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Enterprise /VAT No: NO 919 303 808 MVA

KEYWORDS: Safety

Verification and Validation

Abnormal situations Human factors

# Report

## **CRIOP: A scenario method for Crisis** Intervention and Operability analysis

VERSION	DATE
2025 (as of 07-04)	2025-07-04
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CLIENT(S)	CLIENT'S REF.
HFC – Human Factors in Control	HFC
PROJECT NO.	NUMBER OF
HFC – 102017861	PAGES/APPENDICES:
	233/4

#### 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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REPORT NO. 2025:00192	ISBN 978-82-14-07392-8	CLASSIFICATION Open CC BY 4.0	<b>CLASSIFICATION THIS PAGE</b> Open



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# **Document history**

VERSION	DATE	VERSION DESCRIPTION
2025	2025.07	Norwegian version of Checklist published, minor missing references added
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, <b>T. I. Throndsen</b> (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
	DEDODE NO. 2005 00402

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

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1. Introduction – background, what is CRIOP?

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### 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), Hopkins (2025) 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. Need for periodic high-quality audits/HAZOP has been highlighted by Hopkins (2000), including drift from safety to profit (as at Boeing) in Hopkins (2025). 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) and actions in line with hierarchy of controls.

#### 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.

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. (See also Hopkins, 2025)
Deepwater Horizon (in 2010)	11 deaths; Loss more than 60 000 Mill USD; Environmental consequences - Oil spills in Gulf of Mexico	<b>From Deepwater Horizon Accident Analysis CSB (2016)- Volume 3</b> 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.

Table <b>1.1</b>	Incidents	and HF	causes

#### 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.

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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 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.

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### **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.

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

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

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).

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#### **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.

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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

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(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.





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

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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.

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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.

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**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, HF in task based risk assessment is described in Energy Institute (2025).
- 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.

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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:

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	
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).	
	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 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)	
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)	
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.	
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.	
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;	
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)	



	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: <i>Task-related error traps:</i> Unfamiliar tasks, Unpredictable tasks, Complex tasks, Limited time; <i>Organisational error traps:</i> Unclear roles and responsibilities, Task conflicts, Communication issues, Staffing and resources, Work organization; <i>Individual error traps:</i> Insufficient training/skillset, Lack of experience, Lack of rest, Stress ; <i>Technical error traps:</i> 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. <i>Physical ergonomics</i> 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.)
МТО:	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/	<b>Methodology:</b> A system of methods, rules and practices used in a particular discipline. (Example: ISO 11064). <b>Method:</b> Proceedures and techniques
Methodology:	characteristic of a particular field of knowledge. (Example Task analysis, user testing.) Methods provide an organized structure for employing techniques. <b>Techniques:</b> 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.

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HMI:	Human Machine Interface. HMI is the a human operator interacts with a mencompasses all elements that enable the human and the technical system keyboards, handles, knobs, mouse, of buzzers, touchscreens, auditory sign an HMI is to support safe, efficient, a information clearly, facilitating user Effective HMI design considers human minimize cognitive load, reduce the making under varying operational com	he system, device, or platform through which hachine, process, or complex system. It le perception, control, and feedback between , including displays, alarms, control panels, GUI (Graphical User Interface) , lamps, als, and visual cues. The primary purpose of and accurate human interaction by presenting input, and enhancing situational awareness. an capabilities and limitations, aiming to risk of human error, and optimize decision- onditions, (Inspired by ISO 9241-210).
Highly Managed Alarms:	HMA – see Key Alarms	
Human factors (HF):	<b>Cognitive, Physical an Organization</b> the scientific discipline concerned wi humans and other elements of a sys principles, data, and methods to des overall system performance."	al ergonomics. IEA (2000): "Human Factors is th the understanding of interactions among tem, and the profession that applies theory, ign in order to optimize human well-being and
	HF consist of: <b>Cognitive ergonomics</b> perception, memory, reasoning, and among humans and other elements concerned with human anatomical, biomechanical characteristics as the <b>ergonomics</b> is concerned with the op including their organizational struct	-concerned with mental processes, such as motor response, as they affect interactions of a system. <b>Physical ergonomics</b> is anthropometric, physiological and y relate to physical activity. <b>Organizational</b> otimization of sociotechnical systems, ures, policies, and processes.
Human Error:	Human error refers to unintentional expected procedures, often influence shortcomings, unclear guidelines or support to say that a large percenta, Wrobel (2021). Here "Human Error" expectation after the facts, and a sta and actual root causes. Rather than seeks to understand and mitigate th error possible, Endsley (2000), van V (2014). Poor design is often a root ca Kinnersley et al. (2007), Moura et al	actions or decisions that deviate from ed by systemic factors such as design environmental stressors. There is no scientific ge of accidents are due to Human Error, is not seen as a cause, but as unfulfilled orting point for trying to understand events assigning fault, effective analysis and CRIOP e underlying conditions and SA that made the Vinsen & Dekker (2016) and Dekker & Conklin ause for Human Error, Norman (2013), (2016).
HF Competency:	needed. Basic HF knowledge that is et al. (2017) and Stanton et al. (2013 Organizational ergonomics, IEA (200 are design and usability, cognition, h and alarms), human-automation into teamwork, and training/simulations	heeded are as an example documented in Lee (). Important areas are Cognitive, Physical and (): Key practical areas, Laumann et al. (2018) (uman machine interface (displays, controls, eraction, physical workload, mental workload,
Key alarms: Highly Managed:	Key alarms (Highly Managed Alarms as important safety-related and safe alarms, Emergency Power system st Pumps status information and failur	are a selection of high priority alarms, such ty critical alarms. Examples are: Fire and Gas atus information and failure alarms, Fire e alarms, Fire Protection System status
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	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)
САР	Critical Alarm Panel, a hardwired action panel used to control emergency functions
СС	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

## **()** SINTEF

DSHA/ DFU	Defined Situations of Hazards and Accidents ( <i>No:</i> 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
10	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 ( <i>No:</i> Sokkeldirektoratet)
NUREG	Document published by the staff of the Nuclear Regulatory Commission
OT	Operational Technology - OT is controlling physical processes and equipment.
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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
ТА	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 humansystem 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

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#### 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.

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	

Table 21 (		Checklists,	example
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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

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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)

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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. <u>Inadequate Oversight:</u> 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)
- 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. <u>Inadequate AI Maintenance</u>: 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.)
- 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

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#### 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).

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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.

#### 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.



Responsibility
Holds budgetary responsibility, defines the project scope, and approves project milestones.
Responsible for meeting specifications within the specified time and budget limits, and for coordinating resources from both the Operator and the Contractor.
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:

- 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:

Α.	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
В.	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).
D		

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

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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.

Area	Documentation	Yes/No
1. Project description and project plans	<b>Project definition</b> and <b>project plan</b> , including context, scope (interfaces to other installations), and goals with emphasis on planned changes.	
Installation layout	<b>Plant plan</b> or installation plan, Overall layout of Control Suite; <b>HF analysis for Control Suite Design;</b> 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	<b>Process flow sheet (process overview);</b> Safety, risk and emergency preparedness analyses (QRA, HAZOP)	

Table 31 CRIOP documentation chec	cklist- key documents in bold
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	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	<b>Control room or section layout plans;</b> Control room ceiling, lighting, colour plans, and architectural descriptions	
7. Control room equipment	<b>Description of process control system equipment and</b> <b>safety shutdown system equipment</b> 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

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• 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

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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<sup>2</sup>,
  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.
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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	The CRIOP leader should announce the termination of the analysis 30-45
termination:	minutes in advance, allowing participants time to prepare for final
	conclusions.

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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 preidentify 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.

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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.

Activities	Results/milestones
3.1 Describe scope and precondition for study.	<ul> <li>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.)</li> </ul>
	<ul> <li>Identify methods (ISO 9241-210, ISO 11064, CRIOP).</li> <li>(Identify standards: EEMUA 191/ISO 62682, IEC 63303)</li> </ul>
	• 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

### Table 3.-3 Activities and results from preparation activities



3.2 Planning and deciding on the "timing" of the CRIOP analysis	<ul> <li>Document workplan and tasks, document when the CRIOP analysis should be performed in relation to the design and operation of the control centre.</li> </ul>				
	Allocate and document necessary resources.				
3.3 Establishing the analysis group	<ul> <li>Establish and document the participants in the analysis group (include users from the sharp end and HF experts)</li> </ul>				
3.4 Collecting relevant	Document the status (see Table 3.2), including:				
documentation	<ul> <li>Control room layout, alarm strategy, screen prints (screen layout), process characteristics, and installation layout.</li> </ul>				
	<b>Document potential changes and development plans</b> , 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	Collect and distribute introductory information and relevant documentation to participants before the analysis				
CRIOP workshop	<ul> <li>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)</li> </ul>				
	Conduct a briefing and debriefing				



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

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#### 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.
- 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 62682. 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

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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. Relevant ISO/IEC standards for AI engineering are listed in Oviedo et al. (2024). ISO/IEC 5338:2023 describes the AI system life cycle processes and should be mentioned.

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.

Торіс	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.

