



NKS-405
ISBN 978-87-7893-493-2

Safety Culture Assurance and Improvement
Methods in Complex Projects –
Final Report from the NKS-R SC_AIM

Kaupo Viitanen¹
Nadezhda Gotcheva¹
Carl Rollenhagen²
Teemu Reiman³

¹VTT Technical Research Centre of Finland Ltd.
²Royal Institute of Technology (KTH) and Vattenfall AB, Sweden
³Lilikoi Consulting

February 2018

Abstract

A good safety culture is an essential ingredient for ensuring nuclear safety. The predominant approaches for safety culture improvement are based on the assumption of stable and relatively homogeneous organizations, which often does not apply to contemporary project-oriented and turbulent environments. This research activity aims to provide guidance for methodical safety culture change in complex nuclear industry projects, and how to utilize existing safety culture tools or create new ones to support this effort.

A set of twelve principles of safety culture change were developed that summarize the essential good practices of leading safety culture change. The principles are based on up-to-date practical experience and theories in the fields of systems thinking, organizational management and safety science. The principles are related to the generic characteristics of safety-critical project environments to illustrate their relevance in the context of complex projects. We propose that these principles are instrumental in leading safety culture activities in an informed manner, and to avoid mechanistic or superficial methods.

Guidelines for the implementation of safety culture ambassadors were developed on the basis of the empirical work carried out in the Nordic nuclear power industry. Safety culture ambassadors group is novel method for safety culture improvement which aims to support the development of good safety culture by involving safety-conscious individuals from different parts of the company in safety culture activities. The guidelines can be utilized as a reference for practitioners in the nuclear power industry aiming to implement the method.

Key words

Safety culture, safety culture improvement, project management, organizational change

NKS-405
ISBN 978-87-7893-493-2
Electronic report, February 2018
NKS Secretariat
P.O. Box 49
DK - 4000 Roskilde, Denmark
Phone +45 4677 4041
www.nks.org
e-mail nks@nks.org

Safety Culture Assurance and Improvement Methods in Complex Projects

Final Report from the NKS-R SC_AIM (Contract: AFT/NKS-R(17)121/4)

Kaupo Viitanen¹
Nadezhda Gotcheva¹
Carl Rollenhagen²
Teemu Reiman³

¹ VTT Technical Research Centre of Finland Ltd.

² Royal Institute of Technology (KTH) and Vattenfall AB

³ Lilikoi Consulting

Table of Contents

1. Introduction	3
2. Principles of Methodical Safety Culture Change	6
3. Safety Culture in Complex Projects	25
3.1 Generic characteristics of complex projects	25
3.2 Safety culture change principles in projects	27
4. Case Study: Safety Culture Ambassadors	33
4.1 Introduction	33
4.2 Background and methods	33
4.3 Findings	33
4.3.1 Follow-up of case study at Organization A	33
4.3.2 Information exchange with Organization D	35
4.4 Comparison and discussion	36
5. Conclusions	40
6. References	42
Appendix. Safety Culture Ambassadors Group Implementation Guideline	47

1. Introduction

Safety culture was first introduced in the aftermath of the Chernobyl power plant accident in 1986 (IAEA, 1991, 1992). In the early 1990's, safety culture was defined as "*the assembly of characteristics and attitude in organizations and individuals that establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance*" (IAEA, 1991, p. 1). The main message conveyed by this concept was that in addition to technical and individual human factors, social, organizational and managerial factors need to be taken into consideration to ensure safe operations. After its introduction, safety culture has received a lot of attention. Safety practitioners have utilized it in accident analyses, organizational assessments and development activities, and safety researchers have modelled and validated the concept against other related theories. Safety culture has become an established institution especially in the nuclear industry, where it has been included in various requirements (e.g., IAEA, 2006b, 2016a; STUK, 2014; WENRA, 2014).

This research activity is motivated by the shortcomings of the concept of safety culture as it is currently used and understood, and the demands set by contemporary operating environment for safety culture assessment and improvement activities in the nuclear industry. To date, the focus of safety culture work and research has largely been on creating models and definitions of safety culture and developing methods to assess its state. These efforts have resulted in a multitude of definitions of safety culture (see e.g., Choudhry et al., 2007; Guldenmund, 2000; Wiegmann et al., 2004), safety culture models (for reviews, see Glendon et al., 2006; M. S. Wright et al., 1999) and assessment tools (e.g., IAEA, 2016b; Oedewald et al., 2011; Reiman et al., 2013; Reiman & Viitanen, 2018, see also Mkrtchyan & Turcanu, 2012 for a review). However, the improvement of safety culture and related practical tools and methods has received less research attention. It remains unclear what tools and methods are available, what is their validity, how and whether they can be generalized to any type of safety-critical organization, what the prerequisites of their successful implementation are, and what assumptions are embedded in them regarding their use.

Contemporary operational environment of the nuclear industry is characterized by project-orientation, organizational fragmentation and turbulence. Safety culture related adverse events have already taken place in the context of networked project organizations such as the Olkiluoto 3 nuclear power plant construction project (STUK, 2006, 2011). How safety culture is affected by these special conditions and how they should be taken into account when assessing and improving safety culture has received only limited attention (for exceptions, see Kujala et al., 2016; Oedewald & Gotcheva, 2015a, 2015b). It is not clear whether the assumptions (e.g., the nature of companies, their internal stability and permanence, structures and power relations), that were made during the development of the concept of safety culture and related practical tools and methods, are still applicable. Furthermore, it is not clear whether existing approaches, methods and tools of safety culture assessment and improvement can be tailored to meet the requirements and constraints of contemporary challenges or whether completely new ones need to be developed. In this research activity, we address these questions theoretically and empirically through case studies in the Nordic nuclear industry.

This report documents the results of the two-year (2016-2017) NKS-R SC_AIM research activity. The report aims to provide guidance to safety practitioners operating in temporary and dynamic organizational contexts, such as modernization projects and nuclear new builds,

in their effort to assure and improve safety culture. We believe that many of the research insights are applicable in stable and established safety-critical organizations as well.

The aims of the research activity were as follows:

1. To identify and specify methods to improve and facilitate safety culture in complex projects
2. To identify and specify methods to assure safety culture in complex projects

In 2016 the focus of the study was on identifying and analysing the currently used safety culture improvement methods and understanding the characteristics of project organizations. A literature review in the field of organizational (culture) change was conducted to identify what are the most essential approaches to change and how can different types of safety culture change be characterized. We examined safety culture change utilizing the categorization proposed by By (2005), which distinguishes change through its originator, its rate of occurrence and its scale. Another literature review was conducted to identify what kinds of safety culture change methods and tools have been documented. The identified examples of tools were loosely categorized on the basis of their apparent objective under the following seven groups: organizational structures, direct behavioural modification, interaction and communication, commitment and participation, training, promotion and selection. We did not find documented descriptions of methods that are specifically intended for project environments. Finally, the nature of projects was examined from the perspective of safety culture. Four lines of research into projects were distinguished and used as the framework for a literature review: projects as temporary organizations, projects as cultures, projects as safety-critical organizations and projects as networks of organizations.

Empirical case studies were also conducted in 2016: the main case study focused on the implementation and use of safety culture ambassadors group. The second case study utilized a project manager seminar with a safety culture theme to develop insights and to facilitate dialogue among different stakeholders in a project. In addition, information exchange via online sessions was carried out with safety culture experts from a Nordic nuclear power plant, where the focus was on understanding how safety culture was viewed and used by project managers in that organization. The detailed descriptions of the findings from 2016 are documented in the intermediate report of the activity¹.

In 2017, the study emphasized scientific publication: two conference papers and a book chapter were written. The first conference paper² focused on the topic of methodical safety culture change by examining the principles of safety culture change (described in Chapter 2 of this report) from the perspective of implementing safety culture change tools. The second conference paper³ discussed the concept of adaptive safety culture – a culture which allows

¹ Viitanen, K., Gotcheva, N., & Rollenhagen, C. (2017). Safety Culture Assurance and Improvement Methods in Complex Projects – Intermediate Report from the NKS-R SC_AIM (No. NKS-381). NKS.

² Viitanen, K., Reiman, T., Rollenhagen, C., & Gotcheva, N. (2018). Mapping methodical change in safety culture. To be presented at the Probabilistic Safety Assessment and Management conference, Los Angeles, USA.

³ Viitanen, K., & Reiman, T. (2017). Building an “Adaptive Safety Culture” in a Nuclear Construction Project – Insights to Safety Practitioners. Presented at the 7th Resilience Engineering Symposium, Liège, Belgium.

and supports qualitatively different and potentially contradicting organizational manifestations of safety management – in the context of nuclear power plant construction project, and examined how commonly used safety culture tools contribute to conflicting approaches to safety management. The book chapter⁴ discussed the nature of the co-existence between safety science and safety practice from a cultural perspective to identify barriers between these two domains: how the barriers influence the development of actionable science such as practically usable research results or tools and methods. The scientific publications contribute to the principles of safety culture change (described also in detail in Chapter 2 of this report) from their respective perspective by elaborating a particular aspect of the principles.

This report is organized as follows. Chapter 2 describes a set of principles of safety culture change, which crystallize the issues practitioners should consider when leading safety culture change. The principles aim to guide practitioners when they utilize methods or tools for safety culture assurance or improvement. Chapter 3 summarizes the special characteristics of safety culture in the context of projects and relates the principles to projects. This summary gives an overview of the opportunities and constraints of safety culture assurance and improvement in project organizations. Chapter 4 describes and concludes the main empirical case study carried out by the first author on the topic of safety culture ambassadors and reports the results of the information exchange activities of 2017. Furthermore, a guideline for implementing a safety culture ambassadors group was developed on the basis of the case study and is presented in Appendix 1. The overall implications of this research activity are concluded in chapter 5.

⁴ Reiman, T., & Viitanen, K. (forthcoming). Towards Actionable Safety Science. In J.-C. Le Coze (Ed.), *New Directions in Safety Science* (working title). Routledge.

2. Principles of Methodical Safety Culture Change

To clarify the cultural mechanisms and the organizational phenomena that are relevant to safety culture change, the authors – experts in the field of safety culture with research and practical backgrounds – carried out a mapping exercise during a workshop. The workshop was built around the following topics:

- Identifying the elements and mechanisms underlying safety culture and its change
- Identifying the characteristics of sociotechnical systems that either enable or inhibit safety culture change initiatives
- Mapping the leverage points which safety culture change tools and methods should influence

In practice, several exercises were conducted during the workshop, such as:

- Identifying the essential elements and sub-elements of a sociotechnical system and visualizing their interactions
- Filling out a safety culture tool by system element matrix to identify how the tools relate to system elements and what system characteristics need to be considered when applying the tools
- Deriving examples of principles of safety culture change, which crystallize the essential good practices of safety culture change and the implementation of safety culture tools by jointly analysing the outputs of other exercises

In this report, we will present the principles of safety culture change and explain the assumptions and theories underlying them. A total of twelve principles were devised. Table 1 summarizes the principles and the related assumptions along with examples of questions that can be utilized to evaluate whether the principle is met by a particular safety culture change activity or not. The underlying assumptions are an integration of what the authors propose to be the most relevant scientific theories that relate to safety culture change, including theories of sociotechnical systems, organizational management and culture, and safety management and leadership. The assumptions serve as an explicit description of the basis of each of the principles. In the following subchapters, we describe each principle in detail and give examples of their application in practical settings.

Table 1. Principles of methodical safety culture change		
	Assumptions	Examples of assessment questions
<u>Principle 1</u> : Consider the dynamics between classes of system elements	Systems consist of a diverse set of elements that define how safety culture develops	<p>What kinds of behaviour patterns and structures exist in the organization?</p> <p>What do they imply about the underlying values or assumptions?</p> <p>How do the underlying values or assumptions influence behaviour or structures?</p> <p>How are the values and assumptions connected to each other?</p> <p>Which values and assumptions are particularly strong (or weak)?</p> <p>Which are shared by everyone, which only by subgroups?</p>
<u>Principle 2</u> : Select the boundaries of the system you want to change	System boundaries define who influences and is influenced by safety culture	<p>Which group of people is targeted with the change and which will be influenced?</p> <p>Who has an effect on how the change is implemented or received?</p> <p>What prerequisites are there to redefine the boundaries of the system, or the safety culture change activity itself?</p>
<u>Principle 3</u> : Select the system elements you want to change	System elements have desirable and undesirable characteristics	<p>What is the relation between the system elements and safety?</p> <p>Is the safety significance direct or indirect, obvious or covert?</p> <p>What type of safety is the system element concerned with?</p> <p>What type of safety is the focus in safety culture change?</p> <p>Which system elements are in need of maintenance to avoid their deterioration?</p> <p>Which need to be created?</p> <p>Which need to be eliminated or avoided?</p>
<u>Principle 4</u> : Acknowledge that safety culture is not monolithic and internally coherent, and try to benefit from this	Systems are inherently paradoxical and conflicted	<p>What subcultures exist in the organization and who are they comprised of?</p> <p>How can the subcultures be characterized?</p> <p>How do (partially) external subcultures influence the activities of the organization?</p> <p>How do the subcultures respond to attempts to change culture, and what are their distinctive ways to interpret the change initiatives?</p> <p>Does the organization address all types of requirements for safety management, even if they are conflicted? How do safety culture tools contribute to them?</p>

Table 1 Continued		
	Assumptions	Examples of assessment questions
<u>Principle 5</u> : Make an effort to understand what organizational members actually do and identify leverage points for safety culture change	Shared values and assumptions develop in the context of what organizational members do and in the relation to the activities of others	<p>What is the core task and success criterion for each organizational group?</p> <p>What problems do the employees face in their daily work and how have they learned to solve them?</p> <p>What working practices are utilized in daily work?</p> <p>What solutions or good practices are taken for granted?</p>
<u>Principle 6</u> : Identify the assumptions embedded within safety culture change tools	Safety culture change tools embed assumptions on how they are to be used	<p>Who has developed and disseminated the tool?</p> <p>What was the context where the tool was originally developed and what was its purpose?</p> <p>Is the original context and purpose generalizable to other organizations as such, and if not, how should it be modified?</p> <p>What are the mechanisms of action underlying the tool, i.e., how does the tool produce its effect?</p> <p>What prerequisites (organizational or user) does the tool require to function as intended?</p> <p>What possible side effects can the tool have?</p> <p>How does the implementation approach influence the tool's functionality?</p>
<u>Principle 7</u> : Identify and make use of the indirect effects of safety culture change tools	Sociotechnical systems react and adapt to the effects of safety culture change tools	<p>What were the direct effects of the tools (on behaviour or on structures)?</p> <p>What indirect effects did the tool have? On which class of system element (behaviour, structures or values and assumptions)?</p> <p>How did the organisation respond to the implementation of the tools?</p>
<u>Principle 8</u> : Acknowledge that safety culture cannot be directly changed	Indirect effects of safety culture tools are the only methodical way to change safety culture	<p>How were the values and assumptions influenced in response to the change caused by the implementation of the tools?</p> <p>What measures or indicators were used to assess the state of values and assumptions after implementing the change initiative? Were they valid and reliable?</p> <p>Did the change influence safety positively or negatively (or not at all)?</p>

Table 1 Continued		
	Assumptions	Examples of assessment questions
<u>Principle 9</u> : Consider how power relations influence safety culture change	Power is a strong influencing factor in organizations	<p>Is there sufficient top management commitment to conduct a particular safety culture change activity?</p> <p>How can the top management become involved or actively participate in the safety culture change activity?</p> <p>What other positions of power are there in the organization that can influence how safety is perceived and acted upon (e.g., informal leaders, socially connected persons, thought leaders, experienced workers)?</p> <p>Who are the persons in power who are strongly committed to safety and can thus support safety culture activities?</p>
<u>Principle 10</u> : Involve the target group in safety culture change activities	It is easier to make changes to culture locally, in close interaction with the target group	<p>Who are the contact points towards the shop-floor (or other target group) employees?</p> <p>What activities do they already do naturally as part of their current tasks, or what activities could they do to support safety culture activities?</p> <p>What organizational or managerial prerequisites are available that can be utilized to support the safety culture activities?</p>
<u>Principle 11</u> : All information acquired in safety culture activities may be useful in the future	The meaning of information changes over time	<p>What safety culture change activities were previously considered impossible to implement, or which issues were regarded as inherent to the organization, and why? Are the reasons still present?</p> <p>What opportunities are there presently which could be utilized to address the issues previously thought to be impossible?</p>
<u>Principle 12</u> : Behaviour or structure change may result from safety culture change activities but do not expect rapid change in values and assumptions	System elements vary in terms of temporal stability and susceptibility to change	<p>Is the safety culture change initiative in line with the existing system state (e.g., in terms of behaviour, structures or values and assumptions), or does it contradict it?</p> <p>If not, is there a justifiable reason to carry out this particular change initiative?</p> <p>If the change initiative is required for developmental reasons regardless of potential resistance, are there sufficient prerequisites and long-terms commitment to carry out such a change?</p>

