

# Identification and reduction of risks in remote operations of offshore Oil and Gas installations.

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**ABSTRACT:** Remote operations of offshore Oil and Gas installation are increasing in the North Sea. The motivation for remote operation is increased income, cost reductions and more effective support. Remote operations are influencing the process risk and the Human Factors issues in the change process and operations. The Longford Accident, identified issues that must be under control in remote operations. We have developed a checklist to assist in planning and implementation of remote operation, based on “best practice”. The checklist is going to be included in the CRIOP methodology – used successfully in the North Sea since 1990. The checklist has been developed in cooperation with the largest Oil companies in the North Sea. The checklist is going to be used to identify critical issues to be explored. In addition a scenario setting is proposed to explore the critical issues and events that could lead to major accidents.

## 1. INTRODUCTION AND PROBLEM DEFINITION

Remote operations and remote control of offshore Oil and Gas installations is increasing in the North Sea. The supporting technology related to e-Operations is maturing and creating new possibilities. The main motivation for remote operation is the potential for operational cost reduction and increased income or yield from the fields.

Remote operations of Oil and Gas installations could be a complex undertaking related to the inherent risk in the operating processes but also because of Human Factors issues during the change process and in operations, see Henderson (2002). The Oil- and Gas-industry sees the need for tools and methods to help reduce the risks related to the implementation of remote operations and remote control.

Many projects involving e-Operations have been delayed. The optimistic initial projects, that early in 2000 envisioned a quick implementation of remote operations and remote support, have not been carried through that easily. Many of these early projects have been stopped, changed or delayed substantially. In some instances the goal of e-Operations had not been clearly defined, thereby creating uncertainty and worker resistance. The personnel involved in the e-Operations projects have suggested a tendency to focus too much on the technology, often at the expense on organisational and human factors issues.

Relocation of operations and the increased use of subcontractors and outsourcing imply the need for more communication and co-operation between different organisations. It seems increasingly more important to improve the communication between the oil companies and suppliers in the network of firms serving the oil companies. Some misunderstandings seem to arise from communication problems.

The present status of existing control systems and the poor quality of alarm systems in the Control Centre (CC) indicates that the systems used to support exception handling are still immature, as described in a review performed by the NPD (2003).

Our main hypothesis is that the safety and security of e-Operation and the e-Operation change process can be improved by the use of “best practice” checklists and scenario analysis among the designers, project management and workforce participating in the e-Operations projects. These checklists are suggested incorporated in the CRIOP methodology.

### 1.1 CRIOP introduction and background

CRIOP stands for Crisis Intervention in Offshore Production. CRIOP has been an often used methodology to assess safety issues related to control centre operations in Norway. The methodology has been used in the North Sea from 1990, and has recently

been updated by the industry; see Johnsen et al. (2003). CRIOP is a methodology used to verify and validate the ability of a control centre to safely and effectively 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, drillers' cabins, cranes and other types of cabins, on-shore, off-shore and emergency control-rooms.

The key elements of CRIOP are checklists covering relevant areas in design and operations of a Control Centre (CC), Scenario Analysis of key scenarios and a learning arena where the workforce with operating experience, designers and management can meet and evaluate the optimal CC.

We have suggested developing an additional CRIOP e-Operations checklist to be used together with the scenario analysis, to help identify and reduce the risk related to remote operations and remote control from the concept phase, through implementation and operations. This e-Operations checklist is on a general level. In addition the detailed CRIOP checklist should be adjusted to incorporate e-Operations.

### 1.2 Definition of remote operations

The following definitions apply to this document:

#### *e-Operations:*

The use of Information Technology to change work processes to improve decision-making, perform remote operations and move functions from offshore to onshore.

#### *Remote Support*

The operation is managed or operated locally (offshore), but some assistance is given by onshore experts via teleconferencing, video, phone or radio.

#### *Remote Monitoring*

The operation is managed or operated locally (offshore), but some sort of monitoring is being performed. The whole or parts of the process is monitored from an operation centre localised apart from the installation. Experts at the centre have access to all information and can act as advisors to operators on the installation offshore.

