REPORT

Building Safety

Resilient Decision Processes in Integrated Operations

Summary report

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Abstract

The overall objective of the Building Safety project, *Building Safety in Petroleum Exploration and Production in the Northern Regions*, is to produce knowledge to build resilient operational organisations for petroleum production in the northern regions, with the ability to prevent unwanted events through early warnings.

One of the work packages in this project is called "Resilient decision processes in Integrated Operations", and the objective of this research activity was to develop knowledge and methods that can improve the understanding of the factors that contribute to resilient decision processes in integrated operations, with a particular focus on safety-related goal conflicts. This summary report will account for the literature review and the empirical study performed within this work package.

Keywords: Resilient decision processes, Integrated operations

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Contents

1 Introduction

The present report is written within the framework of the project: *Building Safety in Petroleum Exploration and Production in the Northern Regions*[1]. The overall aim of this project is to provide knowledge for building resilient operational organisations for petroleum production in the northern regions, and the principal objective is to reduce risk to personnel and environment. The project is funded by the program "Health, Environment and Safety in the petroleum sector" (HMSFORSK) by The Research Council of Norway and Eni Norge AS. The research work is carried out in close cooperation between SINTEF, IFE (Institute for Energy Technology), NTNU (Norwegian University of Science and Technology), and Eni Norge AS.

The project has three main research activities:

- Human and organisational contribution to resilience
- Resilient decision processes in Integrated Operations (IO) Teams – Adequate prioritization of safety goals
- Early warnings of major accidents

Originally, the second activity was divided into two work packages: “Conflicting objectives” and “Adaptation”

The overall aim of “Conflicting objectives” was to develop new knowledge and methods that can improve the understanding of human and organisational decision-making, in particular decision makers’ ability to handle conflicting objectives related to safety. The overall aim of “Adaptation” was to develop new knowledge on how technological development affects resilience, and how different development processes call for different approaches to HSE management. More specifically, this work package would develop knowledge on how collaboration technology influences resilience, both positively and negatively and how organisational efforts of personnel training and usage of tools for decision support may support operators’ decision making and facilitate and improve resilience. As these two work packages were closely related to each other – both were concerned with decision making in an IO setting – and as the work packages also were overlapping in time, it was decided that it would be more efficient to cooperate both with the literature review and the empirical phase of the project. The new, joined work package was called: *Resilient decision processes in Integrated Operations (IO) Teams – Adequate prioritization of safety goals*. This report presents an overview and key findings from this joint research activity.

2 Resilient decision processes in Integrated Operations

The objective of this research activity was to develop knowledge and methods that can improve the understanding of the factors that contribute to *resilient decision processes in integrated operations*, with a particular focus on safety-related goal conflicts.

[1] www.sintef.no/buildingsafety

The offshore industry today is undergoing a transition made possible by new and powerful information technology. Several companies on the Norwegian continental shelf have implemented integrated operations (IO) as a strategic tool to achieve safe, reliable and efficient operations (Ringstad and Andersen, 2007). In integrated operations, traditional work processes and organisational structures are challenged by more efficient and integrated approaches to offshore operations. The new approaches make it possible to reduce the impact of traditional obstacles – whether they are geographical, organisational or professional – to efficient decision making (Ringstad and Andersen, 2007).

Integrated operations are both a technological and an organisational issue, and imply both the use of new technology and new work processes. The IO technology consists of high-quality video conferencing, shared work spaces and data sharing facilities and involve people in discussions with each other both onshore and offshore.

Teamwork in a traditional operational environment mainly involves co-located teams, while the introduction of IO implies increased use of distributed teams in operation of petroleum installations. A *distributed team* may broadly be defined as a team with minimum two team members, where at least one of the members is located at a geographical location that differs from the location of the other team member(s), and where the collaboration between the team members is mainly mediated through technology. Members of distributed teams tend to have different professional backgrounds and different departmental or organisational affiliations (Baan and Maznevski, 2008). The term IO team will in the following be used to describe a distributed team engaged in operational activity.

There are some features of IO vis-à-vis traditional operations that are associated with improved decision making, and some features that may challenge decision making in an IO setting. Increased availability of real time data make it possible for personnel at different locations to cooperate based on a shared and up-to-date description of the operational situation. Work performed in a more parallel manner means problems can be solved in a broader context, more alternatives can be evaluated, and decisions are more flexible. Also, multidisciplinary teamwork implies that a higher number of factors are considered in the decision process, and that a higher number of solutions are evaluated. In addition, proactive focus has emerged as an important contributor to improved decision making, where professionals with expert knowledge get more involved in the early detection of potential problems and the development of counter-measures (Ringstad and Andersen, 2007).

However, there are also challenges that are more visible in IO teams than in teams interacting face-to-face. Such challenges are blurred lines of command for group based and distributed decision making, information overload both for operation personnel and expert personnel who have to make sense of the real time data streams, reduced understanding of installation specific factors as decision makers are removed from the drilling and production facilities, and increased complexity and interactivity which can make it difficult for decision makers to maintain their overview during an incident. (Ringstad and Andersen, 2007)

Improved decision making is in many definitions of IO highlighted as the main goal of integrated operations (e.g., Statoil, 2007). It is assumed that improved decision making processes in turn will lead to increased production, less downtime, fewer irregularities, a reduced number of HSE-related incidents, and in general a more efficient and streamlined operation.

In an operational context, a number of decisions are required, the decisions are interdependent, the environment changes, both autonomously and as a consequence of the actions taken by the decision maker; and the decisions are made in real time (Gonzalez, 2005). Because decisions in dynamic environments must be made in real-time, time constraints become an important determinant of performance (Brehmer, 1992). Also, dynamic decisions may involve time delays and decisions that positively or negatively influence one another in complicated ways over time (Diehl and Sterman, 1995). The current work within the Building Safety project has studied resilient decision processes in integrated operations. Chapter 3 will describe the main research tasks performed within the work package, chapter 4 will account for the literature review, chapter 5 describes the main outcome of the empirical study, while chapter 6 summarises the main recommendations given in the case specific advice.

3 Research tasks

3.1 Problem description

This task involved a preliminary review of research and theoretical approaches regarding resilient decision making in IO teams. The primary objectives in the problem description phase were to (1) explicitly state research questions, and (2) establish the scope for the literature review. Two problem descriptions were prepared, as they were written before the two work packages were joined.

Deliveries:

- Problem description memo (Skjerve et al., 2008), completed 13th March 2008.
- Problem description memo (Kaarstad et al., 2008), completed 10th October 2008.

3.2 Literature review

The literature review cover six individual topics that are all related to *Resilient decision processes in Integrated Operations*. The reviewed topics were: decision making, goal conflicts, cooperation, IO teamwork training, decision support, and the impact of collaboration technology on resilience. The overall objective of the literature review was to provide a broad knowledge base that could serve as a point of reference for defining requirements to the empirical studies. Please refer to section 4 for a synopsis of the literature review.

Delivery: Literature review (Skjerve and Kaarstad (Eds.), 2009), completed 1st April 2009.

3.3 Exploring Principles of Resilient Collaboration

An empirical study focusing on a methodological development was designed and performed in order to explore resilient decision processes in an IO team. Please confer section 5 in the report for a presentation of the empirical study. A paper describing the methodological development and its results was presented at Working On Safety (WOS) in Røros, 2010, and is included in its full text in section 5.

Delivery: Skjerve, A.B., Kaarstad, M., Størseth, F., Wærø, I., Grøtan, T.O. (2010). Planning for Operation: Exploring Principles of Resilient Collaboration. Presented at Working On Safety (WOS), Røros, Norway, 7-10 September 2010.

3.4 Case specific advice

The research results served as the basis for providing specific advice to the establishment of the operational organisation of the Goliat field. Please refer to section 6 for a summary of the case specific advice.

Delivery: Case specific advice (Skjerve, Kaarstad, Grøtan, 2010), restricted. Completed November 2010.

3.5 Generic knowledge

The main findings have been published in the following papers:

Rosness, R. (2007). A Contingency Model of Decision-Making Involving Risk of Accidental Loss. Presented at *NeTWork 2007, the 25th International Workshop "New Technologies and Work": Resolving Multiple Criteria in Decision-Making Involving Risks of Accidental Loss*, Steinhoefel, 27-29 September 2007. (Abstract in Appendix A)

Rosness, R. (2009b). A Contingency model of decision-making involving risk of accidental loss. *Safety Science* Volume 47, Issue 6, July 2009, pp 807-812. (Abstract in Appendix B)

Skjerve, A.B., Rindahl, G., Randem, H.O., Sarshar, S. (2009). Facilitating Adequate Prioritization of Safety Goals in Distributed Teams at the Norwegian Continental Shelf. Presented at *IEA 2009, 17th World Congress on Ergonomics*, August 9-14 Beijing, China. (Abstract in Appendix C)

Kaarstad, M., Rindahl, G., Torgersen, G.-E., Drøivoldsmo, A. (2009). Interaction and Interaction Skills in an Integrated Operations Setting. Presented at *IEA 2009, 17th World Congress on Ergonomics*, August 9-14 Beijing, China. (Abstract in Appendix D)

Kaarstad, M. (2010). Using Decision Support to Facilitate Adequate Team Decision Processes in an Integrated Operations Setting. Presented at *Working On Safety (WOS)*, Røros, Norway, 7-10 September 2010. (Abstract in Appendix E)

Skjerve, A.B. (2010). IO Teamwork Competencies. Presented at *Working On Safety (WOS)*, Røros, Norway, 7-10 September 2010. (Abstract in Appendix F)

Skjerve, A.B., Kaarstad, M., Størseth, F., Wærø, I., Grøtan, T.O. (2010). Planning for Operation: Exploring Principles of Resilient Collaboration. Presented at *Working On Safety (WOS)*, Røros, Norway, 7-10 September 2010. (Abstract in Appendix G)

Skjerve, A.B., Kaarstad, M., Størseth, F., Wærø, I., Grøtan, T.O. (2010). Planning for Resilient Collaboration at a New Petroleum Installation. (Submitted for publication in an international journal). (Abstract i Appendix H)

Abstracts of these papers are presented in Appendix A, B, C, D, E, F, G and H.

See also:
http://www.sintef.no/Projectweb/Building-Safety/Publications/

4 Literature review

The first task in this work package was to perform a literature review based on an analysis of the knowledge needed to meet the objective of the work. Figure 1 below illustrates the content of the literature review.

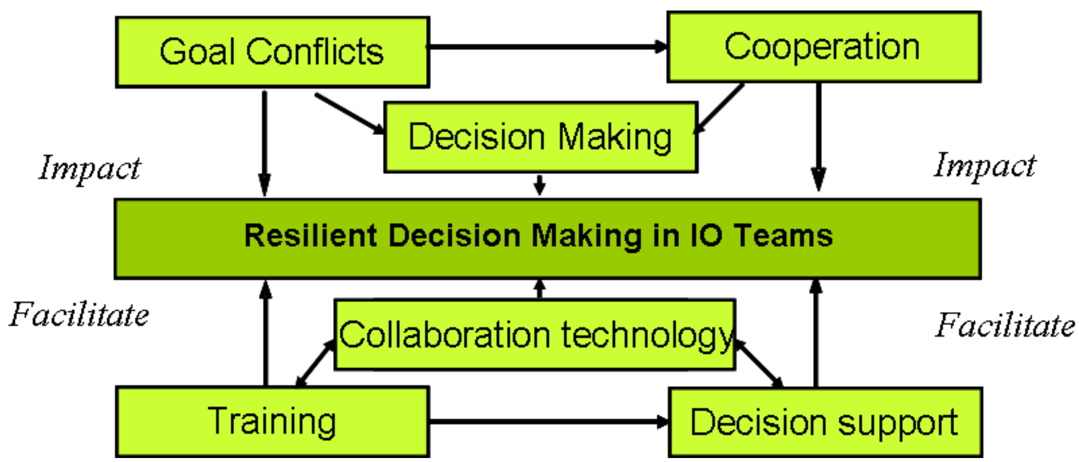


Fig. 1: Overview of the relationships between the various parts of the literature review.

The main focus throughout the surveys was *resilient decision making in IO teams.* The topics decision making, goal conflicts and cooperation were reviewed from the perspective that these are factors, which may come to impact decision processes positively or negatively, depending on how they are addressed in practice. The topics IO teamwork training, decision support, and the impact of collaboration technology on resilience were reviewed from the perspective of how these factors may contribute to facilitate adequate decision processes (Skjerve and Kaarstad, 2009).

It was beyond the scope of the present project to review the literature associated with each of the six topics comprehensively. For this reason, we chose to survey the literature with respect of issues of specific importance for performance of the tasks of this work package. The overall objective of the six literature reviews was to jointly provide a broad knowledge base that could serve as a point of reference when defining requirements to the empirical studies to be carried out. The outcome of each survey is documented in the format of a short paper/report, and the surveys can be read independently. The following paragraphs are partly quoted from and partly a summary of the main ideas from each review. Please use the original source when referring to the work.

4.1 Decision-Making: A Contingency Model

Rosness, R. (2009a). Decision-Making: A Contingency Model. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary:

Decision-making involving risk of accidental loss occurs in a variety of settings, ranging from flight decks and control rooms via executive management meetings and board meetings to political arenas such as governments and parliaments. The first chapter in the literature review develops the idea that different settings impose different constraints on decision-makers, and that decision-makers adapt their decision criteria and decision processes to the constraints of the setting. Improved understanding of the constraints of the setting and their impact on decision-making may thus put us in a better position to provide relevant decision support. In the context of accident and incident investigation, such sensitivity may also put us in a better position to explain the occurrence of apparently irrational or reckless decisions.

The review proposes a descriptive contingency model that can help in making sense of decision-making involving risk of accidental loss. Contingency models of decision-making propose that characteristics of decision processes are, or should be, related to characteristics (contingencies) of the decision task and/or setting (Koopman and Pool, 1991). Five different types of decision settings are distinguished, based on two different dimensions (blunt end versus sharp end and level of authority). Hypotheses concerning dominant constraints, dominant decision criteria and representative decision modes in each of the five settings are derived from the literature on organisational decision-making. The review also identifies a set of concepts that can help us understand ways in which different decisions interact in their impact on safety. Possible problems related to the typical decision modes and patterns of interaction between decisions are identified. Finally, these problems serve as a basis for identifying possible functions of decision aids or decision support.

