

Safety Culture Assessment Tools in Nuclear and Non-Nuclear Domains

Review of safety culture tools

L. Mkrtchyan
C. Turcanu

Nuclear Science and Technology Studies (NST)

March, 2012

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Boeretang 200
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Status: Unclassified

ISSN 1379-2407

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Stichting van Openbaar Nut – Fondation d'Utilité Publique - Foundation of Public Utility
Registered Office: Avenue Herrmann Debroux 40 – BE-1160 BRUSSEL
Operational Office: Boeretang 200 – BE-2400 MOL

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Executive summary

Over the last decades, in many domains especially in high risk industries, the authorities paid increasing attention to safety management systems and, in particular, to safety culture. Consequently, in the applied and academic literature a huge amount of studies explored the main challenges, issues and obstacles related with safety culture. In addition, many organizations are in the process of implementing safety culture self-assessment systems or already have a tool or have the intention to buy or develop a new tool.

In 2007 the Belgian Nuclear Research Centre SCK•CEN conducted a safety culture assessment based on several data gathering methods, namely questionnaire-based self-assessment survey, interviews, documentation reviews and focus groups. The interviews were based on a subset of the IAEA Safety Culture Assessment Team (SCART) questions, that were translated into Dutch and French. The questionnaire was based on *Questionnaire for the Perception of Safety* practiced at *Électricité de France* (EDF), translated into Dutch. In addition, focus groups were conducted for a more detailed view of the identified issues and for revealing ‘intangible’ patterns influencing safety culture within the research centre. It has been decided that SCK•CEN needs to investigate safety culture assessment by doing additional research on available tools, and later on developing a new tool.

The need for a comprehensive tool which gives a deeper insight into key issues of safety culture is explained by the fact that the current tools have several caveats which questions the reliability and the validity of the results.

Note that the need for a broader view on safety culture is argued also by the *International Atomic Energy Agency* (IAEA), and currently the agency is developing a new approach for safety culture self-assessment, as well as a safety culture assessment framework to be used by regulatory bodies.

In this report we explore the current state of safety culture research, focusing on the current tools and methods for safety culture assessment. We undertake a survey of safety culture experiences in the main safety-critical industries such as nuclear, railways, offshore, aviation, airlines, health care, etc. We review both academic and applied literature up to the year 2011. Our results help to establish a comprehensive view on the subject, its main terminologies, existing tools, and main difficulties.

We investigate the similarities and the main differences in the approaches taken by different industries and we formulate suggestions on how the nuclear domain could benefit from the best practices of non-nuclear applications. Our main goal is to explore the existing tools of safety culture assessment, the degree of their computerization, their restrictions, generalizability and usability.

The purpose of this report is to raise awareness about the current tools of safety culture assessment, both in the nuclear as well as in the non-nuclear domain. The report provides also practical recommendations about the possible use of each tool given different circumstances and different factors. We do not aim to rank the tools pointing the best one, but we highlight instead the unique features of these tools, pointing their strong and weak sides.

Acknowledgements

Several colleagues from the Belgian Nuclear Research Centre SCK•CEN contributed to this review giving valuable comments, and we would like to thank all of them for helpful discussions without mentioning their names.

This report is a part of a post doc research of Lusine Mkrtchyan on the project *Safety Culture Assessment Tool*, partially funded by Belgoprocess.

1. Introduction

The concept of safety culture has been introduced after the Chernobyl accident in 1986 though it has been always known that safety performance is strictly affected by an organization's socially accepted beliefs, attitudes and values toward safety issues. Safety culture itself is a complex concept to study and it is even more difficult to measure it. Many researchers investigated safety culture, developing new standards, methods and tools for identifying the main norms and indicators of safety culture, as well as for conducting safety culture assessment. However, every year we face new accidents and failures which can be linked to weaknesses in safety culture, showing a need for more extensive research in this domain.

The purpose of our study is to explore the current challenges of safety culture in different industries focusing on the current tools and methods for safety culture assessment. We undertake a survey of safety culture experiences in nuclear and non-nuclear domain by reviewing both academic and applied literature up to the year 2011. Our results help to establish a comprehensive view of the subject, its main challenges and the main obstacles to be addressed. We investigate the similarities and the main differences between different tools and we come out with a suggestion how to benefit from a specific tool given certain requirements. Our main focus is to explore the existing tools of safety culture assessment, the mathematical methods behind these tools, the degree of their computerization, their restrictions, and their advantages with respect to other tools, their structure, the generalizability and usability level. In addition we give recommendations of the practical use of these tools, given different requirements and circumstances.

The survey in this study shows that in spite of the considerable amount of studies in safety culture, there is still a lack of consensus and agreement on the definition of the concept, on the main indicators that shape the safety culture of an organization, on the assessment methods, on the standards used, on the recommendation system and on the overall structure of safety culture assessment.

The rest of this report is organized as follows. In Section 2 we overview the different definitions of safety culture and safety climate. In Section 3 we review the related literature on safety culture. In Section 4 we discuss the most used methods of safety culture data gathering. In Section 5 we briefly present several noteworthy studies of survey of safety culture assessment tools and in Section 6 we discuss the general findings related with the different tools. In Section 7 we discuss the tools encountered in the context of non-nuclear industry in more details, while the tools used in nuclear industry are reviewed in Section 8. In Section 9 we summarize all the tools, giving practical recommendations about the adequacy of the tools to be used in the nuclear domain. Finally, we conclude this study in Section 10.

2. Safety Culture Definitions

In high reliability organizations (HRO) in which the possible hazards have very high consequences even with low probability of events, the attention to safety issues is given a high priority and it is included into all activities of the organization. In the nuclear industry, all the related organizations such as nuclear power plants, regulatory authorities, nuclear design organizations, and nuclear research centres pay considerable attention to safety assessment which has been shifted from 'feedback' to 'feedforward'. 'Feedback' control assumes waiting until something wrong happens to find the root causes and take actions to prevent similar patterns in the future. Conversely, the 'feedforward' control adopts an opposite strategy of preventing unsafe behaviours, attitudes and actions on beforehand (Fahlbruch and Wilpert, 1999). In (Markus, 1988) investigating 24 US nuclear power stations, the author concludes that the plants in which the attitudes of employees towards safety is proactive, have mostly three times fewer error events and, in general, much better safety records than those without such attitudes.

The concept of safety culture (SC) was first introduced by the *International Nuclear Safety Advisory Group* (INSAG) (formed a year before Chernobyl accident) in their summary report of the Chernobyl accident. In the beginning of the safety culture related research, the concept was merely linked with the nuclear industry and only later, in 1990s, safety culture became a common phenomenon discussed also in other domains such as railways, health care, offshore, aviation, manufacturing, etc. Many definitions of safety culture have been suggested in the related literature across different industries.

Here we cite several definitions from nuclear related organizations.

The IAEA definition of safety culture in 1991 is as follows (INSAG 4, 1991):

"that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receives the attention warranted by their significance".