Principle 1: Consider the dynamics between classes of system elements

Assumption: systems consist of a diverse set of elements that define how safety culture develops

Sociotechnical systems consist of various classes of elements that interact with each other, thus forming the overall system. Culture is one of the phenomena that emerge in a sociotechnical system. The way in which the concept of safety culture is used can sometimes be misleading when it is viewed from the perspective of sociotechnical systems. This is due to the inconsistency and lack of an elaborated view of systems that many safety culture models suffer from (see also Reiman & Rollenhagen, 2014): the models may refer to artifacts, values, structures, or behaviour, and few (if any) to basic assumptions, but rarely do the models explicate how these classes of system elements interact and form culture. For example, the International Atomic Energy Agency's safety culture framework (IAEA, 2006a), which has been widely adopted in the nuclear industry, mostly focuses on listing behaviours and structures that are associated with a good safety culture. The same applies to many other established models such as INPO's model of traits of a healthy safety culture (INPO, 2012b) and INSAG-4 model of safety culture (IAEA, 1991). There are some exceptions emerging from scientific literature. For example, Guldenmund (2000) reviewed existing work on safety culture and related it to Schein's model of organizational culture (Schein, 2010), thus creating an understanding on how the different levels of culture interact and relate to safety. Choudhry et al. (2007) proposed an integrative model that explicated the interaction between persons, behaviour and environment, and how safety culture emerges from this. Recently, a model of safety culture was proposed by Vierendeels et al. (2018), which aimed to aggregate insights from all sub-disciplines under safety science. However, what is typically discussed under the label of "safety culture" often does not help to understand what takes place in the system and how culture can actually be changed. We propose under this principle that *safety culture change should involve an understanding of what are the different elements of the system that are relevant to safety, how they interact with each other, and what are their temporal dynamics.*

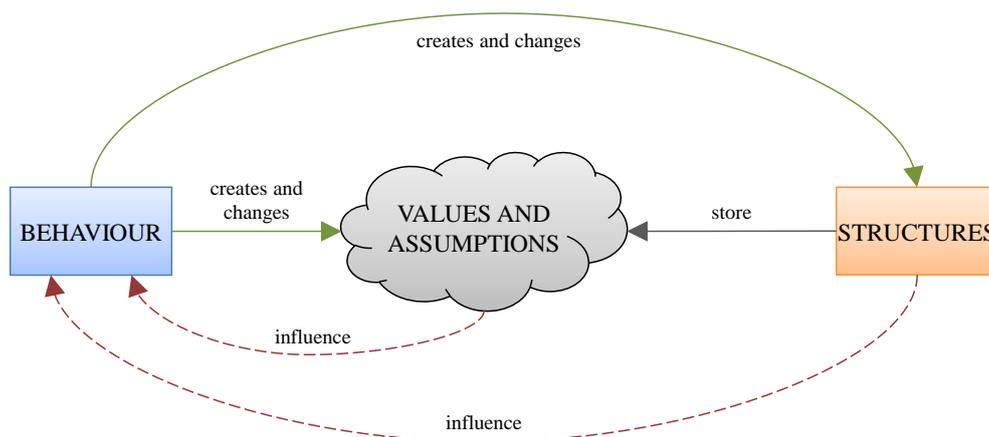


Figure 1. Illustration of how behaviour and structures are related to values and assumptions (Viitanen et al., 2017, adapted from Reiman and Rollenhagen, 2017)

We utilize insights from Reiman and Rollenhagen's iterative model of organizational culture, which describes how culture changes as a result of the interaction between shared values and

assumptions, structures and behaviour (Reiman & Rollenhagen, 2018). Figure 1 summarizes this model. Values and assumptions define, for example, what is considered relevant, important or possible and what meanings are given to actions, decisions or perceptions (Schein, 2010). In the context of safety culture, values and assumptions can relate to conceptualizations of safety, accidents, hazards, human error and safety management. Values and assumptions are often characterized as being the most inaccessible element of culture and are associated with “the core of culture”, with other elements as its manifestations (Schein, 2010). Values and assumptions can be explicit (e.g., organizational strategies and visions, espoused values) or implicit, (e.g., unconscious and taken-for-granted basic assumptions). Structures, on the other hand, store values and assumptions as they are reflected in the contents of administrative structures (e.g., management systems, processes, procedures, rules, regulations, and other institutionalized practices) or physical structures (e.g., buildings, technology). Behaviour creates and changes structures, values and assumptions (e.g., through managerial decisions or personnel initiatives). Behaviour, like structures, also reflects values and assumptions. Understanding the dynamic interplay between these three classes of system elements (i.e. values and assumptions, structures and behaviour) is essential for understanding cultural change.

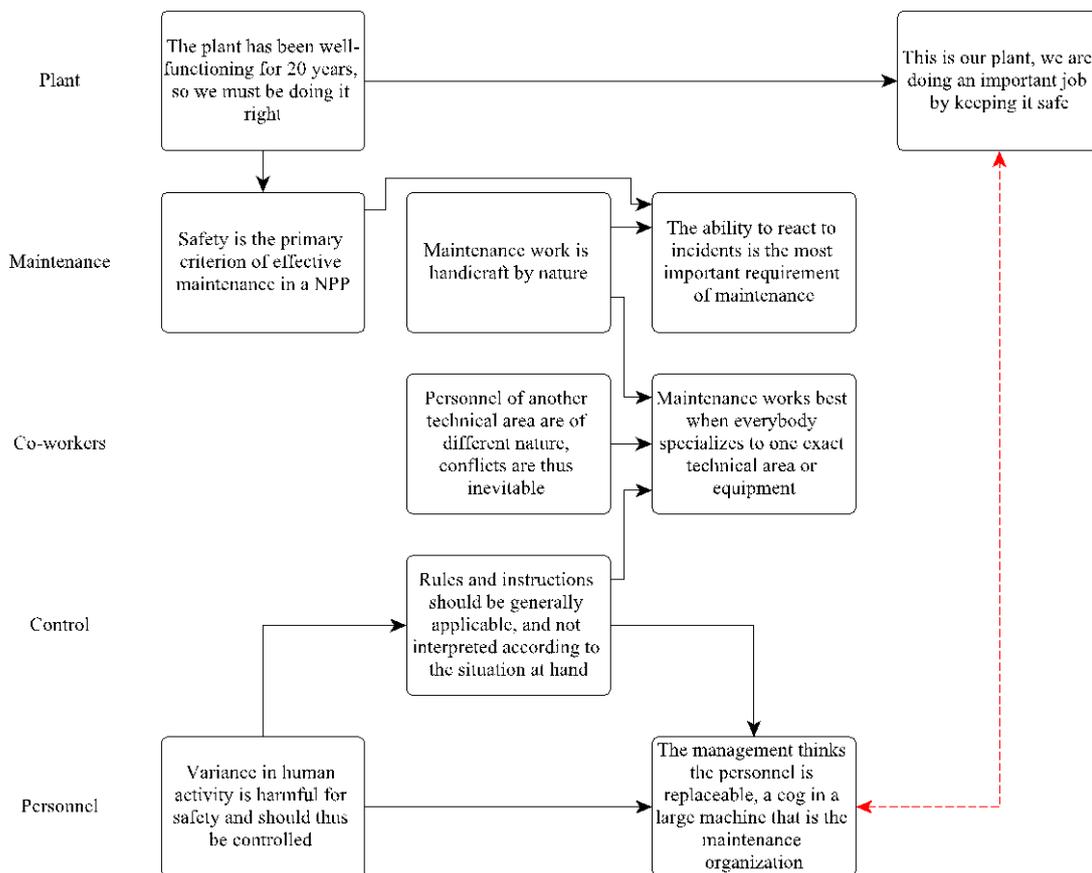


Figure 2. A network of shared values and assumptions of a nuclear power plant’s maintenance unit, grouped by the (apparent) topic (adapted from Reiman & Oedewald, 2006). The dashed red line indicates a conflicted relation

Values and assumptions result from the interactions between behaviour and structures, but also between other values and assumptions. Figure 2 illustrates an example of how a network of shared values and assumptions (cf. “cultural paradigm” in Schein, 2010) discovered in a study of a maintenance unit of a nuclear power plant (Reiman & Oedewald, 2006) can connect to create a culture. In this figure, the values and assumptions are grouped by their apparent topic (loosely drawing from how Schein views dimensions of basic assumptions).

The existence of dynamic interactions between system elements also suggests that one cannot target only one element when leading safety culture change (e.g. pick a value or an assumption and change it). This is because a sociotechnical system is an adaptive entity, and will reject and compensate any disturbance that it is not compatible with. Thus, other interconnected elements of the system are likely to change the system back to its original state, which often results in change resistance or unwanted side effects. This suggests that system elements can on the one hand be viewed as the objects of change (e.g., when one attempts to influence undesired behavioural patterns or unwanted assumptions), but on the other hand, they can also be viewed as “nuisance factors”. The latter can be the case when the aim of the safety culture activity is to implement a certain organizational structure, without specifically trying to influence the underlying assumptions: if the assumptions incompatible with the organizational structure, the change will face resistance.

Values and assumptions are not always equivalent. For instance, assumptions can be evaluated at least along the following four dimensions (Denison, 1990): mission, strength, consistency and adaptability (see Table 2). When attempting safety culture change that involves the change of values and assumptions, it can be beneficial to evaluate where the targeted values and assumptions are located along these dimensions. Depending of that evaluation, safety culture change activity can be better focused and tailored to purpose, or even abandoned in case the assumptions are not likely to be formed or changed as a result of the safety culture change initiative. For instance, in situations where the assumptions are strong and highly shared, it might not be feasible to influence them, at least without excessive effort. This can be the case when dealing with behavioural patterns or structures that stem from cultural processes that have evolved over very long periods of time, such as those associated with nations or religions. In some cases of change resistance, the safety culture change initiative itself might benefit from self-reflection: strong resistance may indicate that the safety culture change effort is based on flawed assumptions, i.e., that the existing values and assumptions are in fact well-adapted for the purpose and that it is not desirable to try to change them.

Table 2. Some dimensions of values and assumptions (adapted from Denison, 1990)	
Dimension	Description
Mission	What is the direction where the values and assumptions steer the group members
Strength	How strongly held are the values or assumptions
Consistency	The extent to which the values or assumptions are shared, agreed and consistent within the group
Adaptability	The extent to which the values and assumptions have the predisposition for renewal and change

Principle 2: Select the boundaries of the system you want to change

Assumption: system boundaries define who influences and is influenced by safety culture

The boundaries of a sociotechnical system can be viewed from several perspectives, for example, vertically by separating different levels of the system, or horizontally by separating between entities at the same level. Vertical levels may include the levels of work conditions, staff, management, company, regulators and associations, and government (cf. e.g., Rasmussen, 1997), while horizontal levels may include different occupational or functional groups such as maintenance, design or engineering departments at a nuclear power plant. Depending on how the boundary has been selected, the system can contain groups of individuals, organizational departments, or several (networked) organizations.

An informed selection and awareness of system boundaries is needed to understand who or what influences and is influenced by safety culture, i.e. who is the target and what is the context of safety culture change. The selection of boundaries thus affects the spatial scale (in organizational terms) of things that are taken into consideration. A narrow selection of the boundary can help focusing safety culture change activities and thus help avoid diluting the activity with irrelevant nuisance factors. At the same time it can contribute to losing the big picture of how different system elements interact and create emergent patterns (cf. principle 1). Such an approach can result in a mechanistic approach to safety culture change: trying to change one part of the system at a time while disregarding the surrounding system, possibly resulting in invalid or detrimental safety culture change initiatives. On the other hand, a too wide selection of the boundary can result in information overload, “operational paralysis” or lack of progress in safety culture activities if one tries to account for every single interaction and minuscule factor influencing the system. This suggests that *a right balance between local and global scales needs to be found (cf. Reiman et al., 2015) and the effects of the potential trade-offs need to be understood.*

In addition, it should be acknowledged that due to the “open” nature of sociotechnical systems (i.e. they have interactions with their environment), the selection of system boundaries is often artificial as there is likely to be no “real” or objective boundaries. The boundary is always a circumstantial compromise. This uncertainty further stresses that the selection should be informed by an understanding of how the particular selection influences safety culture work. Consequently, the selection of system boundaries should be redefined if necessary. Since sociotechnical systems are inherently dynamic and evolve over time, the temporal dimension needs to be taken into consideration. As the system changes, so do the needs, opportunities and challenges of safety culture change activities (see principle 11). Thus, one needs to be prepared to continuously monitor the system and, when necessary, abandon the previously selected system boundaries and select new ones to meet better the contextual needs or overall goal of the safety culture change. Such a need can occur, for example, when the system adapts to the already implemented safety culture change initiatives.

Principle 3: Select the system elements you want to change

Assumption: system elements have desirable and undesirable characteristics

Methodical safety culture change needs an understanding of the purpose of the change. What class of system element is the target of change (behaviour, structures, or shared values and assumptions), and what characteristic of a system element requires changing (e.g., what kind of behaviour or structures is the target of the change, or which set of assumptions or values need to be influenced)?

The characteristics of system elements in safety-critical organizations vary, for example, from those that have no direct relation to safety, to those that do have, and also between different types of safety. We believe that it is important to acknowledge that *almost any system element can be safety-related*. For instance, several values or assumptions within the culture depicted in Figure 2 do not specifically concern safety (e.g., “maintenance work is handicraft by nature”), but contribute to how people make sense of their work or what is expected of co-workers and the organization, which eventually can influence safety-related actions or decisions, or the formation of structures. However, some values or assumptions may be more safety-related than others, and identifying the extent to which they are safety-related can often be difficult. Nevertheless, it should not be overlooked: safety culture should always be perceived in relation to other associated values and assumptions that may exist in organizations (incl. subcultures).

Especially in organizations that do not deal directly with safety, either in functional (i.e., tasks that do not concern direct control of safety-critical processes, such as design or construction organizations) or temporal terms (i.e., safety-critical processes are not yet present, such as in nuclear new builds), the system elements’ relation to safety may not always be clear. Understanding direct and indirect effects on safety can be difficult since the borderlines between these two categories are not always clear. In complex and dynamic organizations, tasks that at first sight seem to be less important for safety may in reality have strong safety significance in combination with other tasks. Basing safety culture change activities on implicit understanding of how the system elements relate to safety can lead to undesirable changes. For instance, this may be the case when safety culture is associated with occupational safety (instead of process safety), and the selected activities subsequently focus on the use of personal protective equipment or personal risk analyses. The explosion at BP Texas City Refinery in 2005 (U.S. Chemical Safety and Hazard Investigation Board, 2007) can serve as an illustrative example of how a lacking understanding of the nature of risks and a focus on occupational safety can lead to complacency towards process safety risks and eventually to a process safety accident.

