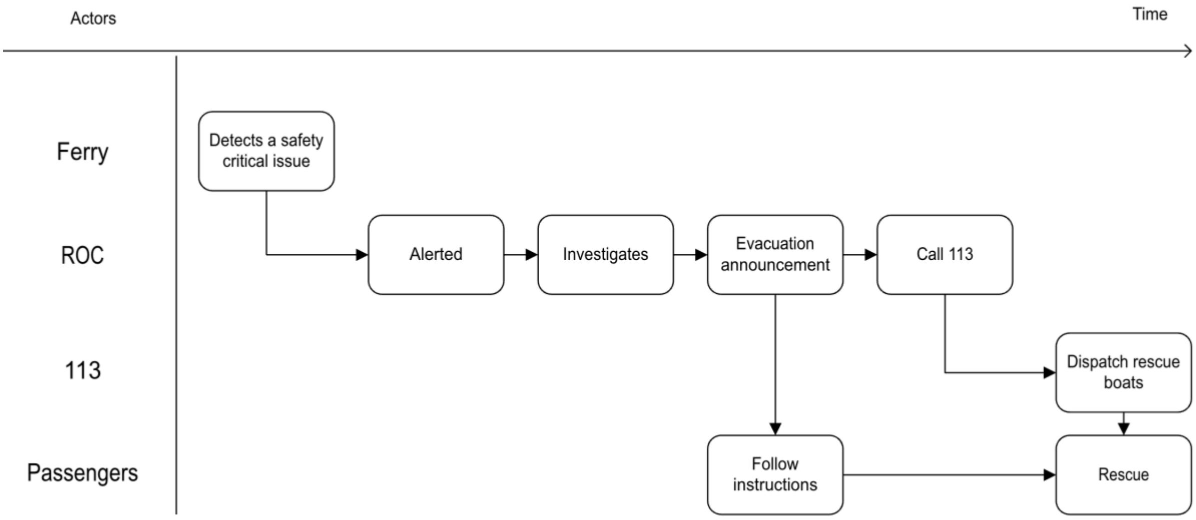
In a situation where the autonomous ferry cannot ensure passenger safety, such as in the event of a fire on board or sinking, the passengers must evacuate immediately using evacuation means available onboard.

When the Remote Operations Center (ROC) decides to initiate an evacuation, an announcement is made to instruct passengers to follow the evacuation directions. The ROC also contacts local support to dispatch a rescue boat to bring the passengers safely back to the port.

Main Steps of the Scenario

1. Onboard Sensors / Autonomous Ferry System detects a critical safety issue (e.g., fire, sinking, or structural failure), automatically sends an alert to the ROC.
2. ROC receives the emergency alert and assesses the situation using onboard cameras and sensor data.
    a. ROC Makes a clear evacuation announcement, instructing passengers to:
        - Remain calm and follow the evacuation procedures.
        - Proceed to the muster stations or designated evacuation points.
        - Use the available evacuation means (e.g., life rafts, life jackets).
3. Onboard System broadcasts the evacuation instructions in multiple languages (if applicable).
4. ROC contacts local emergency services and rescue teams to inform them of the situation and requests rescue boats to be dispatched to the ferry's location.

STEP:



Scenario B5 – Stability loss

Scenario Description

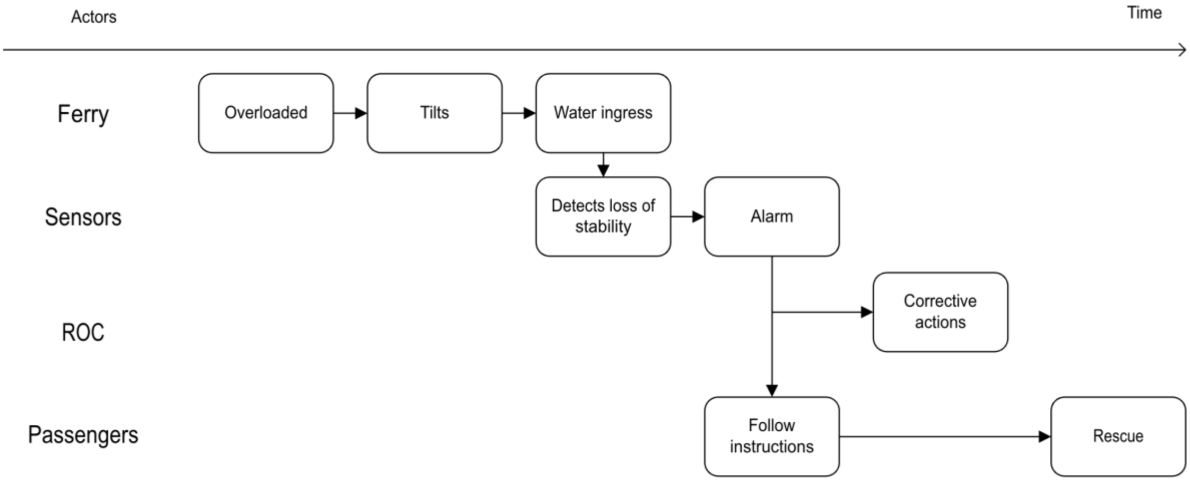
The ferry encounters stability issues due to overloading and uneven weight distribution. As a result, the ferry tilts to one side, causing water to enter the deck.

