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Teamwork competence required across operational states: Findings from nuclear power plant operation

Ann Britt Skjerve & Lars Holmgren
Institute for Energy Technology, Norway

ABSTRACT: The tasks of Nuclear Power Plant (NPP) operators are highly interconnected, and operators need to engage in teamwork to ensure plant safety. Traditionally, teamwork-competence taxonomies for NPP operators do not distinguish among operational states. This study explored if differences exist among teamwork-competence requirements across the three main operational states in a NPP: normal operation, outage and emergencies. Data was collected from a north European NPP using observations, semi-structured interviews, and a questionnaire survey, and analyzed using a thematic-analysis approach. The study suggested that the teamwork competencies needed by NPP operators are similar, but not identical across the three operational states. The variations were suggested to be caused by a combination task differences and different impacts of three performance-shaping factors: time pressure, task complexity, and proactive attitude to safety. Based on the results, it was suggested that refresher training should be adjusted to increase resilience in teamwork in NPP operation.

1 INTRODUCTION

Nuclear Power Plants (NPPs) are key means for producing electricity in a range of countries today. NPPs are dynamic and highly complex production systems, and training of operational staff is one of the cornerstones for ensuring safe and efficient operation.

Competence can be defined as the "... ability to apply skills, knowledge and attitudes in order to perform an activity or a job to specified standards in an effective and efficient manner" (IAEA, 2002). Training of NPP operators addresses both technical and teamwork competencies (IAEA, 1996): The operators need technical competence to understand the design and functioning of the process system, and they need teamwork competence to be able to work in a team setting, due to the inter-dependability of their tasks. The technical competencies required of NPP operators is well established (e.g. U.S. NRC, 1998; 2007), and training of these is under continuous development within NPPs. The teamwork competencies required is less well-specified. This paper aims at contributing to the understanding of what teamwork competencies NPP operators need.

Teamwork can be defined as "... a distinguishable set of two or more people who interact dynamically, interdependently and adaptively toward a common goal" (Blickensderfer, Cannon-Bowers & Salas 1997, 250). There is general agreement that teamwork is a multi-dimensional concept, but there is no final agreement about the specific dimensions the concept encompasses.

In an NPP, teamwork is highly regulated by procedures and routines. Still, the level of details with which teamwork is regulated varies substantially. For example, in some cases it is specified exactly what information and operator should contribute, where as in other cases, it is merely stated that operators should contribute *all relevant* information. In addition, operators need teamwork competence to adapt performance to emerging situational characteristics, e.g., to the competence possessed by individual colleagues, the colleagues' level of workload, personal concerns, etc.

A teamwork-competence taxonomy is important to support the development of teamwork-training programs. A taxonomy facilitates identification of training needs, as well as documentation of what competencies a training program covers. Within the domain of NPP operation, various teamwork-competence taxonomies exist (e.g. Broberg, 2009; Crichton and Flin, 2004; IAEA, 1996; IAEA, 2001; O'Connor, O'Dea, Flin, and Belton, 2008; Skjerve, Kaarstad and Holmgren, 2013).

Traditionally, the teamwork-competence taxonomies are general in nature, covering the entire span of teamwork competencies needed by NPP operators to perform their tasks safety and efficiently. Still, based on the observation that the NPP operators' tasks are not identical across operational states, it was hypothesized that the teamwork-competence requirements might also not

be identical. If this hypothesis is true, traditional re-fresher training might not fully address all the teamwork competencies required by NPP operators, as it tends to focus on emergency scenarios.

The purpose of this study was to explore if differences exist between teamwork-competence requirements to NPP operators across the three main operational states in a NPP: normal operation, outage and emergencies.[1]

In this paper, the concept NPP operators, include the following roles on a shift: Shift Manager (SM), Reactor Operator (RO), Assistant Reactor Operator (ARO), Turbine Operator (TO), and Field Operator (FO). O'Connor et al. (2008) and Broberg (2009) both report that no differences were found between the teamwork-competence requirements to the two main groups of NPP operators: control-room operators and field operators. For this reason, there will be not distinctions between these two types of roles.