Table 3. Safety culture change actions, with examples and things to consider		
Action	Examples	Things to consider
<u>Maintain</u> a desirable characteristic	<p>Collecting, sharing and institutionalizing good practices that have been developed over time (<i>maintain behaviour</i>)</p> <p>Updating procedures to match reality and ensuring that there is top management commitment and resources available (<i>maintain structures</i>)</p> <p>Remind regularly via various communication channels what is important for the organization and what the top management considers vital for success (<i>maintain values and assumptions</i>)</p>	<p>Maintaining can be a potential emerging challenge nowadays as established safety-critical organizations face contemporary issues (e.g., cost-cutting, changes in technologies and management styles) and the proven practices may not apply any more</p> <p>Generation changes and other discontinuities may result in a “loss of culture” unless sufficient emphasis is not put on maintenance</p>
<u>Eliminate</u> an undesirable characteristic	<p>Identifying unwanted behavioural patterns and utilizing training or behavioural conditioning techniques (e.g., sanctioning) to eliminate them (<i>eliminate behaviour</i>)</p> <p>Following-up on safety culture improvement initiatives and abandoning those that have not had impact or that do not have potential impact (<i>eliminate structures</i>)</p> <p>Eliminating unwanted safety-related attitudes by conducting trainings that aim to acculturate employees to embrace safety-conscious set of values (<i>eliminate values and assumptions</i>)</p>	<p>In safety-critical contexts, unwanted behaviour may occur because individuals do not fully understand the potential consequences of their behaviour: risk information may thus be an appropriate measure to address the problem (e.g., explicating the potential risks evoked when leaving fire doors to eliminate unwanted behaviour). In other situations it can be more appropriate to change physical structures (e.g., implement a physical design which makes it impossible to leave the fire doors open) rather than behaviour.</p>
<u>Create</u> a desirable characteristic	<p>Communicating and implementing desirable behavioural patterns by introducing a Human Performance Program (<i>create behaviour</i>)</p> <p>Developing and implementing a formal safety culture program and/or policy (<i>create structures</i>)</p> <p>Organizing safety culture trainings that aim to develop the safety consciousness of personnel (<i>create values and assumptions</i>)</p>	<p>The properties of new designs should always be investigated with reference to potential side effects. For example, the introduction of new routines or behaviours for safety-related assessments can dilute responsibilities unless clearly defined during the implementation.</p>
<u>Prevent</u> the emergence of an undesirable characteristic	<p>Create rules and procedures that set safety limits and forbid certain type of behaviour (<i>avoid behaviour</i>)</p> <p>Before implementing organizational changes, identify incompatibilities or potentials for adverse side-effects by utilizing internal networks within the organization to get feedback from the shop-floor (<i>avoid structures</i>)</p> <p>Continuously monitor and follow-up safety culture, and develop corrective actions with regards to the organization’s safety culture strategy and activities (<i>avoid values and assumptions</i>)</p>	<p>Unwanted behaviour may be created when the physical structures are not well designed or the procedures are not suitable. In design and/or redesign of structures, it is consequently important to imagine what a likely behaviour would be given the specific design. This also means that when considering safety culture actions, the dynamics between the different elements need to be considered.</p>

Since some of the system's existing characteristics may be desirable, and some may not be, it is necessary to consider, what "safety culture improvement" specifically entails. We draw from the theory of elementary actions (G. H. von Wright, 1968) to formulate four types of safety culture change actions: maintaining a desirable characteristic, eliminating an undesirable characteristic, creating a desirable characteristic and preventing the emergence of an undesirable characteristic (see Table 3 for further details and examples). Conceptualizing safety culture change activities from this perspective can help ensure that the organization's safety culture strategy does not only focus on one type of action without considering other types of actions. For example, if safety culture change activities are merely focused on creating desirable characteristics or eliminating undesirable characteristics, as often is the case, the more maintenance-oriented types of activities may be left without due attention, potentially weakening those positive system elements that already exist. Over time, this can lead to severe problems, such as unidentified drift of the culture towards increased risk acceptance, or a loss of desirable cultural traits during temporal discontinuities such as organizational reforms, generation changes, or other dynamic events.

Principle 4: Acknowledge that safety culture is not monolithic and internally coherent, and try to benefit from this

Assumption: systems are inherently paradoxical and conflicted

Traditionally, the concept of organizational culture assumes unity and homogeneity of a group. Many organizational culture theories are based on this assumption, including Schein's theory of organizational culture (Schein, 2010), which views organizational culture as reflecting something that is shared. However, this does not mean that the group in question is the whole organization: in reality most, if not all, organizations consist of subcultures, each with their unique sets of values and assumptions, sometimes conflicting and competing with each other, sometimes co-existing in harmony (Martin, 1992). This means that there can be a multiplicity of safety cultures in the organization, and that they are constantly created and recreated as groups of people interact with each other and their environment (Richter & Koch, 2004). Various intra- and inter-organizational structures influence the ways in which subcultures form. For example, within an organization, subcultures can form around functional departments (e.g., operation, maintenance, engineering; Rollenhagen et al., 2013), or physical proximity (e.g., rooms/areas in buildings, or between the organization's locations). Inter-organizational structures such as peer groups or networks also contribute to a formation of subcultures (Rollenhagen et al., 2013), and influence their content, which suggests that cultural influences are not constrained to a single organization.

The existence of subcultures has implications to methodical safety culture change: attempting to create a uniform safety culture might not be possible or even be a desirable goal. The cultural heterogeneity implies that such attempts at influencing safety culture, which assume that culture is uniform, may result in unexpected outcomes because each subculture may respond to the safety culture change intervention differently. For example, in the context of a construction of nuclear power plant, the groups of employees who have different conceptualizations of risk and hazards may misunderstand the concept of safety culture. Construction workers may view safety (and thus safety culture) as exclusively related to occupational safety, while in actuality the purpose of the concept of safety culture in the nuclear industry is primarily to promote nuclear safety. If this is not taken into consideration

during the design and implementation of the safety culture change, the groups may interpret safety culture promotion activities differently, which can lead differing effects between the groups. Thus, *the cultural heterogeneity may call for a tailored (cf. principle 10) or at least subculture-aware approach to safety culture change.*

Conflicts can also manifest within cultural entities, i.e., between or within different classes of system elements. Values and assumptions might not be in line with each other, or behaviour and/or structures might not always reflect or support each other, or the values and assumptions. For example, procedures may not always match the way in which work is done in reality (structures-behaviour mismatch) or the values espoused through promotion might not reflect what the values or assumptions of organizational members really are (structures-values mismatch; see also Figure 2). The extent to which these cultural elements agree with each other may influence the organization's ability to manage safety (see e.g., Antonsen, 2009b). Similarly, the organization can have a conflict between the system elements that are (more obviously) concerned with safety and those that have a more peripheral or indirect connection with safety. Safety-production trade-off is one of the classic manifestations of this. These discrepancies may result from system complexity (see Reiman et al., 2015), its inherent tensions (e.g., the existence of competing values, see Cameron & Quinn, 2006), or lags in adapting to internal or external changes (cf. principle 12).

The existence of conflicts and paradoxes in safety-critical organizations is not a negative phenomenon per se; rather, it is an inherent characteristic of any complex, sociotechnical system (Reiman et al., 2015). Sometimes the conflicts and heterogeneity can in fact be a necessity for safe activities: for instance, a system requires sufficient variety (e.g., in terms of interpretations) to be able to regulate safety-critical activities or to facilitate learning (Antonsen, 2009a; Weick, 1987). The system can also have conflicting requirements for safety management, which necessitates the use of conflicting approaches to safety management (Reiman et al., 2015), and such a safety culture that allows and supports the use of the conflicting approaches (Viitanen & Reiman, 2017). Figure 3 describes how different safety culture assessment or improvement tools relate to conflicting approaches to safety management and shows that, for example, a given tool can contribute positively to one approach, but negatively to another, and that the use of a tool can require the fulfilment of certain preconditions to function as intended (Viitanen & Reiman, 2017). To ensure sustainably safety in long-term, the organization should have the capability and tools to cover all of the six conflicting approaches to safety management (Viitanen & Reiman, 2017). Leading a safety culture change thus involves acknowledging the paradoxes and conflicts, and trying to benefit from them.

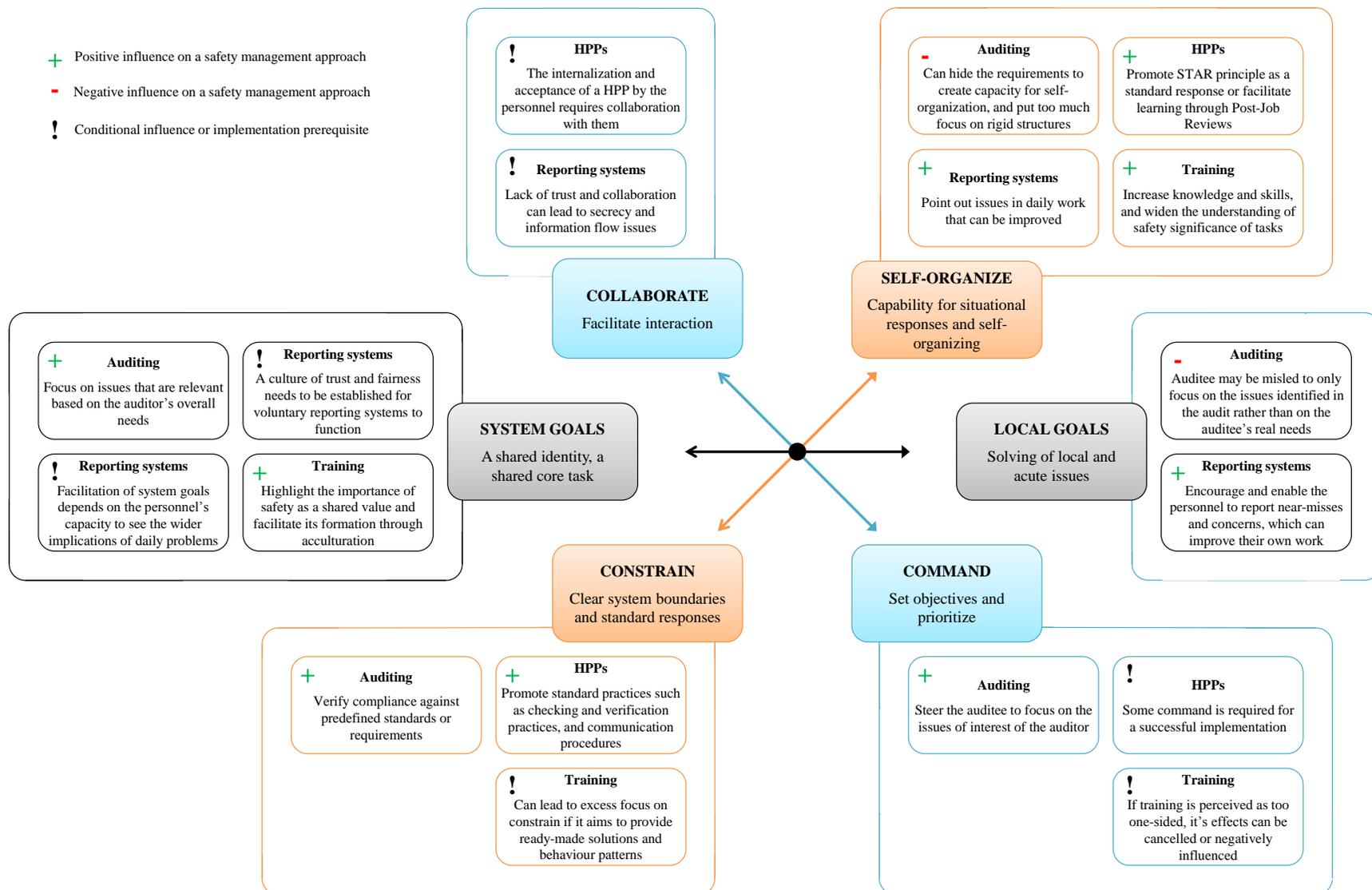


Figure 3. Conflicting approaches to safety management and examples of how safety culture tools can contribute to each approach (adapted from Viitanen & Reiman, 2017)

Principle 5: Make an effort to understand what organizational members actually do and identify leverage points for safety culture change

Assumption: shared values and assumptions develop in the context of what organizational members do and in the relation to the activities of others

Since culture is a group-level phenomenon, one of the essential ingredients for the formation of shared values and assumptions are the interactions between individuals. Culture forms when a group of people interacts with each other, solving externally or internally induced problems (Schein, 2010). Understanding the interaction between different organizational groups is thus essential in the study of safety culture (e.g., Antonsen, 2009b). This suggests that the arena of interest for methodical safety culture change is where the organizational members interact: their everyday work. Therefore, *the leaders of safety culture change should not distance themselves from the organizational members, but instead they should make an effort to understand what is (and has been) actually done.* This can give insight into what are the driving forces that have resulted in the existing values and assumptions. Consequently, this insight can help identify the leverage points for safety culture change.

Being aware of the contextual problems the organizational members face in their everyday work allows for a better understanding of why certain values and assumptions are held. If the goal of methodical safety culture change is to influence these values and assumptions, the leverage point might be found from addressing these contextual problems or creating opportunities for the employees to deal with them. Conflicting values can illustrate this reasoning: in a work context where economic pressures are salient, the group values associated with production may be stronger than those associated with safety. In this work context, explicating the relation between decisions made to meet economic pressures and their influence on safety can serve as a starting point for safety culture improvement, and/or the approaches to safety culture improvement can utilize economic arguments to make their intention more meaningful for this particular group. This example implies that safety culture change should consider the whole work context and the perceptions people may have.

Principle 6: Identify the assumptions embedded within safety culture change tools

Assumption: safety culture change tools embed assumptions on how they are to be used

Since the introduction of the concept of safety culture over 30 years ago, a wide variety of tools and methods have been developed that attempt to change safety culture. Some of the most common types of tools include safety culture trainings and seminars, influencing behaviour using, for example, Human Performance Programs, increasing the awareness of safety or safety culture through promotional materials, building employee involvement and participation, and developing organizational structures with the intent of ensuring a good safety culture (Viitanen et al., 2017). These safety culture change tools and methods are often specified or described in reports or guidelines directed at practitioners (e.g. IAEA, 1997; INPO, 2007, 2012a). The selection of documented tools and methods is quite heterogeneous and targeted at different system elements, which essentially suggests that the mechanisms of action also differ between the tools and methods.

All safety culture change tools are developed and used based on certain assumptions regarding how the tools function and influence the system. These assumptions can include the developers' views regarding safety culture and its change, models of the organization or perspectives of management and leadership. Because tool development is influenced and steered by these assumptions (either consciously or unconsciously), they get embedded in the tools. Sometimes the assumptions are explicated in tool descriptions or instructions, but often they are not. This may result in a mismatch between the assumptions made during the development of the tools, and the assumptions made by the end-user regarding the tools' intended function and effect. The mismatch can lead to the end-user utilizing the safety culture change tool in an unintended manner, or otherwise render the tool ineffective. Therefore, a sufficient understanding between those who develop or introduce the tools and those who implement them is needed: the end-user needs to be active in identifying and understanding the assumptions that the developer has embedded in the tools. This understanding helps ensure that the end-user is aware of the tool's function, benefits, and potential limitations and prerequisites of implementation. Effectively, the shared understanding would enable such an implementation of the tools that reflects their inherent nature. Alternatively, the shared understanding may also provide information regarding whether the tools can successfully be utilized for purposes they were not originally intended for. This may be useful in situations where the end-user identifies a novel and better use for a safety culture tool – something that the developer has not considered; or perhaps more commonly: when the end-user requires adaptation of the tool or method to suit a particular context.

From a wider perspective, assumptions are not only embedded within safety culture change tools and methods, but also within safety culture programs and development targets, safety culture models (either mental or documented) and overall approaches to safety culture improvement. The same insights apply as in the case of individual tools: the validity and applicability of the approaches should not be taken as granted (e.g., Viitanen, 2015). For example, one may be led to assume that behaviour change is the right way to change some aspect of safety culture, which may result in neglect of the reasons behind the particular behaviour pattern (e.g., bad structural design). In such a situation, it would be better to redesign the structures instead of attempting influence behaviour, because behaviour change would just be compensating for the underlying flaw. Overall, an informed caution is necessary when adopting safety culture improvement tools, methods or approaches: *even if they have been promoted as “best practice” or enforced by peer networks, they still might involve such assumptions that make them invalid in a particular context.*

Principle 7: Identify and make use of the indirect effects of safety culture change tools

Assumption: sociotechnical systems react and adapt to the effects of safety culture change tools

We make a distinction between direct and indirect effects of safety culture change tools. The direct effects of safety culture tools include changes in organizational structures (e.g. outcomes of tools that aim at organizational development) or behaviour (e.g. outcomes of tools that aim at behavioural modification). In addition to direct effects, all tools have various types of indirect effects. The indirect effects stem from the complex nature of organizations (for overview see e.g., Anderson, 1999; Reiman et al., 2015): sociotechnical systems that

involve humans are not machines and thus they cannot be “built up”. Instead, they grow, learn and adapt. This means that when using safety culture tools, attention is required on what kinds of adaptive and emergent patterns result. For instance, a change made in one part of the system may trigger adaptation in another part; sometimes leading to cascading and non-linear (much larger or much smaller than the initial, direct effect) outcomes, that sometimes can be system-wide.