The onboard sensors detect the loss of stability and immediately send an alert to the Remote Operations Center (ROC).

The ROC Operators assess the situation using live camera feeds to monitor the ferry's condition in real-time. They activate onboard alarms to alert passengers about the stability issue and guide them to safety. They initiate corrective actions, such as adjusting ballast or altering the ferry's course to restore stability. Additionally, they coordinate with local rescue services as a precautionary measure to ensure passenger safety.

The passengers are instructed to move to designated safe zones to redistribute weight and restore stability. The situation is monitored until the ferry safely reaches the nearest port.

STEP:



Scenario B6 – Passengers' medical and safety emergencies

Scenario Description

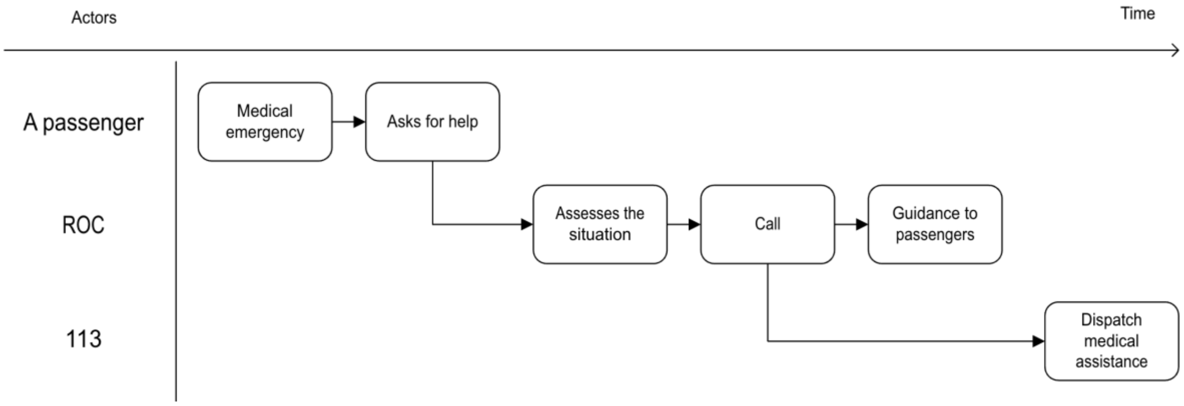
A passenger onboard the autonomous ferry suddenly experiences a medical emergency, such as chest pain or difficulty breathing. The ROC is alerted and assesses the situation using live camera feeds.

The ROC contacts local emergency services to dispatch medical assistance to the ferry’s location. An announcement is made to calm passengers and provide first-aid instructions if necessary.

On another day, vandalism is reported in the seating area. The ROC monitors the situation, identifies the responsible individuals using camera footage, and contacts local authorities for intervention.

In both situations, the ROC coordinates the response and ensures passenger safety until the ferry reaches the nearest port.

STEP:



Scenario B7 – Connection failure

Scenario Description

The ROC suddenly loses connection to the autonomous ferry, resulting in a complete communication breakdown.