2 NUCLEAR POWER PLANT OPERATION

The main task of a NPP operator team is to ensure that plant safety is upheld. Overall, NPP operation can be decomposed into three operational states: normal operation, outages, and emergencies. The three operational states are defined below based on the tasks that are prototypically associated with each state.

Normal operation is the period when an NPP is producing electricity according to plan and is operated based on the requirements in the standard operating procedures, the technical specifications of the plant, the plant orders and/or other directives provided by the Operational Department. Normal operation may also be referred to as power operation. The overall task of an operator team is to ensure that the operational activities progress according to plan. The team's activities are largely based on routines, and involve monitoring plant parameters and intervening with planned adjustments and with immediate adjustment if necessary. When a shift begins, the first task is to engage in shift-handover: First, each position will have a semi-structured dialogue with his or her opposite on the departing shift to learn about ongoing and planned tasks and deviations (if any). Then all operators on the team will meet to jointly build a common understanding of the situation at hand, and decide how to proceed. Often, the SM will be away from the control-room for longer periods of time, leaving the RO in charge of the team. During normal operation, operator teams are required to perform a set of administrative activities, in addition to the operational activities. These involve, e.g., logging, preparing for upcoming tag-outs, refreshing knowledge, updating descriptions of plant systems, and job appraisal talks.

Outage is the period from when an NPP is brought to shut down for preventive maintenance, upgrades, and refueling until it has been started up again and is ready for production. During an outage, a plant is operated based on the standard operating procedures for shut-down and start-up, the technical specifications of the plant, the Outage Plan, and the outage direction documentation and plant orders. The overall task of an operator team is to ensure that the planned tasks are executed in accordance with the specifications in the Outage Plan and associated documentation to the extent this is possible. Team members' tasks are usually proceduralised, but often non-routine. Their taskload is high, and they need to engage in teamwork with staff members, whom they may not know well in advance (e.g. staff from the maintenance departments) and with external parties (e.g. various types of consultants). Also throughout an outage, time management is an issue of key concern. The conditions in the control-room will be non-normal during an outage compared to power operation: A high number of alarms will go on-and-off in unusual ways due to the various tests performed in the plant, and there tend to be more people present in the control-room. The RO and the TO each with their associated field operators may come to create what looks like two islands in the control-room, and it is important that the SM, who is offloaded at day time by an administrative support, contributes to ensure internal coordination in the operator team.

Emergency operation is the period in which an NPP is in a state described by the Safety Analysis Report (SAR) or in the plant specific Probabilistic Risk Assessment (PRA). In these situations, a plant is operated based on the emergency operation procedures, functional restoration guidelines and in extreme cases severe accident mitigation guidelines. The incidents and standard operation procedures may also be applied. The overall task of the operator team is to ensure that the plant is brought to a safe state. When an event occurs that has been addressed in SAR or PRAs (e.g. a rupture of a tube in the steam generator), task performance is heavily guided by procedures. When multiple failures (events) have occurred, the crew members will to a larger degree need to adapt the procedures to the characteristics of the situation. During emergencies, RO and ARO will typically be working together to execute the actions required

1. The paper is based on and a further elaboration of results reported in a 'limited distribution' work report by Skjerve & Holmgren (2016).

on the reactor side, whereas TO will execute the actions on the turbines, power and I&C supplies. The FOs will assist in the control-room or out in the plant. The SM will take a stand back position and survey the plant's behavior, including the critical safety functions, and coordinate the crew members' activity and plan ahead.

3 METHOD

The study was based on data collected in a PWR unit of a north European nuclear power plant. Data collection included 108 hours of observation in the control-room during normal operation and outages, distributed between two operator teams by the authors. Observations were further carried out across refresher training (i.e. regular training after the operators has been licensed to refresh and update competencies, comprising simulator and classroom sessions), including eight days of simulator runs addressing emergencies. In addition, data were obtained from 14 semi-structured interviews lasting in average 1.5 hours with plant personnel, and a questionnaire survey administered to 33 NPP operators. Method triangulation (Denzin, 1978) was applied to seek to increase the validity of the findings by cancelling out the limitations associated with each of the three methods.

Data was analyzed using a thematic analysis approach, i.e. a qualitative method that makes use of labelling and iterative restructuring of data, to identify patterns—or themes in the dataset. The analysis process was developed based on Braun and Clarke (2006). It contained four phases.