The indirect effects, as defined here, are not necessarily negative (i.e., as is the case with adverse side effects), they can also be positive or neutral. In fact, the indirect effects, if well understood, can potentially be harnessed to create effects not otherwise possible. This can be the case when attempting a change in safety-related basic assumptions (cf. principle 8). Therefore, for a successful safety culture change it is essential to *keep a close eye on how the organization actually reacts to the implementation of safety culture tools*.

Principle 8: Acknowledge that safety culture cannot be directly changed

Assumption: indirect effects of safety culture tools are the only methodical way to change safety culture

In the context of principle 1 we briefly reviewed Reiman and Rollenhagen’s (2018) safety culture model that describes how values and assumptions iteratively change as a result of changes in behaviour and structures. One of the main messages of this model is that it is unlikely that there is a “direct access” through which values and assumptions can be changed – attempting to influence them directly is likely to be ineffective. Thus, the only way to influence values and assumptions is through changing behaviour or structures. This suggests that the key ingredient to methodical safety culture change is to understand the indirect effects of behaviour and structural change induced by safety culture change tools (cf. principle 7). It is often the case that the documents or instructions that describe safety culture change tools do not explicitly describe how they are supposed to influence culture: it is often taken for granted or just assumed. On the other hand, it is also possible that such a description would be futile in any case: all organizations and their cultures are unique and they are likely to react uniquely to standardized safety culture tools or methods. Therefore, it might not be possible to predict the indirect effects of safety culture change tools or methods before their actual implementation. Assuming that this is the case, *emphasis should be put on understanding the cultural mechanisms of the particular organization, and monitoring and following-up safety culture status when using any methods*.

Principle 9: Consider how power relations influence safety culture change

Assumption: power is a strong influencing factor in organizations

Understanding power relations is crucial in leading safety culture change; however, it is often neglected in safety culture studies (see e.g., Antonsen, 2009a). The interests of individuals in various positions of power influence the implementation and efficiency of safety culture activities. Different types of power exist, including formal power gained from organizational position, and other types of power that can stem from expertise, networks or charisma (Antonsen, 2009a). Top management commitment is viewed in many safety culture models as an important prerequisite for a good safety culture (e.g., IAEA, 2016a; INPO, 2012b). One

reason for this is the fact that top management is in a position of formal power in the organization. A weak top management commitment can mean that safety culture does not receive the attention or support needed for methodical improvement. Management commitment is a multi-faceted phenomenon and can manifest differently. Most often, a weak commitment manifests as insufficient resources or weak organizational position of safety culture experts. A conflicted situation is also possible: individuals at powerful positions can be “immune” to the organization’s safety culture themselves (i.e., they have the power to continue to make decisions that are detrimental to safety even if the organization disagrees). The conflicted situations may result when the top managers are unable to successfully deal with the incompatible interests of various stakeholders (e.g., owners whose interests are in production, authorities whose interests are in safety, personal interests in career development, etc.). On the other hand, power-related conflicts can also lead to positive outcomes: for example, a strongly committed individual in a position of power can help make a difference in safety culture even if most other organizational members are opposed to the change. We believe that the *key to managing organizational power relations is being aware of them and the challenges and opportunities they pose upon safety culture change activities.*

Principle 10: Involve the target group in safety culture change activities

Assumption: it is easier to make changes to culture locally, in close interaction with the target group

Organizational culture – especially its deeper elements such as values and assumptions – can usually be characterized as a dynamic, but stable phenomenon that does not change easily (Schein, 2010, see also principle 12). On the other hand, as discussed in the context of principles 4 and 5, culture can be diverse and is formed when organizational members interact. Thus, sustainable ways to implement safety culture change in ways that are compatible with the target groups should be identified, in order to avoid using an excessive amount of resources on futile or insignificant change efforts that are either rejected or resisted by the culture. *Approaching safety culture change from a local rather than global perspective* can help address this question.

In practice, locally tailored safety culture change can utilize organizational members that are characterized, for example, by high social connectivity (i.e., they are “hubs” who know everyone and who are known by everyone), or by having desirable safety-related competences or values. After the identification of these individuals, they can be utilized as drivers of positive influence towards safety culture by ensuring that they have sufficient opportunities to contribute to the development of a healthy safety culture. For instance, the method of safety culture ambassadors is one of the practical means to facilitate individual organizational member involvement and tailor safety culture change activities to local contexts (for further detail, see Viitanen et al., 2017, and chapter 4 and appendix of this report). Safety culture ambassadors are a group of people nominated from various parts of the organization (usually functional departments) whose purpose is to support managers in developing safety culture. Their activities may include, for example, bringing safety culture messages to the meetings of their respective units, ensuring that safety is taken into consideration in decision-making, and observing the atmosphere to identify trends that could be adverse to safety. It should, however, be noted that involving the target group in safety culture activities does not mean there should be no top-down involvement. In fact, both are needed as the local group is often

blind to its assumptions and may be thus hesitant to change things they consider meaningful, despite them being potentially detrimental on the system level (cf. principle 4).

Principle 11: All information acquired in safety culture activities may be useful in the future

Assumption: the meaning of information changes over time

Implementing safety culture interventions and conducting safety culture assessments usually produces a large amount of information about the organization and its culture. However, the usefulness of this information may vary. For instance, some of the insights gained from safety culture-related information at a given moment of time can include things that appear to be insignificant, irrelevant, or concern things that cannot be changed. However, due to the dynamic and evolving nature of sociotechnical systems, the meaning and relevance of the information can also change over time. Safety culture problems previously perceived as impossible to influence or inherent to the system can later be found to be trivial, and within the scope of common safety culture change tools. In other words, a sociotechnical system opens some opportunities as it develops over time and adapts to previous change initiatives, as it closes other opportunities. As one carries out various safety culture activities during a longer period of time, *care should be taken to avoid anchoring to initial preconceptions of what can and cannot be done to develop the system, because this may result in dismissing opportunities.*

Principle 12: Behaviour or structure change may result from safety culture change activities but do not expect rapid change in values and assumptions

Assumption: system elements vary in terms of temporal stability and susceptibility to change

The various classes of system elements react differently to attempts to influence them. As discussed in the context of principles 1 and 8, change in values and assumptions is an indirect result of the change in behaviour and structure. This suggests that the effect of intentional change in values and assumptions is likely to lag behind the changes in behaviour and/or structures. When successfully implementing a safety culture change tool or method, the direct effect of the method should result in behaviour or structure change, but most likely does not lead to significant, immediate change in values and assumptions.

Immediately after a change effort, the system can be seen to be in a non-equilibrium state: the behaviour and/or structures and values and assumptions do not reflect each other the same way as they did before, because the change initiative has disturbed system balance. If the system perceives the changes as useful and experiences successes as a result of their implementation (e.g., when personnel try out a working practice and find out that it makes their job easier and improves quality), eventually the values and assumptions may begin to change as the change is internalized. On the other hand, if the change is not perceived useful (e.g., if an organizational structure is implemented that cannot be integrated to existing activities), the system may protect itself against any changes to values and assumptions, and possibly also against change in structures and behaviours (e.g., by not complying or by developing workarounds). This means that if the safety culture change initiative is not

sufficiently in line with the content of the existing system elements (i.e., behavioural patterns, structures, and values and assumptions), even the interventions targeted at behaviour or structures might receive change resistance and thus become slow. The change may also be unsustainable if it is at odds with or not supported by other system elements: for example, once the safety culture initiative that changes behaviour is discontinued or workers become indifferent towards it, the behaviour may return to baseline (e.g., DeJoy, 2005).

The change in values and assumptions is therefore a result of a long-term evolution of the system. This evolution takes place naturally, as the system responds to various internal and external stimuli, but can be steered to some extent by changing behaviours and structures. Thus, *methodical safety culture change requires a long-term strategy, commitment and perseverance.*

Summary

The abovementioned principles represent a systemic approach to leading safety culture change, which is based on a variety of contemporary views of safety science and organizational management. The principles cover topics that include explicating the nature of sociotechnical systems and how culture forms and changes in them, how goals are set in complex, nested and conflicted systems, how various types of interactions can be leveraged for safety culture change, and how different time scales manifest when initiating culture change.

We propose that the principles can be utilized to support various practical endeavours at safety-critical organizations such as nuclear power plants. For example, the principles can support practitioners such as safety (culture) managers in the following ways:

- Help steer safety culture change activities
- Help decide which safety culture change tools or practices one should or could use, and how
- Help explain why a safety culture change effort has failed or proved ineffective
- Help identify the leverage points in the system that drive positive change in safety culture
- Help identify the prerequisites that are required for successful implementation of safety culture tools or methods

3. Safety Culture in Complex Projects

The safety culture change principles described in chapter 2 were developed with the assumption that they can be utilized both in on-going operations and in project environments. In this chapter, we will link generic characteristics of complex projects and the safety culture change principles in order to elaborate how the principles can be applied in project environments.

3.1 Generic characteristics of complex projects

Organizing businesses as projects is increasingly prevalent and the specifics of projects have been widely discussed in the literature. The Project Management Institute defines project as “*a temporary endeavour undertaken to create a unique product or service*” (Project Management Institute, 2013, p. 1). All projects thus have defined boundaries, a temporary nature and a unique goal, which determines the reason for its existence. Projects can be viewed as temporary organizations, distinct from permanent ones, as cultures with special characteristics, as safety-critical organizations where safety-critical work is done, or as networks of multiple companies⁵. Below we summarize key insights from existing literature.

An inherent characteristic of projects is that they are *time-delimited* (i.e., they have defined start and end points), which has consequences on how time is perceived in project. Time becomes a scarce resource, which in safety-critical context may result in either perceived or actual time pressures to achieve the predetermined task. Thus, the prioritization of economy over safety may occur more naturally in projects than in permanent organizations. Radical task orientation may ensue, which can contribute negatively to safety if corners are cut to keep the schedule, or if project completion is prioritized over quality. Time is more likely to be perceived from a linear perspective (instead of cyclical or spiral as might be more natural for continuous operations), which leads to activities being divided into distinct and sequential phases (e.g., initiation, planning, implementation and handover). This requires understanding of the unique goals, features and conceptions of what actions are desirable of each of the phases (Lundin & Söderholm, 1995; see also Gotcheva & Oedewald, 2015a for unique safety culture challenges and inherent developmental needs in each lifecycle phase of a nuclear power plant).

Projects are also characterized by their unique *team and group interdependencies* (Bakker, 2010). Project teams need to manage a diverse set of skills and knowledge while negotiating project uncertainties without having prior joint working experience. Shortcomings in managing the diverse project members can lead to misunderstandings regarding the requirements, regulations or procedures, lack of openness in communicating and reporting, and may eventually result in quality control deficiencies (see e.g., STUK, 2006, 2011). Project members may also be tempted to prioritize their own local goals as opposed to the overall goal of the project, which may affect commitment (Leufkens & Noorderhaven, 2011). The loyalties

⁵ In the intermediate report of this research activity we give a more detailed description of these lines of research, see: Viitanen, K., Gotcheva, N., & Rollenhagen, C. (2017). Safety Culture Assurance and Improvement Methods in Complex Projects – Intermediate Report from the NKS-R SC_AIM (No. NKS-381). NKS.

of project members thus need to be managed in relation to their membership in other projects, in the coordinating organization or in other social groups such as subcultures (Bakker, 2010).

New project teams may need to proceed with task implementation without having first developed *trust among team members*, or utilize alternative methods of developing trust, such as swift trust (Meyerson et al., 1996). Swift trust formation relies largely on focus on roles instead of persons, as well as on the reputation of project coordinator as being able to select trustworthy project members (Meyerson et al., 1996). In the nuclear industry, previous experience in the nuclear industry or other related safety-critical fields can influence perceived trustworthiness. In safety-critical domains, blind trust regarding the safety competency of team members may lead to adverse outcomes (Burt et al., 2009), which implies that a conservative approach to trust is necessary.

Projects exist to fulfil a specific and often complex *objective*, defined by the coordinating (or parent) organization (Bakker, 2010). Transparent and efficient interaction and bi-directional communication channels between the project and the coordinating organization are required for the task and its safety significance to be understood in the same way in the whole consortium. The coordinating organization and the project managers are in important roles in achieving this goal. In safety-critical projects, communication and cooperation between the various actors in the project consortium have been identified as important success factors (Hannevik et al., 2014).

Organizing in projects can also pose challenges to *knowledge management*. For instance, due to the time-delimited and potentially unique nature of projects, there can be a lack of continuity of activities, which can negatively affect the development of organizational routines, or disrupt the socialization processes leading to a lack of transferring tacit knowledge (e.g., Bresnen et al., 2003; Lindner & Wald, 2011). This can result in loss or fragmentation of knowledge (e.g., knowledge created in project remains in individuals, who then leave after the project ends), especially if strategies have not been devised for managing safety-related knowledge, which is often the case due to strong task-orientation.

Projects that operate in fields involving significant *safety risks* to the environment or society have been studied recently. Saunders (2015) identified the similarities and differences of safety-critical operational and project environments in order to ascertain whether the same models of achieving safety (specifically the High Reliability Organizations (HRO) theory, Weick & Sutcliffe, 2015) are applicable in both environments. While on-going operations and projects were found to differ by uniqueness of tasks or technology, time-delimitation, the extent of change, and level of uncertainty in the environment, sufficient amount of similarities were identified to argue that the HRO theory could bring useful insights to project management community. A “high reliability project organization” may include, for example, explication of trade-offs between cost-schedule-safety in project decision-making, building upon the experiences from prior safety-critical projects, facilitating openness and learning, and tolerating different viewpoints between the project members, and acknowledging that there are inherent uncertainties and paradoxes (e.g., allowing freedom vs. ensuring predictable delivery) in a project (Saunders, 2015).

Recent studies carried out in the Finnish nuclear industry context have argued for the need to frame projects as *networks of organizations* (Ruuska et al., 2009, 2011). This was triggered by the need to better understand the relationships between coordination of activities in a

subcontractor network and the overall system safety. To improve the success of complex projects, the networks should be managed both as a single entity and as a collection of partially autonomous partners. Oedewald and Gotcheva (2015a) used the Olkiluoto 3 nuclear power plant construction project as a case example to study how safety culture development is affected when the context is a complex dynamic network of subcontractors. They identified a set of challenges characteristic to networks. Identification of the unit of analysis is one challenge (i.e., whose culture should be assessed or improved). Acknowledging the temporary nature of the project network, and the discontinuation and insecurity that the project environment brings are other challenges (e.g., companies and individuals join and leave the network). It is also a challenge to acknowledge the national culture differences and heterogeneous nuclear knowledge of the actors. Oedewald and Gotcheva proposed that safety culture development activities should take the entire network as the unit of analysis, instead of focusing on separate companies, and further argued that because of the heterogeneity and dynamic nature of the network, the development of safety culture is especially crucial because formal management approaches are not able to govern the whole system. Following this line of thought, Kujala et al. (2016) highlighted in a recent study that in project networks, no single organization has full control over the project and multiple organizations are making decisions that influence the project performance. The perspective of viewing projects as networks emphasizes the importance of taking the complexity of nuclear industry projects into account when safety culture change initiatives are planned and implemented in projects, as well as paying attention to relationships between the project partners.