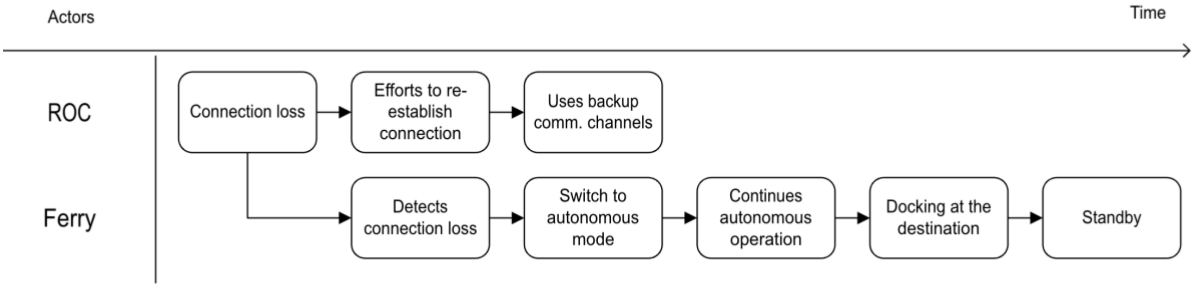
Despite the loss of connection, the autonomous ferry is designed to maintain autonomous crossing and continues to the planned dock according to its pre-programmed route.

The onboard system detects the communication loss and automatically switches to autonomous mode. It continues the crossing safely by maintaining the planned speed and route. Upon arriving at the designated dock, the ferry stands by until the connection is restored, or assistance arrives.

The ROC Operators identify the connection failure through system alerts and attempt to re-establish communication using backup communication channels. They monitor the situation through secondary systems and coordinate with local support if necessary.

The ferry remains safely docked until the connection is restored, ensuring passenger safety and operational continuity.

STEP:



Appendix C – CRIOP Human-AI Collaboration Guidelines

Barry Kirwan, March 2025

Summary

As CRIOP is in the process of being updated, it was decided to add a section in an Appendix on Human-AI Collaboration. Although Artificial Intelligence is relatively new to industrial domains such as Oil and Gas, in other industries (e.g. aviation, healthcare) it is moving at a relatively rapid pace. It was therefore decided to include guidance on this area based on best practice in other domains (principally aviation), to ensure that CRIOP is ready when being used to evaluate an oil and gas system with AI components. The guidance is to be considered preliminary, and focuses principally on Machine Learning AI systems, also called Narrow AI as such systems are focused on specific industrial and operational problems. However, due to the pervasive use and adoption of Generative AI tools (so-called Large Language Models or LLMs) such as ChatGPT both at home and in the office, some preliminary and tentative guidance is also given in this area (equivalent guidance on human-LLM interactions does not yet exist in the aviation sector). AI is a fast-moving area, and it is therefore advised to review this guidance in 1-2 years' time to see what new advances have been made both in AI (and the status of its integration into the Oil and Gas industry) and in Human-AI Teaming research.

Background

Human Factors guidance has been developing for decades, and is periodically updated as in the development of a new version of CRIOP for Oil & Gas, and in a recent update of guidance on Human Factors tools and techniques for aviation and maritime sectors[1].However, although Artificial Intelligence (AI) has also been around for decades, since the release of ChatGPT in early 2023, which made AI a household talking point, the research and innovation in AI has sky-rocketed. In aviation there have been successful projects using Machine Learning tools which 'crunch' large amounts of data leading to more precise tools for air traffic controllers, for example, to predict weather, cut down on travel times and stay greener. But most of these can be considered 'just more automation'. What is of current interest to the aviation industry is the concept of intelligent agents that could cooperate and collaborate with human operators. Such Intelligent Agents could support pilots in rare emergencies, or even replace one pilot, or safely coordinate urban drone traffic around large cities. This has led to a significant effort by the principal regulator, the European Union Aviation Safety Agency (EASA), to prepare the way with guidance and regulations for AI use in aviation, with a strong focus on Human Factors and how the human operators and AI will work together (called Human-AI Teaming, or HAT).

While it is comparatively straightforward to write guidance and regulations for Machine Learning systems, Large Language Models (LLMs) are a different animal altogether. LLMs literally crunch words rather than numbers, and whilst many have been astounded by their capabilities and apparent creativity, and welcome support in writing reports etc., such systems also demonstrate a capacity for errors and fabrications (known as hallucinations). For this reason, the current EU Act on AI vetoes usage of LLMs for safety critical situations.

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[1] https://safemodeproject.eu/EhuridIndex.aspx

Research on HAT in aviation is therefore focusing on near-future (2030+) usage of AI (ML) systems in the cockpit to assist flight crew or single pilots, and in the air traffic control operations centre or tower to assist controllers, either doing some of the more repetitive tasks, or assisting when operations become more complex.