#### *Remote Control*

Part of the operation is managed and operated remotely. This can cover a wide spectrum of possibilities, from control of parts of the process in a normal situation to a full control of the installation in an emergency situation. Scenarios where operators on the installation are occupied with field operations, while the process is controlled from an onshore-based operation centre are possible. CC operators are present at the installation.

### *Remote Operations*

The operation is managed and operated from a remote location. This is the situation for the unmanned (or not normally manned) installations and is the most radical solution for installations when all the control room functions and other operation functions are executed from a remote location. This is the case for sub-sea installations today.

### 1.3 Research questions

The new CRIOP checklist should address what we believe are the critical phases of e-Operations: Project initiation, the change process and the new operational phase. The change process could be seen as a continuous change, because improved processes and organisational development is based on learning and exploitation of new technology by humans and this is an iterative and continuous process. The continuous organisational learning could influence the change process and the final operation. To ensure that we have the right focus of our exploration of safety and security issues, we must ensure that there exists a precise definition of the change project to be analysed.

The main issues and research question in this paper are suggested to be:

*“How can we ensure that the safety and security of operations is not decreased during and after implementation of an e-Operations change project?”*

Based on the preceding discussion, the scope for the development of the “best practice” questions are:

- 1) *What is the definition and scope of the project implementing remote operation and/or remote control?*
- 2) *What are the key HSE issues during the change process when remote operation is implemented?*
- 3) *What are the key HSE issues when remote operating an offshore Oil and Gas installation?*

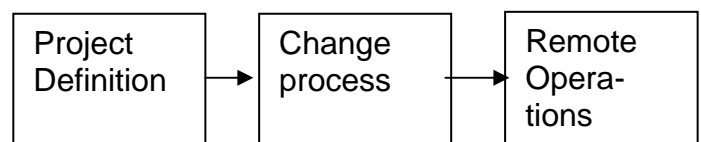


Figure 1: Scope of the identification of risks in our paper

We have chosen to cover the early planning phases of Remote Operations, discussed in the Project Definition, in order to assess and influence the key decisions affecting the HSE issues in later Operations. It is very important to be able to influence these early

decisions since the cost of changes increases significant between each phase. Experience shows that the costs of additional changes increases almost exponentially, between each phase; see K. Samset (2001), B. Boehm (1974). This is an additional motivation to focus on common understanding of goals and definitions early in the e-Operations project.

## 2. KEY ISSUES AND THEORETICAL BACKGROUND FOR NEW QUESTIONS

Based on interviews, presentations and reports from the Oil and Gas industry (Johnsen et al. 2004, OLF 2003) we have identified several problems and challenges that should be assessed and analysed when implementing remote operations and remote control:

- Many different terms and definitions are being used – creating some confusion and misunderstandings related to remote operations and remote control.
- Management of the change process when implementing remote operations and remote control has been a challenge in the Oil & Gas industry as in other industries and the quality of the change process can impact the risk in the operations. The change process is seen as highly political, changing the influence of several key stakeholders, moving personnel off-shore and reducing jobs. The implementation of e-Operations may require some basic re-engineering of fundamental key processes and it is important to ensure the safety and security of operations during the change process and after the change process has taken place.
- Remote operation and control of the complex production and maintenance process increases the need for common situational knowledge, and ability to communicate clearly and efficiently to ensure correct operating procedures at a remote site. The monitoring and supervision of local operators by remote personnel could be a challenge. Poor monitoring and supervision was mentioned as a cause of the Longford accident. (Hopkins 2000).
- Increased reliance on several ICT systems used to support remote operations and remote control leads to the need for more secure and robust ICT solutions in addition to need for robust emergency shutdown systems and procedures.

These problem areas has been used as a basis for workshops, discussions and interviews with specific project managers, key resource personnel (as Human Factor specialists, engineers and management) from

the Oil companies, vendors, engineering companies and research institutes (Johnsen et al.2004).