An interesting suggestion of a safety culture definition has been proposed by the US Nuclear Regulatory Commission (NRC) in 2009 as follows:

"the assembly of characteristics, attitudes, and behaviours in organizations and individuals which establishes that as an overriding priority, nuclear safety and security issues receive the attention warranted by their significance".

Actually, the latter has a quite similar formulation with the one from the IAEA. As far as we found, this is the only definition of safety culture that targets also security. In fact, security culture and safety culture are sometimes in conflict, even if the two concepts complement each other in many respects. Normally, safety culture assumes a great focus on preventing unsafe actions and behaviours that would result in an unintentional incident / accident, while security culture focuses on the prevention of deliberate attacks or diversion of certain materials resulting in short or long term harm. Therefore, for a positive safety culture one should be open to communicate with a high level of

trust, whereas in a good security culture openness and trustworthiness can lead to unsecure actions.

However, in 2010 already the above definition of safety culture by NRC has been changed and the concept of security has been eliminated. Though the reasoning to eliminate the term security is not the conflict between safety and security, but rather the view that safety culture addresses both safety and security and there is no need to point out security in the definition anymore. The current definition of safety culture from NRC is as follows:

"the core values and behaviours resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment".

Another definition of safety culture has been proposed by the Institute of Nuclear Power Operations (INPO) as:

"an organization's values and behaviours modelled by its leaders and internalized by its members that serve to make nuclear safety the overriding priority".

Either very high level or more detailed, implicit or explicit, all definitions of safety culture stress the importance of safety (in terms of attitudes, perceptions, behaviours, norms, values, etc.) shared by all members of the organization.

Almost all reviews of safety culture literature talk about the differentiation between safety culture and safety climate. Some studies use both terms interchangeably, while others try to make a clear distinction between climate and culture though. In many definitions the two concepts are yet difficult to distinguish. While the talk about safety culture appears in academic and applied literature only after 1986, the discussion about safety climate goes back to 1950s.

An excellent review of culture and climate (both organizational and safety) is done in (Guldenmund, 2000). An interesting remark is pointed about the difference between the two terms in organizational and safety context. While the organizational culture replaced the organizational climate (organizational climate has been narrowed including only attitudinal or psychological aspects) in the safety culture and climate research, however, both terms are still used. Thus, climate has not been simply substituted with culture; rather, culture expresses itself through climate.

Another important differentiation about culture and climate is the way the two concepts are assessed. Climate is usually assessed with quantitative methods (e.g., questionnaire based surveys) while in culture assessment mostly qualitative methods are used such as observations, interviews, documentation analysis, etc. However, questionnaire based surveys are considered also very useful tools for culture assessment.

Summing up the different opinions, we formulate that safety culture is commonly regarded as a permanent characteristic of an organization reflecting its policy towards safety issues according to their importance level. Conversely, safety climate is considered a temporary state of an organization that is subject to change due to specific circumstances.

In Table 1 we summarize some other definitions of safety culture and safety climate that were cited in the literature the most. Note that we list different definitions believing that the differences in definition lead to different assessment methods (IAEA-Tecdoc-1321, 2002).

Table 1: Definitions of safety culture/climate

	Ref.	Definitions of safety culture/climate
Culture	(Collins, 2010)	professional leadership attitudes in an HRO that manages potentially hazardous activities to maintain risk to people and the environment as low as reasonably achievable, thereby assuring stakeholder trust.
	(Akselsson & others, 2009)	values about safety shared by all in an organization expressing itself in three groups of aspects: psychological, behavioural and situational.
	(Pidgeon, 2001)	set of assumptions, and their associated practices, which permit beliefs about danger and safety to be constructed.
	(Guldenmund, 2000)	those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk.
	(Neal & others, 2000)	a special form of organizational climate, which describes individual perceptions of the value of safety in the work environment
	(Flin & others, 2000)	surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time.
	(ACSNI, 1993)	the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.
Climate	(Zohar, 2000)	shared perceptions among group members with regard to supervisory practices.
	(Williamson & others, 1997)	summary concept describing the safety ethic in an organization or workplace reflected in employees'

	beliefs about safety.
(Hofmann & Stezer, 1996)	perceptions regarding management's commitment to safety and worker involvement in safety related activities.
(Cooper & Philips, 1994)	shared perceptions and beliefs that workers hold regarding safety in their work place.
(Dedobbeleer, & Beland, 1991).	an individual attribute, which is composed of two factors: management's commitment to safety and workers' involvement in safety.
(Schneider, 1990)	perceptions of the events, practices, and procedures, as well as the kind of behaviours, that get rewarded, supported, and expected in a particular organizational setting.

As it is clear from the above listed definitions of safety culture and safety climate, sometimes the definitions of culture and climate are very close to each other and it becomes difficult to distinguish the two different concepts. In (Havold, 2007) there was a suggestion that the two terms can be merged under the label of *safety orientation*.

In (Fricke-Ernst and Kluge, 2012) the authors argue that the two terms should be differentiated for three reasons:

- If the results of the assessment are used for the improvement, it is very vital to state what exactly has been measured as the culture takes time to change and it is much more difficult to change with respect to climate.
- One has to know in advance whether it is the culture or the climate is going to be measured to be able to choose the right tool and data gathering methods.
- When analysing the safety culture, the sharedness of the basic assumptions among the organization members has to be analysed.

As a conclusion, it is important to state clearly what the assessment tool intends to measure: culture or climate, and to validate that it indeed measures as it is supposed to.

3. Review of Safety Culture Surveys

A review of safety culture term evolution is done in (Sorenson, 2002). Some important observations of this study are related with INSAG and the first approach of IAEA of safety culture self-assessment ASCOT (Assessment of Safety Culture in Organizations Team) approach. One comment is related with the fact that there is no clear indication how an overall conclusion should be drawn from all collected data; actually, this comment is valid also for many other safety culture methods in the related literature. Another observation is the lack of a proven link between a good safety culture and safe

plant operation: it is simply assumed a positive relationship. The results show that indeed good safety culture is linked with good safety performance. The same assumption holds between safety culture and human performance or human reliability. The INPO conducted a survey in 63 nuclear reactor sites in US to show the correlation between safety culture and safety performance (Koves, 2010).

This survey observes also that the vast majority of studies address only one particular aspect of safety culture. Some researchers focus only on safety culture performance indicators, some others only on safety assessment or on data collection, etc. In addition, several remarks about safety culture research challenges and difficulties are pointed out. The first source of difficulty is the terminology that researchers use to describe, assess and improve safety culture. There is no agreement and consensus among them making it difficult to compare one study with another. The next source of difficulty is the availability of suitable safety matrices. While in some industries there are enough data for empirical analysis, some other industries, like nuclear, have sufficiently low rates of accidents with serious consequences; thus it is not easy to conduct analysis and compare results with previous results. "Near-miss"-es or minor incidents could provide more insight into this matter.