A recent study[2], based on experiences with five such HAT research projects, as well as a literature review of HAT, proposed an overlying high-level architecture for evaluating HAT applications in aviation, shown in Figure D1, and backed up by a set of HAT design principles (Table 1). These eight Human Factors Areas (HFAs) overlap to a large extent with CRIOP areas. Certain areas are however new or more specialized when considering the adoption of AI-based systems, e.g.:

- User-Centred Design (HFA1)
    - *have end users been consulted?*
- Roles and responsibilities - the relation between human operator and AI (HFA2)
    - *who (or what) is in charge?*
- Sense-making of AI interaction, including AI explainability (HFA3)
    - *are operators and the AI on the same page?*
- Trustworthiness of AI advice / decision-making (HFA3)
    - *is the AI decision safe?*
- Communication between AI and operators (HFA4)
    - *Is AI communication effective, or is it 'lost in translation'?*
- Teamworking with AI - including distributed and remote teamworking (HFA5)
    - *how do we get the best of both worlds (humans & AI)?*
- Failure modes and human recovery of AI failures (HFA6)
    - *can operators detect and recover from AI errors?*
- Competency and training requirements (HFA7)
    - *what do operators need to know about the AI?*
- Technology acceptance factors (HFA8)
    - *will users make good use of AI if it threatens their jobs?*
- Impacts on company culture (HFA8)
    - *will AI integration change our company ethos, and who we are?*
- Impacts on Just Culture and Safety Learning (HFA8)
    - *will AI shift the blame for incidents onto people?*

The following sections are based on relevant requirements from the HAIQU system adapted to an Oil and Gas context. This process also led to some new requirements, including several related to potential use of LLMs. In cases where the new CRIOP requirements already match HAIQU requirements, e.g. a number of requirements related to HMI design and alarms, the HAIQU requirements are not repeated, to avoid 'double counting'. The same overriding eight-area framework is utilized in CRIOP as in HAIQU, which will soon be fully and freely available at https://haiqu.eu.

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[2] https://www.preprints.org/manuscript/202501.0974/v1