Phase 1: Familiarization with the dataset. This implied reading through notes from observations, the interview responses, and the responses to the questionnaire survey to obtain an overview of the content.

Phase 2: Generating initial codes: All data obtained, i.e. from observations, interviews, and questionnaire survey, was decomposed into segments. A segment was defined as an entity that described one aspect of the teamwork competence required by NPP operators as it emerged from the data collected. In all 136 segments were identified. Examples on segments include: "Insights into how adults learn" (Learning and Coaching); "Communicating via more information channels to increase the likelihood that a message is understood" (Communication), and "Team-orientation—expanded to unit, plant, and other entities of relevance for ensuring safe and efficient plant performance" (Attitudes).

Phase 3: Searching for themes: Establishing a taxonomy comprising a set of teamwork competence dimensions: First, each segment was assigned to one of the five categories in the taxonomy defined by O'Connor et al. (2008) based on whether the content of a segment. If a segment was judged not to fit into any of the categories, a new category was introduced and/or the definition of one of the existing categories was modified to accommodate a broader range of content. If possible, the segments were allocated one or more of the three operational states: normal operation, outages and/or emergency operation. If not, the segments were defined as common to all states.

Phase 4: The segments associated with each of the three operational states were then grouped across the teamwork-competence dimensions to identify if patterns emerged, which should help clarify the reason for potential differences.

4 RESULTS AND DISCUSSION

The teamwork-competence taxonomy established in analysis phase 3 comprised nine dimensions: Attitudes, communication, coordination, decision making, interpersonal competence, intrapersonal competence, leadership, learning and coaching, and situation awareness.

The distribution of segments across the nine dimensions can be seen in Table 1. The inter-rater reliability between the two authors showed a correspondence of 81%.

The teamwork-competence dimensions identified did not differ substantially from the dimensions identified in earlier studies addressing teamwork competencies in NPP operation. This was interpreted to support the validity of the taxonomy (see Table 2).

4.1 *Teamwork requirements across the teamwork-competence dimensions*

The results suggested that teamwork-competence requirements for NPP operators overall were highly similar: Competence associated with each dimension of teamwork was required in all three operational states. Still, a more detailed analysis showed that except for the teamwork-competence dimension *attitudes*, the specific competence aspects NPP operators were required to master showed some degree of variation across the operational states. Below the main findings are associated with each of the nine teamwork-competence dimensions are summarized:

4.1.1 *Situation awareness*

The task of building situation awareness is done based on somewhat different sources of

Table 1. Distribution of segments across the nine teamwork-competence dimensions.

Teamwork-competence dimensions	Total no. of segments	Segments common to normal operation outages and emergencies	Segments specific to normal operation outages or emergencies	Normal operation	Outages	Outages & Emergencies	Emergencies
Attitudes	8	8	0	0	0	0	0
Communication	13	8	5	0	2	0	3
Coordination	13	4	9	2	1	4	2
Decision making	13	7	6	1	0	3	2
Interpersonal competence	17	7	10	4	3	0	3
Intrapersonal competence	13	1	12	3	3	4	2
Leadership	25	8	17	5	4	0	8
Learning and coaching	16	4	12	7	2	1	2
Situation awareness	18	6	12	1	4	3	4
SUM	**136**	**53**	**83**	**23**	**19**	**15**	**26**

Table 2. Comparison of the taxonomy identified in the study with other teamwork-competence taxonomies.

Crichton & Flin (2004)	O'Connor et al. (2008)	Broberg (2009)	Skjerve (2013)	Present study
Situation assessment	Building situation awareness	Building situation awareness	Situation awareness—build and maintain an accurate and shared situation understanding	Situation Awareness—building and maintaining
Decision making	Team focused decision making	Decision-making Consultation	Decision making—team focused	Decision Making—team focused
Communication	Communication	Communication	Communication—sharing information and insights	Communication
Teamwork	Co-ordination	Planning	Coordination Back-up behaviour	Coordination
	Collaboration			Interpersonal competence
		Leadership	Leadership	Leadership
		Group climate	Attitudes—towards colleagues and the plant	Attitudes
			Personality fits	
Stress management				Intrapersonal competence
			Learning and refreshing competencies	Learning and coaching