Another rich literature review in (Silbey, 2009) is offers a critical analysis of existing safety culture approaches. This study gives an interesting and comprehensive overview of safety culture historical development. A noteworthy description is given about the shift from the more risk concerned societies and industries from the middle of nineteenth centuries to the reality in the twenty first century where financial high interests lead to reduced attention of risk prevention and safety measures. In addition, this study summarizes the scholar approaches of safety culture in three categories:

1. as *causal attitude*, regarding safety culture as a measurable source composed of individual attitudes and organizational behaviour or, in other words, safety culture is considered as the product of values attitudes, competencies and behaviours that are themselves the cause of other actions.
2. as *engineered organization*, meaning a learning culture of a specific organization (not in general) by understanding how safety culture leads to particular outcomes, such as reliability and efficiency.
3. as *emergent and indeterminate*, which is a rather sceptical attitude towards safety culture where safety culture consequences cannot be engineered and can be only probabilistically predicted with high deviation from certainty.

In (Guldenmund, 2010) three broad approaches are outlined towards safety culture assessment. The distinction among these three approaches is based on the particular time period on which the research focuses (past, present and future), as well as the research paradigm and used techniques. Below we list the three approaches of safety culture assessment adopted in this study:

- *academic* (anthropological) which explores an organizational safety culture by looking into its past. This is a descriptive approach: thus it tries to describe and

- understand safety culture rather than to judge it. It relies mainly on observations, document analysis and interviews for data gathering.
- *analytical* (psychological) which focuses on the present situation and provides a description of safety culture along quantifiable dimensions. This approach is the most popular and wide-spread approach in safety culture assessment, and focuses specifically on organisational safety climate measured by conducting questionnaire-based surveys
 - *pragmatic* (experience based) which assesses the current state of maturity of organization's safety culture, giving it a ranking on a predefined 'cultural maturity ladder'. This approach does not assess the current situation, but rather defines what should be done to achieve a higher level of maturity of safety culture.

Another interesting discussion about safety culture is its degree of uniqueness. A group of researchers insist that an organization's culture is unique, depending on nation, region, economic and financial situation, technological possibilities, the history of failures or successes, etc. (Pidgeon, 1991). On the other hand, others claim that the uniqueness is a paradox, and in reality organizations share much more in common with regard to culture (Martin & others, 1983). Note that when it comes to 'good safety culture', even the supporters of cultural uniqueness, think that organizations with positive safety culture do have many things in common. In a 'good safety culture' the employees share similar attitudes, perceptions towards safety issues, they have, for example, questioning or reporting attitudes, they are alert to changes and are open to discuss the possible difficulties, etc. However, the same reasoning holds also for the similarities between organizations having 'negative safety culture', such as blaming attitude, the sceptical attitude towards safety (if nothing happened before why should it happen now?), lack of clear responsibilities with regards to safety management, etc. Note that related with this issue, safety culture assessment tools are either domain specific (thus the assumption is the uniqueness of the organization's culture) or very general that can be used in very different domains (thus assuming that organizations are similar in terms of culture).

Another separation point of culture researchers is related with the concept of *subculture*. In this regard, two views are distinguished: integration and differentiation. The former considers that there is only one culture whereas the latter claims that there are many subcultures within one organization (Martin, 2002). For example, (Guldenmund, 2000) cites that there have been found six types of subcultures: national, corporate, organizational, departmental, group culture and psychological climate. Regarding this, a question arises whether the assessment tool should be at global level or at local level. In other words, a decision has to be made in advance if the organization is assessed as one unit (global) or different types of assessments need to be conducted within the organization's various sublevels, such as units, divisions or departments (local).

4. Safety Culture Data Gathering Methods

Safety culture assessment of an enterprise can take many forms, such as safety audits, interviews, observations, checklists, focus groups, error reports, or surveys based on personnel answers given to defined questionnaires. Each form of assessment has advantages and disadvantages, such as time, cost, need for specialized personnel, etc.

The methods can be divided in two groups: *quantitative* and *qualitative*. With qualitative strategies, organization members serve as informants while in quantitative methods they usually serve as respondents. Quantitative methods are in general easy to implement, use and interpret the results. Qualitative approaches, on the other hand, are more complex, but more in-depth information can be obtained through them.

As far as for the analysis methods, as data are either qualitative or quantitative, respectively, the method is either descriptive or normative.

One important observation that one has to endure dealing with safety culture assessment is the fact that it is always desirable to use more than one data gathering methods; it is advised to use at least two methods.

Below we detail the most used data gathering methods, listing their advantages as well as their limitations.

4.1 Questionnaire-based surveys

Questionnaire-based surveys are the most common data gathering method used in the literature. Reviews of merely questionnaire-based safety culture surveys are done in (Singla, 2006), (Health Foundation, 2011), and (RSSB, 2008).

The questionnaires have several advantages compared to the other data gathering methods.

- The anonymity is easier to insure, and usually, the respondents feel biased if they are not sure that their identity cannot be traced back.
- It is relatively quick to collect data using a questionnaire.
- Data can be collected from a potentially large portion of the population addressed. Though in many cases the response rate might be quite low, with questionnaires it is still easier to target a large amount of people.
- A questionnaire-based survey enables organizations to compare safety culture current state with respect to the past experience.
- The results of questionnaires can be valuable for use in focus groups, interviews or workshops for further discussion and clarification.

However, there are also some limitations that make the use of questionnaires less attractive, or at least lead to the need that they are always accompanied by another data gathering method.

- Open-ended questions generate large amounts of data that can be time consuming to process and analyse.
- Questionnaires are standardized tools and depending on the questions' formulations, it is possible that participants might misinterpret them because of misunderstanding. However, this is not always possible to identify in contrast with interviews, for example, where the respondent has more active participation and any kind of wrong understanding can be solved immediately.
- The respondents might answer without deep analysis of questions, especially, with large amount of questions or questions not strictly related with them. In many cases the respondent can simply not have enough knowledge, information or experience to answer certain questions, and still be obliged to give some answers.
- Symptoms rather than underlying causes may be identified.

Several problems might arise related with questionnaires: such as poor response rate, inadequate instructions for completing the questionnaire, lack of feedback of results, absence of a pilot survey to confirm if the proposed questionnaire is suitable, etc.

4.2 Interviews

Interviews represent a personal contact between a reviewer and a respondent that allow getting information about less tangible things that are difficult to find with questionnaires. Interviews can range from a highly structured situation to a fairly informal conversation or semi-structured case. These degrees of freedom represent both opportunities and drawbacks. Topics may be explored with great detail, but the interview may not yield the appropriate information or the reliability of the data might be low.

While a structured interview has a formalized, limited set of questions, a semi-structured interview is flexible, allowing new questions to be brought up during the interview. The interviewer in a semi-structured setting has a general framework of some major themes to explore, but is freer to handle the interview.

Examples of typical attributes that can be assessed through interviews are (IAEA, 2008):

- Individuals have the necessary knowledge and understanding of the work processes;
- Good working conditions exist with regard to time pressures, workload and stress;
- A questioning attitude prevails at all organizational levels.