A Typology of Decision Settings

In order to capture some of the diversity of decision settings, decision settings based on two underlying dimensions may be distinguished:

1. *Proximity to the hazard,* to distinguish between actors at the sharp end and those at the blunt end.
2. *Level of authority,* in the formal sense that actor A has a higher level of authority than actor B if A is entitled to issue orders, instruction or directives to B, but not vice versa.

Proximity is not only conceived in physical terms, but also in causal terms, i.e. the number of intervening links in the causal chains between the decision maker's actions and potential accidents. An operator in a remote control room may thus be physically remote from the process that he/she controls and at the same time very close in terms of causality. The relationship between physical and causal proximity is an interesting research topic in its own right in connection with Integrated Operations. For instance, collaboration rooms may introduce a new kind of "virtual proximity" where broad bandwidth communication tools allow people at different physical distance from the hazard interact more intensively with people that are physically close to the hazard. Whereas the present model merges several aspects of proximity to a single dimension in order to simplify, research on Integrated Operations may profit from decomposing proximity and studying the interaction of various aspects of proximity.

The metaphors "blunt end" and "sharp end" should not be construed as an allusion that life is less stressful at the blunt end. It seems plausible, however, that the available time to reach a decision tends to be shorter at the sharp end. Sharp end decision-makers often have to act quickly in order to avert an accident or a productivity loss.

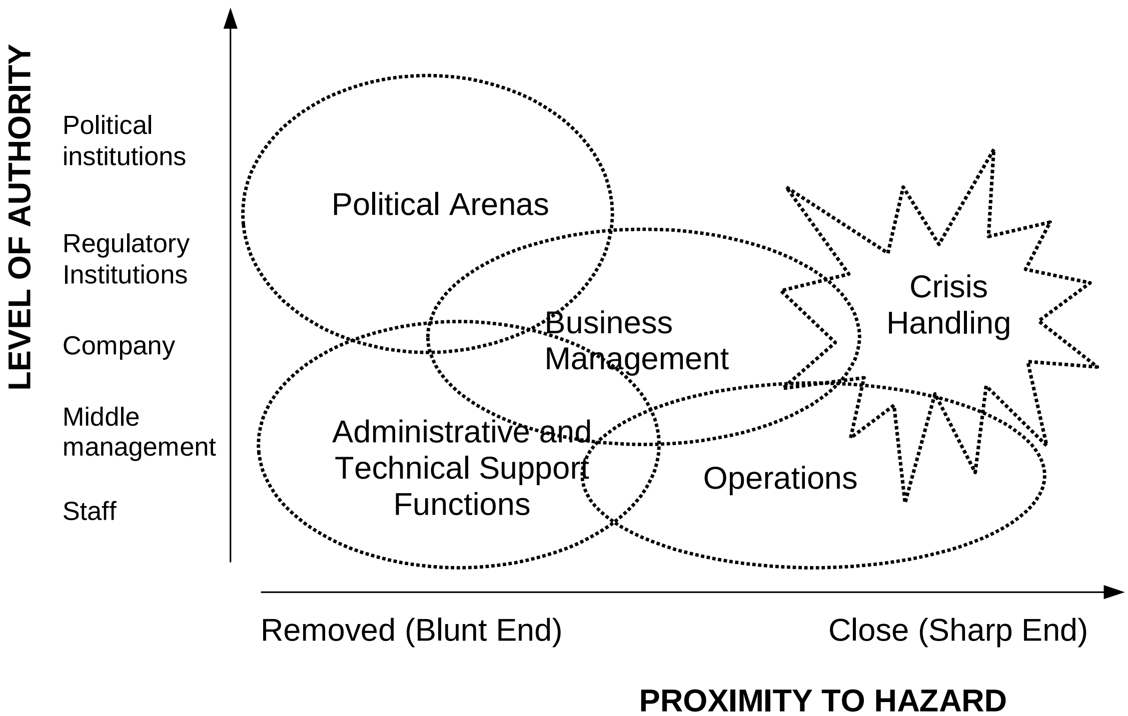


Figure 2. A Typology of Decision Settings (Rosness, 2009a)

Although authority is commonly considered as an important source of power, level of authority should not be equalled to power conceived as a capacity to impose one's will in the face of opposition from other actors. A multinational company may find means to overrule a weak government or regulatory authority. Workers on the shop floor may at times impose their own performance norms even when these are at variance with the norms that management tries to impose.

These two dimensions can be used to build a typology comprising five types of decision settings, as shown in Figure 2 (Rosness, 2000; Hovden et al., 2001; Kørte et al., 2002):

1. *Operations* refer to sharp end settings such as flight decks and control rooms. Example: A cockpit crew decides to interrupt the final approach of an aircraft to an airport because

the speed of the plane is excessive. Management on an offshore installation decides to postpone a maintenance job in order avoid an excessive level of activity.

2. *Business Management* refers to settings for high level decision-making in enterprises, such as company boards, and decisions made by executives and senior managers. Examples: The management of an oil company decides to launch a major safety culture programme. The management of a ferry company decides not to install indicator lights on the bridge of their ferries to show whether the bow and aft doors are closed.
3. *Administrative and Technical Support Functions* refers to settings towards the blunt end with limited formal authority, such as design, risk analysis, and handling of routine cases by a regulatory authority. Example: A human factors engineer decides to recommend a modification of a proposed control room layout in order to facilitate communication between the control room operator and the shift supervisor.
4. *Political Arenas* are assigned the task of handling decision-making involving conflicting interests. Political arenas include local councils, governments, parliaments, and EU institutions. Example: The Norwegian Parliament decides to allocate funding for Automatic Train Protection infrastructure in the budget for the following year.
5. *Crisis Handling* refers to settings where important values, such as human lives, are exposed to an imminent threat which requires prompt action. Example: The manager of an offshore production platform decides to keep part of his crew on the platform to fight a gas blow-out rather than evacuating everybody immediately.

Constraints, Criteria and Decision Modes

The author propose that these decision settings can be characterised in terms of dominant constraints on decision-makers, dominant decision criteria, and representative decision modes as summarised in Table 1. The table may be read as a set of hypotheses concerning how decision-makers typically adapt to the constraints of each type of decision setting.

These decision settings were further elaborated in the review. The paper concluded in the following way:

Decision-making involving risk of accidental loss occurs in a variety of settings. The constraints of the decision settings have a strong impact on decision-making. Different decision settings may thus call for different approaches to decision support. The proposed contingency model represents an attempt to capture important differences between decision settings. It may be used as a framework for organising theory and research on organisational decision-making and safety. The typology may also be used to identify possible problems related to each setting and to propose advice for adapting decision support to the setting.

Decision-making is constrained and influenced by previous decisions, and decisions may interact in the way they influence the risk of accidental loss. I have therefore proposed a set of concepts that may help us understand how decisions may interact in their impact on safety. These concepts may also be used as a starting point for proposing decisions aids.

It was not the intention to present a closed and complete system, but rather to invite others to explore the possibilities that arise from thinking of decision-making as action adapted to situational constraints.

Table 1. Characteristics of five decision settings (Rosness, 2009a).

Decision Setting	Dominant Constraints	Dominant Decision Criteria	Representative Decision Modes
Operations	Workload Limited situation awareness	Smooth and efficient operations Acceptable workload	Skill based and knowledge based action intermittently interrupted by knowledge based problem solving (Rasmussen, 1986) Recognition-Primed Decision-making (Klein, 1993)
Business Management	Information processing capacity Dependence on information filtered by subordinates	Optimise profit (or other KPIs) Avoid trouble Efficient decision-making Ensure commitment or compliance	Satisficing (Simon, 1947; March and Simon, 1958) "Irrational" decision-making devised to gain commitment (Brunsson, 1985)
Administrative and Technical Support Functions	Limited hands-on-knowledge No authority to enforce decisions	Comply with rules and standards Consistency Optimise a single attribute	Extensive reuse of solutions Intermittent, limited optimisation efforts (one attribute)
Political Arenas	Conflicts of interest Changing constellations of power	Robust consensus Secure status of decision-maker	Muddling through (Lindblom, 1959) Symbolic decisions not necessarily followed by action (Brunsson, 1989) Covert decision-making to avoid attention (Brunsson, 1989)
Crisis Handling	Stress Time to obtain information and act	Avert catastrophic outcomes Avoid extreme stress levels	Recognition-Primed Decision-making (Klein, 1993) Hot cognition (Janis and Mann, 1977)

When applying this framework to integrated operations (IO), it may be worthwhile to consider the dimension proximity to hazard in some detail. Some IO concepts involve that decisions with a fairly direct causal impact on the sources of hazard are taken by personnel at a remote site rather than by the personnel that are directly exposed to the hazard and have the daily hands-on-experience with the installation in question. Other IO concepts involve more intensive interaction between decision-makers at the blunt end and at the sharp end. This might in principle lead to several possible outcomes, ranging from a clash of cultures via one decision-making culture dominating the other to a mutual enrichment and improved decision-making.

4.2 A Goal-Conflict Typology to Support Adequate Prioritization of Safety Goals

Skjerve, A.B.. (2009a). A Goal-Conflict Typology to Support Adequate Prioritisation of Safety Goals in Industrial Settings. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary:

At petroleum installations on the Norwegian Continental Shelf, the standing order is that safety should always be prioritized. The presence of this order shows that the petroleum companies recognize that their employees – as employees in other high-risk industries (Rasmussen, 1997; Hollnagel, 2004) - have to balance safety goals versus other types of goals as a part of their work activities. The need for ensuring safety is also clearly emphasized in the petroleum companies' standards of operation, which document the requirements associated with task performance. Regardless of petroleum companies' emphasis on the need for ensuring safety, incidents and accidents investigation reports reveal that safety is not always prioritized in practice.[2] When looking at a cross-section of the investigation reports, it is clear that inadequate states of a set of safety-related factors recurrently are found to contribute to incidents and accidents. These factors include inadequate: work practices, operating procedures, staff training, and maintenance.

Lee, Locke, and Latham (1989) state that a goal conflict exists when "...achieving one valued goal inhibits achieving another desired goal" (ibid. 300). When the concept goal conflict is defined as a psychological construct, the judgment of whether a goal conflict is present or not lies exclusively with the individual. If the individual does not perceive any goal conflicts, there will, per definition, be no goal conflicts. Still an accident investigator, analysing the course of events that lead to the accident, may conclude that a goal conflict was actually present in the given situation – even though it remained unnoticed to the employees at the time. This may for example be the case, when prioritizations made by employees (e.g., to complete a task without checking the state of particular valves), implied that safety precautions required by the operational standards were violated. Even the employees, who took part in the original event, may agree with the conclusion of the accident investigator, when looking back at the course of events, although they did not recognize the goal conflict at the time the events unfolded.

The practical consequences that may follow from inadequate prioritization of safety goals will be similar - and potentially fatal - regardless of whether a goal conflict was recognized by the employees, but inadequately dealt with, as the events unfolded - or not recognized by the

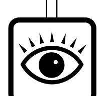
[2] www.ptil.no/investigations/category157.html

employees, and thus not taken into consideration, when the employees made their decisions on how to proceed, as the events unfolded. For this reason, initiatives aimed at facilitating adequate prioritization of safety goals in work settings should be focused on both ensuring that safety goals are identified in real-time (i.e., situation assessment) and that safety goals are adequately prioritized. To support this, the concept goal conflict should be extended.

In the literature survey, it is suggested that the concept goal conflict, when addressed in work settings, could be defined as situations in which a (safety) goal is in conflict with one or more other desired goal(s), as judged by individual(s) in real time and/or as judged based on the safety standards of the organisation. To the extent that the standards of the organisation provide criteria for how to make trade-offs between a specific safety goal or/and other type of goals (e.g. prohibited or mandatory activities), the employees should recognize this during their task-performance process. In various situations, no trade-off criteria will be readily available, and the employees have to make prioritizations in real time, based on the overall principles in the standards of operations, e.g., that safety concerns should be prioritized. In some situations, it might be reasonable for the employees to violate certain trade-off criteria, e.g., because the situation at hand has not been foreseen when the criteria were defined. However, it is important that the employees are *aware* of requirements of the standards, and *reckon* when they violate the standards.

Based on the extended definition of the concept goal conflict, a simple goal conflict typology was developed. The typology covers four situations in which a goal conflict exists either because the employee (or team, depending on the level of analysis) perceives that a goal conflict exists, or because a goal conflict can be said to exist, based on the content of the organisation's standards (see Figure 3).

Trade off criteria / Team's perception	No relevant trade-off criteria exist	Relevant trade-off criteria exist
A perceived safety-related goal conflict	Type I	Type II
No perceived safety-related goal conflict	Type III	Type IV



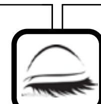


Figure 3. A simple goal-conflict typology for industrial settings (Skjerve, 2009a).

The first dimension is called Team/individual perception. It refers to whether or not an employee/team in real-time perceives that a safety goal conflicts with other goals. This dimension corresponds to classical definitions of the concept goal conflict. The second dimension is called Trade-off criteria. It refers to whether or not the standards of the company in question contain trade-off criteria, which specify how safety goals should be prioritized in the given situation.

Type I goal-conflicts imply that an employee accurately perceives that a safety goal conflicts with another goal and accurately assesses that no specific trade-off criteria exists for how the situation should be handled. This type of situation may (depending on the content of the organisation's standards) arise, e.g. when an employee is asked to achieve multiple conflicting outcomes (e.g., to perform a highly complex task fast and safely), or when two safety goals are in conflict (e.g., when the need for rescuing staff has to be balanced against the risks a rescue operation will imply for members of the rescue team). In these situations, the employee will have to prioritize the various tasks based on insights into the state of the current situation and the overall principles guiding performance in the organisation.