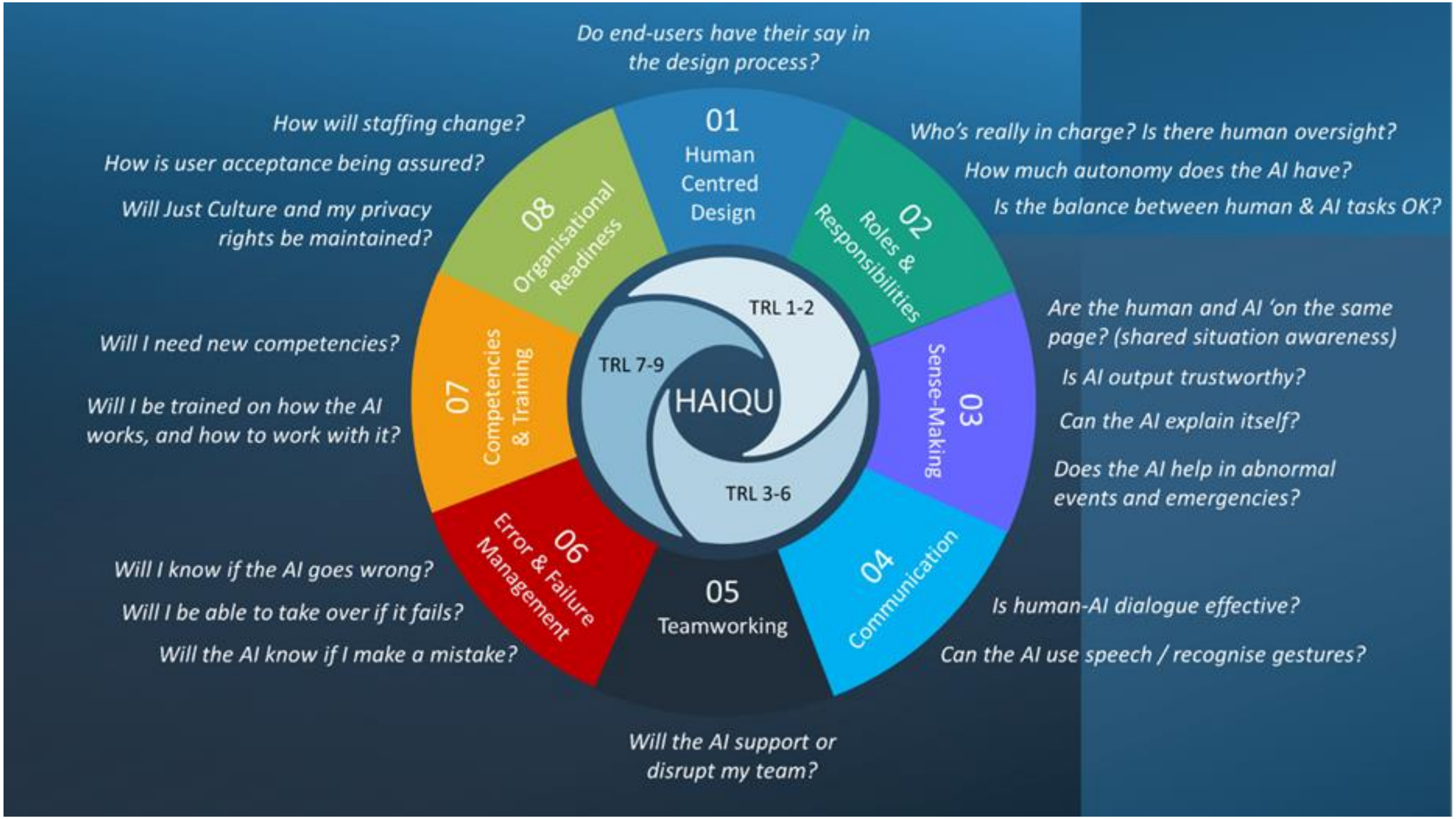

Figure C1: Human-AI Teaming Requirements Architecture (Kirwan, 2025) [2]

Table C1 High-level principles for Human-AI Teaming (HAT) systems design

HFA	Principle	Rationale
1	Adopt a human-centred design approach	• To optimize human-AI performance • To maximize technology acceptance • To avoid problems of goal misalignment between AI and the human operator
2	Maintain human judgement and oversight of system safety	• AI cannot value safety, only people can • AIs may downplay or underestimate certain rare situations or conditions (called edge cases) • AIs will optimize according to a number of parameters and can make trade-offs with safety, whereas people know when to put safety first
2	People must have meaningful roles when working with AI	• AI should be used primarily to augment human performance – this maximizes user acceptance of AI and overall system performance • If operators have less meaningful roles and their tasks are driven by the AI, they will be far less able to detect AI errors
3	The aim of HAT interface design is to keep the operator and the AI on the same page	• The AI can work at a deeper, faster and more complex level, but the operator must be able to comprehend its outputs and challenge them if they don't look right. • In abnormal situations, the operator needs to verify alignment between their 'worldview' and that of the AI (albeit simplified). • By optimizing situation awareness and sense-making, the HAT will be far more effective.
3	When employing operational explainability, use a multi-level approach	• People have different levels of understanding and acceptance of an AI rationale – some will accept it at face value, others will need to probe deeper to assure themselves. • Experienced and novice users may differ in their explainability needs • There may be current local factors of which the AI is unaware, so the operator needs to be able to check what the AI 'knows'
3	Human-AI interaction in emergencies must be tailored for fast and robust response	• In emergencies there is very limited time for explainability. • High level situation displays are desirable to track event conditions in real time. • Procedural communication between human and AI may be best.