Interviews have several advantages over other data gathering methods, such as:

- allowing for in-depth analysis of complex issues and collecting complex information,
- helping to clarify unclear or unexpected results from questionnaires,
- helping to find the real causes of certain situations, attitudes, behaviours, etc.

However, there are also some limitations of using interviews to get valuable information:

- The loss of anonymity might lead to biased answers or, for example, employees give answer according the way they think the management would have liked to present the situation.
- Small groups of respondents might not be representative enough to get the entire view of an organization.
- As a qualitative tool, interviews are difficult to analyse and quantify.
- Depending on the interviewer's skills, interviews can lead to conflicting results especially in case of a lack of trust between the interviewer and the interviewees.

(SCOP, 2010), (IAEA, 2008), (Health and Safety Executive, 2005) are good guides for conducting interviews providing details for the organization and structure of interviews, as well as techniques to elicit the desired information from interviews.

4.3 Observations

The aim of conducting observations is to find the actual performance, attitudes, and behaviours in real time. Observations of facilities are often valuable as an input to prepare other assessments methods such as questionnaires, interviews, etc. Observations can be based on checklists or may be combined with asking direct questions to the people being observed. In general, observations can be divided in two types: i) natural, where the observer is passively observing people in their daily work activities, or ii) participant observations, in which the observer is to some degree a part of the observed activities. There are three types of information which can be obtained by observations: descriptive (for example, certain signs or labels are missing), inferential (for example, people with different power are regarded differently), and evaluative, where the observer makes own judgments.

Some of the situations to be observed are meetings, field activities, trainings, or some other informal activities like breaks, lunches etc. Examples of safety culture related aspects that can be assessed through direct observation are (IAEA, 2008):

- Management is clearly involved in safety activities.
- There is a high level of cooperation in teamwork.
- Housekeeping and material conditions reflect commitment to safety.
- There is no blaming attitude towards other colleagues.

Some of the disadvantages of observations are the followings:

- They may give information about one particular moment that is not reflecting the reality and there might be a danger of over-generalizing from a small number of cases.
- Only a limited number of people or events can be observed.
- Observers need to be trained in order not to misinterpret or miss certain issues.
- It is difficult to guarantee anonymity reporting the observation results.
- The observer can judge according to his own norms, not the ones accepted and followed in the organization.

Note that observations of safety culture are different from task observations. Task observations are based on normative standards and the outcome is usually a judgment on how well the task is executed compared with expectations, whereas cultural observations are only descriptive.

4.4 Document reviews

Document reviews can be conducted in advance of any other method in order to have more background information about how the organization prioritizes safety through its documentation, and how it adjusts its policies in practice. Document reviews give insights into differences between stated, intended and actual behaviour. Safety culture cannot be assessed only by reviewing documentation, however; the evidence gained from documentation analyses can support information from other assessment methods.

Documents can be primary, such as work reports, meetings reports, etc., or secondary documents, such as event reports. Both types are useful for documentation reviews as they target different issues.

Some of the documents that can be reviewed are the safety procedures, external inspection results, internal assessments results, previous safety culture assessments results, improvement plans, license event reports, training materials, code of ethics, etc.

As other methods, documentation reviews also have unique advantages such as:

- Keeping track of historical data related with important aspects of safety culture.
- Revealing the adequacy of guidance or procedures related with possible unsafe scenarios.
- Finding the adequacy of procedures for resource allocation and qualification of the personnel who deals with safety.
- Giving information on how the organization handled previous incidents and what lessons have been learnt.

Some of the obvious problems related with documentation reviews are:

- Obtaining and analysing necessary documents can be very time and labour consuming.
- Documents might not reflect the true internal situation in terms of collective thinking, attitudes, behaviours, etc., especially if the documents are written to meet templates requirements.

4.5 Focus groups

Focus groups are group discussions to explore a certain set of topics. Focus groups are different from group interviews by the explicit use of group interaction for data generation. Focus groups are good tools to explore people's experiences, concerns, opinions etc. For example, in (Lee and Harrison, 2000) focus groups are used to generate items for the development of a safety culture questionnaire.

There are several challenges to conduct focus groups, such as:

- Should participants be familiar with each other?
- Should the group be more homogeneous or the opposite, and how to choose the right people for group discussion?

Some of the questions to be discussed during focus groups can be:

- What are the main areas that need special attention and greatest effort to ensure safety?
- What are the main ways to stimulate employees' safety-oriented attitude and behaviour?
- What are the recent issues raised by employees related with safety?

As other qualitative methods of safety culture assessment, focus groups have several advantages:

- As an interactive method, focus groups help to discover patterns that would have been impossible to find with other more structured methods.
- Focus groups can be used as a preliminary step for other methods (e.g., interviews) to set up the topics of the main interest.
- Focus groups can be very useful to discuss the results of questionnaires clarifying certain issues.
- Focus groups allow finding answers as to 'why' certain events happened or certain behaviours are common.

Some of the possible problems with focus groups are:

- The success of the focus group heavily depends on the skills of the moderator, who will be responsible to have a fruitful discussion without much deviation from the main topic, or without having tension during discussions.

- It could happen that managers will exclude the potential critics who would raise many questions about the disagreed points.
- Power relationships may lead to not fair and objective discussion, even though this pattern is also useful information about the organization's safety culture.

As we have already stated it is essential to do safety culture assessment based on at least two different methods: preferably a static (e.g., a questionnaire) and a more interactive method (e.g., an interview). Only by analysing the results of different methods independently and comparing them, the assessment team can give some relevant concluding remarks.

5. Surveys of Safety Culture Assessment Tools

There are several reviews of safety culture assessment tools, mainly from applied literature. As far as we found, these summaries focus on the available tools of a specific domain or a specific data collection method.

In (Health Foundation, 2011) the authors review safety culture and safety climate existing tools in the healthcare domain, naming also few tools of other industries. It is a good structured review giving full description of the tools, their structure, weaknesses, strong points, the validation and reliability level as well as the statistical evidence of its usage. It also differentiates safety climate tools from safety culture tools. However, this study is limited to the tools that are based on questionnaires.

An extensive survey of safety climate tools is done in (Offshore Technology Report 063, 1999). This study is a good reference for questionnaire based tools as it provides many valuable details. Another review of questionnaire based self-administered surveys is done in (Singla, 2006) with detailed analysis of questionnaire structure, and comparison between revised tools. A very detailed and instructive review of 19 tools is done by in (The Keil Centre Ltd., 2003). The latter is a good guide for choosing the most appropriate tool based on specific requirements. A review of 18 safety climate tools is done in (Flin & others, 2000) which summarizes the most frequent indicators assessed in safety climate questionnaires. This study does not provide too many details about each individual tool; it is rather a summary of the most commonly measured dimensions.