Type II goal-conflicts imply that an employee accurately perceives that a safety goal is in conflict with another type of goal, but is unaware that relevant trade-off criteria actually exist (if the individual is aware of the trade-off criteria he or she will not experience a goal conflict, but simply prioritize the goals involved in accordance with the requirements in the standards). This situation may arise, e.g., when the employee faces a situation with which he or she has limited familiarity, or when an order is misperceived to imply that multiple conflicting outcomes should be achieved. In these situations, the employee will experience unnecessary uncertainty. He or she may come to spend an excessive amount of time considering, how to prioritize the various goals, and may even – unintentionally – come to violate existing standards.

Tools and techniques aimed at increasing awareness of the content of the organisation's standards can be expected to support adequate prioritization of safety goals, when goal conflicts of type I and II occur. When goal conflict type I occurs, it will contribute to ensure that the prioritizations made, will not come to violate existing standards (even though no specific trade-off criteria readily can be applied, an intervention plan will still have to adhere to requirements of the overall standards, e.g., prohibited and mandatory activities). Goal conflicts of type II would, in principle, are eliminated, as the trade-off criteria would effectively guide the employees' prioritization of the safety goal involved.

Type III goal-conflicts imply that the employee does not experience a goal conflict in a situation where a goal conflict (as judged based on the organisation's standards) exists, and where no trade-off criteria are available (or sought after) to guide performance. This type of situation essentially arises when an employee has not adequately considered the situation at hand from a safety perspective. A type III goal conflict may, e.g., arise when a situation is new or unexpected to the employee, or when the employee does not have sufficient time (given the means available) to establish an adequate situation overview.

Type goal-conflicts refer to a similar situation, as type III goal-conflicts, except that in this case trade-off criteria actually do exist, although the employee is not aware of or attending to this fact. Type IV goal conflicts may, e.g., arise when an employee routinely applies short cuts of the type: "Normally OK, no need to check it now", and across time forgets that this approach implies that safety goals are not adequately attended to.

Tools and techniques aimed at increasing situation awareness can be expected to support identification of safety goals, and thus contribute to overcome goal conflicts of type III and IV. The tools and techniques could, e.g., comprise the establishing work practices, which imply routinely effective strategies for identification of safety goals and/or the implementation of technology to support identification of safety goals and the organisational standards of relevance in the particular situation.

The potential practical implications of the findings based on the literature study were discussed with reference to a generic model of the task-performance process of teams that work together via co-operation rooms. The discussion was directed at decision-making by teams performing safety-critical tasks in real-time.

4.3 Cooperation and Team Performance; Challenges and Key Differentials

Kaarstad, M.. (2009a). Cooperation and Team Performance; Challenges and Key Differentials. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary:

The concept of *cooperation* is traditionally referring to a *social process* (Marwell and Schmidt, 1975), which involves the “association of persons for common benefit”. Cooperation between humans has been the subject of studies within various fields of research. Deutsch (1962) suggests that cooperation involves the existence of a positive correlation between the goal achievements of two (or more) individuals. He considers that a psychological state of cooperation exists when an individual perceives that his goal is positively correlated with the goals of others. Further, he states that an interpersonal state of cooperation exists when individuals mutually perceive their goals as positively correlated.

Cooperation in an integrated operation setting may happen both face-to-face, and across distance. With the invention of technology supporting videoconferences, people may communicate easily with each other and accomplish difficult work processes even though they are located remotely from each other and/ or rarely overlap in time. The socio-technical conditions required for effective distance work are discussed by Olson and Olson (2000). In order to succeed with remote work, they claim that teams need to have a high common ground, loosely coupled work, with readiness both for cooperation and the technology that support cooperation. The factors they mention as most commonly working against success, is a lack of common ground and trust, that people cooperate within different time zones, and that people from different cultures cooperate. Social psychological factors that are likely to affect cooperation, are individual aspects, such as how well individuals are able to cooperate, team factors, such as whether or not the team has a democratic or authoritative style, and external factors, such as how much time pressure there is to accomplish a task, and how much workload the individuals feel or actually have.

The review performed was not a complete review of all aspects underlying cooperation, but focused on cooperation aspects that are of particular importance for integrated operations.

Spatial and temporal boundaries

In the petroleum industry, some companies have offices spread around the world, which implies that their teams have to cooperate both across time zones and across location. Spatial boundaries include the geographic differences among team members (different location) and temporal boundaries include the workday differences among team members (different time zones).

Spatial boundaries impact the likelihood of face-to-face contact, spontaneous communication, and shared social settings (Humphries et al., 2004). Temporal boundaries impact the likelihood of synchronous communication, real-time problem solving, and workflow availability (Damianos et al., 1999).

Communication technologies allow team members to communicate at a distance through the use of audio, video, text, graphics, and other features. Researchers have categorized communication technologies according to whether they are used synchronously or asynchronously, as well as whether they are used in the same place or in different places (Klein, 2001; Malone and Crowston, 1994). For example, telephone communication is synchronous and is often used when two people are in different places, while e-mail communication is asynchronous and is often used when two people are in different places.

Opportunities for informal communication, which give team members a chance to update one another on progress and develop mutual knowledge, are more difficult to create in teams separated by spatial boundaries. Developing common practices for dispersed coordination is difficult, and requires aligning the effort of all parties involved (McGrath, 1990).

Through experience, members can build awareness of who is doing what, and try to forecast when interaction is necessary (McGarth, 1994). Team members with greater awareness of other members should be in a better position to connect when needed (Nardi, 1996). An alternative to interaction outside of the typical work day is through asynchronous communication such as email. Email can be used to share information, coordinate work, and create a shared identity for the team. Other technologies allow team members to share a desktop, on which they can save files, leave messages, and interact asynchronously if both people are available at the same time.

O' Leary and Cummings (2007) found that the more members depend on one another, the less likely there is to be coordination delay. How long members have known one another and how aware they are of when and where others are working, can be beneficial for reducing coordination delay. While member awareness can be encouraged, team members who have just met for the first time will need additional support for building relationships.

Studies related to distance present mixed findings about whether distance is challenging to teams' effectiveness. The role of distance is probably depending on which team processes and outcomes one is exploring and how distance is measured. Some argue that distance matters – some contend that physical distance makes it more challenging for leaders to engage in relational and task behaviours with followers. As part of this discussion, scholars are beginning to question the extent to which face-to-face communication is necessary for distributed teams to function effectively and why. In global teams, it is important to identify and be aware of which processes work well across spatial and temporal boundaries and which processes that need some kind of support in order to work well.

Multinational and multicultural cooperation

Another factor that impacts on how easy it is for people to cooperate is national and cultural belonging. Culture has been defined in numerous ways in academic research (Jenks, 1993). Culture has a complex, multifaceted nature. Chao and Moon (2005) present a model of cultural mosaic, where they suggest that a complex pattern of demographic, geographic, and associative facets make up an individual's cultural identity.

The current work on multinational and multicultural teams has often focused on the geographical facet, conceiving of culture in terms of broad national differences.

Some findings suggest that cultural differences matter, whereas other research suggests that they may not in team that experience high trust or regular communication (Anderson et al., 2007). Globally distributed teams will probably be effective vehicles for knowledge sharing in an organisation as long as individuals learn the cultural logic of others' divergent beliefs. If not, culture might be constructed as something which divides individuals.

Importance of communication in cooperation

Several findings suggest that communication frequency is necessary in team effectiveness. Frequent informal and unplanned communication has been shown to be related to shared identity and shared context (Hinds and Mortensen, 2005).

Face-to-face communication is found to be beneficial to reducing task conflict, fostering trust, and enhancing team dynamics. Although communication frequency and face-to-face communication are aspects of communication, they alone do not reflect the complexities of communication. Gibson and Gibbs (2006) found that a psychologically safe communication climate can help minimize the effects of distribution and national diversity.

Face-to-face communication is tied to team effectiveness, and is perceived as critical early in the development of a team (Oertig and Buegri, 2006). As with the findings about the role of distance in global teams, the role of face-to-face communication is questioned in the literature. Walther (1996), for instance, found, surprisingly enough that geographically dispersed and culturally diverse team members who relied completely on computer-mediated communication without ever meeting face to face, communicated more affection and reported higher levels of intimacy than individuals who were collocated. These findings complement other findings in team research. Zack (1994), for example, found that initial face-to-face interactions enhance team processes and as time goes on, and team members become more familiar with one another, mediated communication does not hinder team processes. Moreover, Alge et al. (2003) found that teams with an established history are able to use electronic means of communicating just as effectively as face-to-face. These studies indicate that distance does not necessarily involve obstacles for efficient communication.

Importance of goal clarity on cooperation

As teams become more virtual, the absence of experiences gained from FTF interactions may lead to difficulties in creating and maintaining a shared vision and commitment to goals. Among team members who are geographically or temporally distant, individual goals may become less clear if they are not directly attached to some sort of organisational mandate (Manzevsky and Chudoba, 2000), potentially leading to less cooperative effort. Although empirical studies are lacking, Keszbom (1999) notes that a common vision or sense of purpose is more difficult to achieve with virtual teams.

Montoya-Weiss et al. (2001) found that the way virtual team members manage conflict is crucial in their success, and that temporal coordination has some effect on team performance. Distribution was not found to influence conflict in these teams. Over time, it seemed that distributed team members became more harmonious as team members, and developed shared familiarity and shared processes.

Importance of trust on cooperation

Several researchers depict team development processes as occurring over time. Global teams are characterised as having a temporal rhythm (Maznevski and Chudoba, 2000) or a natural history (Baba et al., 2004). Jarvenpaa et al. (1998) hypothesised and found that earlier in a team's development, trust is better predicted by perceptions of integrity than by benevolent actions, but that later on, benevolence will have the stronger effect.

Trust has received considerable attention, especially in relation to virtual teams and innovation. Research has found that perceptions of physical distance impacted individuals' willingness to trust counterparts in computer-mediated interaction (Bradner and Mark, 2002). Jarvenpaa and Leidner (1999) found that timely and consistent communication was likely to engender trust within virtual teams. Lynn and Reilly (2002) found that members of virtual teams reported lower levels of trust and that these lower levels of trust correlated with lower levels of innovation and cooperative behaviour.

This review argues that cooperation is important for achieving safety and efficiency. What is essential for integrated operations is to enhance the positive aspects with the team processes and cooperation climate in teams who have a diversity of thought, perception, background and experience. In a team everyone should be involved and facilitate the creation of a harmonious cooperative climate. In integrated operations it is important to challenge people from different disciplines and cultures to cooperate towards common goals and achieve safe, reliable and productive cooperation.

4.4 IO Teamwork Training

Skjerve, A.B.. (2009b). IO Tamwork Training. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary:

The increased use of IO teams makes it pertinent to obtain a better understanding of what teamwork competencies IO team members need to perform proficiently as a team. If the needed teamwork competencies under IO differ from the needed competencies under the traditional operational concept, it is important that the training programs applied by petroleum companies are updated to include these changes.

The literature study of IO teamwork training involved a survey of 30 papers on co-located teamwork, distributed teamwork, and/or teamwork in offshore operation. The purpose of the survey was to develop a model comprising the main attributes of teamwork competencies needed by members of IO teams. The survey was structured in three parts.

The first part aimed at identifying generic attributes of teamwork competence, and was based (mainly) on studies of co-located teams. Overall, this first part of the literature survey suggested that competence in communication (e.g. giving feedback, critique and suggestions), in leadership (e.g., resource management and use of authority/assertiveness), and in establishing shared situation awareness are necessary for ensuring proficient teamwork. It, moreover, suggested that the ability to flexibly adapt to the situation at hand (e.g., competence in coordination and in mutual performance monitoring) and to maintain a positive attitude to teamwork are key factors for ensuring proficient teamwork.

The second part focused on establishing attributes of teamwork competence based on studies of distributed teams. In general, the second part of the survey indicated that the teamwork competencies required by members of co-located and distributed teams - at least at the general level addressed in the present study - are highly similar, except for the requirement that concerns mastering of collaboration technology. Still, the particular knowledge, skills, and attitudes required to master the specified attributes of teamwork competence may differ in co-located and distributed teams, due to the differences in the two work settings. It seems, e.g., that trust between non co-located team members needs to be built and maintained by other means than trust between co-located team members (e.g., Baan and Maznevski, 2008; Skjerve and Rindahl, 2010).

The third part of the review aimed at understanding the attributes of teamwork competence required in offshore operations. This part of the literature study provided more detailed information about the required teamwork competencies within offshore operations. In particular it emphasized the importance of understanding how IO is intended to work, and of mastering the associated work processes. It, further, introduced the attribute personal resources.

Based on the findings in the literature study the Main Attributes of IO Teamwork Competence (MAITEC) model was developed (see Figure 4). The model comprises what is suggested to be ten main attributes of IO teamwork competence. The attributes were included based on comparisons between the findings in the literature study and the generic characteristics of IO teams and IO teamwork. The term competence is used as a reference to all ten teamwork attributes to signify that each attribute, with the specific knowledge, attitudes, and skills it involves, contributes to the overall teamwork competence required of IO team members.