information and under various workload levels across the operational states. For example, during normal operation the ability to establish accurate situation awareness involves teamwork-competence aspects associated with obtaining information from shift-handovers (i.e. semi-structured dialogues with colleagues), from various logs, etc. and to systematically assess these with colleagues to build a shared understanding. During outages and emergencies, NPP operators needs teamwork-competence aspects associated with obtaining information from colleagues about a dynamic situation on-the-fly, as well as competence aspects related to distinguishing between critical information and other types of information and addressing critical information in crew updates in a way all colleagues understand.

4.1.2 *Decision-making*

A range of teamwork-competence aspects associated with decision-making was shared across the operational states. This included, proactively determining how to verify the consequences of a decision and acknowledging and proactively addressing uncertainties together with team members. The differences found were mainly associated with the overall workload level, but also to some extent with concerns for ensuring the continuous learning of in the operator team. For example, during normal operation competence aspects associated with contributing to (depending on role) a more participatory decision-making process ensuring all understand the basis on which the decision should be made, aimed at jointly developing 'optimal solutions' were required. Whereas during emergencies, competence aspects associated with execution of a more authoritarian decision-making approach aimed at finding 'good enough' solutions were needed.

4.1.3 *Communication*

The communication tasks were basically the same across the three operational states. They involved, e.g., the use of "Three-way communication", adapting communication to the receiver(s)' competencies and active listening. Still, across the operational states the frequency with which communication tasks had to be executed varied, and thus the overall level of time pressure associated with task performance. This implied that the operators needed to master the communication competencies with substantially more *fluency* during outages and emergencies than during normal operation: the number of communication tasks was higher in these operational states, and the time available to identify and correct misunderstandings was more limited. Some communication tasks were further associated mainly with one operational state. During outages, e.g. the operators need to be prepared to communicate with consultants in English (a non-native language to the operators). Also during emergencies, there is a distinct need to uphold continuous communication among team mates during complex and/or stressful situations to promote collective sense-making processes and the provision of mutual support.

4.1.4 *Coordination*

The requirement to coordination competencies is essentially similar across operational states, in the sense that it covers a wide range of activities from performance-adaptation on-the-fly, engaging in backup behavior, to planning aimed at ensure coordination of future activity, which may be needed across the operational states. Still, the requirements to teamwork-competence aspects associated with coordination vary more than e.g. was the case for communication. The reason is that the content of coordination tasks prototypically associated with each operational state is more varied, and involves different teamwork-competence aspects. For example: During normal operation, it is necessary to continually to coordinate performance of operational tasks versus performance of administrative type of tasks; During outages, the need for carrying out Pre-Job Briefings is more pronounced than during normal operation, and will involve more staff, including external specialists; During emergencies coordinating activities to ensuring clear, precise and not least timely is a task of key importance.

4.1.5 *Interpersonal competence*

The inter-personal teamwork-competence aspects were to a large degree similar across the operational states, except they in general had to be mastered with greater *fluency* from normal operation, over outages, to emergencies. They comprised, e.g., building trust, mastering interactions, and recognizing the achievements of colleagues. The interpersonal teamwork-competence aspects were, however, suggested to serve different purposes during normal operation and emergencies: During normal operation, the overall purpose was to transform operators into a team and/or to strengthen the team spirit, whereas during emergencies the purpose was to uphold the operators' ability to function efficiently as a team under highly challenging conditions.

4.1.6 *Leadership*

This competence dimension was assessed to be useful for all operators, regardless of their particular role in the team, because all (with different degrees of likelihood) may end up in a situation, where they need to lead teammates. The teamwork-competence aspects required across the operational states varied, e.g., concerning the leadership style the operator should master: During normal operation, competencies associated with executing a more democratic type of leadership were needed, e.g. promoting team mates' motivation by involving them in decision-making processes and promoting learning processes. During outages, and especially during the acute part of emergencies, competence aspects associated with executing a more authoritarian type of leadership were needed, e.g. giving and meticulously following-up on orders.