Another interesting review of safety culture and climate is done in (Fricke-Ernst and Kluge, 2012). Three main questions are discussed: if the safety culture and climate is the same with just a different label used, if safety is a negligible element in safety culture or climate, and if an assessment method can be a generic one to be used in different domains. Referring to the results of their previous study, the authors conclude that it is recommended to develop one safety assessment method for all different industries.

Our study focuses on the safety culture assessment tools used in practice and in academic literature up to 2011. We highlight the potential strengths and weaknesses of the tools and we give recommendations about the tools usability and applicability. Note

that we do not aim to point the best tool (in fact, some reviews attempt to rank tools) or to judge about the tool quality. We only focus on the beneficially of the tools in different requirements: some of the tools are valuable for interviews for example, some others for surveys, etc.

By reviewing safety culture assessment tools we aim to assess for each tool the main data collection methods, the degree of generalization, the structure, the practical applicability level, the key strengths and limitations as well as the degree of the computerization.

For finding relevant information about current tools we looked in the safety assessment database (NLR, 2010), in the references of the related articles, in the organizations websites, in Google Scholar database and in available articles in the local repository of SCK•CEN publications. Among many existing tools we chose the ones that correspond to several criteria such as availability of relevant information, the reliability of the source, etc. Note that the extent of our recommendations is limited by the availability of information about the tool. Some tools have very thorough reporting, while others are described partially detailing only a specific feature of the tool. In Section 6 we list a subset of tools revised which are representative enough for the overall review.

6. Discussion of Findings

Several observations have been noted during the review process of this study.

- In the vast majority of tools there is a lack of validity as regards, for instance, construct or discriminant validity. Construct validity refers to the extent to which an assessment instrument actually measures what it intended to measure. On the other hand, the discriminant validity of a tool refers to its power to differentiate (e.g., by number of accidents, near misses) between organizations or groups with different levels of safety. However, within high-reliability organizations, accidents and incidents are very infrequent, so the usefulness of this method becomes arguable.
- The majority of tools use only one data gathering method (mostly questionnaires). Only few tools use other methods such as interviews, behaviour observations, documentation analysis, focus groups, and process or system inspections.
- The number of safety culture dimensions varies significantly from one study to another. There is no consensus neither in terminology used (for example, characteristics, indicators, attributes, norms can refer to the same concept), nor in the concepts' definition even though there is a great degree of overlap between different tools and methods to this regard. In (Singla, 2006) among 23 safety culture dimensions some have been used in 85 % of surveyed tools, while other dimensions have very low overlapping degree (e.g., only one tool uses a certain dimension).

- The majority of quantitative tools use more or less the same structure for scoring, namely numerical scores in Likert-type scaling or linguistic terms associated with numerical scores. In some cases, these numerical assignments are arguable since a huge amount of information is evaluated by only one score. For example, an indicator can be evaluated based on interviews, observations and documentation analysis results.
- The vast majority of tools do not have enough documentation about the algorithms used to aggregate the assessments made by different respondents into an overall score. The available methods are mostly oversimplified, taking for example the average or the median value of the individual assessment scores.
- The number of questions varies from one questionnaire to another even in the same domain. Some questionnaires have less than 10 questions, while others have more than 100. This is an important issue as one of the reasons of low response rate might be the questionnaire design in terms of questions formulation, their easiness, as well as the number of questions.
- The target group of respondents varies from one approach to another. In some questionnaires the questions are grouped according to responders level of responsibility in the organizational hierarchy, while many questionnaires are designed very general without considering the responders job specificity, position, demographic features etc.
- Many tools do not provide recommendations, which is a more desirable feature for companies than a mere assessment.
- There is a lack of available real-life case studies of safety culture assessment applying a certain tool.
- Namely, the tools are limited to understanding and exploring the safety culture, instead of improving or adopting it.
- Some other comments related with the difference of the tools in terms of their degree of computerization, the easy to use structure, availability of applied examples, etc.

7. Safety Culture Assessment Tools : Non - nuclear Domain

Table 2: RSSB approach

Title	Rail Safety and Standards Board (RSSB)
Year/Ref.	2011(the last version) / (RSSB, 2008).
Domain	Railways.
Data collection	Questionnaire.

method	
Structure	<p>Four key elements of safety culture are considered, each of them consisting of one or more factors (11 in total):</p> <ul style="list-style-type: none"> – Effective and appropriate safety management systems <ul style="list-style-type: none"> ○ Barriers and influences, ○ Training, ○ Communications. – Demonstrable management commitment to safety <ul style="list-style-type: none"> ○ Organizational commitment, ○ Management commitment, ○ Supervisor’s role. – Participation involvement and workforce attitude to safety <ul style="list-style-type: none"> ○ Personal role, ○ Work mate’s influence, ○ Risk taking behaviours, ○ Employee participation. – Organizational learning and continuous improvement <ul style="list-style-type: none"> ○ Organizational learning. <p>Each factor consists of several sub-factors (27 in total)</p>
Assessment Method	Five point Likert-type scale is used for questionnaire, the percentage of the answers, the mean values and standard deviations are calculated for each safety culture factor.
Computer Assisted	Yes
Objectives	Provide a user friendly self-administered tool to assess the safety culture of railway related organizations, to report the results and to suggest the possible action path for safety culture improvement.
Description	The last version of the questionnaire is based on its previous questionnaire as well as the HSE Safety Climate survey questionnaire and considers the elements included in the Safety Culture Maturity Model™ developed by the Keil Centre (see Table 5).
Key strengths	<ul style="list-style-type: none"> – easy to use software tool, – good visual interpretation of results, – identification of sub-cultures based on employees position, department, etc., – possibility to compare the results through different time period, – possibility to compare the results with the results of another company in the same domain, – easily adjustable for various companies, – good documentation.
Limitations	<ul style="list-style-type: none"> – based only on the questionnaire, – the scaling system,

	– the aggregation method.
Usage	Has been used by Birse Rail, GB Rail freight, Scotrail, Southern Railways, etc.

Table 3: HMRI approach

Title	Her Majesty's Railway Inspectorate (HMRI)
Year / Ref.	2005 / (Health and Safety Executive, 2005).
Domain	Train Operating Companies, Freight Operating Companies, Infrastructure Maintenance Companies, and Train Maintenance Companies.
Data collection method	<ul style="list-style-type: none"> – Interviews; – Document reviews.
Structure	<p>Evaluates against five indicators:</p> <ul style="list-style-type: none"> – Leadership, – Two-Way Communication, – Employee Involvement, – Learning Culture, – Attitude Towards Blame. <p>Uses 22 criteria incorporated with safety indicators. Uses six different scenarios for information elicitation:</p> <ul style="list-style-type: none"> – Normal Operations of the Day, – Safety Issues, – Degraded Operations: Time Critical or Difficult Situation, – Safety Consideration During Change Management, – Incident Operations: Incident Management, – Management of Safety. <p>For each scenario a series of questions is developed.</p> <ul style="list-style-type: none"> – Positive or negative evidence points are used categorized as being indicative of either satisfactory or unsatisfactory performance. – A series of questions are developed to identify the extent to which the company is satisfying the evidence points associated with the specific assessment criteria relevant to each of the five indicators of safety culture.
Assessment Method	<ul style="list-style-type: none"> – Only qualitative analysis, – Reporting by inspectors based on documentation reviews and the results of interviews.
Computer Assisted	No.
Objectives	Focuses on the psychological aspects of safety culture and incorporates a methodology that, as far as practicable, captures what happens in the