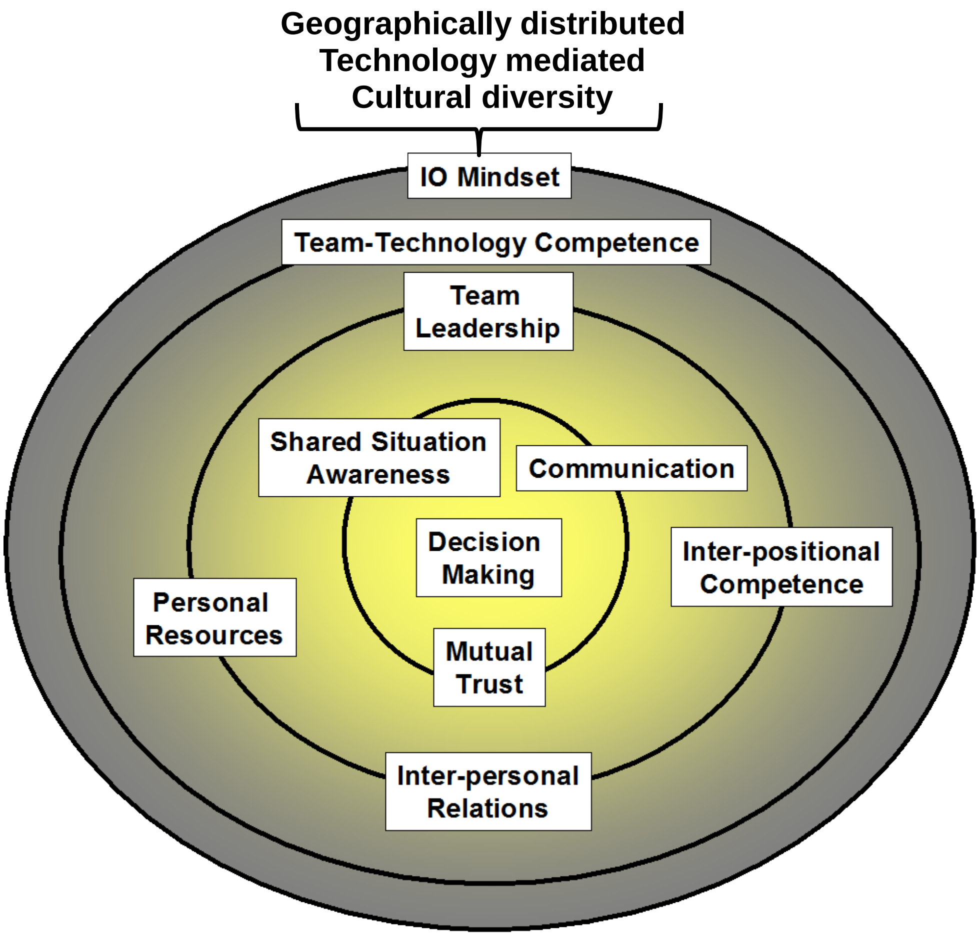


Figure 4. The MAITEC model of the main attributes of IO teamwork competence (Skjerve, 2009b).

The attributes are distributed across four layers. The layered structure is used to signify that the teamwork attributes are highly interrelated. Competencies located at the outer layers will facilitate the ability to master competencies at the inner layers in the IO environment (Skjerve, 2010).

The attribute *decision making* is located in the centre of the model. Decision making refers to the competencies needed to "... gather and integrate information, use sound judgement, identify alternatives, select the best solution, and evaluate the consequences" (Salas and Cannon-Bowers, 2000, p. 317). Decision making is at the centre of the model because facilitating adequate decision processes.

The teamwork attribute contained in the outermost circle of the MAITEC model is called *IO mindset*. An IO-mindset implies that a team member has insights into how IO is intended to work and holds positive attitudes towards working in this way. IO team members need to recognise the main characteristics of IO teamwork, and to understand what it takes to facilitate teamwork in this setting.

IO teamwork training should, at least at an introductory stage, focus on providing the trainees with insight into why and how IO teamwork is intended to work. In this process, training scenarios, which ensure that the differences between the traditional way of working and the IO way of working become clear to the trainees, should be applied.

Team-technology competence is located on the second circle from the outside of the MAITEC model. It refers to the competence required to master the technology implied by IO teamwork. The technology comprises collaboration technologies, such as video conference equipment, as well as other types of groupware tools, e.g., tools for maintenance planning.

Team-technology competence includes the ability to operate the technologies and the ability to work with team members via the technologies. Studies show that lack of technology competence can be interpreted as a lack of functional ability by team members (e.g., Greenberg et al., 2007). This also seems to be the case in IO teams (Skjerve and Rindahl, 2010). A team member, who does not adequately master the collaboration technology, may receive less attention from team mates during decision processes than his or her actual level of disciplinary competence would warrant. The team member may, further, find it more difficult to steer a meeting and to bring forward important issues.

Team leadership, inter-personal relations, inter-positional competence, and personal resources

Four attributes of teamwork competence, which directly relate to team members' ability to interact, are located on the third circle from the outside of the MAITEC model.

Team leadership refers to competence in leading, in directing team mates' activity. This competence is considered to be useful for all team members regardless of their actual role in the team (Gaddy and Wachtel, 1992).

Inter-personal relations refer to competence in optimizing the quality of the collaboration processes within the team. This may include, e.g., attending to team mates' needs and to encouraging their performance.

An important attribute of leadership and inter-personal relations competence in an IO setting is the ability to collaborate with people from diverse cultures, i.e. people from different professions, with different departmental or organisational affiliations, and/or with different nationalities. People with diverse backgrounds may hold dissimilar expectations to, and have different norms for how to deal with, e.g., team leaders, new team members, instructions, and agreed deadlines. Team members with insights into the potential impacts of cultural differences on team performance, may adapt the way they relate to team mates to facilitate that cultural diversity will not come to complicate, but rather positively benefit, IO teamwork.

Inter-positional competence refers to an individual's ability to take a team mate's perspective, based on insights into his or her functional role in the team, and to perform a certain subset of the team mate's task. Inter-positional competence facilitates communication between team members. It further makes it possible to re-allocate tasks between the team members, and thus contributes to increase the team's ability to flexibly adapt to the situation at hand.

As IO team members often have different departmental and/or organisational affiliations, they may from time to time have partly different concerns. A supplier may, e.g., wish to deliver goods as soon as possible, while an operation and maintenance leader may wish to avoid placing further workload on the employees, who are to receive the goods, etc. For this reason, it is reasonable to expect that some degree of goal conflicts may arise within an IO team, and to be well prepared for handling these situations (Skjerve, 2009a). It may, moreover, be relevant to guard against polarization between subgroups, e.g., based on locations. Negatively charged attitudes between subgroups – e.g. us-versus-them attitudes - will work against the possibility for establishing proficient teamwork (see, e.g., Cramton and Hinds, 2005).

The last attribute is called *personal resources* (cf. O'Connor and Flin, 2003). It refers to a team member's ability to monitor and manage his or her own physical fitness (e.g., in terms of stress and fatigue), and to inform team mates, if he or she is unfit to fulfil the allocated team function. This competence is suggested, here, to be of key importance for members of IO teams. Staff members, who are unfamiliar with each other, hold different cultural backgrounds, and/or work from different locations, may not readily notice if a team mate is no longer fit to fulfil his or her function in the team. If an unfit team member continues to work, this may potentially have a negative impact the safety level at the installation.

Communication, shared situation awareness, and mutual trust

The innermost circle that immediately surrounds the attribute decision making contains three teamwork attributes: Communication, shared situation awareness, and mutual trust. These attributes were identified by Baan and Maznevski (2008) to be critical success factors for distributed teams. A recent exploratory study, moreover, found that communication, information flow, and trust between team members were three of the main challenges associated with IO teamwork by members of IO teams (Skjerve and Rindahl, 2010).

Communication is the process "... by which information is clearly and accurately exchanged between two or more team members" (Salas and Cannon-Bowers, 2000, p. 317). When teamwork is technology mediated, communications are generally suggested to be fewer and degraded, as compared to in co-located teams (Salas et al., 2001). Misunderstandings may arise more easily, because communication is restricted (Nemiro et al., 2008), and - in some cases - because the team members at different locations do not have access to the same information. The heterogeneity of IO team members may also increase the risk for misunderstandings, as key concepts, such as HSE, may be defined and/or prioritized differently by the team members. It is of key importance that IO team members are able to communicate in a way that makes their messages readily understandable to their team mates. IO team members should avoid the use of institutional language and they should master traditional presentation techniques. They should, moreover, be sensitive to potential tacit or implicit assumptions that may impact a team mate's standpoint (e.g., what the team mate regard as an unacceptable risk), and be able to adequately address these assumptions, if needed.

Shared situation awareness (SSA) refers to the process "… by which team members develop compatible models (shared understanding) of team's internal and external task environment" (Salas and Cannon-Bowers, 2000, p. 317). To obtain and maintain SSA, information/knowledge of relevance for the team's performance should be distributed to all team members, preferably simultaneously, and be jointly addressed by the team. Relevant information/knowledge should, moreover, be adequately transferred to new or returning team members during shift handovers. Groupware technologies may facilitate this process, e.g., by visualizing and storing task-relevant information.

The requirements for IO teams to flexibly adapt to the situation at hand, implies that IO team members continuously should be aware of - and in agreement about - the current operational mode (e.g., normal, beyond design basis, emergency). Accurate mode awareness increases the likelihood that the team will follow correct instructions (i.e., work processes), and that adaptations made by the team to accommodate the situation at hand will have the intended outcomes.

Establishing mutual trust between members of distributed teams is needed, because team members depend on each other to achieve the team's goal. It is, however, a demanding task (Greenberg et al., 2007; Nemiro et al., 2008). Trust relies on a personal relationship, and the traditional sources of trust involve familiarity, shared experience, and reciprocal disclosure (Meyerson et al., 1996). Personal relationships are challenging to develop with non co-located team members. Still, a special type of trust called swift trust has been observed to arise in distributed teams (ibid.). Rather than personal familiarity, swift trust is based on depersonalized judgments of a person's trustworthiness (e.g., based on organisational affiliation, role, and sex). Swift trust may arise with a short time span, and it may be easily broken.

Mutual trust must be well-calibrated. Both too little and too much trust may have detrimental effects on the team's performance (Skjerve and Rindahl, 2010). Even though some members of IO teams may know and trust each other in advance, a team will typically also contain members that do not know each other well. Skjerve and Rindahl (ibid.) suggest a set of initiatives to promote trust between members of IO teams. These include establishing physical and virtual meeting points, encouraging the development of inter-positional competence, and ensuring that team members use tags specifying their name, function, and company affiliation, to facilitate depersonalized trust assessments.

The MAITEC model contains, what is suggested to be, ten main attributes of IO teamwork competence. The model may assist designers of IO teamwork training in deciding what teamwork competencies to include in the training programs. In general practice-based methods, e.g., simulator training and role play, are argued to be the potentially most effective methods of team training (Salas and Cannon-Bowers, 2000). The MAITEC model may offer some assistance in deciding in which sequence the various teamwork competencies should be the focal point of attention throughout a practice-based training program, and thus in defining the training scenarios. Still, the detailed content of a specific training program has to be derived based on analysis of the requirements related to IO teamwork in the particular organisational context.

Teamwork competence is necessary to ensure that an IO team will perform proficiently. It is, however, not sufficient. To ensure proficient teamwork it is, moreover, necessary that the team members possess the taskwork competence required to achieve the team's goal(s). In addition, a range of contextual factors will impact the proficiency of IO teamwork. If, e.g., the work processes that guide a team's performance do not leave adequate time for team members to interact, and/or if the needed collaboration technology is unavailable, teamwork proficiency will degrade. To attain proficient IO teamwork, it is, thus, necessary to ensure that the team members possess the required teamwork and taskwork competencies, and that the work environment is designed to facilitate IO teamwork.

4.5 Using Decision Support to Facilitate Adequate Team Decision Processes

Kaarstad, M. (2009b). Decision Support: Using Decision Support to Facilitate Adequate Team Decision Processes. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary:

Because the successful performance of many important tasks requires skilful decision making, the identification of forms of decision support for dynamic decision making has become a research priority. However, this identification process has proven to be very challenging (Lerch and Harter, 2001).

Personnel working in an IO setting will often benefit from decision support in different situations. In this review, we take a look at what decision support is, and in which situations decision support would be useful in IO.

What is decision support?

The term decision support contains the word "support", which refers to supporting people in making decisions. Thus, decision support is concerned with human decision making. The definitions of decision support rarely mention this characteristic and rather assume it implicitly. In this paper we explicitly differentiate between machine and human decision making, and associate decision support with the latter.

In the figure below, it is illustrated that the two disciplines that closely correspond to decision support, are *Decision Theory*, a broad discipline concerned with human decision making, and *Decision Systems*, which (primarily) deals with computer-based programs and technologies intended to make routine decisions, and monitor and control processes.

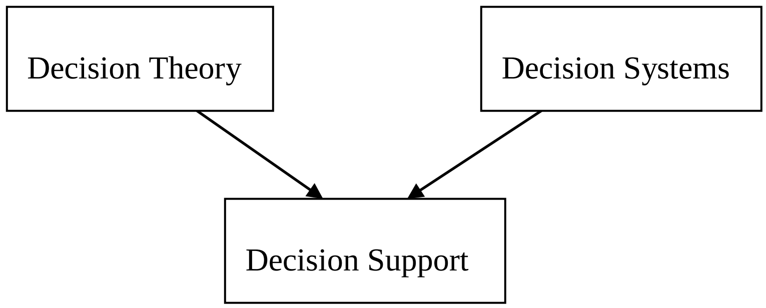


Figure 5. Decision support as impacted by decision theory and decision support (Kaarstad, 2010).

Decision theory

The human cognitive modes of comprehension, perception, representation and decision making have been studied for decades and has been used as basis for the development of several decision support systems.

A decision can be defined as the choice of one among a number of alternatives (Bohanec, 2003), and decision making refers to the whole process of making the choice, which includes: assessing the problem, collecting and verifying information, identifying alternatives, anticipating consequences of decisions, making the choice using sound and logical judgment based on available information, informing others of decision and rationale, and evaluation decisions (Bohanec, 2003).

Decision systems

Decision systems are computer technology solutions that can be used to support complex decision making and problem solving. Decision support systems have evolved from two main areas of research – the theoretical studies of organisational decision making (e.g., Cyert and March, 1963) and technical work. In the 1960s, researchers began systematically studying the use of computerized quantitative models to assist in decision making and planning (Raymond, 1966; Turban, 1967).

There are numerous tools and techniques that help people in organising data and thoughts. Decision support may not solely be understood as a computer tool, but in a broader sense, it includes tools and techniques that help people in making a decision, like procedures, guidelines, advice, visualisation tools, communication technology as well as training initiatives in decision making.