Ref	Question/ Weak points	<b>Comments/ Recommendation</b>	Resp.
Prio			
L4.7	Can the operator maintain a natural	Redesign seating at the VDUs	Equinor/H
(High)	posture while seated at the workplace?	(desk/chairs).	MS/NN
20 votes	The operator's legs touch the lower part of the desk at the VDU workstations.		
W5.4	Are vibrations in the control room within	Increase distance or implement	Equinor/H
(Med)	acceptable limits?	measures to reduce vibrations.	MS/NN
10 votes	The control room is planned below vibrating equipment.		
C9.2.1	Are suppression mechanisms used to	Excessive unimportant alarms	Equinor/H
(Med)	reduce the number of consequence alarms?	divert the operators' attention from critical alarms, limiting	MS/NN
10 votes	Unnecessary alarms are not suppressed.	time for analyse. Implement suppression mechanisms.	
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#### Table 4.2- Documentation of results – Example (General Analysis)



C10.2	Are warnings provided if out-of-range	Enable warnings for out-of-	Equinor/H
(Med) 10 votes	Values are entered? There is no warning function for out-of- range values, risking entry errors (e.g. 44000 instead of 4400).	range entries.	MS/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	Describe IO/Operational philosophy more precisely and communicate goals.
(Weight 31)	(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 Alarm management, Multi Facility Control, new HMI standards, SA flow, 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
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?
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).
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<sup>-</sup>

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**Checklist G: General Questions** 

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### Checklist G: General questions

Facility	Performed by / date	Approved by /date

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G1	<ul> <li>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?</li> <li>A too narrow scope may ignore safety critical issues. Thus, it is important to discuss the scope including MTO (Human factors, Technology and organizational issues.) 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).</li> <li>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.</li> </ul>				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.		
G2	Are (all) the important stakeholders identified, analysed (roles identified), and involved in the project?				ISO 11064 (Series) ISO 9241-210 (2019)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The different stakeholders should be identified and involved in the project in the right way to support the project. A guiding coalition consisting of the influential stakeholders and management should be established. (This could be telecom, energy, security, etc.) 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				Kotter (1996) Pinto (1996)		
G2.1	implementation. 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)		
G3	Has a relevant HF method/process been selected to guide and ensure iterative user- based approach?				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		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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. (Guidance Haptic interactions see ISO9241-810)				ISO 9241-810 (2020); ISO 10218 (2025) For Al, check Oviedo (2024).		
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		
G6*	Have operational tasks been designed based on the strengths and weaknesses of the technology and human operator(s)?				ISO 9241-210 (2019) FR §9, §10		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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).				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 i.e. imagined. Identify critical tasks, explore issues that makes work difficult, and areas of high 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				MR §18. Nazaruk (2022). Dekker, Conklin (2014). IEA/ILO (2021). Thun (2021). Federation of Norwegian Industries (2025).		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	feedback? (A safe psychological environment where individuals are open about 'work as done', not being afraid of punishment?) (Thun, 2021)						
G9*	<ul> <li>Does the system support Meaningful Human Control i.e. ensuring sufficient time, mindset, organization, and systems/information to act before incidents occur?</li> <li>Is human oversight of safety-critical (AI) systems designed and implemented if necessary?</li> <li>Is design based on a TA (or SCTA) and user centred design ensuring clarity in responsibility, rapid detection and comprehension through HMI?</li> <li>Has workload been assessed to ensure operators have sufficient time to acquire SA and handle safety-critical tasks – especially situations of defined hazards?</li> <li>Has training and user testing of safety critical situations and key scenarios been approved by the users.</li> </ul>				FR §9, §21, MR §18 EU/AI act (art 14)- system oversight Bergh et al. (2024a)		
G10	<ul> <li>Has the system been tested and accepted by the relevant users, systematically step by step including unit testing, user testing, and whole system testing?</li> <li>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.)</li> </ul>				<ul> <li>CRIOP (2024) E15</li> <li>FR §9, §19; AR §24; TOR §45</li> <li>ISO 9241-11 Usability</li> <li>ISO/IEC 25000 series</li> <li>ISO/IEC 25010 effectiveness, efficiency, satisfaction and context of use</li> <li>ISO/IEC 25022 quality in use, measures of effectiveness, efficiency and satisfaction</li> <li>ISO/IEC 25023 measures for product quality</li> </ul>		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	*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.				<ul> <li>ISO/IEC TS 25011 service quality model for services or support IT</li> </ul>		
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	<ul> <li>Has the video equipment (screens and cameras including CCTV) been tested and approved by the end users?</li> <li>The video equipment should be tested and approved by the users. Important issues are: <ul> <li>Usability/ Simplicity of use</li> <li>User guides and user training</li> <li>Stability, fitness related to use, quality in use related to coverage, resolution and brightness.</li> <li>ATEX; and robustness and simplicity in maintenance.</li> </ul> </li> </ul>				HSE (2003)		
G11*	Does the operational concept in review going to use remote operations or new (non- traditional) ways of working?						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Then the remaining questions are relevant						
G12	Is the degree of remote operations or remote support defined and precisely described?				FR §10, §11 Kotter (1996)		
	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:				Johnsen (2005a)		
	<ol> <li>Remote Support: The operation is done offshore, but remote support is being given by onshore experts via teleconferencing, video, phone, or radio.</li> <li>Remote Monitoring: The operation is done offshore, but some sort of remote monitoring is being performed.</li> <li>Remote Control: The operation is managed and operated remotely.</li> </ol>						
G12.1	<ul> <li>A. Is a clear vision and goal for remote operations defined in cooperation with key stakeholders?</li> <li>B. Are the vision and goals of remote operations aligned with the organization's underlying values, philosophy, and procedures?</li> </ul>				FR §12, §13 Kotter (1996)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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.)						
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 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.				Kotter (1996): Nystrøm (2019), Adressa (2023).		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G12.3	<ul> <li>A. Are remote operations specified and developed in cooperation with the key users and stakeholders?</li> <li>B. Is the functional requirement for remote operations developed based on user requirements?</li> <li>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.</li> </ul>				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 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.				HSE (2003) Kotter (1996)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
G13*	<ul> <li>Are multiple facilities controlled?</li> <li>A. Has the scope and level of multi-facility control been identified (i.e. heterogenous, homogenous)?</li> <li>B. Has a verification (or simulation) of what is compatible to combine been performed?</li> <li>C. Has the human factors challenges been identified through a systematic process and planning identifying challenges of: <ul> <li>Maintain situation awareness across facilities.</li> <li>Handle simultaneous disturbances at multiple facilities.</li> <li>Workload and ability to prioritize.</li> <li>Manage differences between facilities (confusion/ Human Error).</li> <li>Unfamiliarity with construction and physical properties.</li> <li>Misconceptions about responsibilities.</li> <li>Social needs of the operator/ how to avoid isolation, where the operational context may lead to less contact.</li> </ul> </li> <li>D. Have the HF challenges been mitigated and accepted by the users?</li> </ul>				Hurlen (2022). FR §9, §10, §11, §13; MR §13; FA §10; §20 IEA/ILO (2021)		
G13.1 *	<ul> <li>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)</li> <li>IF the CC operator is going to operate drones (air, surface, underwater, etc.) HMI, layout and workload</li> </ul>				FR §9 Waraich (2013) Bakken et al (2020)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	must be addressed as mentioned in G13. Operator error rate of drone-operations is high – Waraich (2013)						
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 when remote operations are changed (i.e. onshore installations has been returned to offshore), to support knowledge and good practice. (Safety/SIL experience is important to share.)				Kotter (1996) Nyström et al. (2019))		
G15	<ul> <li>For new ways of working/ remote operation:</li> <li>A) Are the changes in the work processes specified and documented?</li> <li>B) Are the changes in work processes analysed in a Human Factor perspective considering Man, Technology, and Organisation?</li> <li>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. 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</li> </ul>				FR§ 9; MR §13 ANSI/HFES 400-2021 HRL DNV-RP-A203 (2021) HSE (2003) NIST (2023) SP 800-82 Johnsen (2006) Henderson (2002)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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	<ul> <li>A) Are all interfaces clearly defined and are all organizational areas of responsibility clearly defined and described?</li> <li>B)* Are "See-To" responsibilities clearly defined and described for SCT- safety critical tasks (ex. through work processes)?</li> <li>Who has the "See-To" responsibility of work-processes and workload, (EU Framework directive 89/391)?</li> <li>An example of interface could be responsibility between operator and supplier related to a firewall, or an IT network. Related to an interface, the following responsibilities should be defined:</li> <li>Who is actually operating the interface and has responsibilities to follow the SLA.</li> </ul>				HSE (2003) Henderson (2002) IOGP (2017) 423 Safetec (2023 <i>EU Framework directive 89/391</i> IEA/ILO (2021)		

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

POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	<ul> <li>able to function as a team to solve an emergency and possible operational problem. (Ref Orasanu) Does the requirements cover:</li> <li>1) Knowledge and assumptions about the current situation, termed "situational knowledge" or SA.?</li> <li>2) Professional knowledge about each participant's roles and responsibilities?</li> <li>3) Professional knowledge and understanding about standard operating procedures, termed "procedural knowledge"?</li> <li>4) Cultural knowledge, e.g. beliefs and norms based on company specific policies and norms?</li> </ul>						
G18	<ul> <li>A. Has a risk assessment of the operations been performed both prior to and after implementation of remote operations?</li> <li>B. Is the risk analysis approved by responsible senior management?</li> <li>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.</li> </ul>				MR §17 HSE (2003) ISO/IEC 27002 (2022) NOG 104 (2016); Hopkins (2000)		
G18.1	<ul> <li>A. Are new risk-based barriers established as remote operations are implemented?</li> <li>B. Are the barriers sufficient? Examples of barriers in this context are:</li> </ul>				ISO/IEC 27002 (2022) Johnsen (2006) Havtil (2017) Barrier Memorandum IFE (2020)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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 with better quality?						
G19*	<ul><li>A. Is the principle of safety/security by design established?</li><li>B. Are suppliers/technology selected based on safety/security by design?</li></ul>				CISA (2023a) NIOSH "Prevention through Design Program" (2024)		
G19.1*	<ul> <li>A. Has the scope of IT/OT systems been clearly documented?</li> <li>B. Has an assessment of the scope and criticality of these IT/OT systems been conducted?</li> <li>C. Is this assessment performed periodically?</li> </ul>				ISO/IEC 27002 (2022); NOG 104 (2016) CISA (2023), CRIOP (2024) E11.1		
	IT/OT integration is increasing to enhance operational efficiency and automation. However, the criticality of these systems may evolve over time due to several factors, including increased user reliance of systems, reduced manning (e.g., fewer personnel onboard), task relocation (e.g., transferring responsibilities from offshore to onshore teams).						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A system that was initially non-critical may become safety-critical, either through expanded operational roles (becoming a possible single point of failure), or the emergence of new vulnerabilities (e.g., cybersecurity threats). It is essential that criticality assessments consider operational continuity(C) and adhere to the (CAIC), CIA principles—Confidentiality, Integrity, and Availability—particularly when systems are involved in safety-critical operations.						
G19.2	<ul> <li>A) Is the safety and security of the individual IT/OT systems regularly assessed?</li> <li>B) Is a safety and security policy established based on identified major risks?</li> <li>C) Is the policy enforced and adhered to by relevant stakeholders?</li> <li>D) Is a formal risk management process in place for IT/OT systems?</li> <li>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 Norwegian Office of the Auditor General (Riksrevisjonen, 2019).</li> </ul>				ISO/IEC 27002 (2022) IEC62443 series NOG 104 (2016) Riksrevisjonen (2019)		
G19.3*	A) Does all the system have designated owners or responsible party?				ISO/IEC 27002 (2022) NOG 104 (2016)		

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POINT	DESCRI	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	B) C) D) E)	Does the "PåSe/ See-To" responsible actively follow up on system performance and the supply chain obligations? Is the IT/OT network segmented appropriately in accordance with the safety and security policy? (Are segmentation controls documented and maintained?) Are maintenance and system changes carried out in alignment with the safety and security policy, and risk management process? Is access to critical systems based on appropriate access control? (such as role-based access, two factor authentication, time limited credentials for contractors?) Is the code checked to avoid "back- doors" or malignant code? (Code to transfer data to another country)				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)		

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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?				HSE (2003) Jaatun (2007)		
	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).						
G 21	Are all necessary questions asked regarding the general questions (Remote, Security, etc?)						