4.1.7 *Attitudes*

Attitude requirements included, e.g., safety concerns pervade all thinking and decision-making processes, and conscientious and commitment to quality. For this dimension no variation was found. The attitudes identified were of key importance across all operational states.

4.1.8 *Intrapersonal competence*

This dimension contained a set of teamwork-competence aspects of generic importance for sustaining sound teamwork, such as the competence to monitor own ability to operate the plant safely and efficiently, and courage to speak-up when needing assistance to achieve these goals. Since intrapersonal competence was used to fulfill different purposes across the operational states, the teamwork-competence aspects associated with each state varied somewhat. For example, to uphold attention towards the plant processes during normal operation where 'little happened' over longer periods of time, teamwork-competence aspects associated with reducing the risk for complacency were needed. To uphold attention during outages and emergencies during prolonged periods with high workload and/or safety-critical situations, on the other hand, teamwork-competence aspects associated with preventing negative impacts of fatigue and/or of stressors on the task-performance process were required.

4.1.9 *Learning and coaching*

Learning and coaching activates may be carried out as an integrated part of task performance or as a dedicated activity. The teamwork-competence aspects implied include, e.g., coaching competence, the ability to give/receive and constructively use feedback, and techniques for self-improvement alone or with or assisted by other people.

Dedicated activities to promote learning are prototypically associated with lower workload periods during normal operation. The likelihood that such activities will take place seems to increase, if the operators find that continues competence improvement is important for the team.

During outages and emergencies, competence development may to a certain degree be an integrated part in the task-performance processes, involving teamwork-competence aspects associated with coaching.

However, dedicated learning activity in relation to outages and emergencies will usually be postponed to after the shift period is over and/or after the outage or event has been handled. At this time, a required teamwork-competencies aspect is the ability to address occurrence/events constructively in team setting, i.e. avoiding that the parties involved will be defensive and refuse to share and discuss actions, which may contain important lessons learned from the entire team.

4.2 *Why teamwork-competence requirements are not identical across operational states*

Exploratory analysis of the variations found in the requirements to teamwork-competence aspects across the three operational states, suggested that the dissimilarities might be caused by a combination of two influences: (1) differences among the operational tasks across the operational states, and (2) differences among the impact of performance-shaping factors on otherwise similar operational tasks across the operational states. These two potential causes for dissimilarity will be discussed below.

4.2.1 *Task differences*

The operational tasks that are prototypically associated with each of the operational states, as described in section 2, are not identical.

Shift-handover is a task that is prototypically associated with normal operation. This is, e.g., reflected in traditional refresher training where the hand-over process is substituted by a training instructor simply describe the plant state to the operator team. From an NPP operator's perspective, the shift-handover session in the beginning of a shift include, a semi-structured dialogue with the opposite on the departing team to obtain an accurate understanding of the plant state, including issues that need attention. Learning how to interact with the opposite to obtain the needed information is an important competence. It includes abilities to identify and constructively address potential omissions, misunderstandings and uncertainties in the information provided to build situation awareness. This type of competence is not addressed in dedicated training session following licensing.

The requirement to work with people from different professions and/or with whom the NPP operator is less familiar or unfamiliar is prototypically associated with outages. During outages extended workgroups may arise, which in addition to the NPP operator team consist of colleagues from other operator teams, maintenance personnel, contractor staff from external companies, etc.

In this setting, a key teamwork-competence aspect required is associated with promoting common ground between the diverse members of an extended workgroup. This includes the ability to present information in ways that are understandable to people with different professional background, and ensuring that the concerns of all parties are adequately brought forward and addressed. This type of teamwork-competence aspect is not addressed during training.

Handling of emergencies is highly proceduralised activity, especially in the first part of an event, which is traditionally the part that has been addressed in refresher training. In cases of multiple failures, the requirement to making situation assessment to understand how to proceed will increase. A teamwork-competence aspect that is particularly needed in this situation is the ability to uphold communication throughout periods of

uncertainty when operators tend to keep quiet and focus keep on making sense of the situation on their own. Emphasizing communication is important to promote the team's ability to build situation awareness and making sound decisions. Unless refresher training progresses into this type of situation, these skills may not be upheld.