3.2 Safety culture change principles in projects

Due to its relatively general nature, *Principle 1: Consider the dynamics between classes of system elements* is likely to retain its essence when applied in the context of complex projects: the classes of system elements still interact with each other and influence the formation of culture. However, in case of complex, networked projects, the nature of actors can differ and the diversity of actors can be much higher than in a single company: a network culture forms as a result of the interaction between structures, behaviour, and values and assumptions between multiple companies. Companies participating in networked projects often come from different operating environments and thus have formed different manifestations of how to succeed within them. This may include, for example, values and assumptions concerning what is safe, appropriate, or desirable when it comes to work processes or products, or behavioural patterns, policies and procedures that result from the values and assumptions. Unless the network members have experience working together, it is also likely that network-wide, shared values and assumptions are weak and highly diverse, at least in the beginning of the project. They may, however align and strengthen over time if the participants manage to achieve their targets working together. Aligning the classes of system elements in the network and creating a strongly shared (or at least compatible) culture is thus likely to require effort, which includes both structural (e.g., contractual agreements between project members) and cultural approaches (e.g., ensuring interaction between project members). As a process, network culture formation is likely to be similar to when subcultures within one company interact, but unlike subcultures, companies in networks are more formally established and might not have had any previous contact with each other. Especially the formal establishment can make the cultures of the project members difficult to align, because applying changes to company policies or other organizational structures just for one project might not be considered worthwhile. Referring to Table 2, it is thus likely that, the project network's

culture may have more issues in terms of creating a shared mission, strength and consistency when compared to single companies.

Companies and actors have different positions, importance and influence in the project network. For instance, the main supplier of a turnkey project is in a very central role as ensuring that the whole supply chain functions as intended, while more peripheral suppliers have less influence on the functionality of the whole, and can often be interchangeable. The tasks and their safety-significance of the companies can also differ significantly. When leading safety culture development activities in a complex project, it is relevant to understand the structure of the network, how the companies are (formally and informally) connected, i.e., what is included in the project and what is not, where the project starts and ends. *Principle 2: Select the boundaries of the system you want to change* suggests that the system boundaries, which define who influences and is influenced by safety culture, need to be identified. For example, the target of the safety culture activity may be to affect the whole network directly (e.g., defining general requirements or distributing training materials to all project members). Alternatively, the target may be to affect it recursively (e.g., defining the requirements that each supplier must require from its own suppliers), or to only affect specific project members (e.g., assessing the state of safety culture of a particular project member, or carrying out safety culture trainings at selected project member companies).

Elaborating the concept of safety when implementing safety culture activities is important because it ensures that those who are targeted by the activity understand “safety” in the same way. In a complex, large-scale project, member organizations may not always have prior experience in the nuclear industry, and thus it is unlikely that they readily identify the nuclear safety significance of their work. Safety culture change efforts need to be well defined in such an environment, thus the relevance of *Principle 3: Select the system elements you want to change*.

In complex projects, various stakeholders often co-exist with a multitude of opportunities for collaboration (and conflicts) between them, which points to the importance of considering *Principle 4: Acknowledge that safety culture is not monolithic and internally coherent, and try to benefit from this*. Project actors typically have at least dual (own company vs. project organization), if not multiple loyalties (e.g., other projects), which can affect prioritization and dilute commitment to the joint project goals. Thus, the formation of universally shared culture might not be a feasible goal in projects, which implies that the existence of multiple subcultures needs to be considered as a context for improving safety culture. The heterogeneity of cultures in projects can be a positive thing for safe activities, since a system requires sufficient variety in perspectives and interpretations to regulate the safety-critical activities or to facilitate learning. On the other hand, from a safety culture improvement perspective, a sufficient level of shared understanding of the hazards and nuclear safety significance of tasks among project actors is also needed. For the coordinating organization, the challenge is to distinguish diverging, but informed perspectives from those that emerge from inexperience or unfamiliarity with the context.

The details of the scope of work, or what the project actors do as they actively interact through their daily efforts to implement the project, can be very diverse, but for the coordinating organization, sometimes difficult to grasp. However, following *Principle 5: Make an effort to understand what organizational members actually do and identify leverage points for safety*

culture change, for the safety culture activities to be effective, the coordinating organization needs to get to know its project network, understand what kinds of issues the organizations face, and what their operating environment and daily reality is like. Interactive methods may be useful for carrying out this effort, such as project network seminars, working groups, or cross-organizational workshops (see e.g., project management seminar, Viitanen et al., 2017, Chapter 3.2). Similarly, during the implementing safety culture activities in the project network, *Principle 10: Involve the target group in safety culture change activities* should be considered. This means that various local groups in projects should participate in the design of safety culture initiatives, to make them more meaningful for them, and from the perspective of their actual work. The notion of “local group” may relate to a specific company or its department, differentiation based on hierarchical level, language, age, tenure, remote actor such as a manufacturing site abroad, a subcontractor company, etc.

Change is inevitable in complex projects. However, the assumptions behind the multitude of change initiatives (incl. safety culture-related ones) are often left implicit. This relates to *Principle 6: Identify the assumptions embedded within safety culture change tools*. Many of the methodical approaches to safety culture are developed in the context of a nuclear power plants in operating phase. Considering the history of nuclear new builds (i.e., after the introduction of the concept of safety culture, not many newly established nuclear power companies have been introduced), the safety culture improvement tools are probably based on the assumption of a stable, established nuclear organizations. In the review of common safety culture improvement methods, we did not find methods that would specifically take project environments into account (Viitanen et al., 2017). The main safety culture challenges of operating plants are most likely related to things like avoiding complacency and ensuring continuous improvement, dealing with generation changes and aging phenomena, and ensuring successful normal performance (Gotcheva & Oedewald, 2015b), which differ from complex projects, or organizations in other phases. Thus, the underlying assumptions of a safety culture change tool need to be identified and it needs to be evaluated whether they are still valid in project context. For instance, in a complex project network with a large number of companies, safety culture assessments that are geared towards an in-depth evaluation of a single organization are not economically feasible to implement. Lighter and more agile ways to assess safety culture are needed (e.g., using safety management audits for safety culture evaluations, Reiman & Viitanen, 2018). Similarly, if a safety culture change tool requires the long-term presence of the same individuals to build a shared culture (e.g., continuous acculturation workshops or trainings), the fast turnover of staff and companies may make this tool inefficient: a quicker and more efficient may be needed.

Projects are sociotechnical systems; as such, they react and adapt to the effects of safety culture change tools: it needs to be acknowledged that a change made in one part of the project network may trigger unanticipated change in another part of the network, which can in turn have network-wide indirect effects. This can be further amplified due to the large scale and multitude of the activities and actors in a complex projects. For example, the introduction of a safety culture change tool by one influential and highly connected project network member, can result in its (same kind of) implementation in the whole network. This is not always desirable, especially if the tool is not applicable everywhere. On the other hand, if it is, getting the “buy-in” from the influential network member can be the key to changing the whole network culture. Another example could relate to rewarding (a tool, which can be used for influencing safety culture) in project environment: a rewarding strategy based solely on

achieving such project goals as schedule, budget or task completion may contribute to the development of a culture where it is not natural to take safety into consideration in decision-making. The rewarding strategies need to be carefully designed to avoid adverse side effects to safety motivation (Kujala et al., 2016). Thus, the consideration of *Principle 7: Identify and make use of the indirect effects of safety culture change tools*, is relevant. The indirect effects in complex systems can be seen as an opportunity to deliver desired changes, which may otherwise be impossible to bring up systematically. However, continuous awareness of the dynamic effects and feedback loops between the different factors of the system is needed.

This leads to *Principle 8: Acknowledge that safety culture cannot be directly changed*, which points to limited number of options when safety culture change is planned. In safety-critical engineering projects, managers may tend to rationalize the approach for changing culture by assuming that safety culture can be changed directly by planning the change, implementing it and seeing the effects. However, project leaders have an important role to provide inspiration and information through which they need to nurture the foundation for safety culture change: project leaders need to focus on changing behaviours and project structures, which can then result in safety culture change, possibly reflected in values and assumptions of the project actors. This may require a change from traditional project management mind-set.

People in positions of power have a strong influence of defining what kind of culture is nurtured and what the possibilities for culture change are. In projects, project managers and the way they manage conflicting (or otherwise the multiplicity of) goals are in an important formal role in creating the prerequisites for a safe and high quality end product. Projects naturally tend to be highly task-oriented, emphasizing the goals of schedule, budgets and task completion. Project managers as responsible for meeting these goals need to be able to acknowledge the effects of their decisions in relation to safety and quality of the end product. In best-case scenario, decision-making power in the project is given to actors with the necessary information to enable them to make appropriate decisions and to understand the effect of decisions on overall performance (Kujala et al., 2016). However, this is not always possible and other means for ensuring project management safety commitment should be utilized (e.g., project management safety (culture) training, structural means of assuring that safety is taken into consideration in project decisions, such as safety committees with sufficient power). When aiming at maintaining or creating good safety culture in projects, awareness of the nature and dynamics of power relations requires the fulfilment of *Principle 9: Consider how power relations influence safety culture change*.

Achieving *Principle 11: All information acquired in safety culture activities may be useful in the future* can be challenging to implement in complex projects because there are a number of reasons that can cause the loss or insufficient consideration of this kind of information and knowledge in projects. These include time pressures towards the project completion, high personnel turnover, lack of motivation or willingness to put efforts to learn from mistakes or share successes, lack of enforced and institutionalized practices and coordination for project-based learning and not having sufficient skills to utilize learning methods. Focus on milestones and the energy needed for implementing each project phase makes it difficult to keep a long-term focus. The information acquired in safety culture activities typically highlights major and minor deficiencies and contains a set of recommendations for improvement. Perceiving such information as potentially useful in the future may call for

senior management who is willing and able to listen to negative news and to gain a “big picture” about the project.

Time pressures in project contexts can also affect the depth of culture formation regarding basic assumptions: short-lived temporary organizations or turnovers of personnel and companies do not provide a fruitful foundation for the development of a shared culture. This relates to *Principle 12: Behaviour or structure change may result from safety culture change activities but do not expect rapid change in values and assumptions* – especially in complex and dynamic project context, changes are likely in project actors’ behaviours and structures but not that long-lived in values and assumptions. This may call for a graded approach to safety culture change activities where the longer-term companies, groups or individuals are identified and more the profound activities that aim at the development of deeper cultural elements are targeted towards them.

Table 4 Table 1 summarizes the links between safety culture change principles and complex projects.

Table 4. Examples of links between safety culture change principles and complex projects	
	Link to complex projects
<u>Principle 1</u> : Consider the dynamics between classes of system elements	In a project network, companies interact to create culture, not only groups and individuals; thus, it may be challenging to create a shared mission, and a strong and consistent culture in a project network
<u>Principle 2</u> : Select the boundaries of the system you want to change	The roles and positions of project network members need to be identified and their implications assessed
<u>Principle 3</u> : Select the system elements you want to change	Project members come from different operational environments and their conceptualization of safety may differ
<u>Principle 4</u> : Acknowledge that safety culture is not monolithic and internally coherent, and try to benefit from this	Complex projects are characterized by diverse members and multiple loyalties; this diversity can be both a good and a bad thing
<u>Principle 5</u> : Make an effort to understand what organizational members actually do and identify leverage points for safety culture change	The coordinating organization needs to get to know its project network and understand the operational environment of its members
<u>Principle 6</u> : Identify the assumptions embedded within safety culture change tools	Commonly used safety culture change tools are developed for operating plants, which may mean that they are not directly applicable in projects: the assumptions underlying their functionality need to be evaluated before implementation
<u>Principle 7</u> : Identify and make use of the indirect effects of safety culture change tools	Project networks can be very large and unexpected behaviour may occur: the outcomes (incl. unexpected ones) of interventions need to be constantly monitored
<u>Principle 8</u> : Acknowledge that safety culture cannot be directly changed	Project managers are most likely to be the leaders of culture formation – a mindset change from traditional project management may be needed in safety-critical projects
<u>Principle 9</u> : Consider how power relations influence safety culture change	Project managers and the way they manage project goals are central in creating the prerequisites for a safe and high quality end product; their safety competence and awareness of the safety consequences of their decisions is crucial
<u>Principle 10</u> : Involve the target group in safety culture change activities	To ensure effective safety culture change, the tools need to be implemented in a way that is meaningful for the project members
<u>Principle 11</u> : All information acquired in safety culture activities may be useful in the future	Short-term, task-oriented project environment can lead to a neglect of long-term knowledge goals
<u>Principle 12</u> : Behaviour or structure change may result from safety culture change activities but do not expect rapid change in values and assumptions	Temporary nature of projects and turnover of personnel and companies can make the formation of shared values and assumptions difficult

4. Case Study: Safety Culture Ambassadors

4.1 Introduction

In recent years, several organizations in the nuclear industry have implemented a safety culture ambassadors group – a novel approach for safety culture improvement. Safety culture ambassadors are a group of people nominated from different parts of the organization to participate in supporting safety culture activities as an addition to their normal duties. They have various tasks ranging from providing an opportunity for the employees to voice their concerns or initiatives, observing activities and intervening if safety might be compromised, or otherwise promoting and encouraging safety-conscious activities in daily work (Viitanen et al., 2017).

4.2 Background and methods

In the previous year (2016) of this NKS activity we conducted a case study which focused on safety culture ambassadors at a nuclear industry organization (Organization A) with a purpose of understanding how this method of improving safety culture is implemented and how it can improve safety culture (for further details, see Viitanen et al., 2017). At the time of our case study the ambassadors group was at an early stage of its implementation. This year (2017), Organization A began a reorganization of the safety culture ambassador group. As a preparatory work for this reorganization, Organization A conducted interviews with all ambassadors and reviewed other materials of relevance. The main insights from the preparatory work for this reorganization were made available to the researchers, and served as a follow-up to the previous year's case study.

In addition, a workshop was held with safety culture experts from Organization A and a Nordic nuclear power company (enumerated as Organization D to distinguish from other case studies in this research activities), which also had (independently) implemented safety culture ambassadors group. The purpose of this workshop was to share, discuss and compare the knowledge gained from practical implementation experience in both organizations, and in relation to the findings of previous year's case study.

A summary and discussion of the overall findings regarding safety culture ambassador's method are presented in the next chapter. We focused mainly on the goals and purposes of the ambassador group, the experienced benefits, implementation challenges and ways to address them, and the management and coordination aspects. Furthermore, a comparison between the approaches of Organizations A and D is made to identify overarching themes and good practices.

4.3 Findings

4.3.1 Follow-up of case study at Organization A

The formally specified purpose of the ambassador group at Organization A was to support managers in implementing a good safety culture and to facilitate the sharing of safety-related information. During our case study in 2016, we found that safety culture ambassadors could be potentially useful for a wide variety of activities, including facilitating interaction and communication between employees, training personnel, monitoring the state of safety culture,

promoting safety culture-related issues and influencing staff's behaviour through interventions. We also identified some examples of experienced benefits in the interviews with the ambassadors: being an ambassador was viewed as a useful pretext for bringing up safety-related topics and promoting safety culture in various situations (e.g., in meetings). Furthermore, the ambassador group meetings were viewed as a useful hub for transferring and receiving information between departments and ambassadors, and as a useful source of information for monitoring the state of safety culture in the organization. At that point of the implementation, the safety culture ambassadors did not yet have an exact job description and therefore their activities varied widely. The focus, however, was on promotion of safety culture, facilitation of communication and monitoring the state of safety culture.

In the 2017 follow-up, more concrete examples of experienced benefits became available. For example, safety culture ambassadors were found to be an essential element in maintaining and increasing the visibility of safety culture at the organization. Due to the representativeness of the ambassadors (i.e., most departments had an ambassador), they were also found to be an important link between the departments and safety culture experts. Consequently, the safety culture experts viewed the ambassadors group as a valuable source of information regarding what is happening in the departments in terms of safety culture. Furthermore, safety culture ambassadors were found to be useful as a redundant, easy-to-talk-to channel for the personnel to convey their concerns or initiatives. Overall, the experienced benefits in 2017 were relatively similar to the early signs of benefits or potential benefits hypothesized in 2016.

In 2016, we identified various challenges that can influence the effectiveness and usability of the use of ambassadors as a method for safety culture improvement. One of the key challenges related to the definition of roles and tasks. This challenge was further complicated because the ambassadors themselves had differing views of what their role and tasks should be, which manifested in a need to balance between harmonization and contextual adaptation of the implementation (incl. task definition), and to balance the workloads between the ambassador tasks and primary job tasks. One of the reasons behind this was the diversity of the ambassador group. In addition, challenges were found in creating awareness among co-workers of the existence of the ambassadors group and in ensuring sufficient safety culture related training and competence of the ambassadors. Being able to create and maintain trust in the relationship between ambassadors and other personnel was found to be an important success factor.