4	AI communication needs to be context-sensitive	• AI communication style must be adaptive to the working conditions (e.g. normal, abnormal, emergency). • In many situations procedural language style may be preferable (less misunderstanding)
5.	The AI must support and 'blend in' with team performance	• Team shared situation awareness is critical to system safety, especially in distributed and remote teams. • An operator, rather than an AI leading the team enables effective management of team resources, via sensitivity to workload peaks and troughs and shared situation awareness, as well as keeping an eye on HAT performance and reliability.
6 & 7	Train operators on how the AI works and how it can fail.	• Operators need a basic knowledge of how the AI works and how it can fail. • Operators need to see examples of what AI failures look like, including not only unavailability, but aberrant behaviour. • If LLMs are in use, training on their strengths and weaknesses should be given, as well as how to supervise their usage.
8	Reporting is key especially in the early introduction of AI-based systems.	• Feedback on early AI usage will be key to refining and optimising AI-based systems and HAT partnerships. • Just Culture policies, practices and protections will be needed to ensure honest and detailed reporting.
8	Adopt a staged approach to AI development and validation to ensure technology acceptance and successful integration into operational settings.	• Experience in other sectors (e.g. healthcare) shows that 'parachuting' AI-based systems into organisations, with little adaptation or testing, causes systemic problems. • Single-shot or once-through validation of HAT systems is unlikely to capture all the problems or issues to resolve before system integration. • A more measured staged validation approach allows designers and operators time to optimize human-AI interactions and ways of working.
8	Avoid using LLMs for safety-critical tasks and ensure human oversight and supervision of their application in other non-safety critical work areas.	• LLMs are powerful and increasingly accurate, but can still suffer from hallucinations, data bias and toxicity, and a lack of fairness. • LLMs have no 'reasoning' capability, and usually are not good with numbers, and occasionally omit key details. • LLMs have no morality or ethics. Whist there is an appeal to use them in Human Resources tasks, for example, there are dangers. • LLMs are generally reductive, often converging on commonly held answers that lack insight or true originality.

1. Human-Centred Design for Human-AI systems

1. Are licensed operators involved in the design, development and requirements specification for new AI-based systems, including participation in focus groups, scenario-based testing, simulations, and other validation activities?
2. Are operators working within an integrated project team that involves data scientists, safety and Human Factors experts?
3. Are operators involved in hazard identification and mitigation studies of the new AI system?

2. Roles and Responsibilities

2.1 Role Allocation – who's in charge?

4. Have all role changes been specified, including suppression of existing roles, changes in role and new roles? Does the new arrangement of roles make sense to the operators?
5. Has task analysis been used to verify that the allocation of tasks (to humans and AI) and their working arrangements will deliver safe and effective system performance, including human ability to 'take over' if required?
6. Have decisions about the allocation of roles/tasks/functions to operators / AI been based on where human and AI relative strengths lie, rather than being driven by AI acquisition and the need for the operator to do what the AI cannot (known as the 'left-over principle', maximising AI utility and giving what's left to humans)?
7. Is the operator still in charge? If not, does a human operator or supervisor have oversight of the tasks / functions being executed by AI, e.g. via a display dynamically showing who is doing what (operators and AI)?
8. Have simulations shown that workload and operator situation awareness are within tolerance during a range of scenarios, including handoff from AI to operators, and unexpected AI shutdown/unavailability?

2.2 Human Judgement and Oversight

9. Does the operator have responsibility for overriding the AI if required, and taking over its role? If not, and the operator does not trust the AI's judgement/decision/action, can the operator seek authority further up the chain of command?
10. Can the operator (or supervisor) monitor and adjust the AI's goal priorities and see the trade-offs it is making?
11. If negotiation between operator and AI takes place, who makes the final call?
12. Can the AI take action in case of no decision/action by the operator in a hazardous time-critical situation?

3. Sense-Making

3.1 Situation Awareness

13. Is there at least one display showing system status using inputs unfiltered by AI?

14. Is the HAT interface designed to be sensitive to context, and tested to ensure that the AI and operator remain 'on the same page', irrespective of the operational context (normal operations, maintenance, emergency)?
15. Do workload and system displays allow operators to remain proactive, as well as able to step back in emergency or abnormal situations and consider whether recovery steps are working or not?
16. Is the operator always aware when the AI is 'on', and if it changes mode, e.g. from normal to emergency or maintenance, or switches itself off (or back on)?

3.2 Trustworthiness

17. Is the accuracy, precision and timeliness of the information provided by the AI sufficient to enable operators to judge it before accepting and acting upon it?
18. Is the AI-based system or system element provided by the supplier trustworthy, designed to high quality standards including Human Centred Design principles, and already extensively tested?
19. Are operators aware of the AI's data sources and inputs being currently used?
20. When an AI is carrying out safety critical tasks, is safety as a goal always prioritised by the AI?