We have identified several relevant issues that should be assessed and analysed when developing “best practice” questions. These issues are:

- 1) Common understanding of goals and definitions
- 2) Well executed change process: The change process must be conducted in a political environment and safety and security must be ensured during and after the change process
- 3) Common situational knowledge: It is necessary to establish common situational knowledge between the different actors in e-Operations as shown by experiences from previous relevant accidents
- 4) Information security and safety: It is necessary to ensure the information security and safety of the supporting ICT infrastructure

Based on these relevant issues and relevant theory we have identified questions in a checklist, which is going to be assessed and evaluated through workshops and peer-reviews in the industry. The development of the methodology has been done as illustrated in figure-2.

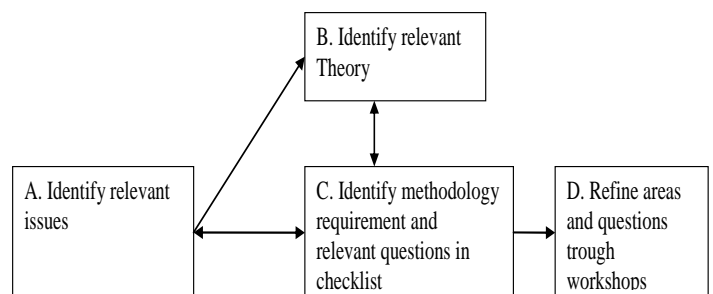


Figure-2: The development of the proposed method consisting of “best practice” checklist

In the following we identify relevant theory (B) based on the relevant issues (A).

### 2.1 Common understanding of goals and definitions

To avoid confusion and misunderstandings related to remote operations and remote control and to establish a common ground for the change process – it is important to establish common understanding of goals and definitions. In addition we want to create a positive environment for the change process, trying to establish goals in co-operation with the key stakeholders, as recommended by Kotter (1996) and Karp (1996).

## 2.2 Well executed change process

The implementation of Remote Operations could be a challenge related to two main issues:

- To lead a demanding change operation in a political climate having to navigate between the different and sometimes conflicting interest of Management, Employees, Unions and Government
- Insure that the safety of operations are not reduced during and after the change process

Key works related to performing a demanding change in a political climate are presented by Kotter (1996) and Pinto (1996). Key works related to performing a demanding change and at the same time ensure safety of operations during change is presented by: HSE (2003).

Kotter (1996) is suggesting an eight-stage process to create a major change in a political climate, consisting of the steps:

1. Establish a sense of urgency
2. Creating the Guiding Coalition.
3. Developing a vision and strategy
4. Communicating the change vision.
5. Empowering broad-based actions
6. Generating short-term wins.
7. Consolidating gains and producing more change
8. Anchoring new approach in the culture

The implementation of remote operations is a major change process, and the work of Kotter has identified some of the major requirements in a large change process. Each requirement has been reformulated as a question to be included or combined with other issues in our proposed checklist.

Pinto (1996) is suggesting analysing the relevant stakeholders in the change process to ensure commitment and to avoid political conflicts. This is a key requirement to our checklist.

HSE (2003) is suggesting a three-stage process to ensure safety of operations during change. The three steps consist of:

- Step-1: *Getting Organised*. Covering key areas as: Have a strong policy. Make senior-level managers accountable. Have a clear change-management procedure. Communicate and include everyone. Review and challenge.
- Step-2: *Risk assessment*. Covering key areas as: Identify the people involved. Identify all changes. Assess the risks. Consider human factors, competence and workload. Test scenarios.

- Step-3: *Implement and monitoring*. Covering key areas as: Provide enough resources to make the change safely. Monitor risks during change. Keep your plan under review, track actions. Monitor performance after change. Review your change policy.

Based on the hazards related to drilling, production and maintenance in the Oil and Gas industry we would like to include relevant requirements from HSE (2003) in our checklist.