In 2017, Organization A identified development needs for safety culture ambassador activities and formulated actions to rectify them. The main themes related to formal implementation, and daily management and coordination of the safety culture ambassadors group. Defining ambassador tasks and roles remained an issue and was raised up by almost all of the ambassadors during the follow-up interviews. The safety culture experts from Organization A concluded that the ambassadors' activities should be clarified and simplified to make the activity more focused. One approach under discussion was making a distinction between the activities that the ambassadors do as a group (or as sub-groups), and the activities that the ambassadors do as individuals. For example, as a group, the ambassadors could go through observations or initiatives from their respective departments, as sub-groups contribute to a specific, on-going task in the organization (e.g., self-assessments), and as individuals observe and promote good safety culture in daily work in their respective departments. Overall, the development plan for the ambassador group at Organization A appeared to favour doing a

specific set of tasks well instead of trying to do everything at once. This implies that a gradually changing approach for task definition might be most appropriate.

The safety culture experts from Organization A also found that creating a common understanding of the expectations set for the ambassadors is one of the prerequisites of a successful implementation of the ambassadors group. This can include, for example, helping it make clear what is required of a safety culture ambassador (i.e., specification of the expectations and obligations), and ensuring that the ambassadors are committed to organize their work so that they can be active in carrying out ambassador activities. The safety culture experts acknowledged that for personnel in some jobs, ambassadors' tasks can more easily be integrated to the primary work than in others. This suggests that some individual ambassadors may require more support for integrating the ambassador obligations to their work.

Top management support was regarded as another important prerequisite for the implementation: for example, the safety culture experts found that a statement describing top management's expectations concerning the safety culture ambassadors would help establish the group and its activities in the organization.

The safety culture ambassadors' group meetings were previously the main way of coordinating the group's activities in Organization A. While the group meetings were considered useful and essential as such, the ambassadors considered that the meetings should be organized more frequently and with a clearer agenda. This finding was probably a result of the recent inactivity of the group when regular meetings were not held and may indicate that there is a need for a continuous maintenance of such a group in order to keep it functioning. To address this issue, the safety culture experts at Organization A decided to ensure that regular and more frequent group meetings with semi-formal agendas (e.g., with default structure and items in each meeting) are held. Furthermore, a parallel system of safety culture working groups for specific tasks (e.g., self-assessments, safety culture promotion, etc.) is being developed. This is expected to address the issue of finding common tasks for the diverse group of ambassadors: when the ambassadors are clustered into relatively homogeneous sub-groups they can more easily carry out similar tasks.

Other developmental needs and possible solutions were identified. This included the monitoring and follow-up of safety culture ambassadors' activities (e.g., through monthly reporting or informal meetings) and addressing training needs (e.g., by making more information about safety culture available to the ambassadors, or creating practical examples of what the ambassadors should do). A need to promote the existence of the group (e.g., by introducing the ambassadors already in the induction training) was also identified.

4.3.2 Information exchange with Organization D

At Organization D, safety culture ambassadors have been utilized in two waves, with different approaches and with different purposes. The first wave took place in mid-2000s. Back then, Organization D aimed to introduce the concept of safety culture to their personnel by organizing a series of large, cross-functional seminars on the topic. Safety culture ambassadors were selected from all departments to act as teachers in the seminars, and to support in developing training materials. The safety culture experts from Organization D regarded ambassadors group as essential in making the concept of safety culture known and appreciated at Organization D. However, once the organization stopped holding the large

seminars, the ambassadors group became passive. This indicates that the ambassadors group was mainly created and used for supporting that particular organizational change project, without a built-in mechanism for renewal.

The second wave, or the restart of the safety culture ambassadors group, started in mid-2010s. Safety culture ambassadors were now reframed as a support for the daily activities in their respective units, rather than being support for organization-wide activities. The original goal was to have multiple ambassadors in all departments, but this was not achieved and only the most safety-critical departments set up an ambassador group. The ambassadors were nominated from the departments' units. The ambassadors within each department coordinated their activities through regular meetings where they, for instance, exchange experiences and discuss topical issues, or meet ambassadors from other departments.

The ambassadors' role was defined as doing safety culture work as a part of their normal work. Their role was formalized in the management system, yet kept sufficiently general to retain flexibility so that it could be adapted to the working context of each of the ambassadors. An effort was made to define the role in more detail together with the ambassadors in workshops. Examples of the role descriptions from the workshops included: ambassadors are role models that are visible in the field and listen to the personnel; they react to unwanted behaviour; and they support the continuous development of safety at the plant. The workshops were considered as exercises to help build a shared understanding of the nature of safety culture ambassadors group, and also set targets for future development. However, the safety culture experts from Organization D felt that translating these expectations or roles to concrete tasks was challenging: it proved to be difficult for the ambassadors to relate safety culture to their normal work in such a manner that they would come up with concrete safety culture improvement tasks. Since the working context of the each individual ambassador is different, the safety culture experts cannot always explicate specific tasks for everyone. Overall this suggests that ambassadors may require support (e.g., from safety culture experts) in finding the best way for them to carry out the ambassador tasks, and that this needs to be done in collaboration with the individual ambassador.

Concerning experienced benefits, the safety culture experts from Organization D found that for them, the reformed safety culture ambassadors group is especially useful for monitoring the state of safety culture. The ambassadors can help support or confirm what the experts have observed in the organization, or elaborate on specific issues (e.g., in case the safety culture experts have questions about what is going on in the field). In this sense, they provide an easy-to-reach communication channel for the safety culture experts. Furthermore, the ambassadors were found to be useful for promoting safety culture in the field (e.g., by being good role models). In comparison to the first wave of implementation, this means that the ambassadors now serve a different purpose and address different organizational needs.

4.4 Comparison and discussion

Both case organizations shared the same overall approach in their implementation of the safety culture ambassador group: a group of individuals from different departments was assembled with the general purpose of improving safety culture. This is arguably the defining characteristic of the method of safety culture ambassadors. However, if concrete tasks of the ambassadors are examined in more detail, some contextual differences emerge. For instance, the ambassadors at Organization D initially had only one main task (training), while

ambassadors at Organization A had a very wide variety to activities that they did naturally as part of their daily work. When Organization D restarted the ambassadors group, the focus moved to daily work. This suggests that the ambassador's method can readily be *adapted* to various purposes, depending on the organization's current needs.

The potential for a diverse and flexible implementation can also pose a problem. The case study at Organization A shows that assigning too many or unclear tasks for the ambassadors at the early stages of the implementation can cause frustration or confusion among the ambassadors, which may potentially weaken the effectiveness of the method. Difficulty in defining clear tasks was also found to be a challenge in the second wave of implementing safety culture ambassadors at Organization D. The underlying reason for this appeared to be the very diversity of the ambassador group: it is difficult to assign common tasks for a group of people that work in very different contexts and have different sets of competencies. Organization A attempted to address this by creating homogeneous sub-groups of ambassadors with common tasks (working groups), while Organization D attempted to address the issue by organizing workshops, which aimed to support the ambassadors in their effort of identifying the most suitable ways for them to conduct their activities in practice. Although certainly plausible, at this stage of the implementation it was not yet clear how successful these actions were.

Another overarching theme that relates to flexibility of implementation is that there seems to be a certain level of *need for renewal* of the safety culture ambassadors group. As illustrated by the first wave of ambassadors at Organization D, if the group is not able to renew and change its purpose, it may become stagnant and eventually fade away – especially if it is tied to a specific project or need, which may end as the organization grows and develops. And vice versa, as pointed out by ambassadors at Organization A, the ambassador group should not be used as a long-term fix for organizational deficiencies, but as a (relatively) temporary support for the managers that develop the more permanent solutions. This suggests that while clear focus and purpose are important success factors in the implementation of the ambassadors group, so is the capability to change the purpose (and consequently the tasks of the ambassadors) if the organization's current or anticipated needs necessitate this. This may call for a regular follow-up, evaluation of the relevance and redefinition of ambassador activities, perhaps jointly with the ambassadors, safety culture experts and top management. Thus, an informed identification of the organization's development needs is crucial: unless properly specified, such activities may be assigned for the ambassadors, which may make the group dysfunctional or unsuccessful.

The ambassador group also requires some sort of *continuous management and coordination* to keep the activities ongoing and the ambassadors motivated and, for example, to share information between the ambassadors and the safety culture experts. While both Organizations A and D utilized meetings for the coordination, they had slightly different approaches due to the way in which the ambassador groups were organized. Organization A holds joint ambassador meetings, where all ambassadors are expected to participate, and is in process of introducing task-specific working group meetings, where sub-sets of ambassadors participate depending on their interests and competences. Organization D, on the other hand, holds meetings within the departments where ambassadors from different units have been nominated, and ambassadors from other departments also participate optionally. Since the ambassador meetings are useful both for coordinating the ambassadors and for information

sharing between the ambassadors (or other meeting participants), the selection of participants may require acknowledging trade-offs. In small and task or unit-specific meetings, there are less opportunities for organizational learning, but easier to find common ground. In large and organization-wide ambassador meetings, there are more opportunities for organizational learning, but harder to find common ground. This suggests that arranging different types of coordination and information sharing meetings may be required to ensure both effective coordination and organizational learning.

In both Organizations A and D *benefits* were experienced on two levels: from organizational perspective, and from the perspective of the safety culture experts. The former type of benefit included improved visibility and knowledge of safety culture, improved safety-related communication, and in general carrying out face-to-face safety culture work that has the potential to increase personnel involvement. These stemmed from activities that the ambassadors carried out in the field together with co-workers. The latter type of benefit was directed at the safety culture experts and included mostly monitoring of the state of safety culture in the field, or serving as an extra resource for the safety culture experts.

Table 5 summarizes the comparison between the implementations of the safety culture ambassadors group at Organizations A and D. As a conclusion to the case study, we propose that consideration of the following factors is essential in implementation of a safety culture ambassadors group:

- A clear definition of the purpose and expectations with regards the ambassadors group
- Support for individual ambassadors in defining their concrete activities
- Top and line management commitment, which would support, for example, setting expectations for the ambassadors group, and help finding solutions for allocating resources for ambassador responsibilities and balancing between the primary job responsibilities
- Practices for continuous management and coordination of the ambassadors group, which may include, for instance, joint meetings
- Mechanisms for following up the functionality and effectiveness of the ambassadors group against the organization's development needs, and for the renewal of the purposes and activities if needed

Based on the insights from the implementation of safety culture ambassadors groups at Organizations A and D, we formulated a tentative guideline (Appendix), which can be utilized as a reference for safety practitioners considering to implement the method in their organizations.

Table 5. Summary of the comparison of safety culture ambassadors groups between Organizations A and D			
Theme	Organization A	Organization D first wave	Organization D second wave
Purpose	Support managers in implementing good safety culture, facilitate the sharing of information	Train the personnel on the concept of safety culture	Provide support for safety culture-related issues in daily work
Implementation Nomination of ambassadors Ambassadors' tasks Target of ambassadors' activities Experienced challenges	From all departments Function as a link between safety culture experts and other personnel, provide safety culture-related information to the personnel, make observations, promote the principles of good safety culture, act as good example Ambassador's respective department, organization-wide tasks or projects Definition of tasks and expectations, balancing between primary tasks and ambassador tasks	From all departments Act as teachers and development of training materials on safety culture for organization-wide seminars Whole organization n/a	From units in selected departments (most safety-critical) Doing safety culture work in own unit as part of normal work Ambassadors' respective units Translation of the ambassador role to concrete tasks
Management and coordination	Regular ambassador group meetings, working groups	n/a	Regular ambassador meetings within units
Experienced benefits For the organization For safety culture experts	Maintaining and increasing the visibility of safety culture, channel for personnel for conveying concerns or initiatives, hub for transferring and receiving information between departments and ambassadors (group meetings) Source of information about what is happening in the departments, support and feedback for specific questions or tasks	The concept of safety culture became known and appreciated in the organization n/a	Maintaining the visibility of good safety culture in the field (e.g., by being good role models) Useful for monitoring the state of safety culture in the organization and easily reachable sources of additional information about issues on hand

5. Conclusions

In this research activity, we aimed to create insight and to support safety (culture) practitioners working in temporary and dynamic organizational contexts in their effort to assure and improve safety culture. The issues that motivated our research study included the following: What practical safety culture tools and methods are available? How do they influence safety culture? Are they generalizable across contexts (incl. project organizations)? What are the success factors of their implementation, and what assumptions do they embed? Can they be tailored to meet the requirements and constraints of temporary and dynamic organizations? The research study had the following aims: 1) to identify and specify methods to improve and facilitate safety culture in complex projects and 2) to identify and specify methods to assure safety culture in complex projects.

To address these aims, we collected descriptions of safety culture tools or methods from scientific and practitioner-oriented literature and found a large and diverse variety of tools that can potentially be useful for improving safety culture. Tools that were explicitly reported to be designed for or to be utilized in project organizations were not found at that point (see however Reiman & Viitanen, 2018). We also created an overview of how project environments can potentially influence safety culture, its formation and improvement, viewing projects from the perspectives of time (e.g., temporary and sequential nature, scarcity), team (e.g., diversity, trust-building), task (e.g., radical task and action orientation) and context (e.g., losing knowledge and culture, existence of subcultures). Some of these characteristics were also identified in the empirical studies carried out in 2016. Finally, we proposed a tentative framework for evaluating safety culture improvement methods. These findings were reported in the intermediate report of this research activity⁶.

To provide guidance in utilizing the existing safety culture tools, we produced a set of twelve principles of safety culture change. They draw from theories of sociotechnical systems, organizational culture and management to summarize the good practices of leading safety culture change. The principles can be utilized by safety (culture) practitioners in, for example, the selection, implementation and use of safety culture tools. To address the question of safety culture assurance and improvement in project environments, we related the generic characteristics of project environments to the principles to identify how the principles can be understood in project context. We believe that the principles are instrumental in ensuring that safety culture activities are carried out in an informed manner, avoiding mechanistic and superficial approaches. This work is presented in chapters 2 and 3 of this report.

To specify new methods for safety culture assurance and improvement, we produced a guideline for implementing a safety culture ambassadors group on the basis of the empirical work done during the research activity. The empirical work on the topic of safety culture ambassadors consisted of a case study at one nuclear power organization (which was the main case study in 2016), follow-up of the case study, and information exchange with another nuclear power organization. Due to the flexibility and adaptability of the ambassador's

⁶ For details, see: Viitanen, K., Gotcheva, N., & Rollenhagen, C. (2017). Safety Culture Assurance and Improvement Methods in Complex Projects – Intermediate Report from the NKS-R SC_AIM (No. NKS-381). NKS.

method, and the evidence gained from the heterogeneous case studies, we propose that it is likely to be applicable in (almost) any type of nuclear organization, including project organizations.

Acknowledgements

NKS conveys its gratitude to all organizations and persons who by means of financial support or contributions in kind have made the work presented in this report possible.

The authors express gratitude to the personnel at the nuclear organizations for their great collaboration during the data collection and information exchange for the case studies.

Disclaimer

The views expressed in this document remain the responsibility of the author(s) and do not necessarily reflect those of NKS. In particular, neither NKS nor any other organisation or body supporting NKS activities can be held responsible for the material presented in this report.