Decision support in an IO-setting

In integrated operations, individuals often make decision in small groups or in large organisational networks. The decision support tools that are designed are supposed to support different user groups and can be divided into individual, group, and organisational tools. There are further three distinct situations in integrated operations where decision support is assumed to be of particular importance. These situations can be divided into:

1. Daily operation and planning
2. Project work
3. Risk situations and emergencies

Decision support for the *daily operation and planning*, include normal, real-time dynamic operation, day-to-day and long-time planning including planned maintenance, and will generally be used when there is sufficient time to think and plan ahead. Each organisation will have separate needs for decision support in daily operation and planning. The main support tools that need to be in place for decision making in IO, are efficient collaboration tools for knowledge sharing and discussion, as equipment for video conferencing, wide screens for presentation, and mobile and wearable equipment. In general, a successful decision support system can generate a variety of benefits. It can provide information that is timely, accurate, relevant, concise, and in an attractive format.

In the concrete and task specific *project work*, tools that facilitate the sharing of information and expertise to improve the quality of team decision making are needed. Given that team members in integrated operations may be positioned on different parts of the globe, multi-cultural issues may become prominent. Project planning and decision-making, therefore, becomes yet more complex and intricate. The modern organisation, also an IO organisation, can no longer be viewed as a group of loosely related departments with specific formal links, but as a series of highly interconnected business processes (Richardson et al., 2000). The increased use of information technology, and the resulting interconnectivity, from local area networks, through intra-nets, has increased the capability for individuals and groups to exchange information rapidly.

The third situation where decision support is important is in *risk situations and emergencies*, and when a normal situation is developing into an emergency. Risk is not a static and inherent characteristic with a given activity which is not possible to influence. Risk develops over time, together with the activities that is performed, the implementation of initiatives, learning from incidents, accidents, and success, use of new technology, development of work processes, and updating of procedures and guiding rules. Risk-informed decisions imply that one has to know whether the decision foundation is sufficient, and to evaluate the need and the possibility to further reduce the uncertainty before a decision is made (Walle and Turoff, 2008).

Rasmussen (1997) developed a model of three boundaries for acceptable performance in a high-risk organisation. These three boundaries can be described as 1) the boundary for financially acceptable performance, 2) the boundary for unacceptable workload, and 3) the boundary for functionally acceptable behaviour in terms of risk. When the pressures towards one of the boundaries increases, the operators may respond by using different short-cuts, which implies that safety concerns are not attended to as properly as they ought to be. When one or several of the boundaries are crossed, there is a risk that an accident may happen.

It could be possible to develop decision support systems supporting the thinking of the boundaries of acceptable performance, showing when the operational team is approaching a corner/ a barrier, and provide suggestions for what possible actions could be taken to avoid a risk.

Teams must be encouraged and trained to handle emergencies. Emergencies often differ from situations operators normally are trained in, and often the solutions they are trained to take do not fit to the actions and decisions they need to take in an emergency. Therefore, training initiatives in collaboration and decision making will be an important tool in risk and emergency situations.

Teams, and in particular teams working in complex environments, such as an IO setting is, need to adopt the flexible, exploratory approaches necessitated by the complex environment they face. Surviving in the competition in the future will depend on the ability to utilize the company's overall expertise, and the knowledge of their suppliers, swiftly and correctly. People must be able to contact each other continuously, large amounts of data must be transferred when necessary, and the right decisions must be made in a timely fashion (Richardson, 2000).

In the future, IO will imply that the people, technology and organisation subsystems will be even stronger coupled and interdependent, and the boundaries between them will be blurred. Intercultural interaction, and even faster moving and more opaque technology, trust (both in technology and co-workers), and shared understanding among people at different locations are some of the issues that are likely to become even more important on the IO agenda in the next few years (Ringstad and Andersen, 2007).

Decision support practice, research and technology continue to evolve. Decision support research and development will continue to exploit many new technology developments and will benefit from progress in very large data bases, artificial intelligence, human-computer interaction, simulation and optimization, software engineering, telecommunications and from more basic research on behavioural topics like organisational decision making, planning, behavioural decision theory and organisational behaviour (Power, 2007).

Organisations can benefit from the use of new and advanced technology in many ways. The challenge is not so much the technology in itself, but more the organisational aspects, such as developing clear roles and tasks, common goals, trust and knowledge and skills. These elements are essential for developing an efficient organisation where highly motivated and skilled employees and managers can make safe and efficient decisions with adequate decision support.

4.6 The effect of introducing collaboration technology on resilience

Albrechtsen, E., Størseth, F., Grøtan, T.O. (2009). The Effect of Introducing Collaboration Technology on Resilience. In: Skjerve, A.B., Kaarstad, M. (Eds.). Building Safety. Literature Surveys of Work Packages 2 and 3: Decision Making, Goal Conflicts, Cooperation, IO Teamwork Training, Decision Support, and the impact on Resilience of New Technology, (IFE/HR/F-2009/1388), Institute for Energy Technology, Norway.

Summary

"*The exercise of choice, the making of decisions and the scanning and grasping of opportunities are as fundamental to the contemporary life as the air we breathe*" (Kallinikos, 2007).

Collaboration across organizational and geographical lines to achieve improved decision-making processes is one of the characteristics of integrated operations. If this collaboration is to function efficiently and resiliently, one is dependent on adequate collaboration technology, primarily in terms of ICT systems.

The literature study looks at resilience and collaboration technology from three complementary positions which can be bridged as follows:

1. *Computer Supportive Cooperative Work* (CSCW) is a design-oriented research area studying the relation between ICT and cooperation, which includes a wide range of disciplines, and which directs attention to four factors: 1) common ground; 2) coupling in the work; 3) attitude to cooperation; and 4) attitude to technology (Olson and Olson, 2000)
2. *Joint Cognitive Systems* (JCS) treats humans and technological artifacts as an integrated system in its own right rather than considering them as separate systems that must interact (Hollnagel and Woods, 2005; Woods and Hollnagel, 2006). JCS is different from CSCW as it is focusing on (mainly individual) human action *through* the artifact rather than the CSCW focus on individual interaction *with* the artifact as a support for human collaboration.
3. ICT as a *technology of re-presentation* (Lilley et al., 2004). By virtue of information, the world becomes represented as a stock of parts that can be recombined at will. Objects, or re-presentations, loose their original essence and take on a mode that can be metaphorically exemplified by Lego. This also raises a *power* issue. Re-presentations can in turn be seen as *artifacts* in themselves, that collaborative parties interact through and with, in order to accomplish (resilient) collaboration.

Several research issues of resilient collaboration can be derived from the above approaches, and, more important, they can be combined.

CSCW issues

The CSCW field portray human activity as highly flexible, nuanced and contextualized. Ackerman (2000) argues that technical systems are rigid and brittle – not only in any intelligent understanding, but also in their support of the social world.

Hence, the challenges addressed in the CSCW approach comprise (Carstensen and Schmidt, 1999):

- What makes work situations complex to actors, and how computer systems can help to cope with this complexity.
- Mutual awareness as a mode of articulation work used to meet current work requirements in the everyday world (Schmidt and Bannon, 1992).
- As collaboration cannot be prescribed to the level of detail that computer based systems require, basic building blocks and platforms should be established so that actors themselves can establish a CSCW system according to their needs.

JCS issues

As the JCS approaches the human/machine interaction as the behaviour of a unified (join cognitive) system, the issue of how people cope with the resulting complexity of technological and socio-technical developments is at centerfield also here. However, emphasis is put on how people make use of technological artifacts (a process, tool, computer etc., and the analytical focus is on how humans and artifacts can be described as joint cognitive systems (rather than human collaboration as such). The artifact becomes an intermediary between the human and the system. However, the notion of the "system" may be extended to comprise other system operators, although that is not part of the original scope of JCS. The main point is that interaction is therefore *through* the artifact as opposed to with the artifact.

The hallmark of a (joint) cognitive system is the ability to adapt. Systems adapt in order to be increasingly competent at handling designed-for-uncertainties. This results in a 'textbook' performance envelope that consists of how systems have adapted formally in order to be competent at handling designed-for-uncertainties (Woods and Hollnagel, 2006). Resilience is however concerned with how a (joint cognitive) system recognizes and handles situations which challenge or fall *outside* of textbook competence (Woods and Hollnagel, 2006). As routines are underspecified, these kinds of episodes cannot be avoided.

Representation Technology (RT) issues

The RT perspective relates to the observation that more and more heterogeneous networks are constructed, interconnected and closed for the purpose of "seamless" interaction in a globalized world, that is, a fundamental drive for integration of heterogeneous worlds. As our knowledge of these "closed" domains is doomed to be partial and incomplete, the challenge of experiencing side-effects and unexpected impact from the environment will be huge, thus creating a need to be theoretically informed about new, emerging vulnerabilities and control options.

According to Hanseth and Ciborra (2007), technology has generally been seen as a tool for control, and, accordingly, risk management or reduction. But this capability is more limited than it seems. Technology is a structural form whose main characteristic is functional closure and simplification, that is, the "technological" way of dealing with reality is by simplifying it into a closed domain and specifying how the technology can deal with each element in this domain and its states. This approach is by definition very vulnerable vs. the unexpected. According to Kallinikos (2007): "technology deals with the unexpected by excluding it".

In order to understand the impact of ICT in such scenarios, the RT approach see complexity and (human) reflexivity as two sides of the same coin (Hanseth and Ciborra, 2007), and we must grant ICT a much less passive role than it most often is conceived to have. The RT paradigm emphasizes that a key *artifact* constituted by ICT, namely the symbols, models and representations of the "real" world that humans use and exchange for collaborative purposes, actually are *re-presentations*. In the RT perspective, ICT is thus seen as a more complex, active mediator of organizational and human action and intention, something through which organizations act, and subsequently have to act in response to. This means that ICT is creating a new whole class of risks, escalated by the fact that organizations (still) tend to use it rather myopic as a “magic” remedy, or a kind of overarching organizational technology. RT thus addresses a type of risk that cannot be escaped in a contemporary world of globalization, of which “Integrated Operations” is a manifestation.

Lilley et al. (2004, p. 76) argue that the appearance of detached representations is productive of a new form of power that enable a view of the world as a table top ruled by the human hand and eye. The attempt to trap all uncertainty tends to-wards an overarching and closed system. As a result everything is dragged closer together and made smaller, is displaced and abbreviated in order to facilitate remote control. The deployment of ICT holds out the dream of grasping the uncertainty created by its own dispersal.

Hence, ICT (as RT) has a Janus face: it is a booster of efficiency, but may also be effective of the risky propagation of an “artificiality” that may detach from reality, and enable a new form of power that is unevenly distributed.

In order to propose countermeasures against the hazards of ICT as representation technology, however without jeopardizing its benefits, we must draw a sharp line between information and human knowledge. Information can appear as knowledge, but is still detached from the human knowledge and practice.

We then need some conceptual framings of this human counterweight to the powers of ICT-enabled re-presentation, to ensure some kind of reflexivity awareness that the technology never can mobilize by itself. As the quest for organizational intelligence is almost doomed at ending up with some form of knowledge management system, we could deliberately choose to do so by the premises of a practice-oriented knowledge perspective resembling the CSCW premises above, encompassing the tacit, situational, provisional, mediated and contested nature of knowledge (Hislop, 2005).

Grøtan (2008) and Grøtan and Asbjørnslett (2007) propose a framework for balanced use of ICT (as RT), emphasizing the “joint function” of two ways of utilizing ICT:

- ICT used as Representation Technology is a highly useful but “runaway” *information* technology that must be used and mastered cautiously.
- Reflexivity and awareness that can only be mobilized on the premises of human practice and collaboration.

Resilience implies a (metaphorical) balance between the two concepts. The balance is complicated by the fact that the “representation technology” has a “runaway propensity”, while the “knowledge mediation” is (comparatively) characterized by its (decision) slowness due to the human factor. The solution is not to lock up or stop the re-presentation process, because the capabilities with respect to information sharing, permutation and recombination are important sources of potential knowledge and control capabilities.

A synthesis of the three approaches is possible

A synthesis of the CSCW, JCS and RT approaches is possible and feasible for the purpose of supporting resilient collaboration. The JCS emphasis on humans acting through (ICT) artifacts is the starting point. However, as the JCS perspective is downplaying human collaboration, we will need to adjust some of the basic premises.

A key JCS issue is the difference between the hermeneutic relation (HR) and the embodiment relation (ER). These are the two fundamental modes in the phenomenology of co-agency of a JCS (Hollnagel and Woods, 2005; chapter 5). While the HR implies a use of the technological artifact as a "prosthesis" providing ready-made interpretation of the world, the ER implies a use of the artifact as a tool, or "amplifier" of human cognition. In a cybernetic perspective, a well-functioning JCS reflects a dynamical equilibrium between canonical and exceptional performance.

Hollnagel and Woods (2005) make co-agency a normative issue in relation to resilience. Their preference for the ER, instead of the HR, is understandable on strict JCS. It may be straightforward "anti-resilient" for the human to be locked into a ready-made interpretation.

However, by taking into consideration the above CSCW and RT premises and issues of resilient collaboration, the choice between ER/HR is no longer obvious. By using the term "hermeneutic relation" Hollnagel and Woods (2005) makes explicit reference to hermeneutics as a science of interpretation (of texts). More specifically, the definition of the HR as "prosthesis" providing a ready-made interpretation, points to what is called the "objectifying hermeneutics" in which the thesis is that it is possible to reconstruct the "original meaning" of a text. Philosophical hermeneutics, on the other hand, instituted by Martin Heidegger, claims that this is not possible, but instead claims that the creation of meaning is a unique merging of the reader's pre-understanding and the text as such. Philosophical hermeneutics in relation to human cognition and communication is foundational for the RT literature. It can also be argued that the CSCW focus on "common grounds" for communication and interaction carries a similar hermeneutic premise in terms of a "Community of Practice" orientation. Extending the "human factor" cognitive constituency with this alternative hermeneutical premise also explains the "warning" of Hollnagel and Woods (2005) that humans actually can be tempted to accept a ready-made "prosthesis" (HR), because this is "economical" from a (hermeneutical) cognitive point of view.