3.3 Operational Explainability

21. Does the AI have an explainability function, rather than being 'black box?
22. Has explainability been derived via operational experts and novices, as well as different members of the team (e.g. operator and supervisor) to find out what explanations they may need across a range of operational conditions?
23. Is explainability multi-levelled, e.g. from 'headline' explanations (principal factors driving its advice) to operational reasoning including hazards, optimising factors and trade-offs between parameters, down to the detail of data sources, both used and ignored (e.g. anomalies and outliers)?
24. Can the AI explain its current (possibly tactical) goal as well as its longer-term (strategic) goal, if it has one?
25. In emergencies, can the operator always track what the AI is doing and why?

4. Communications

26. Is AI-operator communication via a proceduralised language, and if so, is it easy to learn for the operator?
27. If natural language is used, is context-sensitivity ensured, to avoid misunderstandings?
28. Are operators always aware when they are dealing /communicating with an AI?
29. Is AI communication clear and concise in times of high stress (e.g. emergencies)?
30. Is the overall style and amount of AI communication acceptable to operators, including those whose first language is not the same as the one used by the AI?

5. Teamwork

31. Is the AI's situational representation (it's current 'worldview') shared between team members, to ensure coherent team situation awareness?

32. Does an operator (or supervisor) coordinate the workflow tasks to different team members and the AI, rather than the AI performing this function?
33. Are teams trained in fallback procedures in case of AI failure or error, and are there sufficient staff to execute such procedures safely?
34. Is team performance more fluent and error-free with the AI?

6. Error and Failure Management

35. Is the AI-operator interface tolerant to user errors, allowing e.g. detection and correction of input errors? Does the AI assist the operator in such error detection/correction?
36. Is the AI-based system robust against edge and corner cases, data bias, toxicity and poisoning, and hallucinations?
37. Are operators trained in simulations to recognise strange or erroneous AI outputs and take corrective action if required, including overriding or disabling the AI?
38. Are there sufficient non-AI-based displays of critical functions and safety parameters to allow the operators to verify that context is changing?

7. Training and Competencies

39. Will training departments develop new training strategies and approaches for Human-AI Teaming, to cover understanding and working with AI (including pitfalls such as personification of AIs, over-reliance on AIs, etc.), explainability and AI language limitations, querying and verifying AI outputs, negotiating with AIs, AI errors and how to recognise them, and when and how to override the AI?
40. Will training strategies include avoidance of critical skills-fade, either by periodically having the AI switched off or having simulation training exercises without the AI?
41. Will experienced operators be involved in AI supervised learning and testing?
42. Is training available for end users of LLMs / Generative AI tools in non-safety-critical situations, covering how they work, where to use them and when not to use them, the dangers of ‘hallucinations’, bias, toxicity, the seductiveness of LLMs’ very polished language skills, the lack of any morality/ethics in LLMs, how to optimise their usage via considered prompting, the need to supervise and verify their output, and the dangers of end user skills loss (including critical thinking)?

8. Organisational Readiness/ Technology Acceptance

8.1 Impact on Staff

43. Will the strategy for AI introduction be to augment human performance and working conditions, to help current operators do their work better, rather than eliminating or downgrading existing staff roles?

8.2 User Acceptance

44. Do operational end users think implementing the AI is a good idea? Have their concerns and ideas for improvement been canvassed and taken seriously?

45. Are operators (and managers) comfortable with any legal liability implications of using the AI in safety-critical environments, as well as Just Culture provisions in the organisation to protect staff working with an AI when an incident occurs?
46. Are reporting and feedback systems in place (including user-friendly reporting formats, focus groups and interviews), particularly in the first six months and year of implementation, to enable fine-tuning of the AI and HAT approach?
47. Is rushed AI introduction avoided, and instead a more measured integration approach with several validation steps adopted, to ensure sufficient time to understand and avoid or mitigate potential problems and side effects?

8.3 Wellbeing

48. Does the AI system avoid creating over-reliance and critical skills loss, and manipulating end user behaviour? [Note that this also applies to LLM / Generative AI usage in non-safety-critical work situations]?
49. Does the AI system comply with national and best practice data protection provisions, especially with respect to any personal data being collected by the AI, or user profiling by the AI?
50. Have AI datasets and models been evaluated for bias or ‘toxicity’ that could have a negative effect on performance or a segment of the user population [again, this also applies to LLMs / Generative AI tools]?