4.2.2 *Performance-shaping factors*

The study points to three Performance-Shaping Factors (PSF) impacting the requirements to teamwork-competence aspects across the operational states: *time pressure, task complexity* and *proactive attitude to safety.* The influence of these PSFs implies that the performance of otherwise similar teamwork tasks will come to require partly different teamwork-competence aspects.

Time pressure implies that a task needs to be completed within a given time window. The time window is typically defined by constraints in the plant, e.g., the amount of break flow in a storage tank can secure. The impact of time pressure on task performance generally increases from normal operation over outages to emergencies. When time pressure is high, teamwork tasks should be mastered with a greater *fluency*. The ability to communicate concern to a team mate should, e.g., preferably be mastered effortlessly, as the time available for re-stating information and correcting misunderstandings is reduced.

As the level *of task complexity* increases, the more factors (parameters) and interdependencies an operator needs to address when performing a task. For this reason, task performance should preferably be thorough, highly systematic, and be ideally carried out without any time pressure. In situations with high task complexity, teamwork-competence aspects associated with the ability to lead and coordinate teamwork is particularly required, to help ensure that all parties involved in the task performance process will obtain accurate situation awareness, and thus a sound common basis for making decision about the course of actions needed. As for time pressure, task complexity tends to increase from normal operation, over outage to emergencies, providing the latter contain multiple failures. In situations with both *time pressure* and *task complexity*, there will be a need for mastering the teamwork-competence aspects associated with handling task complexity with more fluently.

The PSF *proactive attitude to safety* implies the conviction that it is important to establish the best possible basis for sound teamwork in future settings. This may be done by promoting learning processes, by coaching or encouraging team mates to engage in self-studies, e.g., by studying the background materials for given procedures, etc. If the proactive attitude to safety is deeply rooted in the operators, it will help overcome a tendency to perceive coaching and dedicated learning sessions as an "add on" to the normal wok practices. It will encourage the operator to perceive competence-promoting initiatives as an integrated and important aspect in task performance processes.

The impact of this PSF is most visible during normal operation, where operators may or may not priorities to engage in learning processes. It seems also to be visible in the extent to which operators are able to uphold a 'questioning attitude' while carrying out their work, e.g. reflected in the extent to which they critically review current work practices to protect against drifting.

4.2.3 *Are capturing variations in teamwork-competence requirements necessary?*

Even if the teamwork-competence requirements are not identical across the three operational states, they are highly similar. Has it any real impact on a training program if is based on a generic set of teamwork-competence aspect, rather than a set, which is decomposed across operational states? From a practical perspective, any of the three operational states may contain characteristics that from time to time may be warranted in one of the other operational states: During an outage, there may be intervals resembling operation, such as longer periods of time where 'little happens', and during normal operation, situations may arise where NPP operators need to collaborate with unfamiliar people with a difference professional background, etc. Since a certain level of overlap exists between the tasks that may arise across the three operational states, it should in principle be possible to uncover all teamwork-competence aspects required of NPP operators by studying any of the three operational states exclusively. However, this approach would be substantially less effective than studying the characteristics of each of the three operational states, as the situational characteristics, which traditionally are associated with any of the other two operational states, might likely be manifest only with highly irregular intervals in the given operational state.

Another way of answering the question is to explore the level of teamwork-competence aspects missed if leaving out one of the operational states from an analysis. This can be done based on the distribution of segments reported in Table 1. The exploratory analysis indicates that if data from normal operation is left out of an analysis, 23 teamwork-competence aspects required by NPP operators may be at risk for remaining hidden, because the need for these competence aspects is rare during outages and emergencies. This corresponds to 17% of the entire set of teamwork-competence

requirements identified in the present study. If an analysis does not include data from the outages, 14% of the teamwork-competence aspects (i.e. 19 segments) may be at risk for remaining hidden. If emergencies are left out of an analysis the corresponding figure is 19% (i.e. 26 segments). In addition, outages and emergency situations share a unique set of teamwork-competence aspects segments which together amounts to 11% (i.e. 15 segments) of the teamwork-competence aspects required.

Overall, the results indicate that it is useful to analyses each operational state when establishing requirements to teamwork competence for NPP operators.

4.3 *Implications for teamwork training*

The IAEA (1996) recommends that the Systematic Approach to Training (SAT) is used as a basis for developing training programs.