Such a combination of JCS and CSCW on hermeneutical premises also enables us to see ICT as a vehicle for organizational resilience (Nathanael and Marmaras, 2008), facilitating (not short-cutting) the mute, but productive *dialectic* between "work as imagined" and "work as done" across various boundaries in an organization.

By combining JCS, RT and CSCW in this way, we however implicitly demand a new interpretation of the claim of Hollnagel and Woods (2005, p. 22) that "organization are cognitive systems, … with a purpose". That is, we argue that there is an inherent hermeneutical premise for (human) cognition also in the embodiment relation. The possibility of a multitude of understandings of the purpose(s) may actually facilitate organizational resilience, not hamper it.

Moreover, what adds extra power to the combined CSCW/JCS/RT view is the possibility to consider "re-presentations" (models, filters, optimizers etc.) as shared *artifacts*. Hence, we can consider artifacts (re-presentations) as socially constructed and shared interpretations of heterogeneous worlds, including the premise of power. From a CSCW point of view, such "prosthesis" in the form of clusters of re-presentations, could be seen as vehicles for creating, modifying, accepting or rejecting "common grounds" across different communities of practice. In a networked context, "prosthesis" will likely circulate and "advocate" other users' views in terms of ready-made interpretations.

The pressing issue is though, how to make the combination and exchange productive. We argue that his requires that the normative preference for the embodiment relation (ER) is abandoned, that the hermeneutical premise of the ER is recognised, and that the "organizational JCS" facilitating organizational resilience requires a continuous pending between "ER" and "HR", even in an asymmetrical fashion across organizational boundaries. The HR may specifically be considered as an efficient means of distributing/sharing new insights, new (proposed) patterns of action, while the ER may specifically be considered as a means of revealing, discussing and questioning; together they will be facilitating the mute dialectic necessary for organizational resilience. The combined use of ER/HR may further be framed in terms of the concepts of:

- *Dynamic Artifact*s: Artifacts (ensembles of representations) that can be clustered in many ways, and that are instantly open to (networked) modification according to hermeneutical or embodiment agency.
- *Heterogeneous Agency*: A mode of collaboration in which specific artifacts are used for collaboration between multiple parties, employing a (dynamic) mix of hermeneutical and embodiment relations.

The proposed merger of the CSCW/JCS/RT approaches can be used as the analytical device for an evaluation of the ICT contribution to resilience (understood as Contributing Success Factors, Størseth et al., 2010), in terms of:

1. How Collaboration Technology (CT) support the execution of resilience (conceptually)
2. How CT is a prerequisite for resilience
3. How CT (and ICT in general) in itself is an originator of the problems that justify the focus on resilience.

5 Empirical study: Exploring Principles of Resilient Collaboration

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Planning for Operation: Exploring Principles of Resilient Collaboration

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ABSTRACT

This paper presents a methodological approach for supporting operator staff members involved in planning for operation at a new petroleum installation in ensuring that collaboration at the installation will be resilient. It describes the development of the methodology and the outcome of an initial test. The methodology attempts to strike a balance between scientific research and coaching. The research question addressed was: *How can we coach the team on resilient collaboration?* The methodological approach was participatory in nature, and involved the conduction of five workshops. It aimed at: (1) assisting a planning team in establishing a joint understanding of what *resilient collaboration* should imply in their organisation, and (2) establishing a reflection guide to serve the on-going and future planning of real operations in terms of facilitating that collaboration at the new installation will be resilient. This paper presents and discusses the methodological approach, illustrates its use through the findings in an initial test, and considers the strengths and limitations of the methodological approach.

Keywords: Coaching, research, method development, petroleum, resilient collaboration.

1. INTRODUCTION

The current paper presents the development and initial testing of a methodology for supporting staff members involved in planning for resilient collaboration at a new petroleum installation. It comprised two purposes:

1. To facilitate the participants in developing a comprehensive and joint understanding of what *resilient collaboration should* mean in their organisation.

2. To develop a reflection guide to serve the on-going and future planning of real operations by facilitating that decisions made during the planning process would come to support resilient collaboration.

The methodology attempts to strike a balance between scientific research and coaching. The attempt was put into action in response to a specific enquiry. The request was *to coach a personnel group that was in their initial stages to plan for operation of a new petroleum installation, on how to plan for resilient collaboration*. Gaining access to this kind of 'live organisational planning' is a unique research opportunity; and as the coaching request came as part of a large on-going research project, the obvious solution was to strike a balance between research and the coaching request: *How can we coach the team on resilient collaboration?*

It was as a starting point important for the researchers – in the following referred to as the coaching team - to clarify with the participants that the coaching team's role was to facilitate the participants' reflections, whereas the role of the participants was to generate the results based on their own reflections and discussions. This is in line with Grant (2001), who states that coaching must be distinguished from therapy, mentoring, and training. Coaching is "not about *telling* people what to do" (ibid, p8). A basis for coaching as a process is the recognition of both the autonomy and expertise/knowledge of adult learners.

The methodology involved the conduction of a workshop (WS) series, containing five WSs spread out on a timeline of approximately five months. With this as our scope, it was agreed upon that a specific result of the WS series was to develop a *Reflection Guide* (RG). Within the framework of the methodology a RG was understood as a collection of prompts (words and sentences) to trigger reflections about the extent to which resilient collaboration is supported or challenged in the particular plan[3] under consideration. A RG will, to a larger extent than a checklist, accommodate the fact that the decisions made by a planning team are complex. A planning team has to take into account a wide range of factors pertaining to the interplay between human, technology, and organisational factors that may come to impact operation. For this reason, issues cannot simply be ticked off once on a checklist, as changes in other factors may impact the extent to which the issues are (still) adequately attended to.

The result orientation associated with the methodology in establishing a RG was considered an important feature of the coaching process. This is supported by Grant's suggested definition of workplace coaching, as *a solution-focused, result-orientated systematic process in which the coach facilitates the enhancement of work performance and the self-directed learning and personal growth of the coachee (Grant, 2001, p8).*

The overall coaching process leading to the RG is illustrated in Figure 1.
The bottom line in Figure 1 illustrates the workshop series. Five workshops were held with a comparatively long pause between (1). The bent arrow (2) illustrates that the planning team uses the input from one workshop in their ordinary planning process, which again feeds back to the next workshop.

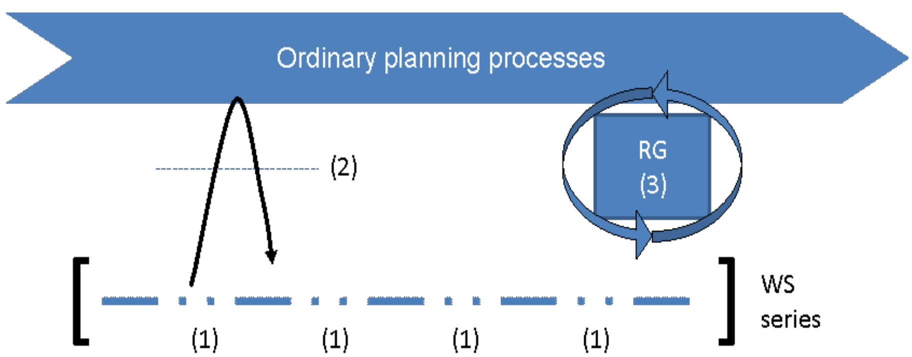

Figure 1. Scope of the coaching method.

In addition the bent arrow illustrates that the main lessons learned from the last workshop was repeated in the beginning of the next workshop. The reflection guide (3) was developed in the last WS. The arrows surrounding it indicate that the RG will be used in the ordinary planning process, which continues after

[3] Note, in the present context, a plan is perceived to exist when the requirement related to the performance of a task has been defined in terms of the required work processes, tools and technologies, and staff competence.

the workshop series is finished, and that it will be a continuously updated document, taking into account the upcoming needs of the planning team.

The coaching process and its *composite scope* involved some challenges:

1. The inevitable act of isolating, focusing or - in a phenomenological sense - attemptedly "bracketing" the WS series[4] to ensure continuity and maintain proper focus.
2. The explicit aim of the WS series to manifest in a RG to enable similar future processes *without* external coaches.
3. The inevitable need to enable/facilitate the exchange of ideas with on-going planning processes, however without any responsibility or aim for conclusion or finalization of the issues raised.

Within this composite scope, the third point reflects two important issues, namely (a) the need to pay due attention to the Heideggerian claim that "there is always an already", and (b) that the ultimate aim of the WS series and the production of the RG is to serve the on-going and future planning of real operations.

The current paper is organized to broadly refer to the steps in the coaching methodology (FullCircleFeedback, 2008): Section 2 accounts for the planning/design of the methodological approach. Section 3 describes the conduction of the initial test. Section 4 evaluates the methodology. Section 5 discusses a set of issues identified based on the outcome of the first test, and indicate the next step in the methodological development.

2. METHODOLOGICAL DESIGN

This section describes the coaching approach the WS themes, and the workshop elements applied to structure the WSs.

2.1 Coaching approach

The methodological approach was participatory in nature (Elliott et al., 2005). The WSs were developed based on principles generally associated with humanistic and cognitive learning theory (Conner, 2002). The starting point was that learning should aim at developing thinking. It was assumed that learning would be most efficient if: 1) the content of the WSs was adapted to the participants' needs and interests and, thus, directly related to the on-going planning processes; 2) the participants themselves took an active part in the learning process and contributed with their own experiences and thoughts. It was, moreover, assumed that new knowledge would most easily be acquired, retained, and retrieved if the methodology build on the participants' prior knowledge, and that repetition and reminding about key points were useful means to ensure positive learning effects.

The following guidelines were defined to support the coaches' performance:

Encourage participants to get involved in the dialogues – and show respect for their view points.

Ensure that the topic of resilient collaboration is addressed from several angles by introducing questions related to different perspectives (e.g., type of operational state, and issues related to team member heterogeneity).

The coaches should guide the discussion by introducing key words (see section 2.3) in the format of open questions (e.g., is transparency an issue here?), and "reality check" questions (e.g., has this solution been tried out earlier/what can be learnt from the previous implementations?)

The coaches should, when judged to be appropriate, provide psychological and Human Factors knowledge and ask the participants to clarify and/or further elaborate on particular issues.

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[4] Consisting of short workshops with a comparatively long pause between

2.2 Workshop themes

Each of the five WSs had its own *theme*. The themes in WSs 1, 2, and 5 were decided in advance by the coaching team. The themes in WSs 3 and 4 were decided by the participants.

The theme *resilient collaboration* (WS 1) served to introduce the concept *resilience*, and to initiate the dialogue about what *resilient collaboration* should imply at the new installation. The coaching team provided a broad description of what *resilient collaboration* initially could be taken to imply, i.e., "Employees working together in a way that is sufficiently robust and flexible to function in a good way, across all the operational states that may arise". This definition served as a point of reference for guiding the direction of the dialogues, including to ensure that collaboration were addressed from the perspective of various operational states (rather than, e.g., only from the perspective of normal operation).

The theme *distributed teamwork* (WS 2) served to clarify the main characteristics of the operational setting (e.g., that it would come to imply a high-level of technology-mediated collaboration between geographically distributed teams with heterogeneous team members to solve safety-critical tasks).

The last WS (number 5) was dedicated to development of an RG.

The possibility for the participants to decide on the themes to be addressed in two of the workshops served to further involve the participants in the WS series. The coaching team offered a list with possible ideas referring decision making, goal conflicts, cooperation, IO teamwork training, decision support, and the impact on resilience of new technology based on a literature survey (Skjerve and Kaarstad, 2009), but emphasized that other themes could just as well be included.

2.3 Workshop design and structure

The WS series was developed aimed at participants with a busy work schedule. Each WS was designed to last approximately 2.5 hours. It was seen as optimal if 4-8 participants took part in each WS, preferably the same group of participants from one WS to the next. No home work were required from the participants between the WSs, expect for questionnaire completion.

A set of recognizable WS elements ("building blocks") were applied. These were included both to facilitate the coaching process and to provide the data needed to assess the impact of the methodological approach. The structure of the WSs 2, 3 and 4 was similar, while the structures of the first and last WS differed, because of their specific purposes (see above). The WS elements applied were:

- Welcome and introduction
- Summary of lessons learned
- Theme of the day
- Joint reflections
- Association task
- Guide words task
- Rounding off

All WSs were initiated with *welcome and introduction.* The purpose of the current WS was introduced, and if first-timer participants were present, also the purpose of the WS series was presented.

Except from the first two WSs, a coach would *summarize the lessons learned* from the previous WS, based on the understanding of the coaching team. The participants could comment on the summaries, and if needed, the summaries were adjusted. The purpose of this element was to create continuity by inviting the participants to reflect back on the previous WSs, and encourage reflections on how each specific theme related to the issue of resilient collaboration. It, moreover, served as an immediate validation of the researchers' understanding of the participants' stances on the issues addressed in the previous WS.

The *theme of the day* was introduced by a coach. This was a presentation lasting about 15 minutes about the specific theme of the WS. The purpose of the presentation was to provide the participants with knowledge about factors known to impact collaboration and to stimulate reflection about what resilient collaboration should imply at the new installation. This was the WS element, which to the least degree, required active involvement of the participants.

In all WSs, the participants were asked to use around 10 minutes on individual reflection, involving the performance of an *association task.* The purpose of this individual task was to let the participants have a few minutes by themselves in a busy working day, and let them sit down and reflect around the topic addressed at the current WS. The participants were given a question adapted to the theme addressed in the particular session, and were to write down associations around the question at hand. For instance, in WS number 4, *How to build trust*, the question was: “In your view, what are the most important elements for building an adequate level of trust in distributed teams?” The participants were asked to mark the three associations they considered as most important. These three associations were presented in plenum, in relation to the *joint reflections*.