	company, (a 'reality check') rather than focusing on the perceptions of staff.
Description	A toolkit for railways safety culture assessment used by inspectors.
Key strengths	<ul style="list-style-type: none"> – scenario-situation based questions, – the use of pocket cards and diagrams, – partial assessment possibility, – good documentation.
Limitations	<ul style="list-style-type: none"> – heterogeneity of the answers structures, – based only on interviews, – lack of scoring guideline, – complex structure.
Usage	Has been used in UK railways and based on this toolkit a similar toolkit was developed for Australian railways safety culture assessment.

Table 4: AHRQ approach

Title	Hospital Survey on Patient Safety Culture by the Agency for Healthcare Research and Quality (AHRQ)
Year / Ref.	2004 / (Health Foundation, 2011)
Domain	Health Care.
Data collection method	Questionnaire.
Structure	<p>The survey measures seven unit-level aspects of safety culture:</p> <ul style="list-style-type: none"> – Supervisor/Manager Expectations & Actions Promoting Safety (4 items). – Organizational Learning—Continuous Improvement (3 items). – Teamwork Within Units (4 items). – Communication Openness (3 items). – Feedback and Communication About Error (3 items). – Nonpunitive Response to Error (3 items). – Staffing (4 items). <p>In addition, the survey measures three hospital-level aspects of safety culture:</p> <ul style="list-style-type: none"> – Hospital Management Support for Patient Safety (3 items). – Teamwork Across Hospital Units (4 items). – Hospital Handoffs and Transitions (4 items). <p>Four outcome variables are included:</p> <ul style="list-style-type: none"> – Overall Perceptions of Safety (4 items).

	<ul style="list-style-type: none"> – Frequency of Event Reporting (3 items). – Patient Safety Grade (of the Hospital Unit) (1 item). – Number of Events Reported (1 item).
Assessment Method	<ul style="list-style-type: none"> – Five point Likert-type scale is used for questionnaire. – the percentage of positive, negative and neutral responses are shown in graphs.
Computer Assisted	Yes.
Objectives	The survey places an emphasis on patient safety issues and on error and event reporting.
Description	Medical Errors Workgroup of <i>the Quality Interagency Coordination Task Force</i> sponsored the development of a hospital survey focusing on patient safety culture. Funded by the AHRQ, the <i>Hospital Survey on Patient Safety Culture</i> was developed by a private research organization under contract with AHRQ.
Key strengths	<ul style="list-style-type: none"> – applied and tested in a large number of hospitals, – assesses safety culture at the individual, unit and organisational level, – makes comparisons with other hospitals and benchmark against larger datasets.
Limitations	<ul style="list-style-type: none"> – based on questionnaire only, – questionnaire is domain dependent, – many detailed questions about the respondent: thus for small groups it is difficult to guarantee the anonymity as it is easy to guess about the identity of the respondent.
Usage	Has been used hundreds of hospitals in US.

Table 5: SCMM approach

Title / Ref.	Keil Centre Safety Culture Maturity® Model (SCMM)
Year	1999 / (Fleming, 1999).
Domain	Domain independent.
Data collection method	Workshops.
Structure	<p>Consists of five maturity levels (listed from low to high):</p> <ul style="list-style-type: none"> - Emerging level, - Managing level, - Involving level, - Cooperating level, - Continually improving level.

	<p>Ten elements are discussed:</p> <ul style="list-style-type: none"> - Visible management commitment, - Safety communication, - Productivity versus safety, - Learning organisation , - Health and safety resources, - Participation in safety, - Shared perceptions about safety, - Trust between management and frontline staff, - Industrial relations and job satisfaction, - Safety training.
Assessment Method	Each level consists of ten elements which are the ten most important safety culture components. A simple card sorting technique is used to provide an indication of an organization's level of maturity.
Computer Assisted	No.
Objectives	<p>Aims to assist organizations in:</p> <ul style="list-style-type: none"> - establishing their current level of safety culture maturity, and - identifying the actions required to improve their safety culture.
Description	Is based on the capability maturity model concept, initially developed by the <i>Software Engineering Institute</i> (Paulk & others, 1993), as a mechanism to improve the way software is built and maintained. SCMM is a part of the project sponsored by the UK offshore oil industry and the Health and Safety Executive to provide a structured safety culture improvement process.
Key strengths	<ul style="list-style-type: none"> – evidence of good validity, – greater degree of employee involvement, – assesses change in the safety culture over time, – not time consuming to apply, – the documentation is available in many languages (English, French, Spanish, Dutch, Italian, German and Chinese), – easy to use and manage, – good reporting.
Limitations	<ul style="list-style-type: none"> – workshop organization management, – lack of confidentiality, – relatively expensive, – low attendance level in workshops.
Usage	Has been used in many countries (UK, Singapore, Venezuela, Norway, etc.) in different sectors including aviation, road and rail transport, petrochemicals, offshore oil and gas exploration and production, steelmaking, food manufacture, electronics and health care, etc.

Table 6: ANSPS approach

Title	European Air Navigation Service Providers (ANSPS) Safety Culture Tool
Year / Ref.	2006 / (Mearns & others, 2009).
Domain	Air navigation.
Data collection method	<ul style="list-style-type: none"> – Questionnaire, – Interviews, – Workshops.
Structure	<p>13 important themes are discussed:</p> <ul style="list-style-type: none"> - Commitment to Safety, - Resources for Safety, - Responsibility for Safety, - Involving ATCOs in Safety, - Management Involvement in Safety, - Teaming for Safety, - Reporting Incidents/Communicating Problems, - Learning from Incidents, - Blame & Error Tolerance/Discipline and Punishment, - Communication about Procedural/System Changes, - Trust within the organization, - Real Working Practices, - Regulatory effectiveness.
Assessment Method	<ul style="list-style-type: none"> – Five point Likert-type scale is used for questionnaire. – Simple mean, ranges and standard deviations were calculated to identify trends of favourable and unfavourable responses. – Potential problem areas are decided by taking the items having more than 25 % unfavourable responses.
Computer Assisted	No.
Objectives	To insure that the ATM industry is permeated with a consistently high level of safety culture, and that this high level of safety culture is in place before any possible planned changes get underway.
Description	Based on a scientific study of safety culture in air traffic management sponsored by Eurocontrol.
Key strengths	<ul style="list-style-type: none"> – high level of validity, – different data gathering methods, – involvement of employees in safety culture important themes identification process.
Limitations	<ul style="list-style-type: none"> – the numerical scoring system, – the aggregation method (mean).
Usage	Has been tested in several European ANSPs.