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Checklist C: Control and safety systems

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### 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				Henderson (2002)		
	and documented based on functional and						
	task analysis (i.e. following best HF				DC: Applicable to the DC		
	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:						
	• <b>Direct communication</b> – Face-to-face						
	interaction, informal meetings (e.g., social						
	corners), and direct perception.						
	• Interactive real-time communication –						
	HIVII, telephone, videoconferencing, indirect						
	tools (e.g. MS Tooms, chat)						
	• Asynchronous communication – Logs						
	email and other non-real-time methods						
<u>C2</u>	Are the displays (and large screen displays)				FA §21		
-	designed according to ergonomic				NORSOK S-002 (2018) 7 8 3		
	principles, user requirements and best				FN 614-1 (2006), 4.1.		
	practice to suit the way they are to be						
	used?						

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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				DC: Applicable to the DC		
	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.						
C2.1	A. Are the displays designed in such a				NORSOK S-002 (2018), 7.8.3.		
	way that they support operators'				NORSOK I-002 (2021) 8.2.2.1.		
	tasks? (i.e. based on systematic task				EEMUA 191 (2013), 4.1.2, 2.7.1 &		
	analysis)				4.2		
	B. Is navigation between different				NUREG0700 (2020), 2.5.		
	displays quick and easy? (Based on						
	task analysis)						
	This concerns Graphics/HMI. Examples are				DC: Applicable to the DC		
	"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.						
C2.2*	Are open innovation principles,				OpenBridge (2025); OpenRemote		
	such as Open Remote or Open				(2025); (Standard for OpenCrane in		
	Bridge, considered from the start of				development, OpenBridge used in HMI for		
	the project?				Cranes.)		
	OpenRemote and OpenBridge are						
	human-centred design frameworks that						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
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	support open innovation. They provide				DC: Applicable to the DC		
	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 diso						
	innovation of suppliers must create and						
	maintain various system versions. While						
	open standards help a coherent system						
	architecture with focus on user-centred						
	desian and systemic desian thinking are						
	still essential.						
C2.3*	A. Is the project (and are suppliers)				EEMUA 191		
	following relevant HMI standards				ISO 11064		
	(such as requirements from IEC				IEC 63303-(ISA 101.01-2015)		
	63303 or other relevant standards?						
	B. Is the HMI system developed and						
	managed through an appropriate				DC: Applicable to the DC		
	life cycle model?						
	Does the system standards include						
	HMI philosophy. HMI style auide and						
	HMI toolkits.						
C2.4*	Are approved Management of				IEC 63303		
	Change (MOC) procedures being						
	used during the life cycle (design				DC: Applicable to the DC		
	and operation) of the HMI?						

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POINT	DESCRI	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
		Are tasks, systems, equipment, or						
		HMI that are not in use anymore,						
		removed?						
C3*	Has flo	ow of Situational Awareness (SA)				IEC 63303, Cpt 6 Situation Awareness		
	been o	designed to support "situation at a				(Inadequate situation awareness has been		
	glance	e" as evaluated by the users?				accidents attributed to human error.)		
	o Doe	s the system provide operators with adequate						
	situ	uational awareness across all conditions—				Endsley (2000)		
	em	peraency situations?				Hollifield (2008)		
	○ Is th	ne design aligned with Endsley's three levels of						
	SA:	:1- Perception – detecting critical elements in				DC: Applicable to the DC		
	the	e environment; 2-Comprehension –				DC: Applicable to the DC		
	Und Pro	aerstanding their meaning and relevance; 3- niection – anticipating future states and						
	eve	ents?						
C3.1*		Can SA and decision making be				IEC 63303		
		appropriately supported during				NORSOK S-002 (2018), 7.8.3.		
		high workload?				NORSOK I-002 (2021) 8.2.2.1.		
	•	Are the impacts of function				EEMUA 191 (2013), 4.1.2, 2.7.1 &		
		allocation on human workload,				4.2		
		situational awareness, and need for				NUREG0700 (2020), 2.5.		
		decision-making described and				DC: Applicable to the DC		
		evaluated?						
C3.2	Α.	Does the system present				IEC 63303 (2024)		
		information to support rapid				CRIOP (2024) C1.2		
		detection and comprehension?						
	В.	Does the system provide tools and						
		methods to help operators				DC: Applicable to the DC		
		maintain and enhance their						

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POINT	DESCRI	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
		situational awareness during						
		operations?						
C3.3	ls grap	phical coding effectively used to				ISO 11064-5 (2008), Annex A, A2.4.4.		
	suppo	rt quick understanding and pattern				DC: NORSOK I-002 (2021), 9.2.4		
	recogr	nition?						
	A. Is vi	isual coding applied to highlight						
	deviat	ions clearly?						
	B. Are	graphs used to reveal trends and						
	change	es over time?						
	C. Is gr	raphical emphasis placed on primary						
	inform	nation to guide attention?						
		Using graphical coding—either						
		alongside or instead of numerical						
		adta—can help reduce cognitive load						
		alance"						
C3.4		Does the visual salience (eye-				ISO 11064-5 (2008), table 2.		
		catching) of screen objects				DNV-OS-D202 (2023), 3.3		
		correspond to their importance?				DC: NORSOK I-002 (2021), 9.2.4.3.		
		The visual salience of graphical						
		objects and information should						
		follow this general rule:						
	0	Primary information (alarms and key						
		information): high						
	0	Other dynamic information:				DC: Applicable to the DC		
		medium						
	0	Static information: low						
		Note that the importance might						
		change in different operational						

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POINT	DESCRIPTION		Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
		contexts (e.g. suppressed, not						
		suppressed alarms).						
C3.5*		Are user interfaces designed to				IEC 63303		
		support human capabilities,						
		weaknesses, or possibility for						
		Human Errors?						
	0	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?						
	0	Is confirmation required for						
		commands that are considered						
		critical actions, such as shutdowns?						
	0	Error Tolerance: The system shall						
		take account of the fact that the						
		operator will make errors and						
		minimize the effect of these.						
C3.6*		Are user trained in all operational				IEC 63303		
		contexts, including but not limited						
		to:						
	A)	Interaction with the control system						
		under all modes of operation						
	B)	Use of the alarm system				DC: Applicable to the DC		
	C)	Recognition of abnormal situations						
	D)	Responding to process or control						
		upsets						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	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				IEC 63303		
	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				DC: Applicable to the DC		
	minimizing human error. (Including different						
	vendor packages)						
C4.1	Do operator interaction principles				ISO 9241-810 (2020).		
	for all screen work (systems) follow						
	commonly used interaction						
	principles?						
	It is important that the interaction				DC: Applicable only to DCs where screen		
	principles used follow general				work is much used. "One key commands"		
	conventions to the highest possible				may be used as screen interaction tool		
	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.						
C4.2	Is display information presented				FA §21		
	using consistent and unambiguous				EN 614-1 (2006), 4.4.3.		
	symbols?				EN 894-1 (1997), 4.4.3.		
					NUREG0700 (2020), rev. 3, 1.3.4.5.		

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	Symbols should require little				IEC 62288 (2021)		
	interpretation and memorization				OpenRemote/OpenBridge(2025)		
	and should be consistent within the				DC: Applicable to the DC		
	control room.						
C4.3 <sup>-</sup>	Is the time to complete a visual				FA §34a		
	display with 100 dynamic points				NORSOK I-002 (2021), 9.4.2.		
	less than 2 seconds?				EEMUA 191 (2013), 5.2.3.		
	The time to complete a display						
	should be short, to avoid annoyance						
	to operators. Note that response						
	time may increase when system load				DC: Applicable to the DC		
	is high. Check how modifications will						
	affect response time.						
C5	Are the main objectives for large screen				NORSOK I-002 (2021), 9.2.4.3.		
	displays properly identified and				NORSOK S-002 (2018), 7.8.3.		
	documented?				ISO 11064-5 (2008), table 2		
	Large screen displays should be used when				NUREG0700 (2020), rev. 3, 2.5.1.3 &		
	crew performance may be enhanced by				table 2.5		
	access to a common view of plant						
	information or a means of sharing						
	information between personnel. Check that				DC: Not Applicable to the DC		
	it provides:						
	$\circ~$ key information and overall plant status						
	information to relevant users.						
	$\circ~$ high level information to reduce mental						
	workload or enhance team						
	performance.						
	<ul> <li>permanently visible safety related</li> </ul>						
	information, as key alarms.						

