

CRIOP 2025 – New version

Hei – vil med dette informere om siste oppdateringer av CRIOP som ligger på <https://www.sintef.no/projectweb/criop/the-criop-handbook/>

Oppdateringen er basert på MAS prosjektet og innspill fra møter i HFC forum. (MAS=Meaningful Human Control of digitalization in safety critical systems).

Finansieringen er gjort av Forskningsrådet, HFC forum, NTNU og Equinor.

Oppdateringen er basert på læring fra ulykker (og vellykkede gjenvinninger), brukerkrav (bl.a. mottatt fra Equinor, AkerBP og Eni i perioden 2021-2025), eksisterende praksis fra automatisering og fjernstyring, god praksis fra standarder og metoder, bruk av CRIOP i tidligere og nye prosjekter.

Bruk av CRIOP støtter forbedring av alarmhåndtering som påpekt av Havtil i sine tilsyn av alarmhåndtering i kontrollrom i 2022, og i borekabiner (tilsyn 2024/ 2025). Dette er områder som kan være grunnlag for storulykker, og er prioritert i CRIOP.

Vi har oppdatert beskrivelsen i CRIOP noe for å dokumentere bakgrunn for noen spørsmål samt oppdatert beskrivelsene basert på erfaring fra automasjon/ fjernstyring/ boring og brønn og HOP praksis som dokumentert fra Norsk Industri og Dekker, Conklin, T. (2014). *Safety differently*. Vi bygger videre på prinsippene om systemtenkning, prioritere læring vs skyld og involvering av brukerne som bærende prinsipp fra HOP og aksjonsforskning.

Alle CRIOP sjekklister har vært gjennomgått for forbedringer. Vi har lagt vekt på å oppdatere beste praksis for områdene som nevnt. Metoden dekker relevante HF risikoer, og vi har god erfaring med å redusere omfanget ved å velge ut CRIOP spørsmål basert på AI/ LLM- Large Language Models. (Vi har satt av tid til senere å lage en generator som vil velge spørsmål ut fra industri, område, omfang og fase).

Vi har oppsummert de viktigste tema som 10 spørsmål for de som trenger noe kort fra CRIOP.

Vi har fjernet temaet eDrift og fordelt spørsmålene til følgende kategorier: 1)G-General Questions, 2)C-Control and safety systems, 3)J-Job organization, 4)L-Layout, 5)W-Working environment, 6)P-Procedures and work descriptions, 7)T-Training and competence.

Oppdatering og endringer basert på litteraturgjennomgang, «peer-reviewed papers», workshop, innspill fra fagmiljø og intervjuer (Equinor/ DnV, Kongsberg, IFE, Eggs, Halogen, We are Nice, Eldor, AkerBP, Vysus, NTNU – Samf.Forsk, NTNU Design/Ålesund, Safetec, USN, Airbus, CIRIS).

Dessuten er spørsmålene oppdatert på basis av CRIOP gjennomganger (og innspill fra møter om flerfelts- kontrollrom med Equinor og Aker/BP) og innspill til HMI fra Equinor basert på IEC 63303. EEMUA 201 referert noen steder.

Hovedtema for metoden er som tidligere, å «designe inn» sikkerhet/HF i prosjekter fra starten. Fremhever fortsatt viktigheten av å få inn HF eksperter så tidlig som mulig, og få inn helhetlig

HF/MTO syn fra starten. Vi bygger fortsatt på å støtte teknologi-innføring via bruk av standarder for arbeidet som ISO 11064 eller 9241-210 (eller MoC – Management of Change).

Evaluerings av «Work as Done» bør ha en risikotilnærming og bruke anerkjente metoder. Områder hvor HFE (Human Factors Engineering) fortsatt bør prioriteres er alarmhåndtering (IEC 62682 og EEMUA 191), Task Analysis (TA)/Safety Critical Task Analysis, Workload analysis og SA- Situational Awareness. EyeTracking er også en av de anbefalte teknikkene som kan brukes.

Vi har forenklet sjekklister, sjekket konsistens, og har lagt inn nye spørsmål ut fra innspill. Vi har fjernet/integrert 12 spørsmål. Vi har lagt til 20 nye spørsmål. Vedlagte liste beskriver behov (bakgrunn) og oppsummering av de nye spørsmålene:

Summary Background/Requirement	Short version of New questions
Requirement (research) from Equinor related to Multi facility control FR § 9 Qualification	G13-Are multiple facilities controlled?
HMI standard, IEC 63303 enhances safety by improving HMI design. It ensures HMI standardization across multiple facilities and different vendor packages, making training easier, reducing errors, improving efficiency.	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 in HMI design.	C3 Has flow of Situational Awareness been designed to support “situation at a glance” (and C3.1, C3.2, C3.5, C3.6)
Learning from Security attacks 2019-2021 Hydro, Amedia, Nortura. Assessment from Riksrevisjonen (2019) and Equinor saying- 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 (and points) – Security issues added based on NOROG 104
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 – standardization should be assessed	C2.2- Is standardization through open innovation considered?