The *joint reflections* involved an open dialogue focused on the implications of the day’s theme on the factors to be addressed when organizing for resilient collaboration. In this discussion keywords related to resilience (based on Hollnagel et al., 2006; Størseth et al., 2009) were used by the coaching team to challenge the participants and to guide the discussion. The coaching team would stimulate the discussions by ensuring that resilient collaboration was considered from several angles (e.g. asking questions such as: What would happen if the situation does not develop as planned? How would this impact trust between team members?), and by asking factual questions (e.g., are there any experiences from other implementations on this?). These questions served both for clarification/elaboration purposes, as well as for guidance; meaning that questions were raised as ‘signposts’ (i.e. theme markers, considered to be adequate issues to cover). It should be noted that this kind of direction was not performed systematically with a predefined set of questions to be covered in each WS. Rather, in line with the low key structure that the nature of this study demanded, this type of guidance was applied when deemed appropriate.

In the end of WSs 2, 3, and 4, the participants would perform an individual *Guide-words task*. As opposed to the Association task, the Guide-words task always focused explicitly on *resilient collaboration* - regardless of the particular theme addressed in the WS. The participants were provided with a form containing a list of 18 guide words, which were selected by the coaches based on studies of what resilience implies (Hollnagel et al., 2006; Størseth et al., 2009). The participants were asked to place a mark next to the guide words, which in their opinion were the *most significant* to keep in mind when organizing for resilient collaboration at their installation. There was no upper or lower limit to the number of words that could be marked. The participants would not be informed about the guide words selected by the other participants. Only in the in WS 5 they would be presented with the joint scores by all participants across the three WSs.

The *rounding off* part involved verbal feedback from the participants of the usefulness of the WS and a decision related to the theme to be addressed in the next WS.

2.4 Developing a Reflection Guide

The purpose of the Reflection Guide (RG) was to support that collaboration in the new organisation would become resilient. The RG was designed to encourage participants to evaluate the extent to which the plan holds a sufficiently level of resilience in all defined attributes of collaboration and in all defined operational states.

The RG uses a set of prompts to trigger the participants’ reflections. The overall question addressed in the reflection guide, was: “Will the suggested (part of the) plan contribute to facilitate or challenge resilient collaboration at the current organisation”.

The development of the RG comprised three phases. First, the participants had to determine what *guide words to include in the RG*, i.e. what guide words it would be most significant to keep in mind when organizing for resilient collaboration. To facilitate this decision, the participants were presented with the combined scores provided on the guide words task during WSs 2-4. The participants could decide to use the guide words that had received the highest number of scores, but they could also decide to include other guide words. When the guide words had been selected, the participants participated in defining each of the guide words.

Next, the participants determined what *operational states to be included in the RG*, i.e. in what operational states they want collaboration to be resilient. When the operational states had been identified, the participants developed a definition for each state.

Finally, the guide words and the operational states were organized in a matrix format, and reflection points were added for each guide word and each operational state. The reflection points covered factors that were found to be of key relevance to consider when assessing whether the plan facilitates or challenges resilient collaboration. The RG is meant to be a living document. The planning team should update the guide when they enter new phases in the project, where other attributes of resilient collaboration and/or other reflection points might be more relevant.

3. METHODOLOGY APPLICATION

The methodology was tested in the period November 2009 to March 2010. In total, eight unique participants took part in the test. Across the five WSs, the numbers of participants were respectively: 4, 2, 4, 3, and 2. Four of the eight participants volunteered to fill in a questionnaire with information about their professional background. These participants had been working within the petroleum industry between 10 and 30 years, and all had been involved in upstart projects previous to the current project. The participants decided that the optional *theme of the day* to be addressed in WSs 3 and 4 should be *safety-related goal conflicts* and *how to build trust*, respectively. In each workshop the coaching team consisted of 3-4 persons.

During the WSs, data were collected from the *Joint reflection* session, the *Association task*, the *Guide-words task* (see above), as well as from the development of the prototype version of a *RG*.

3.1 Joint reflection

During the joint reflections, the participants were generally very active. In some WSs the joint reflections were carried out interactively with the thematic presentation. All took part in the open dialogues on how to facilitate the establishing of resilient collaboration. They actively addressed issues related to the theme of the day, and offered insights based on personal experiences and reflections.

The participants had spent a lot of time investigating how *distributed teamwork* could be organized at the new installation, and the considerations and lessons learn were clearly reflected in the dialogues concerning the impact on collaboration resilience. Collaboration at the new petroleum installation is bound to involve distributed teamwork, e.g. collaboration between offshore and onshore support centres, and thus working across organisational and cultural borders.

Reflections related to development of the *work processes* to be applied at the installation, specifying responsibilities, authorities, and the different roles, were central to the participants when focusing on resilient collaboration.

Another important factor for distributed teamwork that was mentioned was *flexibility* - both in terms of the ability to share goals and in terms of technical solutions that are needed in order to support the work processes.

The discussions on *safety-related goal conflicts* revolved on one side around generic challenges regarding safety and on the other side on solutions ensuring that safety is adequately prioritized.

In relation to the theme *how to build trust,* the most important topic addressed related to how to promote trust between different cultures, making ones' competence visible to each other, and the need for ensuring availability of both people and technology to prevent unnecessary lack in the transfer of information and knowledge, as well as in task performance in general.

3.2. Association task

In the association task, a total of 126 associations were written down by the participants during the five WSs.

In the first and the last WS the following question was used in the association task: "In your view, what are the most important elements for resilient collaboration in an Integrated Operations setting*?*" This allowed assessment of whether there had been any changes in the way the participants perceived resilient collaboration from the first to the fifth WS. It was found that the participants in the first meeting typically focused on *characteristics of the individuals* – what kind of competence and skills the personnel should possess, and that the individuals should be trained, and selected on certain abilities. They also focused on the leader role, and delegation of authority. During the last WS the participants focused has changed from a focus on individual to a focus on *common vision*. This suggests a shift in their perception of *resilient collaboration* from the first to the last WS. In the last meeting they emphasised the characteristic of the organisation, and there were more coherence and agreement in the participants' selection of associations related to "Resilient collaboration". The participants mentioned trust, transparency and learning culture/safety culture in their association task at the last meeting, and these were also the three most important words they mentioned in plenum.

3.3 Guide-words task

Across WSs 2-4, the guide-words task was completed by 4 unique participants. Two of the participants filled in the form 3 times, one participant filled in the form 2 times, and one participant filled in the form 1 time.

The suggested guide words received different scores – from 0 to 8.[5] *Trust* was the only guide word that received a score of 8. The guide words *transparency, flexibility, learning culture, common ground,* and *communication* all received a score of four or more. The remaining guide words received less than four scores. This included the four guide words added by participants.

Table 1. Overall characteristics of the participants' scores.

Workshop number	**2.**	**3.**	**4.**
Number of guide words selected	14	18	28
Number of participants	2	4	3
Average number of guide words pr. participants	7	4.5	9.3
Number of unique guide words selected	11	12	16

It was not possible to readily identify a change in the participants' perception of what guide-words that represented the most important attributes of resilient collaboration across the three WSs (see Table 1).

Still, a tendency that might be emerging is that the participants in average marked a higher number of guide words in WS number 4, than in WS number 2, as well as a higher number of unique guide words.

[5] Note that 9 were the maximum score possible, implying that all participants in all of the three WSs had marked the guide word.

This could indicate that the participants at the time were in a process of changing their view on what resilient collaboration implies. It would not be unreasonable to expect that a change from a more individual to a more organisational conceptualization of *resilient collaboration* would also imply that the level of details/nuances/attributes associated with the concept would be broadened. This finding would, moreover, seem meaningful in relation to the finding based on the Association task (see section 3.2).

3.4 Developing a reflection Guide

WS number 5 was dedicated to the development of a prototype RG. A coach presented the overall scores on the guide words task across WSs 2-4 to the participants. The coaching team suggested that the guide words that had received the highest scores were used in the prototype RG. These guide words were: *trust, transparency, flexibility, learning culture, common ground,* and *communication.* The participants decided to exchange the guide words *common ground* and *communication* with the guide word *safety culture*, which had received lower overall scores, but they perceived this guide word to more effectively contribute to facilitate the achievement of resilient collaboration (see Figure 2).

Will the suggested (part of the) plan contribute to facilitate or challenges resilient collaboration at the new installation?

Operational state/ Guidewords	Normal operation	Transition	Beyond design basis	Transition	Emergency
Trust					
Transparency					
Flexibility					
Learning culture					
Safety culture					

Figure 2. Reflection Guide - Essential.

Following identification of the guide words to be included in the RG, each guide word was defined. The coaching team had prepared prototype definitions. These definitions were reviewed, discussed and if needed adjusted by the participants to accommodate their understandings and needs. Then reflection points, which the participants considered to be useful for the planning team to keep in mind, were added. The reflection points covered factors that were found to be of key relevance to consider when assessing whether the plan facilitates or challenges resilient collaboration. Examples of reflections points which the participants wished to include related to the guide word *trust*, comprises, e.g., *trust is relevant with respect to individuals, groups, organisations, and technology*, and *increased familiarity typically facilitates trust*. Similarly, the coaching team suggested a set of operational states in which collaboration should be resilient. These were: *normal operation*, *beyond design basis*, and *emergencies*. The participants found these to be useful, but further added two phases called *transition*: One covering the transition between normal operation and beyond design basis, and another covering the transition between beyond design basis and emergencies. Following this, definitions were worked out, and a first prototype version of the reflection guide took form.

4. EVALUATION

The methodological approach was evaluated by three of the eight participants, following completion of the workshop series. The evaluation was performed formally, using an evaluation form. The three participants had taken part in a different numbers of WSs, i.e. five, three and one.

The participants found that the WS series had achieved its overall objective. On the question “The workshop series generally achieved the stated objectives?” the participants provided score 5, 5, and 4 on a rating scale, ranging from 1 (disagree) to 5 (agree).

When asked what they had found to be *most useful* with the WS series, all participants emphasised working with the guide words. One respondent elaborated on this, stating that the guide words helped keep the participants aligned.

The three participants offered three different suggestions as to how the WS series *could be improved*: First, the description of what the outcome of the WSs could be improved. Second, the WS series ought to be continued over a longer period of time. Third, it would have been beneficial if a higher number members from the future workforce had participated in the WSs.

The structure of the WS series involved three predefined themes and two themes that were decided by the participants. This solution was applied to ensure that the WS series was well-framed – establishing a joint focus - and well finalized. This structure seems to have been successful, as the dialogues throughout the WS series were focused on resilient collaboration and aimed at developing an understanding of the implications of the concept in practice to be able to identify practical means to achieve resilient collaboration.

The workshop elements were all rated for their usefulness in the evaluation form on a scale from 1 (poor) to 5 (excellent). The elements *joint reflections* and *guide words task* both received a sum score on 14.[6] The sum scores on the additional WS elements were as follows: *summary of lessons learned* (13), *association task* (12), and *theme of the day* (11). Even though the results are only based on the scores provided by three (out of eight) participants, they support the coaching team’s assessment of the successfulness of the various WS elements: The coaching team assesses that the participants preferred WS elements, in which they were jointly engaged in dialogues with the coaching team i.e. the *joint reflections*, the process of *developing a RG* (the high score provided by the participants on the guide words task most likely signify that the participants considered this task an integrated part of the development of the RG), and the *summary of lessons learned* were the most engaging parts of the workshop. The purely individual tasks, and the less involving thematic presentations, were seen as somewhat less rewarding, although also these elements received a relatively high score by the participants.

5. DISCUSSION AND CONCLUSION

The test of the methodological approach raised a set of questions with respect to the methodological characteristics.

In the present methodology, each WS was structured to last *2.5 hours*. The coaching team assessed that this was the absolute minimum period of time needed to ensure both coaching (open reflections) and scientific (data collection) concerns. The time-span was used from the assumption that participants would more likely find time to join the WS series, if each session was short. The coaching team found it was challenging to deal with this time constraints. In some cases, the joint reflections were rounded off earlier than the coaching team would have preferred to ensure data collection from the association and the guide words tasks.

[6] Note 15, i.e., 3x5 was the highest score possible.

Even though a WS lasted 2.5 hours only, the number of participants in each WS was not high. One part of the explanation for this was that the planning team was still in the process of being formed and, thus, was sparsely manned, when the WS series was carried out. Another part of the explanation was that the participants had a high level of workload, and sometimes had to prioritize the need for performing other tasks over WS participation.

The 2.5 hour allocated to each WS was felt to be a minimum requirement (see above). If more people had been present and/or if more diverse people had been present,[7] the joint reflections would have required more time, as more perspectives, experiences, and opinions would need to be brought forward to ensure participatory learning. It would, thus, most likely not have been possible to maintain the current WS structure.

The methodological approach was formed to encourage the *gradual development* of a joint understanding among the WS participants regarding what resilient collaboration should imply at the new installation, concluding in the joint creation of a prototype RG. However, only one participant was present in all five WSs. This suggests that methodological approaches, of the type tested here, should be designed and structured to ensure *transfer of lessons learned* from one workshop to the next, across potentially entirely different participants.

The present methodological approach implied establishing a common goal for the WS series, which the participants perceived to be of practical use (i.e., development of a prototype RG). This was demonstrated to be good solution. The objective served as a common point of reference throughout the WSs, and, thus, contributed to ensure the needed continuity across the individual WSs. The *summaries of lessons learned* also efficiently helped to establish continuity from one workshop to the next.

The test showed that a methodological approach, of the type tested here, should be well-structured, *and* suitably flexible to allow adaptation to the situation at hand. A methodological approach should, preferably, be able to work with different numbers of participants (the coaching team typically only knew immediately before each WS what the number of participants would be). Flexibility is also required with respect to the content of the joint reflections. The test show that the participants often referred to *current concerns* regarding what not works today. In many cases, it was beneficial that the coaching team comprised 3-4 members, because the team members jointly covered a wide range of *human and organisational factor issues*, as they could continuously contribute with relevant information/questions to the various issues raised.

Finally, the test showed that the methodological approach matched well with the characteristics of the participants, who took part in the test. The participants were highly experienced staff, each with expert knowledge in his or her own field. They were willing to share experiences and opinions in a constructive manner (goal focused), and even in situations where disagreement arose, they maintained respect and a good tone between themselves, and the dialogue progressed without any problems.