## 2.3 Common situational knowledge

In the e-Operation environment, collaboration between different physical locations using ICT will be essential. The safe operation of a remote operated Oil and Gas field could be a challenge related to exception handling, and remote problem solving when several experts must be trained to understand and be able to communicate to solve an unexpected problem. The absence of engineers(experts) and inadequate procedures and training has been identified as important causes of the Longford accident by Hopkins (2000).

The Human Factors aspects of remote operations in process plants have been explored by Henderson (2002). The requirements for communication between the actors are:

- Common situational knowledge, knowledge and assumptions about the current situation
- Common professional knowledge about each participants roles and responsibilities
- Common professional knowledge about operating procedures, termed procedural knowledge
- Common cultural knowledge (Common goals, beliefs, norms)

All these issues are combined to support common mental models between the different actors, ensuring good communication and understanding.

Based on the Longford accident we have listed some of the key problems (and requirements) of interest to remote operation of Oil and Gas installations:

- Failure to perform a HAZOP analysis of the operation (Eg HAZOP should be performed)
- Inadequate training and procedures for handling of deviations (Training must be established)
- Absence of local knowledgeable engineers (Knowledgeable engineers must be available)
- Poor supervision of operations (Supervision must be improved)

- Operating in alarm mode, many standing alarms (Alarm philosophy should be established)

#### 2.4 Information security and safety

Current “best practice” related to ICT safety and security is being found in IS 17799. We suggest to use IS 17799 where this standard is relevant.

### 3. PROPOSED METHOD

Our proposed framework has been based on the CRIOP methodology. One of the most important principles of the CRIOP method is to verify that a focus is kept on important Human Factors, in relation to operation and handling of abnormal situations in control centres, and to validate the solutions and results. Given that the design process is iterative, the CRIOP method should be applied during the Project Definition, analysis, design and implementation phases of the project. The e-Operations checklists should be used together with a scenario analysis in a group setting.

The key issues identified earlier are:

1. *Common understanding of goals and definitions.*
2. *Well executed change process.*
3. *Common situational knowledge.*
4. *Information security and safety.*

#### 3.1 Questions related to common understanding of goals and definitions

We want to establish common understanding of goals and definitions. In addition we want to create a positive environment for the change process, trying to establish goals in co-operation with the key stakeholders, see Kotter (1996). Proposed questions are:

- *Has a compelling vision and a goal of e-operations been defined in cooperation with the key stakeholders?*
- *Has the extent of remote operation and remote support been defined and precisely described in cooperation with the key stakeholders?*

#### 3.2 Questions related to well executed change processes

The main issues found in Kotter(1996) are discussed in the following section. Relevant issues related to e-Operations are discussed and are proposed to be included as questions in an e-Operations checklist.

*Establish a sense of urgency:* It is very important to establish a sense of urgency in the e-Operations project. This could be done by communicating the importance of cost reductions in tail end production. The urgency should be documented as an important objective for the e-Operations project. A proposed question is:

- *Has a clear objective of e-Operations been established and communicated in the whole organisation, creating a sense of urgency?*

*Creating the Guiding Coalition:* It is very important to establish a powerful team that can work together to lead the change. Within the Norwegian sector, it is important to establish good cooperation between the different important stakeholders as Management, the Unions/work force and Government. Proposed question are:

- *Have the different important stakeholders been identified? and*
- *Has a powerful guiding coalition been established to support the e-Operations project?*

*Developing a vision and strategy:* It is important to establish a powerful and an engaging vision and goal. This should be followed by a realistic strategy to achieve the vision/goal in cooperation with the most important stakeholders such as management and employees. Proposed question is:

- *Has a goal and change vision of e-Operations been defined in cooperation with the most important stakeholders?*

*Communicating the change vision:* It is very important to communicate the change vision (or change goal) to all the stakeholders to ensure common understanding of the established change vision and to identify potential problems. Proposed question is:

- *Has a communication plan been established to ensure common understanding and acceptance of the change vision or goal among the relevant stakeholders?*