6. References

- Anderson, P. (1999). Perspective: Complexity Theory and Organization Science. *Organization Science* 10: 216–232. <http://doi.org/10.1287/orsc.10.3.216>
- Antonsen, S. (2009a). Safety culture and the issue of power. *Safety Science* 47: 183–191. <http://doi.org/10.1016/j.ssci.2008.02.004>
- Antonsen, S. (2009b). *Safety culture: theory, method and improvement*. Farnham, England: Ashgate.
- Bakker, R. M. (2010). Taking Stock of Temporary Organizational Forms: A Systematic Review and Research Agenda: Temporary Organizational Forms. *International Journal of Management Reviews* 12: 466–486. <http://doi.org/10.1111/j.1468-2370.2010.00281.x>
- Bresnen, M., Edelman, L., Newell, S., Scarbrough, H., & Swan, J. (2003). Social practices and the management of knowledge in project environments. *International Journal of Project Management* 21: 157–166. [http://doi.org/10.1016/S0263-7863\(02\)00090-X](http://doi.org/10.1016/S0263-7863(02)00090-X)
- Burt, C. D. B., Chmiel, N., & Hayes, P. (2009). Implications of turnover and trust for safety attitudes and behaviour in work teams. *Safety Science* 47: 1002–1006. <http://doi.org/10.1016/j.ssci.2008.11.001>
- By, R. T. (2005). Organisational change management: A critical review. *Journal of Change Management* 5: 369–380. <http://doi.org/10.1080/14697010500359250>
- Cameron, K. S., & Quinn, R. E. (2006). *Diagnosing and changing organizational culture: based on the competing values framework*. Revised edition. San Francisco: Jossey-Bass.
- Choudhry, R. M., Fang, D., & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. *Safety Science* 45: 993–1012. <http://doi.org/10.1016/j.ssci.2006.09.003>
- DeJoy, D. M. (2005). Behavior change versus culture change: Divergent approaches to managing workplace safety. *Safety Science* 43: 105–129. <http://doi.org/10.1016/j.ssci.2005.02.001>
- Denison, D. R. (1990). *Corporate culture and organizational effectiveness*. New York: Wiley.
- Glendon, A. I., Clarke, S., & McKenna, E. F. (2006). *Human safety and risk management*. 2nd edition. Boca Raton, FL: CRC/Taylor & Francis.
- Gotcheva, N., & Oedewald, P. (2015a). SafePhase: Safety culture challenges in design, construction, installation and commissioning phases of large nuclear power projects (Research No. 2015:10). Stockholm: Strålsäkerhetsmyndigheten. Retrieved from http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Sakerhet-vid-karnkraftverken/2015/SSM_Rapport%202015-10_webb.pdf
- Gotcheva, N., & Oedewald, P. (2015b). Safety culture challenges in different lifecycle phases of nuclear power plants. In P. Oedewald, N. Gotcheva, K. Viitanen, & M. Wahlström (Eds.),

Safety culture and organisational resilience in the nuclear industry throughout the different lifecycle phases. pp. 91–106. Espoo, Finland: VTT Technical Research Centre of Finland Ltd.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety Science* 34: 215–257. [http://doi.org/10.1016/S0925-7535\(00\)00014-X](http://doi.org/10.1016/S0925-7535(00)00014-X)

Hannevik, M. B., Lone, J. A., Bjørklund, R., Bjørkli, C. A., & Hoff, T. (2014). Organizational climate in large-scale projects in the oil and gas industry: A competing values perspective. *International Journal of Project Management* 32: 687–697. <http://doi.org/10.1016/j.ijproman.2013.08.006>

IAEA. (1991). INSAG-4. Safety Culture. Vienna: International Atomic Energy Agency.

IAEA. (1992). INSAG-7. The Chernobyl Accident: Updating of INSAG-1. Vienna: International Atomic Energy Agency.

IAEA. (1997). Examples of safety culture practices. Vienna: International Atomic Energy Agency.

IAEA. (2006a). Application of the Management System for Facilities and Activities. Safety Guide No. GS-G-3.1. Vienna: International Atomic Energy Agency.

IAEA. (2006b). Fundamental safety principles. Vienna: International Atomic Energy Agency.

IAEA. (2016a). Leadership and Management for Safety. No. GSR Part 2. Vienna: International Atomic Energy Agency.

IAEA. (2016b). Performing Safety Culture Self-Assessments. Vienna: International Atomic Energy Agency.

INPO. (2007). Human Performance Tools for Managers and Supervisors. General Practices for Organizing, Planning, Monitoring, and Feedback That Promote Excellence in Human Performance (No. 07-006). Institute of Nuclear Power Operations.

INPO. (2012a). Benchmarking – Nuclear Safety Culture Practices (No. 12-006). Institute of Nuclear Power Operations.

INPO. (2012b). Traits of a healthy nuclear safety culture (No. 12-012). Institute of Nuclear Power Operations.

Kujala, J., Aaltonen, K., Gotcheva, N., & Pekuri, A. (2016). Key Dimensions of Project Network Governance and Implications to Safety in Nuclear Sector. Presented at the European Academy of Management (EURAM), Paris, France.

Leufkens, A. S., & Noorderhaven, N. G. (2011). Learning to collaborate in multi-organizational projects. *International Journal of Project Management* 29: 432–441. <http://doi.org/10.1016/j.ijproman.2011.01.004>

- Lindner, F., & Wald, A. (2011). Success factors of knowledge management in temporary organizations. *International Journal of Project Management* 29: 877–888. <http://doi.org/10.1016/j.ijproman.2010.09.003>
- Lundin, R. A., & Söderholm, A. (1995). A theory of the temporary organization. *Scandinavian Journal of Management* 11: 437–455. [http://doi.org/10.1016/0956-5221\(95\)00036-U](http://doi.org/10.1016/0956-5221(95)00036-U)
- Martin, J. (1992). *Cultures in organizations: three perspectives*. New York: Oxford University Press.
- Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In R. M. Kramer & T. R. Tyler (Eds.), *Trust in organizations: Frontiers of theory and research*. pp. 166–195. California, United States: SAGE Publications, Inc.
- Mkrtchyan, L., & Turcanu, C. (2012). Safety Culture Assessment Tools in Nuclear and Non-Nuclear Domains (No. SCK•CEN-BLG-1085). Belgian Nuclear Research Centre. Retrieved from <http://publications.sckcen.be/dspace/handle/10038/7763>
- Oedewald, P., & Gotcheva, N. (2015a). Safety culture and subcontractor network governance in a complex safety critical project. *Reliability Engineering & System Safety* 141: 106–114. <http://doi.org/10.1016/j.ress.2015.03.016>
- Oedewald, P., & Gotcheva, N. (2015b). Safety culture in a network of companies. In P. Oedewald, N. Gotcheva, K. Viitanen, & M. Wahlström (Eds.), *Safety Culture and Organisational Resilience in the Nuclear Industry Throughout the Different Life Cycle Phases*. pp. 107–127. Espoo, Finland: VTT Technical Research Centre of Finland.
- Oedewald, P., Pietikäinen, E., & Reiman, T. (2011). A Guidebook for Evaluating Organizations in the Nuclear Industry – an example of safety culture evaluation (Research No. 2011:20). Stockholm: Stralsakerhetsmyndigheten. Retrieved from http://inis.iaea.org/search/search.aspx?orig_q=RN:43113518
- Project Management Institute. (2013). *A guide to the project management body of knowledge (PMBOK guide)*. Fifth edition. Newtown Square, Pennsylvania: Project Management Institute, Inc.
- Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety Science* 27: 183–213. [http://doi.org/10.1016/S0925-7535\(97\)00052-0](http://doi.org/10.1016/S0925-7535(97)00052-0)
- Reiman, T., & Oedewald, P. (2006). Assessing the maintenance unit of a nuclear power plant – identifying the cultural conceptions concerning the maintenance work and the maintenance organization. *Safety Science* 44: 821–850. <http://doi.org/10.1016/j.ssci.2006.05.004>
- Reiman, T., & Rollenhagen, C. (2014). Does the concept of safety culture help or hinder systems thinking in safety? *Accident Analysis & Prevention* 68: 5–15. <http://doi.org/10.1016/j.aap.2013.10.033>
- Reiman, T., & Rollenhagen, C. (2018). Safety culture. In N. Moller, S. O. Hansson, J.-E. Holmberg, & C. Rollenhagen (Eds.), *Handbook of Safety Principles*. Hoboken: John Wiley & Sons.

- Reiman, T., Rollenhagen, C., Pietikäinen, E., & Heikkilä, J. (2015). Principles of adaptive management in complex safety-critical organizations. *Safety Science* 71, Part B: 80–92. <http://doi.org/10.1016/j.ssci.2014.07.021>
- Reiman, T., Silla, I., & Pietikäinen, E. (2013). The validity of the Nordic patient safety culture questionnaire (TUKU). *The International Journal of Risk & Safety in Medicine* 25: 169–184. <http://doi.org/10.3233/JRS-130595>
- Reiman, T., & Viitanen, K. (2018). Safety Culture Assurance by Auditing in a Nuclear Power Plant Construction Project. In A. Bernatik, L. Kocurkova, & K. Jørgensen (Eds.), *Prevention of Accidents at Work*. pp. 161–169. Leiden, The Netherlands: CRC Press/Balkema. <http://doi.org/10.1201/9781315177571-26>
- Richter, A., & Koch, C. (2004). Integration, differentiation and ambiguity in safety cultures. *Safety Science* 42: 703–722. <http://doi.org/10.1016/j.ssci.2003.12.003>
- Rollenhagen, C., Westerlund, J., & Näswall, K. (2013). Professional subcultures in nuclear power plants. *Safety Science* 59: 78–85. <http://doi.org/10.1016/j.ssci.2013.05.004>
- Ruuska, I., Ahola, T., Artto, K., Locatelli, G., & Mancini, M. (2011). A new governance approach for multi-firm projects: Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects. *International Journal of Project Management* 29: 647–660. <http://doi.org/10.1016/j.ijproman.2010.10.001>
- Ruuska, I., Artto, K., Aaltonen, K., & Lehtonen, P. (2009). Dimensions of distance in a project network: Exploring Olkiluoto 3 nuclear power plant project. *International Journal of Project Management* 27: 142–153. <http://doi.org/10.1016/j.ijproman.2008.09.003>
- Saunders, F. C. (2015). Toward High Reliability Project Organizing in Safety-Critical Projects. *Project Management Journal* 46: 25–35. <http://doi.org/10.1002/pmj.21498>
- Schein, E. H. (2010). *Organizational Culture and Leadership*. San Francisco, CA: John Wiley & Sons.
- STUK. (2006). Management of Safety Requirements in Subcontracting During the Olkiluoto 3 Nuclear Power Plant Construction Phase (Investigation Report No. 1/06). Helsinki, Finland: Säteilyturvakeskus. Retrieved from https://www.stuk.fi/documents/88234/148256/investigation_report.pdf/29551dcb-928d-434b-bd95-807f808179ae
- STUK. (2011). Investigation of the procurement and supply of the emergency diesel generators (EDG) and related auxiliary systems and equipment for the Olkiluoto 3 nuclear power plant unit. Helsinki, Finland: Säteilyturvakeskus. Retrieved from <https://www.stuk.fi/documents/88234/148256/OL3-EDG-investigation-report.pdf/15eb63a9-90ac-44c4-8953-e8f89b72b2d8>
- STUK. (2014). YVL A.3 Management System for a Nuclear Facility. Helsinki, Finland: Säteilyturvakeskus.

U.S. Chemical Safety and Hazard Investigation Board. (2007). Investigation Report Refinery Explosion and Fire (No. 2005-04-I-TX). U.S. Chemical Safety and Hazard Investigation Board. Retrieved from <http://www.csb.gov/assets/1/19/csbfinalreportbp.pdf>

Vierendeels, G., Reniers, G., van Nunen, K., & Ponnet, K. (2018). An integrative conceptual framework for safety culture: The Egg Aggregated Model (TEAM) of safety culture. *Safety Science* 103: 323–339. <http://doi.org/10.1016/j.ssci.2017.12.021>

Viitanen, K. (2015). Developing Safety Culture in Nuclear Power Plants. In P. Oedewald, N. Gotcheva, K. Viitanen, & M. Wahlström (Eds.), *Safety Culture and Organisational Resilience in the Nuclear Industry Throughout the Different Lifecycle Phases*. pp. 31–51. Espoo, Finland: VTT Technical Research Centre of Finland.

Viitanen, K., Gotcheva, N., & Rollenhagen, C. (2017). Safety Culture Assurance and Improvement Methods in Complex Projects – Intermediate Report from the NKS-R SC_AIM (No. NKS-381). NKS. Retrieved from http://www.nks.org/en/nks_reports/view_document.htm?id=111010214063661

Viitanen, K., & Reiman, T. (2017). Building an “Adaptive Safety Culture” in a Nuclear Construction Project – Insights to Safety Practitioners. Presented at the 7th Resilience Engineering Symposium, Liège, Belgium.

von Wright, G. H. (1968). *An essay in deontic logic and the general theory of action: With a bibliography of deontic and imperative logic*. North-Holland Publishing Company.

Weick, K. E. (1987). Organizational Culture as a Source of High Reliability. *California Management Review* 29: 112–127. <http://doi.org/10.2307/41165243>

Weick, K. E., & Sutcliffe, K. M. (2015). *Managing the Unexpected: Resilient Performance in an Age of Uncertainty*. Third Edition. Hoboken, New Jersey: John Wiley & Sons.

WENRA. (2014). Safety Reference Levels for Existing Reactors. Update in Relation to lesson learned from TEPCO Fukushima Dai-Ichi accident. Western European Nuclear Regulators' Association. Retrieved from http://www.wenra.org/media/filer_public/2014/09/19/wenra_safety_reference_level_for_existing_reactors_september_2014.pdf

Wiegmann, D. A., Zhang, H., von Thaden, T. L., Sharma, G., & Gibbons, A. M. (2004). Safety Culture: An Integrative Review. *The International Journal of Aviation Psychology* 14: 117–134. http://doi.org/10.1207/s15327108ijap1402_1

Wright, M. S., Brabazon, P., Tipping, A., & Talwalkar, M. (1999). Development of a Business Excellence Model of Safety Culture. *Health and Safety Executive*.

Appendix. Safety Culture Ambassadors Group Implementation Guideline

Description

Safety culture ambassadors are a group of safety-conscious individuals selected from different parts of an organization. Their overall purpose is to support the management in the development of a good safety culture. Safety culture ambassadors achieve this by utilizing a set of means or tools that monitor or positively influence safety culture at grass-roots level, possibly adapting them to the needs of their respective work environment. Given that the ambassadors can be nominated to be a representative sample of the organization, they can be especially useful in ensuring that the whole organization is involved in safety culture activities, and that the safety culture activities are carried out in a way that is meaningful and suitable for all parts of the organization. Due to this adaptability and diversity, the ambassadors can be utilized in a variety of organizations and phases of development, including project organizations or operating plants, and mature or newly established organizations.

Implementing a Safety Culture Ambassadors Group

Safety culture ambassadors group is different from many other approaches to safety culture improvement. While most common methods of safety culture improvement involve the use of some type of practical tool (e.g., holding safety trainings; using posters, brochures or other tangible material to promote safety culture, etc.), the ambassadors method instead focuses on *redefining or expanding the roles of selected personnel*. However, the ambassadors themselves can utilize the practical tools in their work. This means that the implementation of a safety culture ambassadors group should be viewed from two perspectives: a) how the group is organized, managed and coordinated and b) what do the ambassadors actually do.

A five-step implementation process for a safety culture ambassadors group is described below. The steps are loosely structured on the basis of Plan-Do-Check-Act cycle of continuous improvement. For each step, a general description and justification are provided. In addition, example narratives and good practices are described, which are based on the case studies of NKS-R SC_AIM research activity⁷.

1. Define Purpose

The general function of the safety culture ambassadors group is to influence positively safety culture in the organization. However, having a more specific and focused purpose is advised because it can help at the various stages of implementation such as task definition and follow-up. The purpose of a safety culture ambassadors group can include, for example, the following:

- Maintain and increase the visibility of the concepts of safety and safety culture in the organization

⁷ For further information, see chapter 4 of this report or chapter 3.1 in Viitanen, K., Gotcheva, N., & Rollenhagen, C. (2017). Safety Culture Assurance and Improvement Methods in Complex Projects – Intermediate Report from the NKS-R SC_AIM (No. NKS-381). NKS.

- Create awareness of how human and organizational factors affect safety
- Identify weak signals and opportunities for development, and help bring this information forward for formulating corrective actions
- Help make it socially acceptable to talk about safety or act on safety-related issues
- Serve as a redundant, local channel for the employees to convey safety concerns or initiatives
- Serve as a resource for safety (culture) managers for various safety-related tasks or projects

The purpose of the ambassadors group should be in line with the current or anticipated safety-related organizational development needs. These needs may be formulated in relation to the overall safety culture strategy and by utilizing insights from various organizational evaluations, including (but not limited to): safety culture self-assessments and independent assessments, other safety or organizational assessments, peer reviews, operating experience trends, etc.

When defining the purpose, it should also be considered that the safety culture ambassadors group should not be used as a permanent fix for an organizational deficiency. Instead, it is preferable that the group temporarily acts as a support for the management until a satisfactory, sustainable solution is found, and then moves on to other tasks. This is to avoid allowing an organizational deficiency to exist indefinitely by compensating for it with the ambassadors.