Appendix D – Example of components and actors on a Drilling Rig

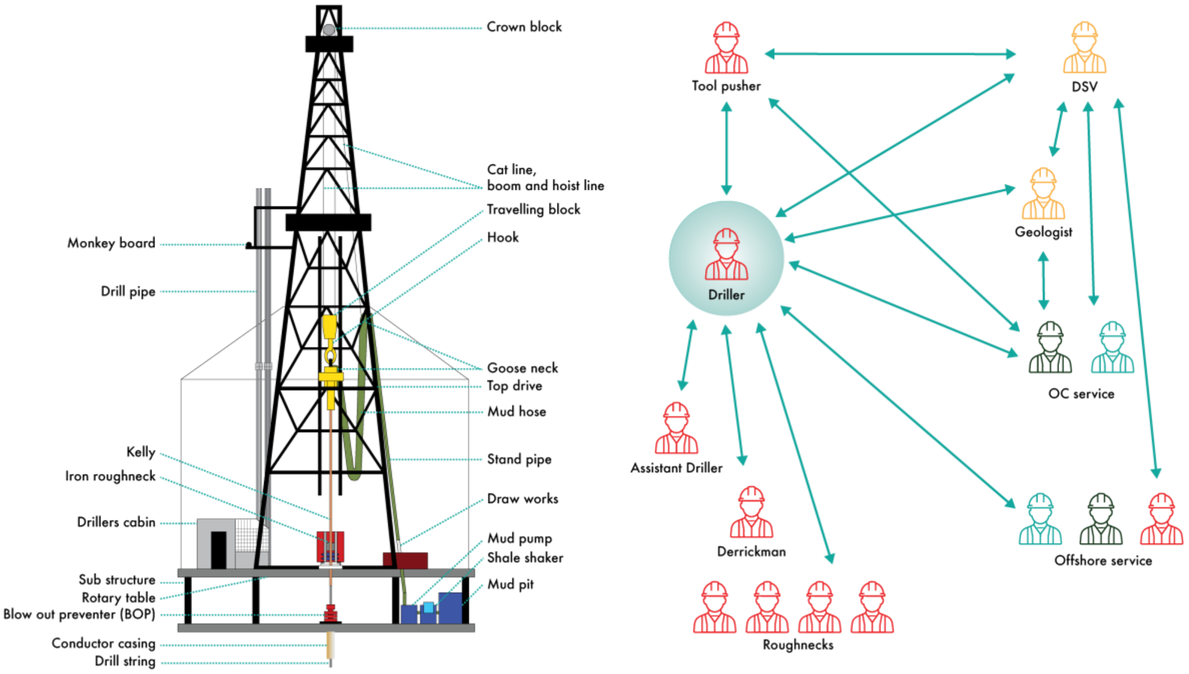

Figure: Drilling Rig and key actors (CC BY 4.0)

Technology and Equipment: The left portion of the image depicts essential drilling equipment including:

- Derrick/Mast: Supports the drilling components.
- Drill Pipe and Drill Bit: Used to penetrate the earth to reach hydrocarbon reserves.
- Crown Block and Traveling Block: Pulley systems used for handling the drill string.
- Top Drive: Provides rotational force to the drill string.
- Mud Pump and Mud Tanks: Used to circulate drilling fluid (mud) to cool the drill bit, stabilize the well walls, and remove rock cuttings.
- Blowout Preventer (BOP): Safety equipment preventing uncontrolled flow (blowouts).
- Generator/Power Supply: Supplies energy required for drilling operations.
- Shale Shakers: Equipment that removes cuttings from drilling mud.

Actors and Roles: The right portion of the image depicts key personnel involved, with a Driller at the centre, highlighting their critical coordination role. The actors include:

- Driller (central role): Manages drilling activities and directs the crew.
- Rig Manager: Oversees the entire rig operation, communicates closely with the driller.
- Assistant Driller: Supports the driller, manages shifts and equipment.
- Roughnecks: Handle physical tasks related to drilling, such as making pipe connections.
- Derrickman: Operates at height in the derrick, managing pipe movements and mud circulation systems.
- Mud Engineer: Manages drilling fluid composition and properties.
- Geologist/Engineer: Provides technical guidance and geological interpretation.
- Company Representative (Operator): Oversees operation from client perspective.
- Safety Officer (HSE): Ensures compliance with health, safety, and environmental regulations.
- Maintenance Team: Ensures operational reliability of equipment and machinery.

The arrows between actors illustrate communication and coordination lines, emphasizing the central position and coordinating role of the driller within the operational structure.