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POINT	DESCRIF	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C5.1		Are the users of the large screen				EEMUA 191 (2013), 3.7.2		
		displays identified?				NUREG0700 (2020), rev. 3, section 2		
		Different personnel may need						
		different information. Consider e.g <del>.:</del>						
		CC operators, technicians, additional						
		personnel needed in a disturbance,						
		system engineers, test personnel,				DC: Not Applicable to the DC		
		emergency preparedness team						
		members, supervisors/management						
		and maintenance.						
C5.2		Are the different operational				NUREG0700 (2020), rev. 3, section 2.		
		contexts for which the large screen						
		display is aiding operators						
	A)	identified and				DC: Not Applicable to the DC		
	В)	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.						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C5.3	Is the information presented on				ISO 11064-3 (1999), 4.5.1.		
	large screen displays effectively				ISO 11064-5 (2008), table 2		
	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				DC: Not Applicable to the DC		
	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).						
C6*	Are the logic and actions of the		EU AI Act (Article 13 and 14) for high-risk				
	automation/ autonomy transparent			systems			
	enough for operators to understand what						
	the system is doing and why?						
	• Are there consistent and clear feedback				DC: Applicable to the DC		
	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?						
C6.1*	Can the operator easily take over				EU AI act (Art 14) mandates that high-risk AI		
	control from the automated system				systems be designed with mechanisms (stop buttons or intervention) to allow operators to		
	in the event of an emergency or				oversee and interrupt operations, when		
	system failure?				necessary.		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	<ul> <li>Can operators easily override automated actions or decisions when deemed inappropriate?</li> <li>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?</li> <li>Operators should not normally override actions of safety systems. They should train to take over (train in simulator).</li> </ul>				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 (if relevant) decision algorithms when using AI?				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). This is an important ability in critical systems, operating systems, etc.				EU AI Act (Article 14, 15) for high- risk AI systems Hollnagel et al. (2008)		

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

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The rationale behind this				NUREG0700 (2020), rev. 3, 4.1.3-1,		
	prioritisation should be documented.				4.1.8-1, 4.2.9-3 & 4.2.9-7		
	It is important to be able to identify						
	the different priorities and to easily				DC: Applicable to the DC		
	identify high priority alarms.						
C8.2	Are key alarms (highly managed				EEMUA 191 (2024), 2.5.1 & 3.5		
	alarms/a selection of high priority				ISO 11064-5 (2008), 6.3.4.		
	alarms) identified and presented in				NUREG0700 (2020), rev. 3, 4.2.7-1.		
	a manner that supports rapid						
	detection under all alarm						
	conditions?						
	The alarm processing system should				DC: This question is applicable only to some		
	clearly highlight alarms that demand				DCs where there are multiple alarms		
	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).						
С9	Is the alarm system designed in accordance				FA §34a		
	with human factors principles (i.e. physical				EEMUA 191 (2024), 2.1 (including		
	and cognitive ergonomics) and best				table 2)		
	practice?				IEC 62682 (2023)		
	The alarm system should be designed based						
	on recognised HF principles to ensure				DC: Visual alarm signals should be in front		
	usability and safe operation. (Especially						
	related to mental workload)						
C9.1	Is the design of the alarm system				EEMUA 191 (2024), 2.1, table 2 & 3.		
	based on				IEC 62682 (2023), 6.2.1.		

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POINT	POINT DESCRIPTION		Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A) an alarm philosophy and							
	В)	an alarm specification?				DC: Applicable to the DC		
		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	<i>i)</i> the role of the operator, how this						
		changes according to operating						
		state, and what support the						
		operator has,						
	iii	i) how the design accounts for						
		human limitations,						
	iv	<ul><li>the use of alarm priorities: their</li></ul>						
		purpose, how they are defined,						
		and the rationale behind the						
		definitions,						
	v	i) the use of alarm						
		acknowledgment, including its						
		purpose, how operators should						
		be trained in its use, standards,						

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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				EEMUA 191 (2024), 2.1, table 2 & 3.		
	procedures to document and				IEC 62682 (2023), 6.2.1.		
	manage the alarm rate over time?				Havtil (2022a), follow up. FA §34a		
	E.g. to improve the alarm system				DC: Applicable to the DC		
C9.2	Are human factors, capabilities and				FA §34a		
	limitations explicitly taken account				NORSOK I-002 (2021), 9.2.4.4.2.		
	for when designing the alarm				EEMUA 191 (2013)		
	system?				IEC 62682 (2023)		
	Some of the key factors to be taken						
	account of include:						
	A. The goal should be fewer than one				DC: Applicable to the DC		
	critical alarm per ten minutes, with						
	up to two per ten minutes being				Note: Fixing standing alarms should be		
	manageable. (EEMUA)				quite easy.		
	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.						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C9.2.1	Are suppression mechanisms used				FA §34a		
	to reduce the number of				EEMUA 191 (2013), 5.5.2 & 5.5.3.		
	consequence alarms?				NUREG0700 (2020), rev. 3, 4.1.2-2.		
	This is especially important during				DC: May not be applicable to the DC, as there is		
	equipment/ process shutdown. Too				a limited number of alarms		
	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)						
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?		

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POINT	DESCRI	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
C9.2.3		Are performance requirements to				EEMUA 191 (2013), 6.2, 6.3 & 6.4.		
		the entire alarm system				IEC 62682 (2023), 16.5.2		
	A)	defined and						
	В)	used?						
		Performance measures include				DC: Applicable to the DC		
		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.						
C9.3		Is the alarm priority context				EEMUA 191 (2013), 2.5.2.		
		sensitive?						
		Check if alarms are designed so that				DC: Applicable to the DC		
		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.						
C9.4	Α.	Does each alarm state have a				NORSOK I-002 (2021), 9.2.4.4.3.		
		unique presentation?				NUREG0700 (2020), rev. 3, 4.2.9.3.		
	В.	Is there consistency between how						
		different alarm states are						
		presented in the process displays				DC: Applicable to the DC		

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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				NORSOK I-002 (2021), 9.2.4.4.		
	process displays?				NUREG0700 (2020), revision 3,		
	Operators cannot know the physical				4.2.9-1 – 4.2.9-5.		
	location of all alarm sensors by heart						
	and should therefore have means of						
	identifying the location of infrequent				DC: Is the location of an activated sensor		
	alarms. Information about the				(pressure, gas, fire, height etc.) presented visually in the drilling displays?		
	geographical arrangements of						
	detectors and fire areas shall be						
	available in the CC.						
C9.6	Are new alarms presented in a				IEC 62682 (2023), 5.5.2.		
	manner that supports rapid				EEMUA 191 (2013), 2.4.1.		
	detection and comprehension?				DC: Applicable to the DC		
C9.6.1	Can all key alarms be read even				EEMUA 191 (2013), 2.5.1 & 6.5.2.		
	when multiple alarms are triggered				NUREG0700 (2020), rev. 3, 4.2.2-1,		
	simultaneously?				4.2.2-2 & 4.2.8.1.		
	A full overview over key alarms						
	should be provided, e.g. on a						
	dedicated display for all alarms.				DC: This question is applicable only to some		
					DCs where there are multiple alarms		
C9.6.2	Are new alarms presented both				IEC 62682 (2023), 11.3.2.		
	audibly and visually?				EEMUA 191 (2013), 4.1.1, 4.3 &		
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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Audible alarm annunciation should						
	be used when new alarms arrive,				DC: Applicable to the DC		
	and special visual annunciation						
	should be used for new alarms.						
C9.6.3	Are auditory and visual alert signals				IEC 62682 (2023), 11.4.2.		
	A) unambiguous and				EEMUA 191 (2013), 4.3.		
	<li>B) perceivable from all relevant</li>				IEC 62682 (2023), 11.3.2.		
	workplaces in the CC under all				NUREG0700 (2020), rev. 3, 4.2.6.1-1,		
	operating conditions?				4.2.6.1-2, 4.2.6.2-1 & 4.2.6.3-3		
	The purpose of auditory and visual						
	alert signals is to attract the						
	operators' attention to a deviation.						
	The use of flashing (or blinking)				DC: Applicable to the DC		
	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, and it should be checked that						
	he can perceive all alarms?						
C9.6.4	Do auditory and visual alert signals				NUREG0700 (2020), rev. 3. 4.2.6.3-		
	have appropriate intensity?				21 & 4.2.6.2-3		
					Barrett (2021)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Alarm signals should not startle,				ISO 7731:2003		
	annoy, or distract operators, or						
	interfere with verbal communication.				DC: Applicable to the DC		
	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.						
C9.6.5	Is alarm information presented				EEMUA 191 (2013), 4.2 & 4.1.1.		
	using consistent and unambiguous				NUREG0700 (2020), rev. 3, 4.2.6.1-2		
	colours?				& 4.2.6.2-6.		
	Colours used to prioritise alarms						
	should not be used for other				DC: Applicable to the DC		
	purposes.						
C9.6.6	Are alarm texts informative and				EEMUA 191 (2013), 1.2.		
	easy to understand?				IEC 62682 (2023), 10.5.2.		
	Alarm texts should be easy to				ISO 11064-5 (2008), 6.3.8.		
	understand, requiring minimal				NUREG0700 (2020), rev. 3, 4.1.2-11		
	interpretation and memorization.				& 4.2.5-1.		
	They should include only the						
	information essential for operators.						
	Acronyms and abbreviations should				DC: The question is applicable to some DCs,		
	be standardized and known to the				similar		
	operator. Operators should be						

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POINT	DESCRI	PTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
		involved in the development of						
		alarm texts.						
C9.7		Can the operator:				NORSOK I-002 (2021), 9.2.4.4.3		
	A)	Silence auditory signals from any				NUREG0700 (2020), rev. 3, 4.3.3-2,		
		workstation?				4.3.3-1 & 4.3.2-1.		
	В)	Acknowledge alarms only from						
		locations where the alarm message						
		can be read?						
		It should be possible to silence an				DC: Applicable to the DC		
		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.	-					
C9.8		Does the operator have access to				NUREG0700 (2020), rev. 3, 4.1.2.11.		
		alarm inputs?						
		The operator should have the ability						
		to view inputs to the alarm						
		processing system (e.g. sensor data).				DC: Applicable to the DC for some alarms.		
		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						