EXAMPLE: a power company was in process of defining the purpose for safety culture ambassador group. Previously it had been established that there are communication deficiencies in the company: employees do not know each other and have trouble finding the right people. Utilizing the ambassadors group for connecting employees from different departments was considered. However, eventually the idea was abandoned because the ambassadors group was not considered a sustainable solution to the issue: the company should structurally ensure that the necessary professional networks are developed.

2. Define Tasks and Activities

In order to achieve the purpose successfully, practical tasks and activities need to be defined for the safety culture ambassadors. The activities may include focused ones such as development projects, which have a distinct beginning and end, or long-term ones that are carried out continuously. The activities may also be targeted towards a small group of people (e.g., ambassador's own department or unit) or be organization-wide. Table A1 illustrates examples of some tasks and activities that safety culture ambassadors can be assigned to.

Table A1. Examples of safety culture ambassador tasks and activities	
Type of activity	Description
<p>Communication and interaction</p> <p><i>(ensure that safety-related information is available and that people understand each other)</i></p>	<p>Being available to co-workers as a confidential and easy-to-approach channel for receiving concerns or initiatives at the shop-floor</p> <p>Transferring messages from top management or safety culture ambassadors group to co-workers and facilitating reflection upon them</p> <p>Serving as a contact point for communication purposes between the shop-floor and the safety culture experts</p>
<p>Training</p> <p><i>(educate personnel on safety and safety culture-related topics)</i></p>	<p>Implementing safety culture-related training sessions or toolbox talks that are adapted to the context of own working environment</p> <p>Helping co-workers identify the safety significance of work done in own department</p> <p>Helping create training materials that are relevant and meaningful for everyone in the organization by bringing contextual insights from different departments and occupations</p>
<p>Monitoring</p> <p><i>(assess the state of safety culture)</i></p>	<p>Sensing how co-workers feel about the safety-related messages being disseminated or the way safety-related things are dealt with in the organization</p> <p>Observing the daily work carried out by co-workers to identify adverse trends or developmental opportunities</p> <p>Providing the safety culture experts insights regarding the state of safety culture or other topical concerns from the field</p>
<p>Promotion</p> <p><i>(improve the visibility of safety culture)</i></p>	<p>Taking a safety-conscious and questioning attitude in safety-related activities to help counter complacency and to help make acting to improve safety a part of daily work</p> <p>Making it known in own department that there are safety culture ambassadors in the organization and explaining their purpose</p> <p>Giving feedback to safety culture experts and other relevant personnel during the development of safety culture promotional materials such as brochures, posters, or newsletters</p>
<p>Influencing behaviour</p> <p><i>(maintain or create behaviour positive to safety, and prevent or eliminate behaviour adverse to safety)</i></p>	<p>Interfering if bad safety culture is displayed or if decisions are made without sufficiently considering safety</p> <p>Reminding in meetings or in informal conversations about the safety significance of the activities that are carried out</p> <p>Contributing to the design of a Human Performance Programme (or similar intervention program) to help integrate it to existing working practices</p>

Due to the expected diversity of the ambassadors, it is likely that common tasks for all ambassadors are difficult to establish – this is because the ambassadors have different strengths and weaknesses in terms of competence and skill sets, and because their work environments face different contextual challenges. This means that the task and activity definition benefits from flexibility and/or grouping:

- *Flexible task and activity definition:* each ambassador has sufficient freedom to define their own way of doing ambassador work
- *Grouped task and activity definition:* ambassador group is split into (relatively) homogeneous subgroups and the ambassadors within these groups do the same tasks. The subgroups can be defined, for instance, functionally (i.e., group defined by a

common task such as a project team that develops materials for a training program) or organizationally (i.e., groups based on organizational structure such as the departments of maintenance, operation, manufacturing and design in a nuclear power plant)

Care must be taken that flexible task definition does not result in misalignment with the purpose of the ambassadors group: if too much freedom is allowed for each individual ambassador, there can be a risk of losing focus because all ambassadors do different things. Conversely, if grouped task definition is emphasized too much, there can be a risk that ambassadors work only in isolated subgroups, and the organizational learning that results from the collaboration between all ambassadors is compromised. Finally, workload needs to be considered during the task definition to avoid causing excessive burden to the ambassadors.

The ambassador activities should be carried out in a way that maintains trust between the ambassadors and other personnel: everyone in the organization should understand the role of the ambassador to avoid misunderstandings, and the ambassador group should establish and follow a *code of ethics* (incl. following the principles of confidentiality and impartiality).

3. Formally Implement

When a safety culture ambassadors group is formally introduced to an organization, it needs to be decided how the group is organized. A safety culture expert can be selected as the leader for the overall group with the task of managing and coordinating the group. Formal implementation usually also includes the consideration of the factors described in Table A2.

Table A2. Factors to be considered during the formal implementation of a safety culture ambassadors group	
Factor	Examples of options and things to consider
Selection of ambassadors <i>(influences the competence and skill set distribution, and hierarchical coverage)</i>	<i>Selection on criteria basis:</i> individuals can be chosen to meet specific requirements <i>Volunteers:</i> highly motivated and interested individuals are likely to participate, but other characteristics (incl. competence) may vary
Hierarchical scope <i>(influences the constraints and opportunities for task definition)</i>	<i>Shop-floor workers:</i> may have a better understanding and feeling regarding what actually takes place in the field <i>Managers:</i> have formal decision-making power
Organizational scope <i>(influences the extent of influence of the ambassadors group)</i>	<i>All departments:</i> ensures best opportunities for organizational learning, but creates a diverse, large and potentially incompatible group if there is no common ground <i>Certain departments of interest:</i> some departments are left out, but the ambassador group size remains manageable and possibly homogeneous <i>Multiple units under departments of interest:</i> some departments are left out, but the large size may require subgroups (e.g., unit-wise) to maintain manageability
Integration to primary tasks <i>(influences the effort needed to adapt to ambassador work)</i>	<i>Naturally integrated:</i> ambassador tasks are effectively a part of the primary tasks, however, not all jobs are easily integrated <i>Clearly separate:</i> requires attention to allocation of work time and definition of job description, potentially support is needed in relating ambassador activities to own work

These factors are not an exhaustive selection of everything that may be relevant when implementing a safety culture ambassadors group, but they are likely to be encountered in most cases. The way in which the implementation decisions that relate to these factors are made can have an influence on what kinds of challenges and opportunities the safety culture ambassadors group will probably face.

EXAMPLE: a power company created a safety culture ambassadors group from a set of volunteers from all departments. The ambassadors were highly motivated, but due to their diversity in terms of occupational backgrounds, working environments and safety culture competences, the definition of tasks and activities for the ambassadors group became very difficult. The power company decided to solve the problem by creating homogeneous subgroups of ambassadors that can carry out similar tasks.

In addition to the above factors, there are certain prerequisites that contribute to a successful implementation of a safety culture ambassadors group. They include:

- *Top (and line) management commitment and support:* e.g., setting expectations and goals for the ambassadors group, making resources available for ambassador activities
- *Ambassador group leader commitment:* e.g., making work time available for leading, managing and coordinating the ambassador group, ensuring that the organizational and structural prerequisites exist
- *Individual ambassador commitment:* e.g., making work time available for ambassador activities, regularly participating in group meetings
- *Promotion of the safety culture ambassadors group:* e.g., introducing ambassadors group in various training sessions, advertising the group in internal communication such as intranet, organization-wide seminars or events, or company newsletters

4. Manage and Coordinate

In order to retain the long-term functionality of the safety culture ambassadors group, continuous management and coordination is required. Unless these activities are done sufficiently regularly, the safety culture ambassadors group may become stagnant as a result of lack of motivation or leadership, or the activities may become unsystematic or lack target-orientation, and thus are likely to not serve the purpose of the group nor address the organization's needs.

Often the most common way to manage and coordinate the safety culture ambassadors group is to hold meetings of various types. Depending on how the group is organized, the meetings can include joint meeting with all ambassadors, or meetings with subgroups of the ambassadors.

The management and coordination activities should address at least the following issues:

- *Shared mission:* ensuring that the activities of individual ambassadors or groups of ambassadors are aligned with the overall purpose of the ambassadors group
- *Tasks and expectations:* ensuring that the ambassadors know what is expected of them and what are their tasks

- *Competence*: identifying and addressing the ambassadors' training and competence development needs (incl. e.g., competence mapping and training plan on safety culture, and also technical aspects of nuclear safety)
- *Contextual adaptation*: providing support for individual ambassadors in finding and explicating how the expectations and tasks of the ambassadors should manifest in their work
- *Motivation*: ensuring that the ambassadors are motivated and committed
- *Coordination*: providing an arena for the ambassadors for sharing and reflecting on safety-related information, such as a regularly held, joint ambassador meetings

EXAMPLE: a power company holds bi-monthly safety culture ambassador group meetings led by a safety culture expert where all ambassadors participate. Regular topics include a round-table discussion where the ambassadors present safety-related observations, initiatives and other matters of interest from their respective departments. These insights are reflected together to identify possible organization-wide trends or opportunities for organizational learning. When necessary, these reflections are communicated to the top management.

In addition to meetings, other means of managing and coordinating the ambassadors may be used. They can include (but are not limited to):

- Development discussions between an ambassador and his/her immediate supervisor
- Mentoring relationships with safety culture experts
- Pair or group work with other ambassadors on specific tasks or topics

5. Conduct Follow-up and Revise

Organizations evolve and mature over time, partially due to the impact of the activities of the safety culture ambassadors group. To ensure that the purpose and the activities of the ambassador group do not become misaligned with the needs of the organization, i.e., that the ambassadors group is always at the cutting-edge in terms of supporting the organization's development, *a mechanism for continuous development of the group itself is needed*. If necessary, the group's purpose should be redefined and the ways of organizing revised. The capacity for renewal can be especially important, for example, during organizational changes or in turbulent environments where the developmental challenges can change rapidly. A variation of the PDCA cycle⁸ illustrated in Figure A1 can be utilized for structuring the development of a safety culture ambassador group.

The results from various assessments and the organization's safety culture development strategy can serve as inputs for the monitoring, reviewing and planning phases. By regularly comparing the ambassadors activities and their outcomes to the purpose of the ambassador group and the safety culture strategy, it can be established whether the ambassador group

⁸ Adapted from Viitanen, K., & Reiman, T. (2017). Building an "Adaptive Safety Culture" in a Nuclear Construction Project – Insights to Safety Practitioners. Presented at the 7th Resilience Engineering Symposium, Liège, Belgium.

functions as intended, requires adjustments to tasks and activities, or whether a specific purpose has been already achieved. In the latter case, a redefinition of the purpose may be needed. During redefinition, care must be taken to avoid discarding tasks or activities that require continuous maintenance by the ambassadors group.

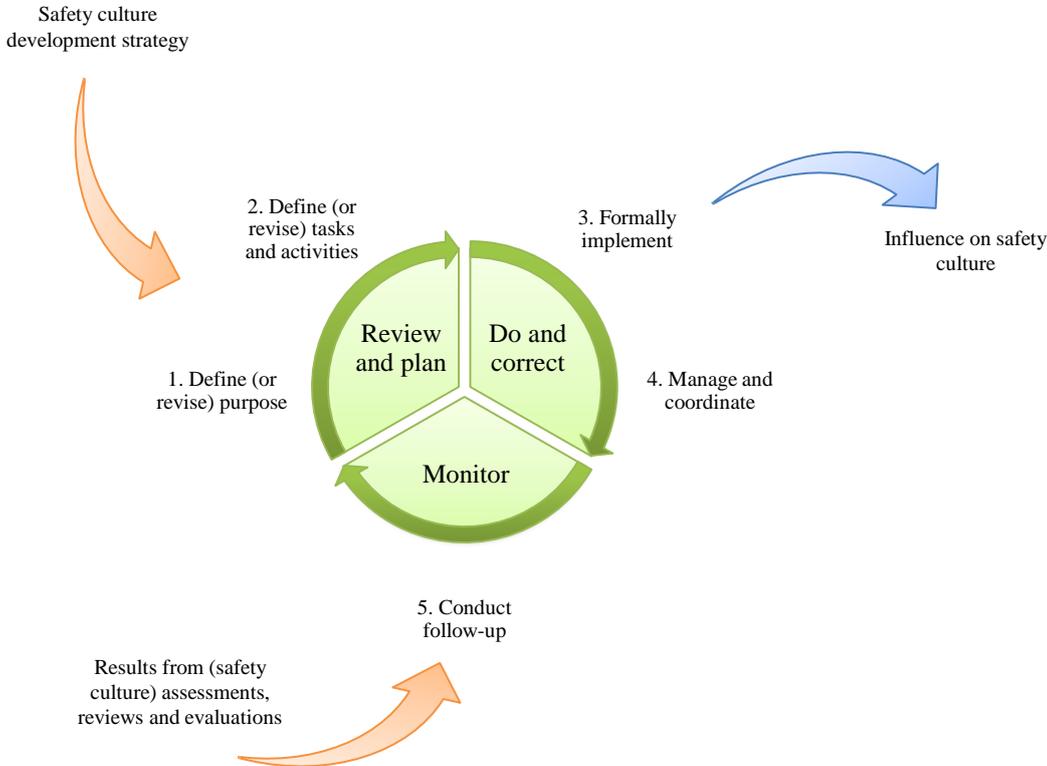


Figure A1. Developmental cycle of a safety culture ambassadors group

EXAMPLE: as a result of a safety culture assessment, a power company recognizes that the concept of safety culture is unevenly known among its personnel and strives to ensure that everyone is familiar with it. Safety culture ambassadors are purposed to serve as trainers and promoters of the concept. In a follow-up assessment, it is found that safety culture is now well known in the company, but the personnel are unsure how to relate the concept to their own work. Continuing with the same ambassador activities is presumed to result in the underutilization of the ambassador group. Instead, the purpose of the ambassadors group is redefined as supporting the operationalization of safety culture in daily work through mentoring and facilitating.

Conclusion

This appendix summarizes the practical insights from the findings of the NKS-R SC_AIM research activity and its case studies on the implementation of safety culture ambassador groups in the nuclear industry. An implementation process for a safety culture ambassadors group was described in the form of a guideline. The guideline can be utilized as a reference for those practitioners who aim to implement a safety culture ambassadors group in their organizations.

Title	Safety Culture Assurance and Improvement Methods in Complex Projects – Final Report from the NKS-R SC_AIM
Author(s)	Kaupo Viitanen ¹ Nadezhda Gotcheva ¹ Carl Rollenhagen ² Teemu Reiman ³
Affiliation(s)	¹ VTT Technical Research Centre of Finland Ltd. ² Royal Institute of Technology (KTH) and Vattenfall AB ³ Lilikoi Consulting
ISBN	978-87-7893-493-2
Date	February 2018
Project	NKS-R / SC_AIM
No. of pages	53
No. of tables	5 + 2
No. of illustrations	3 + 1
No. of references	64
Abstract	<p>A good safety culture is an essential ingredient for ensuring nuclear safety. The predominant approaches for safety culture improvement are based on the assumption of stable and relatively homogeneous organizations, which often does not apply to contemporary project-oriented and turbulent environments. This research activity aims to provide guidance for methodical safety culture change in complex nuclear industry projects, and how to utilize existing safety culture tools or create new ones to support this effort.</p> <p>A set of twelve principles of safety culture change were developed that summarize the essential good practices of leading safety culture change. The principles are based on up-to-date practical experience and theories in the fields of systems thinking, organizational management and safety science. The principles are related to the generic characteristics of safety-critical project environments to illustrate their relevance in the context of complex projects. We propose that these principles are instrumental in leading safety culture activities in an informed manner, and to avoid mechanistic or superficial methods.</p> <p>Guidelines for the implementation of safety culture ambassadors were developed on the basis of the empirical work carried out in the Nordic nuclear power industry. Safety culture ambassadors group is novel method for safety culture improvement which aims to support the development of good safety culture by involving safety-conscious individuals from different parts of the company in safety culture activities. The guidelines can be utilized as a reference for practitioners in the nuclear power industry aiming to implement the method.</p>
Key words	Safety culture, safety culture improvement, project management, organizational change