For AI og AI teaming har prosjektet vært involvert via NTNU for autonome skip, SINTEF Community for autonome biler/busser/trailere/roboter og hatt ett samarbeid med Barry Kirwan. B. Kirwan har prosjekterfaring fra luftfart, og de ligger langt fremme med praktisk bruk av AI/ AI teaming og sikkerhetstenking. Han har laget en oppsummering fra Haiku (Human-AI Teaming) som er lagt inn i CRIOP (som informasjon) med momenter som kan vurderes ved behov/være til hjelp. Dette er lagt inn som vedlegg C i CRIOP, hvor det også er en detaljert sjekkliste, med 50 punkter som kan brukes til støtte.

Metoden er oppdatert som nevnt ut fra brukerkrav (bl.a. mottatt fra Equinor, AkerBP, Eni i perioden 2021-2025), og er deretter validert via alle de muligheter vi har fått fra Equinor, AkerBP, Eni i perioden 2021-2025. Ut fra vedlagte erfaringer er metoden klar for bruk og videre forbedringer i dialog med prosjektgruppen.

Alle kommentarer og konkrete endringsforslag på den nye versjonen av CRIOP som er brukt i praksis tas imot med takk (send til criop@sintef.no). Vi har forsøkt å få til systematiske gjennomganger med så mange forskjellige brukere og «caser» som mulig i workshop, intervju og via gjennomganger. Foretrukne formatet for justeringer er enten 1) Direkte møte med fysisk deltakelse fra MAS prosjektet hvor spørsmål gjennomgås konkret og spesifikke endringer foreslås og dokumenteres (gjennomføres) der og da, 2) Bruk i spesifikke CRIOP analyser hvor metoden brukes – MAS prosjektet deltar og endringsforslag dokumenteres og gjennomgås for evt. justeringer i CRIOP.

Vi har brukt ny CRIOP på nye kontrollrom for å styre flåte av autonome trailere.

Brukte Large Language Models -LLM for å hente ut relevante spørsmål, og få frem relevante «Edge Cases». Fikk ut ca. 20 spørsmål som trakk frem de viktigste elementene og ca. 5 «edge cases» som utfordret styringen fra ROC, og som ble relevante eksempler for Scenarioanalyser. CRIOP spørsmålene fungerte bra, og ble understøttet av noen tilleggsspørsmål, og vi brukte mindre tid. Prosjektet ga positive tilbakemeldinger på nytten av spørsmålene i den nye metoden.

Vi har brukt ny CRIOP for en autonom passasjerferje ESTELLE i Stockholm med ROC (Remote Operational Centre).

Ny sjekkliste fungerte bra, og scenarier fungerte bra. Erfaring dokumentert i to papers (Om CRIOP og HMI) som er godkjent for presentasjon ESREL 2025 i Stavanger. "Challenges and opportunities in remote operations of automated passenger ferries identified using the CRIOP method» "Designing HMI for Remote Operation of Urban Autonomous Ferries with CRIOP Analysis"

Vi har brukt ny CRIOP for Saipem(ENI deleier)/OMV Petrom (Neptun Deep) i

Svartehavet – evaluerer fjernstyring av delvis ubemannet plattform. Vanlig CRIOP i november i samarbeid med TU Dublin (Prof. M.C.Leva). Det fungerte bra. CRIOP rapporten

ble godkjent, OK tilbakemeldinger fra deltakerne. Nye HMI spørsmål i CRIOP sjekklisten fungerte bra – ved hjelp av nye HMI spørsmål fikk vi diskutert standardisert grensesnitt fra pakkeleverandørene, som var et avvik som ble tatt tak i. Mht security var det åpne tema som fysiske sårbarheter for datakommunikasjon og gassrørledning som ble notert

CRIOP 2025 – New version (English)

Hi – I would like to inform HFC about the latest updates to CRIOP which can be found at <https://www.sintef.no/projectweb/criop/the-criop-handbook/>

The update is based on the MAS project and input from meetings in the HFC forum. (MAS=Meaningful Human Control of digitalization in safety critical systems).

The funding is provided by the Research Council, HFC forum, NTNU and Equinor. The update is based on learning from accidents (and successful recoveries), existing practices from automation and remote control, good practices from standards and methods, use of CRIOP in previous and new projects.