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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				NORSOK I-002 (2021), 8.1.6.2		
	alarms sufficiently accurate						
	to represent the correct						
	sequence of events,				DC: Applicable to the DC		
	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.						
C9.8.2	Is the warning alarm related				IEC 62682 (2023), 5.4.6 & 9.4.		
	to trip limit, set in such a				Smidt Olsen & Wendel, 1998, App.2		
	manner that the operator						
	can react before the trip						
	limit is reached?				DC: For instance, height of the top drive. Is		
	This can be done by				mud logging involved in setting the trip		
	monitoring parameter						
	trends.						
C9.9	Are relevant availability				NORSOK I-002 (2021), 9.1.2.		
	requirements defined for the alarm				EEMUA 191 (2013), 5.2.2 & 2.3.4.		
	system?				IEC 61511-1 (2016), 11.4.		
					IEC 62682 (2023), 11.11.2		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The components constituting the				IEC 61508 series		
	alarm system should be fault-						
	tolerant, ensuring that safety-critical				DC: Is independent backup of safety		
	information is always available to				critical systems in the drilling		
	the operators, during normal				module available (H2S, HC, pressure,		
	operations and in emergencies.				flow rates)?		
	Factors to consider include						
	redundant CPUs, I/O and bus						
	systems, UPS as backup for						
	electrical/electronic equipment, and						
	redundant displays.						
C10	Are control actions fault-tolerant and				NUREG0700 (2020), rev. 3, 2.8-1		
	simple to execute?				(table 2.6), 7.3.5-2 & 7.3.1.		
	Errors in manual actions are more likely to						
	occur in stressful situations, such as						
	accurately placing a light pen on displays or				DC: Applicable to the DC		
	entering words longer than seven						
	characters.						
C10.1	Are operational systems,				NUREG0700 (2020), rev. 3,		
	instruments, and controls that are				11.2.2.1.12, 11.2.2.23, 11.2.3.1.1-		
	used together located next to each				3 & 11.2.3.2-1.		
	other?						
	Related controls and displays should				DC: Applicable to the DC		
	be easily identified as being						
	associated such as metering system,						
	marine system, and F&G system.						
C10.2	Are warnings provided when out-				NORSOK I-002 (2021), 6.1.4.		
	of-range values are entered?				ISO 11064-5 (2008), Annex A, A2.4.6		
	Entering out-of-range/extreme				EEMUA 201 (2019), ed. 3, 4.8.		
	values (e.g., values expressed as a						

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

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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				FA §32		
	follow-on actions performed						
	automatically?						
	E.g. PA messages to go out automatically or				DC: Not Applicable to the DC		
	deluge performed automatically. (No hot						
	work)						
C12.1	Is the operator timely informed				FA §33		
	about deviations when performing				NUREG0700 (2020), rev. 3, 4.1.2-1 &		
	the shutdown function?				14.1.3.		
	To be able to intervene, operators						
	must be able to detect any failures in						
	shutdown actions. A separate				DC: Not Applicable to the DC		
	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.						
C13	Can safety systems be started manually				FA §33, §34, §35		
	from the CC?				DC: Partly applies to the DC. Emergency		
	Examples: Hardwired De-pressurisation, fire				shutdown in the drilling area may include		
	pumps etc., through panels.				ESD valves in alfferent levels, stop of all		
					BOP, fire pumps, deluge etc.		

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

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#### Legend

- <sup>a</sup> 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				NUREG0700 (2020), rev. 3,		
	actions protected from				3.1.1.1-3, 13.6-1, 7.3.1-6, 3.1.3-3		
	accidental activation?				& 2.7.6-6.		
	Controls may be recessed, shielded, or otherwise surrounded				DC: Applicable to the DC		

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	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	

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

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

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	auidelines such as FN 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		DC: Applicable to the DC	
	related to Control and Safety Systems?			

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C17 DC	<ul> <li>Has the communication in the driller's cabin been considered with respect to:</li> <li>A) Communication between the driller's cabin and other control cabins in the drilling module?</li> <li>B) Activation of communication equipment whilst operating drilling equipment?</li> <li>C) Communication between driller cabin and drill floor personnel?</li> </ul>	Other relevant cabins are mud logging, derrick man's cabin etc. Check need for communication via other means such as hand-signs.	
	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.		

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Checklist J: Job organisation



#### Checklist J: Job organisation

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
J1	Is it documented that the job and work				HFAM (2003)		
	organisation consider relevant information such as:				ISO 11064-1 (2000), 4.6		
	A) Task analysis covering all modes of system						
	operation and administrative task?						
	B) Workload analysis?				DC: Applicable to the DC		
	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 addressina clear eraonomic 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.						
J1.1	Are tasks adequately allocated				ISO 11064-1 (2000), 7.3.		
	between operator and system?				EN 614-1 (2006), 5.2.1 (table 1)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Check: Are high speed, high accuracy or				De Winter et al. (2014).		
	highly repetitive tasks done				DC: Applicable to the DC		
	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).						
J1.1.1	A. Is the operator fully aware of				HFAM (2003).		
	what he or she is expected to				ISO 11064-1 (2000), 7.4 & 7.5.		
	do at all times? (i.e. will the						
	design provide the operator				DC: Is there a system for safety job		
	with information necessary to				analysis, pre-job meetings and		
	execute the tasks in a safe and				information meetings at departure to		
	efficient manner).				drilling location? Are the drillers		
	B. Are operators given reasons for				involved in preparing and checking the		
	what they are expected to do				procedures?		
	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						

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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				HFAM (2003)		
	incompatibilities in operator						
	tasks and performance						
	criteria?				DC: Applicable to the DC		
	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						
14.2	supervisor?			-			
J1.2	is the allocation of responsibility and				ISO 11064-1 (2000), 7.5		
	authority clear, complete, non-				DC: Is the driller's and assistant driller's		
	the operators and their collaborators?				responsibilities clearly stated and known to		
	Each operators should be informed about				supervisors, drillers, deck personnel and		
	bis or her responsibilities, as this will				relevant operators in the drilling module?		
	ensure that all tasks are conducted as						
	required This is also very important						
	related to collaboration related to						
	remote operations or remote support						
J1.3	Are jobs organized so that all operators				HEAM (NPD 2003)		+
	have a roughly equal workload?						
J1.2 J1.3	be "rewarded" for unsafe acts or for maintaining production when they should have shut down. 				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? HFAM (NPD 2003)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	A workload analysis should be carried				DC: Applicable to DCs where there is		
	out to ensure that all operators have an				more than one operator		
	optimal and roughly equal workload.						
J1.4	Are periods of high and low mental				AR §33, §35		
	workload within acceptable limits?				ISO 10075-2 (2000), 4.5.		
	Good operator performance during high				EN 894-1 (1997), Appendix A		
	workload periods can only be				For NASA-TLX see Stanton et al. (2013)		
	maintained for short periods of time,				or NASA TLX (1986)		
	not to exceed 45 minutes. Describe						
	tasks and periods with high mental or						
	physical workload.				DC: Applicable to the DC		
	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						
J1.5	Are the shifts designed according to				FR §37-§44		
	rules, regulations, and standards?						
	Examples are HSC Rules and regulations				DC: Applicable to the DC		
	(In Norway: Arbeidsmiljøloven).						
J1.5.1	Is job rotation practiced?				ISO 11064-1 (2000), Annex B, B.4.		
	Job rotation implies that						
	operators alternate between						
	the control room and the field.				DC: May not be applicable to the DC		
	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						

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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				ISO 11064-1 (2000), 7.5		
	planned/coordinated with						
	control centre tasks?						
	The workload must be planned				DC: Applicable to the DC		
	so that operators can take						
	breaks during quiet periods.						
J1.6	Is the job and work organisation				FA §73-§77; ISO 11064-1 (2000)		
	designed to handle abnormal				NORSOK Z-013 (2024)		
	situations?				DC: Applicable to the DC		
J1.6.1	Are the changes in				ISO 11064-1 (2000), 7.2		
	responsibilities during an						
	emergency/abnormal				DC: Are the driller's responsibilities		
	operation clearly defined and				versus the company man's or tool		
	established through practice?				pusher's responsibilities in case of a well		
	Responsibilities and operator				control situation clearly defined and		
	task in the CC change from				known by relevant personnel?		
	normal situations to abnormal						
	operations. These changes must						
	be known to and accepted by all						
	personnel.						
J1.6.2	Is relevant and competent				ISO 11064-1 (2000), 7.5		
	assistance to the CC operators				NUREG0700 (2020), rev. 3, 6.1.4-1,		
	from other personnel available				12.1.1.2-2, 12.1.1.6-2.		
	during abnormal situations?						
	The job organisation shall allow				DC: Are other personnel with required		
	operators to exchange or share				certificates and courses available during		
	information in such cases where				abnormal situations? Are there		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	teamwork is required to carry				dedicated personnel for this on each		
	out a task. Check: field				shift?		
	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).						
J2	Is the job organisation designed to provide				ISO 11064-2 (2000), 5.1.		
	effective information transfer?				DC: Applicable to the DC		
J2.1	Does the work permit system ensure				MR §17		
	that operators and supervisors are				AR §30, §31, §32		
	continuously aware of all critical and						
	hazardous work in progress?				DC: Applicable to the DC related to drill		
	A large number of work permits often				floor, drilling cabin, etc.		
	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.						
J2.2	Are procedures for communication in				ISO 11064-1 (2000), 7.5		
	operation drawn up and followed?				SfS (2023)		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Is there clear prioritisation of						
	communication channels when there				DC: Is there a dedicated drilling		
	are several – i.e. radio, telephone,				channel?		
	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).						
J2.3	Are there clear procedures for the				AR §32		
	handover of information and				ISO 11064-2 (2000), 4.5.		
	responsibility between different CC						
	shifts and between different personnel				DC: Are proper handovers between		
	categories?				drillers and assistant drillers performed?		
	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						

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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				FR §13		
	modifications in the current and future				ISO 11064-1 (2000), 10.1 & 10.2		
	designs?						
	Experience from incidents should be used to				DC: Is there a system to ensure		
	ensure that problems are not repeated in the				distribution of information to relevant		
	current system or future designs (of MTO).				personnel such as drillers, derrick man		
	Experience from process disturbances is a useful				etc?		
	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?						
J3.1	Is there a reporting system for				MR §19, §20		
	incidents and near misses in use?				FR §13		
	There should be a focus on the reporting				ISO 11064-1 (2000), 10.2		
	system. The system should be actively						
	used for recording near misses,				DC: Applicable to the DC		
	incidents and accidents. The system						
	should be capable of providing a list of						
	all incidents. (Check possibilities of						
	automated reporting).						
J3.1.1	Are the recommended changes				MR §19, §20, §21, §22		
	following an incident				FR §13		
	implemented within an				ISO 11064-1 (2000), Annex B, B.3.		
	acceptable time frame?						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	All actions regarding				DC: Applicable to the DC		
	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.						
J4	Are all necessary questions asked related to				DC: Applicable to the DC		
	Job Organisation?						