*Empowering broad-based actions:* Broad based actions are important when a major change is going to be implemented. It may be necessary to change several systems or structures that undermine the change vision - even if there is opposition to do these changes. The management and the employees must establish a participatory environment – empowering broad based actions both from the employees and management on different levels. Proposed question is:

- *Have broad-based actions been empowered through participatory processes involving the most important stakeholders?*

*Generating short-term wins:* To give the change project momentum it is important to identify and inform about the short-term wins that is the result of the project. The gains should be consolidated and the organisation should focus on producing more changes to increase the gains. Proposed question is:

- *Has a communication plan been established to inform about the benefits of the change among the relevant stakeholders?*

*Anchoring new approach in the culture:* The changes must be firmly embedded in the culture by changing and adjusting the organisation, processes and training. At the same time it is important that the organisation as a whole feels ownership for the new solutions. An arena for organisational learning should be established to ensure this. Proposed question are:

- *Have procedures and work processes been changed based on the new solutions?*
- *Has a new training program been established?*
- *Has an arena for organisational learning been established?*

In the following we have described the main issues from the three-stage process described in HSE (2003) to implement safe organisational changes.

*Getting Organised:* It is crucial to establish accountability for the change at the right organisational level; i.e. at the senior level of management. At the same time it is important to establish a clear change-management procedure. The changes should be reviewed and challenged. Proposed questions are:

- *Have senior level Management accepted accountability for the change?*
- *Has a clear change management procedure been established?*
- *Has the changes been reviewed and challenged related to Technology, organisation and Human Factors?*

*Risk assessment:* A risk assessment of the proposed change should be performed, by identifying the changes and assessing the risks. Human Factors, competence and work-load should be discussed. Several critical scenarios should be tested, to ensure

safe production after the changes. Proposed questions are:

- *Has a risk assessment of the e-Operations project been performed?*
- *Have several relevant and critical scenarios been performed and analysed to ensure that the associated scenarios can be handled in a safe way?*
- *Has the proposed changes been analysed related to Workload, Competence and Human Factors?*

*Implementing and Monitoring:* When the change is implemented, it is important to provide enough resources to make the change safely. The performance and risks should be monitored during and after the change process. Proposed question is:

- *Has a learning arena been established to monitor the performance and risk after the changes has been implemented?*

### 3.3 Questions related to common situational knowledge

The questions are developed based on the need to establish common mental models to sustain common situational knowledge during all operating conditions including exception handling. Proposed question is:

*Has the system been designed to support common mental models between all the key actors in remote operations, including common:*

- *situational knowledge*
- *knowledge about each participants roles and responsibilities*
- *knowledge about standard operating procedures, termed procedural knowledge*
- *cultural knowledge (Common goals, beliefs, norms)*

Based on the Longford accident, we have suggested the following questions.

*Failure to perform risk assessment:* It is important to establish situational awareness by performing a risk assessment. Proposed questions are:

- *Has a risk assessment of the proposed e-Operation been performed?*
- *Have relevant and critical scenarios been identified and performed?*

*Inadequate training and procedures:* It is important to develop procedures and training to sustain under-

standing of the processes and support necessary situational awareness. Proposed questions are:

- *Have procedures and work processes been changed based on the new solutions to reflect the actual procedures in use?*
- *Has training been designed to sustain understanding of the processes and support necessary situational awareness?*
- *Has an arena for organisational learning been established, to support and refine new work processes and training?*

*Absence of engineers, poor supervision, operating in alarm mode - see Hopkins(2000):* It is important to establish a learning arena between management, engineers and operators to monitor performance and risks during operations. Proposed questions are:

- *Has the operators been trained in cooperating with remote experts (engineers) in solving actual operating problems?*
- *Has a learning arena been established to monitor the performance and risk after the changes has been implemented?*
- *Have a critical review of what needs to be alarmed, performed? (It is important to reduce the amount of alarms and alarm information. A critical judgment must be done. )*

### 3.4 Questions related to information security and safety:

ISO 17799 contains a set of best practice guidelines. To insure that the e-Operations project is following these best practice guidelines we have proposed the following question:

- *Has a safety and security standard been established in accordance with best practice from ISO 17799?*

## 4. CONCLUDING REMARKS

The proposed checklist has been refined through several interviews and workshops. Additional “best practice” questions have been added, but these are of a more detailed nature and have not been included in this article.