The research question was: *How can we coach the team on resilient collaboration?* Overall, the coaching team concludes that the methodology achieved its goal. It succeeded in achieving a fair balance between open reflections (e.g., joint reflections) and structured data collection (e.g. guide words task. The results obtained suggest that the methodological approach succeeded in stimulating the participants to reflect and come to produce a preliminary conclusion with respect to what resilient collaboration implies.

The next step will be to expand the methodological approach to include both operator staff members and staff other organisations, i.e., contractor staff that are also involved in the planning process. Given the lessons learned on time constraints (see above), this will imply that the methodology either has to be re-

[7] The WS participants were overall characterized by a participant as “personnel that have done “everything” before.”

structured and/or that the duration of each WS is increased. Moreover, it will most likely require an even stronger focus on ensuring continuity, including the transfer of lessons learned from one WS to the next.

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6 Case specific advice

The underlying bases for the case-specific advices in this work package are the six literature surveys. All surveys were performed from the perspective “Resilient decision making in IO teams”. Further, the surveys identified relevant theory, and discussed theoretical findings related to the characteristics of an IO setting. Also, the empirical phase of this work package was very important for formulating the recommendations in the case specific advice. The recommendations are focused in three conceptual themes: (1) Competence and culture, (2) Technology and work processes, and (3) Planning process. The recommendations are written specifically for the organisation studied, and will not be presented in detail as this result is restricted (Skjerve, Kaarstad and Grøtan, 2010). The case-specific advices are considered as input to on-going planning activities. Only the overall topics of the recommendations will be outlined here.

6.1 Competence and culture

When a new organisation is built, where a major part of the collaboration is performed through distance, where subgroups and different cultures are present, some aspects need to be trained and consciously emphasized in the organisation. These aspects are:

- Trust
- Cultural understanding
- Common culture
- Continuous learning

Distributed teams are composed of members with different specialist competencies. When team members trust each other, they will also be more willing to change position, and they will be more willing to share knowledge. Trust is thus a great advantage for teamwork and task performance in general, and in particular when different cultures are present. The concept organisational culture concerns the norms, values and beliefs that drive how work is carried out in an organisation. Education and training aimed at understanding the different assumptions and practices associated with various cultures (e.g., national cultures, organisational culture, and discipline culture – depending on what is relevant) is needed in order to achieve cultural understanding, common culture and a positive attitude to multi-cultural collaboration. Both in high reliability organisations (HRO) and in Resilience engineering the need for facilitating continuous learning is emphasised. To learn something, feedback is of key importance to help assess whether one is on the right track. In the case specific advice, concrete recommendations were given for *trust, cultural understanding, common culture* and for *continuous learning*.

6.2 Technology and work processes

In integrated operations, insight into the work processes is important. Accountability and responsibility should follow authority, and it is important to be prepared for decision making in all kinds of situations. The most important recommendations related to integrated operations are organized in the three topics in the case specific advice:

- Sound work processes
- Mindful safety practices
- Technology-mediated collaboration

In order to accomplish sound work processes, the allocation of tasks must be associated with the allocation of the authority needed to perform the tasks. Procedures are important as they can be used to dictate decision making, information flow and situational updates. However, not all aspects of work activities can be accounted for by procedures, and “surprises”, situations not described in any procedure, may occur. Therefore, mindful safety practices, practices that can account for such surprises, need to be developed. Another important issue with regard to technology and work processes is the need to avoid complex technology for distributed collaboration, and to make collaboration technology available to all parties involved in the collaborative activity. In the case specific advice, concrete recommendations were given for *sound work processes, mindful safety practices* and for *technology-mediated collaboration*.

6.3 Planning process

In order to create resilient decision processes, a strong focus on the involvement of staff in the planning process is needed. The highly experienced staff members should be encouraged to contribute with their experiences to generate the best possible solution and establish ownership. Competence, both in the different disciplines and in the collaboration technology is needed.

- Staff involvement
- Attributes of technology and work processes
- Competence requirements
- Systematic reviews

In order to make people feel responsible for the on-going processes in the organisation, it is important that they feel involved. Staff involvement includes creating meeting arenas, processes for dissemination of information and collecting and attending to feedback. Further, in the planning process, it would be a great advantage if desired attributes of technology and work processes are developed and documented. Finally, the planning processes will need competent workers as well as systematic assessments of the solutions and plans under consideration. In the case specific advice, concrete recommendations were given for *staff involvement, attributes of technology and work processes, competence requirements,* and the need to perform *systematic reviews* of on-going plans.

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Appendix A: A Contingency Model of Decision-Making Involving Risk of Accidental Loss

Paper for the 25th International Workshop ”New Technologies and Work”: Resolving Multiple Criteria in Decision-Making Involving Risks of Accidental Loss, Steinhoefel, September 27 – 29, 2007

A Contingency Model of Decision-Making Involving Risk of Accidental Loss

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Abstract:
Decision-making involving risk of accidental loss occurs in a variety of settings. The constraints of the decision settings have a strong impact on decision-making. Different decision settings may thus call for different approaches to decision support. The purpose of this paper is to propose a contingency model of decision-making involving risk of accidental loss. Based on two dimensions, (a) proximity to hazard and (b) level of authority, I identify five types of decision settings: (1) Operations, (2) Business Management, (3) Administrative and Technical Support Functions, (4) Political Arenas, and (5) Crisis Handling. Each setting is characterised in terms of dominant constraints, dominant decision criteria, and representative decision modes.

Decision-making is constrained and influenced by previous decisions, and decisions may interact in the way they influence the risk of accidental loss. The following set of concepts may help us identify ways in which safety may be affected by interactions between decisions: (1) Distributed Decision-Making and Local Optimization, (2) Meta-decisions, (3) Absorption of Uncertainty, and (4) Normalization of Deviance.

Advice for improving decision-making can be derived from the proposed model by identifying possible problems related to each type of decision setting and each pattern of interaction between decisions. The possible problems may be used as a basis for identifying relevant functions of decision aids and to propose specific decision aids. A similar analysis may be performed with regard to the ways in which decisions may interact in their impact on safety.

Link to presentation:
http://www.sintef.no/project/Building%20Safety/Publications/R%20Rosness%20A%20contingency%20model.pdf

Appendix B: A contingency model of decision-making involving risk of accidental loss

Paper published in: Safety Science, Volume 47, Issue 6, July 2009, Pages 807-812

A contingency model of decision-making involving risk of accidental loss

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Abstract
Decision-making involving risk of accidental loss occurs in a variety of settings. The constraints of the decision settings have a strong impact on decision-making. Different decision settings may thus call for different approaches to decision support. The purpose of this paper is to propose a contingency model of decision-making involving risk of accidental loss. Based on two dimensions, (a) proximity to hazard and (b) level of authority, I identify five types of decision settings: (1) operations, (2) business management, (3) administrative and technical support functions, (4) political arenas, and (5) crisis handling. Each setting is characterised in terms of dominant constraints, dominant decision criteria, and representative decision modes.
Decision-making is constrained and influenced by previous decisions, and decisions may interact in the way they influence the risk of accidental loss. The following set of concepts may help us identify ways in which safety may be affected by interactions between decisions: (1) distributed decision-making and local optimization, (2) meta-decisions, (3) absorption of uncertainty, and (4) normalization of deviance.
Advice for improving decision-making can be derived from the proposed model by identifying possible problems related to each type of decision setting and each pattern of interaction between decisions. The possible problems may be used as a basis for identifying relevant functions of decision aids and to propose specific decision aids. A similar analysis may be performed with regard to the ways in which decisions may interact in their impact on safety.

Keywords: *Decision-making; Risk; Accidents; Contingency model; Decision support.*

Link to article:
Safety Science 47(6), pp. 807-812; http:// http://dx.doi.org/10.1016/j.ssci.2008.10.015

Appendix C: Facilitating Adequate Prioritization of Safety Goals in Distributed Teams at the Norwegian Continental Shelf

Paper presented at IEA 2009, 9 - 14 August 2009, Beijing, China

Facilitating Adequate Prioritization of Safety Goals in Distributed Teams at the Norwegian Continental Shelf

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Abstract
Petroleum installation employees have to balance safety goals versus other types of goals as a part of their daily work activities. To reduce the risk for incidents and accidents, it is critical to obtain a better understanding of how to facilitate adequate prioritization of safety goals, i.e., prioritizations in accordance with the standards set by the company in charge. The first part of the paper provides a theoretical fundament for developing techniques and tools to support adequate prioritization of safety goals in a work context. It reviews theories on goal conflicts, and suggests a revised definition of the concept, which also includes the goal of the organisational level. The second part introduces a technology for risk visualization, called the IO-MAP, which is currently being designed. The purpose of the IO-MAP is to facilitate adequate prioritization of safety goals in maintenance planning processes performed by distributed teams.

Link to paper:
http://www.sintef.no/project/Building%20Safety/Publications/IEA2009_paperID2PC0004.pdf

Appendix D: Interaction and Interaction Skills in an Integrated Operations Setting

Paper presented at IEA 2009, 9 - 14 August 2009, Beijing, China

Interaction and Interaction Skills
in an
Integrated Operations Setting

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Abstract
Integrated operations (IO) are in the oil industry looked upon as a strategic tool to achieve safe, reliable and efficient decisions. Integrated operations involve using technology that brings competence, data and tools together in real time, regardless of distance, and which has the potential to enable improved and faster decisions. Interaction in an IO setting may happen both face-to-face, and across distance. Most oil companies have managed to find efficient solutions with respect to technological tools and their usage. The main challenge for IO today, is how the participants are interacting – more precisely, the participants' interaction skills. In this paper, theoretical and empirical foundations for interaction will be presented. A method for Structured Observation and Feedback in Integrated Operation (SOFIO) will be described, and will be described, and general recommendations from an observation study regarding interaction and interaction skills will be presented.

Link to paper:
http://www.sintef.no/project/Building%20Safety/Publications/IEA2009_paperID2PC0006.pdf

Appendix E: Using decision support to facilitate adequate team decision processes in an integrated operations setting

Paper presented at Working On Safety (WOS), Røros, Norway, 7-10 September 2010.

Using decision support to facilitate adequate team decision processes in an integrated operations setting

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Abstract
This paper documents the outcome of a literature review on decision support to facilitate adequate team decision processes in an integrated operations (IO) setting.
In this review, we take a look at what decision support is, based on the two disciplines decision theory and decision systems. Different situations, like daily operation and planning, project work as well as emergencies; and different users, like individuals, teams, and organisations, call for different decision support. The review focuses on integrated operations settings, and in which situations decision support would be useful in integrated operations.

Keywords: *Integrated operations, team decision, decision support.*

Link to presentation:
http://www.wos2010.no/assets/presentations/174.pdf

Appendix F: IO teamwork competencies

Paper presented at Working On Safety (WOS), Røros, Norway, 7-10 September 2010.

IO teamwork competencies

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Abstract
Introduction of the operational concept Integrated Operation (IO) by petroleum companies operating on the Norwegian Continental Shelf implies an increased use of distributed teams (IO teams) in operation of petroleum installations. To develop teamwork training programs for members of IO teams, it is necessary to understand what teamwork competencies IO team members need to work proficiently as a team. This paper reports the outcome of a literature study aimed at developing a model comprising the main attributes of IO teamwork competence. The model may facilitate identification of teamwork competencies to be addressed in training programs for IO teams.

Keywords*: Teamwork competencies, distributed teams, integrated operations, petroleum industry.*

Link to presentation:
http://www.wos2010.no/assets/presentations/173.pdf

Appendix G: Planning for Operation: Exploring Principles of Resilient Collaboration

Paper presented at Working On Safety (WOS), Røros, Norway, 7-10 September 2010.

Planning for Operation: Exploring Principles of Resilient Collaboration

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Abstract
This paper presents a methodological approach for supporting operator staff members involved in planning for operation at a new petroleum installation in ensuring that collaboration at the installation will be resilient. It describes the development of the methodology and the outcome of an initial test. The methodology attempts to strike a balance between scientific research and coaching. The research question addressed was: *How can we coach the team on resilient collaboration?* The methodological approach was participatory in nature, and involved the conduction of five workshops. It aimed at: (1) assisting a planning team in establishing a joint understanding of what *resilient collaboration* should imply in their organisation, and (2) establishing a reflection guide to serve the ongoing and future planning of real operations in terms of facilitating that collaboration at the new installation will be resilient. This paper presents and discusses the methodological approach, illustrates its use through the findings in an initial test, and considers the strengths and limitations of the methodological approach.

Keywords: *Coaching, research, method development, petroleum, resilient collaboration.*

The paper is presented in chapter 5.

Link to presentation:
http://www.wos2010.no/assets/presentations/172.pdf

Appendix H: Planning for Resilient Collaboration at a New Petroleum Installation

Paper submitted for publication in an international journal

Planning for Resilient Collaboration at a New Petroleum Installation

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Abstract
How can we coach a team of planners on resilient collaboration? The paper presents the results of an empirical study addressing this question. The study involved the development of a methodological approach, *Coaching for Resilient Collaboration in IO* (CORECIO) to coach planners on resilient collaboration. The study aimed at (1) increasing the planners‟ consciousness and alignment in terms of what resilient collaboration should imply in the planned for organization, and (2) developing a *reflection guide* to support the planners‟ decision making during the planning process. CORECIO implies the conduction of a workshop series. It was assessed in an empirical study, which was performed over a five months period. Eight planners participated in the study. The planners were employees of a large petroleum company, and engaged in preparing for operation of a new petroleum installation. The paper presents and discusses the results obtained in the study. It addresses the strengths and limitations of CORECIO, and suggests that CORECIO – and similar methods – might constitute useful approaches for coaching highly skilled professionals in planning for resilient collaboration.

Keywords: *resilience, collaboration, coaching, reflection guide, petroleum.*

The Building Safety project has produced the following summary reports:

- Human and Organizational Contribution to Resilience (Størseth et al., 2009)
- Resilient Decision Processes in Integrated Operations (Kaarstad et al., 2010)
- Development of new models and methods for the identification of early warning indicators (Øien et al., 2010)

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