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Checklist L: Layout

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#### Checklist L: Layout

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

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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				ISO 11064-2 (2000), 5.2.		
	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				DC: Applicable to the DC		
	this.						
L3.1	Can personnel work at and move				NORSOK S-002 (2018), section 8		
	past the workstations without				ISO 11064-3 (1999), 4.3.		
	accidentally altering the controls?				NUREG0700 (2020), rev. 3, 13.6-1.		
	<ul> <li>For main walkways:</li> </ul>						
	<ul> <li>Vertical - 2700 mm (2300 mm is</li> </ul>						
	recommended)						
	– Horizontal – 1000 mm						
	<ul> <li>For access ways:</li> </ul>						
	– Vertical – 2100 mm (2300mm in				DC: Applicable to the DC, however the		
	door openings and above each				numbers are not		
	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						

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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				NORSOK S002 (2018), Annex F		
	objects, and slippery liquids						
	avoided?						
	Check: Different floor levels, cables,						
	waste bins, clothes, thresholds and				DC: Applicable to the DC		
	table edges.						
L3.3	Are frequently used walkways				NORSOK S-002 (2018), 8.1 & table 2.		
	within the CC unobstructed?				ISO 11064-3 (1999), 4.3.1.		
	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				DC: Applicable to the DC		
	in walkways, access ways, and						
	transportation ways.						
L4	Is the workplace of the operator designed				NORSOK S-002 (2018)		
	according to ergonomic principles and best				EN 547-1/2/3 (1996)		
	practice?				EN 614-1 (2006)		
	Consult ISO 11064, relevant NORSOK				EN 1005- (2001-2007)		
	standards as mentioned in these checklists.				ISO 11064-1 (2000)		
					ISO 11064-2 (2000), 4 & 5		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
L4.1	Description         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, and possible obstructions from personnel during emergencies.         NB: Requirements from DNV-OS-D202 are used (figure L2) The requirements from EN894-2 are	res			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         Available (A)         Figure L2         DC: NORSOK S-002 (2018), 2.1.1.		Resp.
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.		

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	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				NUREG0700 (2020), rev. 3, 11.2.1-7,		
	operators' workplaces for use of				11.2.1-8, 11.3.4.14 & 11.3.4.1-5		
	written documentation without				ISO 11064-2 (2000), 4.5, Annex A.1		
	interfering with controls and visual						
	displays?						
	The desk at the workplace should be				DC: Applicable to the DC <i>Nearby, at hand,</i>		
	at least 410 mm deep and 760 mm				close to the driller's chair there should be		
	wide.				room jor pipe tunies and procedures.		
	Desks must allow support for elbow						
	in front, keyboard, A3 sheets and						
	books. Provision should be made so						
	that the procedures, manuals, and						

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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.		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	The desk and chair at the operator's				EN 614-1 (2006), 4.3.		
	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				DC: Measures in figure do not apply to DC		
	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.						
L4.8	Can the operator get in and out of				EN 614-1 (2006), 4.3.2		
	the chair at the workplace freely?				NUREG0700 (2020), rev. 3, 12.1.1.2.		
	Minimum requirements for operator						
	manoeuvring space are				DC: Applicable to the DC, but not the measurements shown in Figure 11. It should		
	approximately 760 mm laterally				be possible to rotate the Driller's chair for		
	( sideways ) and 920 mm from the				easy access		
	euge of the desk to dry opposing						
	Surjace ( Dackwards ).						
	KEJ. FIGURE LL. INSPIRED BY						
	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				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		

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#### 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				ISO 11064-2 (2000), 4.5 ISO 11064-2 (2000), Annex A.1. DC: Applicable to the DCCheck that sufficient space is available for doing necessary paperwork (e.g. drilling reports).		
	area should accommodate A3 folders.						

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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				ISO 11064-3 (1999), 4.4.2.		
	workplace allow easy visual				ISO 11064-2 (2000), 5.1.		
	and voice contact with				NUREG0700 (2020), rev. 3,		
	operators?				12.1.1.62.		
	B) If the supervisor is not						
	located in the control room,						
	are dedicated						
	communication lines						
	provided?				DC: Applicable to the DC		
	Communication between						
	operators and supervisors						
	must be possible in spite of						
	heavy communication						
	during abnormal situations.						
L5.2.2	Does the supervisor's				ISO 11064-3 (1999), 4.4.2.		
	workplace allow him to				NUREG0700 (2020), rev. 3, 12.1.1.6-		
	obtain important				1		
	information in the control						
	room?						
	check: process mimics, fire						
	and gas panels, equipment						
	status overviews, initiation						
16	Are the social peeds of the operator				150 11064 1 (2000) 0 2		
LO	considered?				$150\ 11064\ 1\ (2000),\ 9.2$		
	considered:				DC: There should be coffee and rest		
					facilities in the vicinity of (not within) the		

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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		

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Checklist W: Working environment



### Checklist W: Working environment

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

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
W2.2	Are colours and surfaces in the CC				NORSOK S-002 (2018), 7.6.		
	chosen to minimise contrast and				EEMUA 201 (2019), ed. 3, 2.4.4 &		
	reflection?				Annex A2.6.		
	The following features are				ISO 11064-6 (2005), 5.3.		
	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				DC: Applicable to the DC		
	textured finishes reduce reflected						
	glare.						
W2.3	Are measures taken to prevent				NORSOK C-002 (2015), 4.6.		
	static electricity?				ISO 9241-6 (1999), 8.1.		
	Static electricity can cause						
	failure/loss of visual displays when						
	displays are touched. Materials in				DC: Applicable to the DC		
	chairs, floor and footwear should be						
	chosen to reduce static electricity.						
W2.4	Are measures taken to prevent				IEC TR 61000-5-1 (2023), 4.1 & 4.2		
	electromagnetic disturbances of CC						
	equipment?						
	Electromagnetic disturbances may						
	cause interference to electrical						
	signals and damage electronic						
	equipment in the CC. Relevant				DC: Applicable to the DC		
	measures include shielding of						
	equipment and appropriate selection						

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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		

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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				FA §14		
	the sum of the following:				NORSOK S-002 (2018), 7.7.1		
	A. air flow requirements for				NLIA (2013), "Workplace		
	personnel,				Regulations", chapter 2 & 7		
	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				DC: Applicable to the DC		
	personnel calls for an air flow rate of 7 -						
	10 I/s per person. Emissions from						
	normal building materials without						
	2 1/s par m2. Extra girflow should be						
	added for e.a. heat generating						
	equipment.						
W3.4 <sup>-</sup>	Is the air intake located in open air:				NORSOK S-002 (2018), 7.5.4		
	A. at a safe distance from exhaust				NLIA (2013), "Workplace regulation"		
	outlets and vent pipes and				DC: Applicable to the DC		
	B. in a shaded place so the air is as						
	cool as possible in the summer?						
W3.5	Is smoke and gas detection				NORSOK S-002 (2018), 7.5.3.		
	equipment located at the air intake						
	(and air outlet)?				DC: Applicable to the DC		
W3.6	Is easy and safe access provided for				NORSOK S-002 (2018), 6.2.9.		
	operators for				ISO 11064-4 (2013), 4.4.		

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POINT	POINT DESCRIPTION		Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	А. В.	Internal inspection and cleaning of ducts? Change of air filters?				DC: Applicable to the DC		
W3.7 <sup>-</sup>		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 ligh princi	ting designed according to ergonomic ples 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).		

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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 E. 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		

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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				NORSOK S-002 (2018), 8.2		
	and adjustable in intensity and				EU (2017).		
	direction?						
	Adjustable lighting offers the				DC:400 lux for DC		
	following advantages:						
	A. Gives personal control over the environment						
	B. Gives varying light level according to						
	different tasks to be carried out.						
	<i>c.</i> Caters for different physiological						
	lighting needs between day and night.						
	D. Make sure that adjustable						
	directional lighting does not cause						
	reflections						
W4.2.1	Are glare and reflection				NORSOK C-001 (2015), 7.19.1.		
	from lighting avoided?				EEMUA 201 (2019), ed. 3, 2.4.1.		
	Direct glare and reflections				ISO 11064-6 (2005), 5.3 & Annex A.4		
	on displays cause discomfort						
	and problems reading						
	displays. The choice of				DC: Applicable to the DC		
	fittings influences reflections						
	significantly. Indirect lighting						
	snouid be considered used. Eittings should be to the side						
	Fillings should be to the side						

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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		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
W4.3	Is additional lighting provided in				NORSOK S-002 (2018), 7.6		
	areas where greater intensity is				NORSOK C-001 (2015), 7.19.1		
	needed?						
	Lighting intensity at workplace for				DC: Lighting must not disturb view to the drill		
	paperwork should be min. 500 Lux.						
W4.4	Is emergency illumination between				NORSOK S-001 (2021)		
	15 and 50 lux?				EN 1838 (2013)		
	1 lux is the requirement of EN 1838				IEC 61892-2 (2019), 11.4		
	for escape routes 0.5 lux for open				BS 5266 (2016)		
	areas. Areas of high physical risk, or				NUREG0700 (2020), rev. 3, 12.1.2.4		
	the control rooms of dangerous						
	plant and production lines, need						
	emergency lighting to enable them				DC: Applicable to the DC		
	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						
\A/E	Are accustic environment and vibrations				150 11064 (1999-2012)		
VV 5	designed according to working				DC: NORSOK S-002 (2018)		
	environment regulation and best practice?						
W5.1	Is the total noise level below 45 dB				FA §23		
	(A-absolute)?				TOR §6, §7		
	The noise level limit refers to				NORSOK S-002 (2018), 8.2 (table 3).		
	background noise including HVAC as						
	well as noise sources in continuous				DC: Total noise level: 65 dB (+ 5 dB for		
	use within the room. Good				mobile Offshore Units). Noise from the		