The final questionnaire has been tested in 4 different workshops and settings:

- One remote operation of an onshore petrochemical process plant in Norway operated remotely from Sweden

- Two remote offshore operations of well drilling and intervention (in two different oil companies)
- One remote operation of offshore Oil and Gas production facilities

The participants in the workshops had several years operating experience with e-Operations. They were very satisfied with the questionnaire, because it raised issues that had shown to be of great importance – but had not been resolved earlier in the projects.

A web site has been established at [www.criop.sintef.no](http://www.criop.sintef.no) containing the CRIOP methodology and the “best practice” e-Operations checklist. The users can give their feedback on the methodology and the checklists on the web-site. This will be utilised in future updates of the checklist. This will also enable us to validate and verify the questions based on experience transfer later.

## 5. ACKNOWLEDGMENTS

This work has been financed by Norsk Hydro, STA-TOIL and the Norwegian Research Council.

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## APPENDIX: BEST PRACTICE CHECKLIST

1. *Has a compelling vision and a goal of e-Operations been defined in cooperation with the key stakeholders?*
2. *Has the extent of remote operation and remote support been defined and precisely described in cooperation with the key stakeholders?*
3. *Has a clear objective of e-Operations been established and communicated in the whole organisation, creating a sense of urgency?*
4. *Have the different important stakeholders been identified?*
5. *Has a powerful guiding coalition been established to support the e-Operations project?*
6. *Has a goal and change vision of e-Operations been defined in cooperation with the most important stakeholders?*
7. *Has a communication plan been established to ensure common understanding and acceptance of the change vision or goal among the relevant stakeholders?*
8. *Does the communication plan inform about the benefits of the change among the relevant stakeholders?*
9. *Have broad-based actions been empowered through participatory processes involving the most important stakeholders?*
10. *Have procedures and work processes been changed based on the new solutions?*
11. *Has a new training program been established?*
12. *Have senior level Management accepted accountability for the change?*
13. *Has a clear change management procedure been established?*
14. *Have the changes been reviewed and challenged related to Technology, organisation and Human Factors?*
15. *Has a risk assessment of the e-Operations project been performed?*
16. *Have several relevant and critical scenarios been performed and analysed to ensure that the associated scenarios can be handled in a safe way?*
17. *Have the proposed changes been analysed related to Workload, Competence and Human Factors?*
18. *Has a learning arena been established to monitor the performance and risk after the changes has been implemented?*
19. *Has the system been designed to support common mental models between all the key actors in remote operations, including common: situational knowledge, knowledge about each participants roles and responsibilities, knowledge about standard operating procedures, termed procedural knowledge, Cultural knowledge (Common goals, beliefs, norms)*
20. *Has a risk assessment of the proposed e-Operation been performed?*
21. *Have relevant and critical scenarios been identified and performed?*
22. *Have procedures and work processes been changed based on the new solutions to reflect the actual procedures in use?*
23. *Has training been designed to sustain understanding of the processes and support necessary situational awareness?*
24. *Has an arena for organisational learning been established?*
25. *Does the arena for organisational learning support the refinement and improvement of new work processes and training?*
26. *Does the learning arena monitor the performance and risk after the changes has been implemented?*
27. *Have the operators been trained in cooperating with remote experts (engineers) in solving actual operating problems?*
28. *Have a critical review of what needs to be alarmed, been performed? (It is important to reduce the amount of alarms and alarm information. A critical judgment must be done. )*
29. *Has a safety and security standard been established in accordance with best practice from ISO 17799?*