Table 7: LSCAT approach

Title	Loughborough University Safety Climate Assessment Toolkit (LSCAT)
Year / Ref.	1999 / (Loughborough University, 1999)
Domain	Offshore Environments
Data collection method	<ul style="list-style-type: none"> – Attitude questionnaires, – Interviews, – Direct and indirect observations.
Structure	<p>Four main dimensions are discussed with questionnaires:</p> <ul style="list-style-type: none"> – Organisational Context, – Social Environment, – Individual Appreciation, and – Work Environment. <p>Each dimension has several items.</p> <p>Another five dimensions are explored with interviews and focus groups.</p> <ul style="list-style-type: none"> – Co-operation, – Competence and training, – Management style, – Managing change, and – Shared values.
Assessment Method	<ul style="list-style-type: none"> – Five point Likert-type scale is used for questionnaire. – A score of an item is calculated as the average value of all evaluations of the item got from questionnaire. – Dimensions have different numbers of items and, thus, scores are standardised before plotting and comparing the dimensions. – Once dimension scores are computed for each respondent, average scores are computed for the whole group. <p>For interviews an average score of each dimension related question is calculated and plotted.</p> <p>Direct observation of individuals are achieved using a behavioral checklist which comprises a list of behaviors most commonly associated with preventing accidents, incidents and near misses in a particular area.</p>
Computer Assisted	Not specified.
Objectives	To provide an assessment technique that includes a practical tool for the assessment of safety climate and also aids the promotion of a positive safety culture in the offshore environment.
Description	Developed in Loughborough University and designed to be used without expert external assistance.
Key strengths	<ul style="list-style-type: none"> – several data collection methods, – identifies subcultures,

	<ul style="list-style-type: none"> – high level of guidance via website, – good level of validity, – easy to adjust for other domains.
Limitations	<ul style="list-style-type: none"> – quantification of all data might lead to approximate results assessing in fact the climate instead of the culture, – the scoring and aggregating method is too simple.
Usage	Has been used in gas and oil industry .

7.1 Rail Safety and Standards Board (RSSB) survey tool

Note that the previous version of RSSB tool has been assessed as the second best tool of safety culture assessment in UK by Keil Centre Review on Safety Culture.

The survey includes 54 questions to assess employee attitudes, values and perceptions towards safety and safety management systems across 11 safety culture factors. In addition, five safety culture levels are decided based on the current level obtained a number of recommendations are given towards the improvement of safety culture.

Once the survey is conducted, a range of automated analysis reports are generated. This includes up to nine standard reports with general information about the state of each factor, three benchmarking reports with the functionality to enable companies to benchmark themselves against previous surveys. The reports include:

- automatically generated graphical outputs of survey responses that include:
 - scores of factors expressed as the percentage of the given answers,
 - the standard deviation of all factors evaluations,
 - a graph to compare the most important safety culture factors for different roles (managers, engineers, train drivers, etc.),
 - a table showing the factors that are the most important for different roles (e.g. particularly positive or negative answers by train drivers),
 - a graph showing the differences between answers from people with different roles for each safety culture factor.
- the safety culture development level (ranging from one to five) verified by:
 - the nature of line management behaviours to actively promote safety,
 - the level of employee participation in safety improvement,
 - the extent that the organisation recognises and manages any short term conflicts between safety and performance.
- a good practice guidance from rail and other high risk industries linked to the automatically generated results,
- practical recommendations on the management and monitoring of safety culture and enhancement interventions.
- identification of detailed areas to address and potential areas where the organization has good practices of safety culture,
- identification of issues that require further additional investigations,

- links to improvement examples.

In addition to the assessment itself, the tool has some additional useful features making it attractive to explore. Namely, an interactive ‘Safety Culture Discussion Forum’ is available on-line where different experiences can be shared in terms of the safety culture topic in general, as well as the use of the tool itself. In addition, a ‘Safety Culture Improvement Library’ was created where registered members can submit and share good practices.

There are several advantages that make this tool worth considering, especially when developing safety culture/climate questionnaires. This is one of the few tools that considers the sub-cultures based on several criteria (job position, department, etc.). In addition, it is possible to keep track of the changes over time comparing the current results with the previous ones (an automated feature provided in the tool). An interesting feature of this tool is the possibility to compare anonymously the company results against other companies in the same sector. Moreover, this tool has the possibility of partial assessment of only the desired factors, as well as partial comparison (compare the results for only a subset of all factors in different time periods). Of course, the main disadvantage of this tool is the fact that the safety culture assessment is based only on the questionnaire results.

7.2 Her Majesty’s Railway Inspectorate (HMRI) Safety Culture Assessment Tool

The aim of this work is to develop a pragmatic approach and methodology for the inspection of safety culture in UK rail companies, which focuses on five indicators influencing safety culture (mentioned in Table 3). In addition, a number of criteria has been identified for each safety culture indicator. Furthermore, a number of scenarios are selected through consultation with HMRI inspectors and from evidence derived from the literature review. Each scenario is assessed against two or three assessment criteria.

The toolkit has been designed to measure the effectiveness of safety culture within a broad range of UK railway organizations including Train Operating Companies, Freight Operating Companies, Infrastructure Maintenance Companies, and Train Maintenance Companies. The effectiveness of the tool has been validated through a series of inspection visits at a range of UK rail companies.

The tool consists of several components, namely the questions set, pocket cards, overview diagrams and the inspectors guide. The overview diagram and the pocket card provide inspectors with alternative formats to the question set. Although the question set, pocket cards and overview diagram contain the same information, the different formats allow the inspectors the freedom to conduct their inspections using the options that best suit their personal preferences.

There are several advantages of this tool that we consider worth mentioning here.

- Though the tool has been designed to measure all five safety culture indicators, it also provides the flexibility to concentrate on one particular indicator of safety culture, if required. This is a useful feature if an organization wants to repeat the assessment focusing on the indicator that was found the most vulnerable in the previous assessment.
- Another concept that makes this tool attractive is the use of scenarios and evidence points. Scenarios help to acquire a deeper and more thorough view of the culture. Evidence points help having more details before answering the question, thus the answer will be more realistic and reliable.
- The use of the pocket card and the overview diagram are supplementary tools to be used in the interviews, and obviously they help inspectors during the interviews by the summarized and visual representation of the process.

What we consider as a drawback in this approach are as follows:

- the heterogeneous structure of the answering categories to the different questions: some questions require a binary answer (yes or no), some others are open questions; some are descriptive questions, some quantitative questions. There is no clear guidance for the inspector how to put together the answers; this fully relies on the inspector's experience.
- The process is very time consuming and it is not straightforward for inspectors to come to a conclusion. For each assessment criterion the inspector has to evaluate the respondent's answer against the evidence points, considering also the document reviews associated with the scenario.
- The biggest disadvantage of this tool is that it uses only interviews (the documentation review is based only on limited number of documents) for safety culture assessment.