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

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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?						
Are noisy office machines like				NORSOK S-002 (2018), 7.3		
printers, copy machines, servers, air				ISO 11064-2 (2000), 4.4		
conditioners, and air fans placed in						
a separate, unmanned area?						
Such machines should not be in the				DC: Applicable to the DC		
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.						
Are vibrations in the control room				AR §39		
within acceptable limits?				FR §24		
Vibrations cause discomfort and				TOR §26		
fatigue to personnel and may				NORSOK S-002 (2018), 8.2 (table 3)		
damage control room equipment.				NS 4931 (1985, Same as ISO		
Limits for vibration are stated as				6897:1984)		
acceleration $(m/s^2)$ as a function of				ISO 2631-1 (1997), 8.1 & 9.1		
frequency (Hz). (On a personal level				ISO 5349-1 (and -2) (2001), Annex B-		
$2.5 m/s^2$ ).				ט		
For vibration limits, reference is				DC: DC is considered as Catagony 2		
made to NURSUK S-UU2, REV 4,				(Drilling areas)		
	Initialnoisiest 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?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.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/s²) as a function of frequency (Hz). (On a personal level 2.5 m/s²). For vibration limits, reference is made to NORSOK S-002, REV 4,	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?         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.         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/s²) as a function of         frequency (Hz). (On a personal level         2.5 m/s²).         For vibration limits, reference is         made to NORSOK S-002, REV 4,	IndicationIndicationnoisiest 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?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.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/s²) as a function of frequency (Hz). (On a personal level 2.5 m/s²). For vibration limits, reference is made to NORSOK S-002, REV 4,	InstructionInstructionnoisiest 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?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.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/s²) as a function of frequency (Hz). (On a personal level 2.5 m/s²). For vibration limits, reference is made to NORSOK S-002, REV 4,	InstructionInstructionnoisiest 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?NORSOK S-002 (2018), 7.3Are 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), 7.3Are vibrations in the control room within acceptable limits? Ubrations cause discomfort and fatigue to personnel and may damage control room equipment. Limits for vibration are stated as acceleration (m/s²) as a function of frequency (Hz). (On a personal level 2.5 m/s²). For vibration limits, reference is made to NORSOK S-002, REV 4,AR is in the control room (Drilling areas).D: D: DC is considered as Category 2 room (Drilling areas).DC: DC is considered as Category 2 room (Drilling areas).	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?       NORSOK S-002 (2018), 7.3         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         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 <sup>2</sup> ) as o function of frequency (Hz). (On a personal level 2.5 m/s <sup>2</sup> ). For vibration limits, reference is made to NORSOK S-002, REV 4,       AR §39 FR §24 TOR §26 DC: DC is considered as Category 2 room (Drilling areas).

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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				DC: Applicable to the DC		
	to Working Environment?						

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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,				Vatn (1997)		
	use and maintain procedures and work				CCPS (1996)		
	descriptions?				CCPS (2022)		
	A. Has a philosophy and goal/vision for						
	development of procedures and work				DC: Applicable to the DC		
	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?						
P1.1	Are procedures developed in a				MR §13, Chapter V		
	structured manner, based on				AR §24		
	functional analysis and task				Vatn (1997)		
	analysis?				CCPS (1996)		
	The structured approach should				CCPS (2022)		
	consist of the following steps:						
	A. Identify core tasks, identify hazards				DC: Applicable to the DC		
	and working environment issues and						
	identify supporting tasks related to						
	these.						

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POINT DESCRIPTION		Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	<ul> <li>B. Plan the sequence of the core tasks and supporting tasks.</li> <li>C. Perform a hierarchic breakdown of the tasks.</li> <li>D. Perform tabular task analysis of critical and difficult task steps. This should include human – machine interaction and possible erroneous actions.</li> <li>E. Perform structured walk through of</li> </ul>						
	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.				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		

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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		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
P1.1.5	to describe actions, as opposed to a narrative format. Drawings, figures, checkoff provisions and feedback from control room systems should be provided. <b>Do the procedures and work</b> <b>descriptions support fault</b> <b>tolerant work practices</b> ? 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)		
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.				and proceed" 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		

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	should be in the form of						
	reminder checklists with						
	guidance on priorities, rather						
	than detailed instructions.						
P1.3	Is a system for checking and				HSE (2023b)		
	modification of procedures				NUREG0700 (2020), rev. 3, Appendix		
	established and in use?				В, В.З		
	There must be rules and				CRIOP (2024) 1.3.2		
	authorisation to cover these areas. It						
	should be easy to modify procedures				DC: Applicable to the DC		
	when needed. Modification of						
	paper-based procedures can be						
	eliminated or minimized by						
	computer-based procedure designs						
	where practical.						
P1.3.1	Are the procedures available				DC: May not be applicable to the DC because		
	digitally/on-line, and in				of missing on-line terminals.		
	latest version?						
P1.3.2	Are procedures checked				HSE (2023a)		
	routinely, compared with				HSE (2023b)		
	operator action, learning				UKAEA (1985) p.12		
	from incidents, and revised						
	as appropriate?				DC: Applicable to the DC		
	The updating of procedures is						
	often not carried out						
	systematically in the						
	organisation, causing						
	information to be out of						
	date. Check: the company's						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
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	system for updating procedures and that all the written procedures are used and really necessary.						
P1.4	<ul> <li>Do the procedures and work description support handling of abnormal situations?</li> <li>A. Do the procedures and work description describe how to handle the most common abnormal situations?</li> <li>B. Do the procedures and work descriptions support improvisations in critical and unforeseen situations?</li> </ul>				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		

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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.		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
P1.4.5	<ul> <li>In the driller's cabin, and elsewhere, when necessary, there shall be posted: <ol> <li>initial well shut-in procedure and well control action plan</li> <li>kill sheets for the well being drilled</li> <li>emergency disconnect sequence(s) and emergency disconnect procedures (MODU specific)</li> <li>well specific operating guidelines (MODU specific)</li> <li>well control manual</li> <li>well control bridging document</li> <li>contingency procedures for use of BOP secondary control system(s), ROV/acoustic (MODU specific).</li> </ol> </li> </ul>				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		

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Checklist T: Training and competence

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### 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				MR §14		
	documented?				AR §21, §22, §23		
	The requirements should cover what (all				TOR §52		
	operating conditions) and who (who						
	participates in the team?). This can for				DC: Applicable to the DC		
	instance be presented in a competence						
	matrix. A task analysis should be the basis.						
T1.1	A. Is a systematic method used to				MR §5, §16, §17, §18		
	document all CC tasks across all				AR §21, §23		
	operating conditions including						
	abnormal conditions and remote						
	support?				DC: Applicable to the DC		
	B. Is a systematic method used to						
	document associated training						
	needs?						
	C. Have operational barrier elements						
	been identified, and are they						
	covered by training?						
	through a sustematic process						
	covering function and task analyses						
	This process must be carried out						
	when the overall design of the CC is						
	when the overall design of the CC is						
	ready, and the amount of remote					**	

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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				DC: Applicable to the DC		
	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.						
T1.3	A. *Have the required qualification				MR §14, §16, §17, §18		
	and competencies been specified				FR §12		
	for the actual tasks?				CRIOP (2024) T1.1, T1.3		
	B. Does the operator have the				DC: Applicable to the DC		
	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.						

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	How is the qualification objectively						
	documented?						
T1.4	A. Are learning objectives identified?				AR §21, §23		
	B. Are learning objectives				HFAM (NPD 2003)		
	incorporated into the training				EEMUA 201 (2019), ed. 3, 6.3		
	programme?						
	Learning objectives should include				DC: Is there a programme for training of the		
	the team and be based on the task				and incorporated in the programme? Are the		
	analysis conditions and standards of				drillers frequently and systematically trained?		
	performance including HSE issues						
	and include these in the training						
	programme.						
T1.4.1	Are operators trained in all				AR §23		
	operational conditions				HSE (1999), ed. 2, p.17		
	including abnormal				ISO 11064-1 (2000), 10.2		
	situations?						
	This should include start up,				DC: Are the driller, tool pusher, company man		
	shut down, abnormal				etc. trained to work as a team in abnormal situations?		
	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.						

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

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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?				HSE (2003), CRIOP (2024) E14, 14.1		
	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	5			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		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
T2*	Is a system for evaluating, checking and				ISO 11064-1 (2000), 9.7, 10.2		
	modification of training program				DC: Applicable to the DC, especially related		
	available?				to small software updates, new equipment,		
	Check handling of MoC, small software				new small systems		
	updates. (MoC must include training).						
T2.1	Are experience and the information				ISO 11064-1 (2000), 10.2		
	from incidents used in the re-				CRIOP (2024) T4		
	training of operators?						
	Experience and the information from				DC: Applicable to the DC		
	incidents should be spread						
	systematically to all operators						
	involved and relevant personnel						
	through the company training						
	department.						
T2.2	Do changes in requirements for				AR §21, §22, §23		
	task performance result in changes				MR §23		
	in training and training materials?				HFAM (NPD 2003)		
	Multiskilling, job-rotation, new				CRIOP (2024) T4.1		
	equipment, new technology and						
	minor alterations to the CC may						
	change the work situation for the				DC: Applicable to the DC		
	operator. These changes should be						
	documented analyse and new						
	associated training needs should be						
	included in existing training						
	programmes.						
Т3	Is there an attitude of non-penalization				FR §23		
	and organisational learning when an				ISO 11064-1 (2000), 4.6 & 4.7		
	operator makes an error?				HSE (1999), ed. 2, p.18		

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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 T4.1	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. Does the simulator or other training				AR §23 DC: Applicable to the DC AR §22		
	methods allow for training of emergency scenarios that the operator seldom experiences in reality?				AR §21, §23 EEMUA 201 (2019), ed. 3, 6.3.		