We have updated the description in CRIOP somewhat to document the background for some questions and updated the descriptions based on experience from automation/remote control/drilling and well and HOP practices as documented by Norsk Industri.

All CRIOP checklists have been reviewed for improvements. We have emphasized updating best practices for the areas mentioned. The method is extensive, but we have good experience in streamlining the process by selecting CRIOP questions based on AI/LLM- Large Language Models. (We have set aside time to later create a generator that will select questions based on industry, area and phase).

We have summarized the most important topics as 10 questions for those who need a brief overview of CRIOP.

We have removed the topic eOperation and divided the questions into the following categories: 1)G-General Questions, 2)C-Control and safety systems, 3)J-Job organization, 4)L-Layout, 5)W-Working environment, 6)P-Procedures and work descriptions, 7)T-Training and competence.

Update and changes based on literature review, peer-reviewed papers, workshop, input from professional community and interview round (Equinor/DnV, Kongsberg, IFE, Eggs, Halogen, We are Nice, Eldor, AkerBP, Vysus, NTNU – Samf.Forsk, NTNU Design/Ålesund, Safetec, USN, Airbus, CIRIS).

In addition, the questions have been updated based on CRIOP reviews (and input from meetings on multi-field control rooms with Equinor and Aker/BP) and input to HMI from Equinor based on IEC 63303. EEMUA 201 referenced in some places. The main theme of the method is, as before, to “design in” safety/HF into projects from the start. Still emphasizes the importance of bringing in HF experts as early as possible, and getting a holistic HF/MTO view from the start. We continue to build on supporting technology adoption through the use of work standards such as ISO 11064 or 9241-210 (or MoC – Management of Change).

Evaluation of “Work as Done” should have a risk approach and use recognized methods. Areas where HFE (Human Factors Engineering) should still be prioritized are alarm handling (IEC 62682 and EEMUA 191), Task Analysis (TA)/Safety Critical Task Analysis, Workload analysis and SA- Situational Awareness. EyeTracking is also one of the recommended techniques that can be used.

We have simplified the checklists, checked consistency, and added new questions based on input. We have removed/integrated 12 questions. We have added 20 new questions. The attached list describes needs (background) and a summary of the new questions:

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Learning from Security attacks 2019-2021 Hydro, Amedia, Nortura. Assessment from Riksrevisjonen (2019) and Equinor saying- 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 (and points) – Security issues added based on NOROG 104
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Need for cost reductions of control systems –standardization should be assessed	C2.2- Is standardization through open innovation considered?

For AI and AI teaming, the project has been involved via NTNU for autonomous ships, SINTEF Community for autonomous cars/buses/trailers/robots, and explored autonomy in the oil and gas industry. We have collaborated with Barry Kirwan to get insights in AI and AI teaming. B. Kirwan has project experience from aviation, and they are far ahead with the practical use of AI/AI teaming and safety thinking. He has created a summary from Haiku (Human-AI Teaming) which has been added to CRIOP (as information) with elements that can be considered if needed/helpful. This has been added as Appendix C to CRIOP, where there is also a detailed checklist, with 50 points that can be used for support.

We have used new CRIOP on new control rooms to manage a fleet of autonomous trailers. Used Large Language Models -LLM to extract relevant questions, and bring out relevant "Edge Cases". Got out about 20 questions that highlighted the most important elements and about 5 "edge cases" that challenged the management from ROC, and which became relevant examples for Scenario Analyses. The CRIOP questions worked well, and were supported by some additional questions, and we spent less time. The project gave positive feedback on the usefulness of the questions in the new method.

We have used the new CRIOP for an autonomous passenger ferry ESTELLE in Stockholm with ROC (Remote Operational Centre). The new checklist worked well, and the scenarios worked well. Experience documented in two papers (About CRIOP and HMI) that have been accepted for presentation at ESREL 2025 in Stavanger. "Challenges and opportunities in remote operations of automated passenger ferries identified using the CRIOP method" "Designing HMI for Remote Operation of Urban Autonomous Ferries with CRIOP Analysis"

We have used new CRIOP for Saipem(ENI part owner)/OMV Petrom (Neptun Deep) in the Black Sea – evaluating remote control of a partially unmanned platform. Regular CRIOP in November in collaboration with TU Dublin (Prof. M.C.Leva). It worked well. The CRIOP report was approved, OK feedback from the participants. New HMI questions in the CRIOP checklist worked well – with the help of new HMI questions we were able to discuss standardized interfaces from the package suppliers, which was a deviation that was addressed. Regarding security, there were physical vulnerabilities as public known such as for data communication and resilience of gas pipeline that were noted.