When preparing for teamwork training for NPP operators, it overall important to promote their ability to adapt performance to situational characteristics, including characteristics of team members, such as their role, current tasks and the type and level of competencies. Mutual performance adaption among team members, in combination with a clear understanding of the team's goals, will promote teamwork processes. Because of the multitude of requirement posed to teamwork-competence aspects in an NPP, it can be expected that operators, who master a wider repertoire of teamwork competencies will be better able to adapt teamwork processes, than operators, who have a more limited repertoire of teamwork competencies.

One potential use of identifying aspects of teamwork competence that are prototypically associated with particular operational states is to provide a mean for deepening operators' level of teamwork competencies. Expanding the scope of teamwork competencies addressed in refresher training will support the operators in developing and upholding an expanded repertoire of teamwork 'techniques' which can be flexibly applied depending on situational characteristics, reducing the risks for break-downs in teamwork (Skjerve, Holmgren & Widheden, 2015).

A teamwork-competence aspect it may be useful to address as a part of the classroom part of refresher training, despite it being prototypical associated with normal operation, is *team-building competence*, in particular teamwork-competence aspects associated with maintaining team members' ability to work together as a team, including upholding team spirit. A feeling of team efficacy and team spirit may promote the operators' ability to overcome challenges to teamwork, and thus contribute to resilient performance.

Similarly, another teamwork-competence aspect it may be useful to address as a part of the classroom part of refresher training or exercises, despite it being prototypically associated with outages, is *the ability to engage in teamwork with less familiar or unfamiliar parties with different professional backgrounds*. This type of training may be included as an element in emergencies exercises, comprising NPP operator teams and key positions in the technical-support center. It may be done, e.g., by asking participants to state their expectations to one another, describe why they have these expectations, and account for their concerns. This would contribute to resilience in the extended team by further strengthening team mates' ability to select information of relevance to team members and to communicate this information accurately, etc. This will promote building and maintaining situation awareness in the extended team.

Expanding the scope of refresher training by teamwork-competence aspects prototypically associated with normal operation and outages may further contribute to promote 'teamwork mode' awareness.

Being aware of the current 'teamwork mode' may increase the likelihood that they will consciously apply teamwork-competence aspects are prototypically associated with the given mode—despite the operational state they are currently in. For example, during a non-acute phase of an emergency with limited workload, an NPP operator may need to talk to various people from the maintenance to refine the teams' understanding of the situation. If the operator recognized the parallels these dialogues may have with the dialogues involved in a shift-hand over process, it could prompt the operator to remember applying similar 'techniques' (such as focus at distinguishing facts from interpretations, specifying what needs to be further examined after completing the dialogue to get a clear picture of the situation, etc.).

An operator's increased focus on how teamwork-competence aspects interplays, may promote meta-cognition about teamwork competencies. Meta-cognition may enable the operator to more readily identifying and developing solutions to teamwork challenges. Transfer of a message between two persons may, e.g., unsuccessful for a variety of reasons: A message may not be stated clearly, if may not formulated in a way the receiver understands, may be transferred at a time the receiver is unable to pay full attention to the message, the receiver may misinterpret the content due to lack of common ground, etc. Awareness that a message may not be transferred to the receiver for a variety of reasons, will allow the operator to

'troubleshoot' potential teamwork break-downs from a range of different angles, and thus increase the likelihood that a means to preventing teamwork break-down will be found.

Both the ability to transfer teamwork-competence aspects across operational states and to engage in meta-cognition about teamwork, may, thus, further contribute to resilience in teamwork.

5 CONCLUSION

The outcome of the study suggested that the teamwork competencies needed by NPP operators across the three operational states are similar, but not identical. The results indicated that unless requirements to teamwork competence are obtained from all operational states, there is a risk that important teamwork competencies will remain hidden. With respect to refresher training, this would imply that these competencies are not addressed and thus potentially that NPP operators will not maintain these competencies to the required standard.

Based on the results, it was suggested that resilience in teamwork could be strengthened if refresher training expanded its traditional focus on teamwork-competence aspects associated emergencies, to include aspects that are prototypically associated with normal operation and outages.

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