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POINT	DESCRIPTION	Yes	No	NA	REFERENCES	COMMENTS/REF TO DOCUMENTS	Resp.
	Process simulators can benefit in				DC: Applicable to the DC		
	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.						
T4.2	Does the simulator or other training				AR §21, §22, §23		
	methods accurately mimic relevant				EEMUA 201 (2019), ed. 3, 6.3		
	process characteristics?						
	The simulation used should be an				DC: Does the simulator or other training		
	accurate representation of the				methods mimic relevant drilling and well operations, including well control operations?		
	system, with less or more detail				operations, including wen control operations:		
	(depending on whether the						
	simulation if low fidelity or more						
	expensive high fidelity).						
Т5	Is the effectiveness of different training				HFAM (NPD 2003)		
	methods evaluated for the different types						
	of tasks to be performed?						
	Examples of tasks are day-to-day vs.				DC: Applicable to the DC		
	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.).						
T5.1	Is on-the-job training practiced and				AR §23		
	followed up?				NORSOK D-010 (2021), rev. 4, 4.9.1		

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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		
Т6	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		

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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				DC: Applicable to the DC		
	to competence and training?						

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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). Al/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
- o 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.

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- **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 <u>redundancy</u> (having several alternate and independent ways of performing a function), <u>controlled degradation</u> (allow flexible responses, support of improvisation), <u>flexibility</u> (having different ways of performing a function), <u>ability to manage margins close to performance boundaries</u> (getting signals and information proactively close to boundaries), <u>reduction of complexity</u> (reduce complex connections, reduce feedback loops), <u>reduce tight couplings</u> (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. <u>Actors:</u> 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.
- 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. <u>Time:</u> 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?		<ul> <li>Competence and training</li> </ul>
2. Is the information easily perceived in all relevant contexts?		<ul> <li>Procedures</li> </ul>
3. Is the content of the information relevant?		<ul> <li>Human-Machine interface</li> </ul>
4. Can the information be misunderstood?		<ul> <li>Teamwork</li> </ul>
5. Where is the information presented?		<ul> <li>Number of goals</li> </ul>
6. Are more sources of information available at the same time?		<ul> <li>Time of day</li> </ul>
7. Can these sources be contradicting the main source of information?		<ul> <li>Time available</li> </ul>
8. Are there rules/procedures that define which sources to trust?		<ul> <li>Work environment</li> </ul>
9. Is the information timely presented?		<ul> <li>Emergency response</li> </ul>
10. What happens if the information is not presented?		<ul><li>Interventions</li><li>Fatigue</li></ul>
11. Are there problems with attention or perception in relation to information presentation?		
12. Are there other factors that influence observation / identification?		

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### 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?		<ul> <li>Competence and training</li> </ul>
14. Does the order in which information is received have any effect on the interpretation?		<ul> <li>Procedures</li> <li>Human-Machine interface</li> <li>Teamwork</li> </ul>
15. Are necessary informational elements presented required for a correct interpretation?		<ul> <li>Number of goals</li> <li>Time of day</li> <li>Time available</li> </ul>
16. If two sources contradict one another, which is considered to be most trustworthy?		<ul> <li>Work environment</li> </ul>
17. How is the reliability of the information assessed?		<ul> <li>Emergency response</li> </ul>
18. Are there other factors that influence interpretation?		<ul><li>Interventions</li><li>Fatigue</li></ul>

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### 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?		<ul> <li>Competence and training</li> <li>Procedures</li> </ul>
20. Which decisions must be taken?		<ul> <li>Human-Machine interface</li> <li>Teamwork</li> </ul>
21. Are there any alternatives?		<ul><li>Number of goals</li><li>Time of day</li><li>Time available</li></ul>
22. If information is missing, how will this impact on the decision?		<ul> <li>Work environment</li> </ul>
<ul><li>23. Which erroneous decisions can be made?</li><li>For example, use of wrong rule, use of rule in wrong situation, no use of rule, memory errors?</li></ul>		<ul><li>Emergency response</li><li>Interventions</li></ul>
24. Are there other factors that influence planning / decision making?		

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

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Performance	Questions to be considered (for possible Error Traps)
Competence and	
training	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	46) Is the operator interaction means sufficient and easy to use?
interface	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	57) Do goal conflicts exist?
(Multitasking)	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?

### 5.3.7. Checklist for issues related to possible error traps



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)



# 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:

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- **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:	R1:More space should be reserved for alarm texts.	Equ/A. Smith
<ul> <li>Too general, not self-explanatory, do not indicate the nature of the problem</li> <li>Too short and abbreviated, due to insufficient space provided.</li> </ul>	(Importance: High)	
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	Equ/A. Smith
	two dependent key locks). (Importance: Low)	

### 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

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### 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 R		Recommendations and Actions			
ID	Description of the	Checklist	ID	Description	Responsibility
	findings	reference			(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	Descript	ion of	the	Checklist	ID	Description	Responsibility
	findings			reference			(Due date)
F3	Safety	Critical	Task	#G7, G9	CRIOP1	Finalize SCTA. Ensure that	Safety lead
	Analysis	(SCTA) pe	nding	G15		human factors issues raised	(Q1, 2025)
	and need	d to be fin	alized			are considered and paid	
						attention to in the remaining	
						SCTA workshops.	

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.

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Appendix

# **SINTEF**

### 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.

Scenario elements	Possible elements (based on experience) that can be explored
General: Remote	Some issues related to remote: Boredom. Many different tasks, overload
operation	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	Surprise/Incident (i.e. collision/ drone falling down) due to drone in air, at
drone	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	Security incident due to increased integration between technical systems
incident	(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	Exploration of multitasking, how to prioritize and manage parallel
overload -too high	activities, too many alarms Havtil (2022a). Humans cannot perform
Multitasking	multitasking of safety critical tasks without increased risks. Paridon (2010).
General: Data line	Data communication broken. (Example: Line to a remote operational
broken or down	centre.) Discuss consequences, how to ensure proactive and reactive
	mitigation. Discuss need for redundancy and backup.
General: Standing	Standing alarm, complex situation, may shut down power and the ship
alarm on ship	may be without propulsion. See accident report Sjøborg- PSA (2019) or
bridge due to	Viking Sky – Porathe (2023). Proactiv issues – Alarm Design; MoC – Update
	alarms/ check consequences of shut down in critical situations.
Case: Boeing 737	Single sensor failure, automation overrode human action, no safe state,
Max disaster	poor design, poor training, explore accidents reports Endsley (2019), NTSB
	(2019b), ECAA (2019).
Case: KNM Helge	Variations in Work as done, differences in SA between actors involved,
Ingstad collision	poor design of bridge systems, poor alarms, fatigue, fatigue or reduced
	performance due to circadian rnythm, procedures for communicating in a
	nign-risk situation AIBN (2019), Alsos et al (2024)
Case: Autonomous	Not enough sensors in autonomous car (did not see crossing trailer –
car collided -	fatality with Tesla, Joshua Brown ), not enough redundancy in control
	Trustworthy supplier2 NTSP (2017)
Casa: Macanda	Poor HE Door Alarma Door Emorganay proceedures _US_CSP (2016) sheek
Blowout	that the CRO has authority to shut down quickly (i.e. ESD)
Blowout	that the CNO has authority to shut down quickly (i.e. ESD).

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



List of defined hazards and accidents, 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





### 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





### 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





### 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





### 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





### 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





### 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

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- 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





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# 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.
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## 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.





### 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).



## 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 twoway 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.





## 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.





## 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.





## 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.





### 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 reestablish 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.





## 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<sup>1</sup>. 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.

<sup>&</sup>lt;sup>1</sup> <u>https://safemodeproject.eu/EhuridIndex.aspx</u>



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<sup>2</sup>, 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)
  - o 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 eightarea framework is utilized in CRIOP as in HAIQU, which will soon be fully and freely available at <a href="https://haiqu.eu">https://haiqu.eu</a>.

<sup>&</sup>lt;sup>2</sup> <u>https://www.preprints.org/manuscript/202501.0974/v1</u>



Figure C1: Human-AI Teaming Requirements Architecture (Kirwan, 2025)<sup>2</sup>

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

HFA	Principle	Rationale
1	Adopt a human-centred design approach	<ul> <li>To optimize human-AI performance</li> <li>To maximize technology acceptance</li> <li>To avoid problems of goal misalignment between AI and the human operator</li> </ul>
2	Maintain human judgement and oversight of system safety	<ul> <li>Al cannot value safety, only people can</li> <li>Als may downplay or underestimate certain rare situations or conditions (called edge cases)</li> <li>Als will optimize according to a number of parameters and can make trade-offs with safety, whereas people know when to put safety first</li> </ul>
2	People must have meaningful roles when working with Al	<ul> <li>AI should be used primarily to augment human performance – this maximizes user acceptance of AI and overall system performance</li> <li>If operators have less meaningful roles and their tasks are driven by the AI, they will be far less able to detect AI errors</li> </ul>
3	The aim of HAT interface design is to keep the operator and the AI on the same page	<ul> <li>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.</li> <li>In abnormal situations, the operator needs to verify alignment between their 'worldview' and that of the AI (albeit simplified).</li> <li>By optimizing situation awareness and sense-making, the HAT will be far more effective.</li> </ul>
3	When employing operational explainability, use a multi-level approach	<ul> <li>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.</li> <li>Experienced and novice users may differ in their explainability needs</li> <li>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'</li> </ul>
3	Human-AI interaction in emergencies must be tailored for fast and robust response	<ul> <li>In emergencies there is very limited time for explainability.</li> <li>High level situation displays are desirable to track event conditions in real time.</li> <li>Procedural communication between human and AI may be best.</li> </ul>

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

## 

## 1. Human-Centred Design for Human-Al 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 tradeoffs 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-Al 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]?



#### 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.