As a concluding remark about the HMRI tool we observed that it is very good tool as regards the structure of the questionnaire since it links each question with some criteria, indicator and scenario. Additionally, the idea of positive and negative evidence points suggests that the questionnaire reflects the reality with great reliability. This tool can serve as a very good guide for interview-based safety culture assessment.

Though many questions, scenarios and situations described are directly related with railways, it is very easy to adopt the structure of this approach for other industries.

7.3 Hospital Survey on Patient Safety Culture by AHRQ

This tool by the US Agency for Healthcare Research and Quality (AHRQ) is the most frequently used tool in the US for the development of patient safety culture assessment in the hospitals, nursing homes and ambulatory outpatient medical offices. However, recently it has been used also by the hospitals outside of the US (Belgium, Norway, Saudi Arabia, Spain, Turkey, Lebanon, etc).

One of the interesting features of this tool is the possibility of a comparative database report which was developed as a tool for the following purposes:

- Comparison—to allow hospitals to compare their patient safety culture survey results with those of other hospitals.
- *Assessment and Learning*—to provide data to hospitals to facilitate internal assessment and learning in the patient safety improvement process.
- *Supplemental Information*—to provide supplementary information to help hospitals identify their strengths and areas with the need for potential improvement.
- *Trending*—to provide data that describe changes in patient safety culture over time.

An interesting study has been done to use this tool to compare the hospitals safety culture across countries. For example, a case of US and Taiwan discusses which dimensions are similar or different in the two countries, further exploring the possible causes of the similarity/difference. A similar study was done to use this tool to compare different industries. For instance, a survey was conducted in Norway using this tool for comparing the safety climate in two organisations: a university hospital offering a wide range of hospital services and a large petroleum company producing oil and gas worldwide. The results show that safety culture is generally higher in the petroleum industry compared to healthcare (Olsen and Aase, 2010).

In addition, there are several other studies that use the adjusted or improved version of this tool for different industries. In several cases the tool has been used combined with other data gathering methods. In general, this tool is the one (among the tools discussed here) that has been used the most.

7.4 Keil Centre Safety Culture Maturity® Model

The Safety Culture Maturity® Model (SCMM) assists organisations in establishing their current level of safety culture, and identifying the actions required to improve their safety culture. Note that, this tool is recognized as one of the few tools that has employees' full involvement in the identification, assessment and follow up of safety related issues.

However, the organization has to be aware that SCMM can be applied only when meeting certain assumptions. SCMM considers that cultural or behavioural approaches to safety improvement are most effective when the technical and systems aspects of safety are performing adequately and the majority of accidents appear to be due to behavioural or cultural factors. Therefore SCMM can be applied in organisations that already fulfil a number of specific criteria such as:

- an adequate safety management system,
- technical failures are not causing the majority of accidents, and
- the company is compliant with the health and safety law(s).

The purpose of these assumptions is to help organizations not to waste efforts on the improvement of their safety culture when the problems have more technical background. In such cases, it would be more appropriate for them to focus their resources on the technical and systems aspects of safety rather than on the behavioral and cultural aspects.

Figure 1 shows the general structure of SCMM five maturity levels of safety culture and the path to move from one level to another by continuously improving the safety culture. Workshops with a representative sample (approximately 50 % of staff) are used to establish the current maturity level of the organization. During these workshops also the corresponding actions to move to the next more mature safety culture level are discussed. To decide the current level, each participant to the workshop is given five cards and is asked to select the one which according to him/her best describes the current situation. During the discussion each of the ten elements are discussed separately, and for each element each attendee of the workshop explains why the certain level is preferred by him/her. All participants suggest possible actions to be taken by the management, by their group, by themselves.

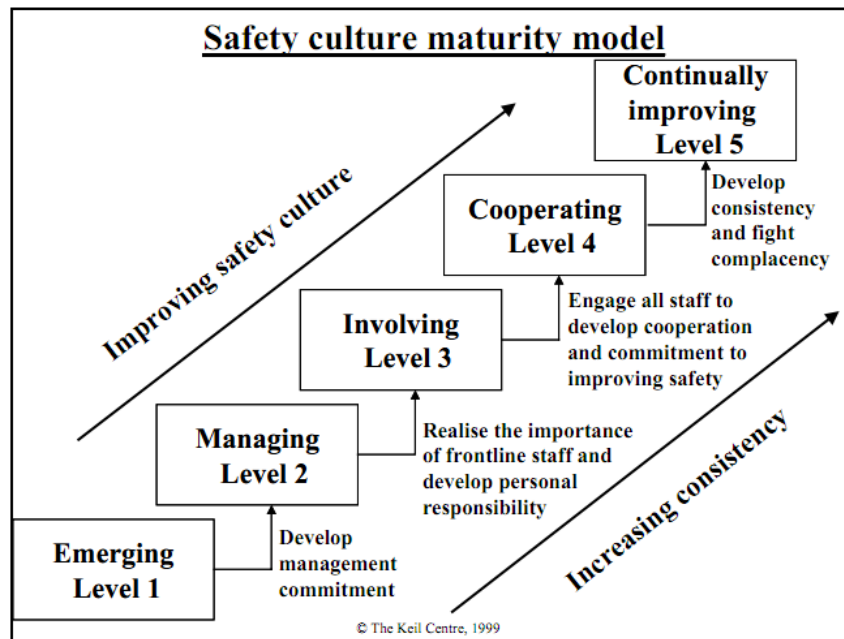


Figure 1: High level view of SCMM structure (Fleming, 1999)

Despite being a very interactive and widely used tool, there are several concerns about SCMM. First, the absence of anonymity during the workshop discussions might lead to results that are not reflecting the real situation. Second, it is difficult and time consuming to organize workshops and assure that all supposed participants will attend the workshop and will contribute to the discussion. However, if this tool is used with other data gathering methods, the result will be fairly reliable as this tool is solution-

oriented and participative, with the possibility to see the change in safety culture over time.

7.5 European Air Navigation Service Providers (ANSPs) Safety Culture Tool

As many other industries, the domain of air navigation has to deal constantly with financial, commercial pressure and to face regular changes. Thus, the possibility of having unsafe actions and behaviours from employees might increase. Consequently, a tool is needed for safety culture assessment which handles dynamic changes over time, which is reliable and will be a supplementary tool for safety management. Note that, in the study (Mearns & others, 2009) it is claimed that ATM is a unique industry and other tools from other industries are not suitable, and it needs its own tailored approach.

Figure 2 shows the steps of the overall analysis process. First, the questionnaire is distributed to gain a snapshot on how the members of the organization perceive safety within their organization. Then, the completed questionnaire is sent to the analysis team who explores trends in favourable and unfavourable responses. Note that, a certain item is considered as a potential problem, if at least 25 % of respondents give unfavourable answers for that item. After identifying the most important key issues that need further discussion, workshops or interviews are organized to gain deeper insight into key issues.

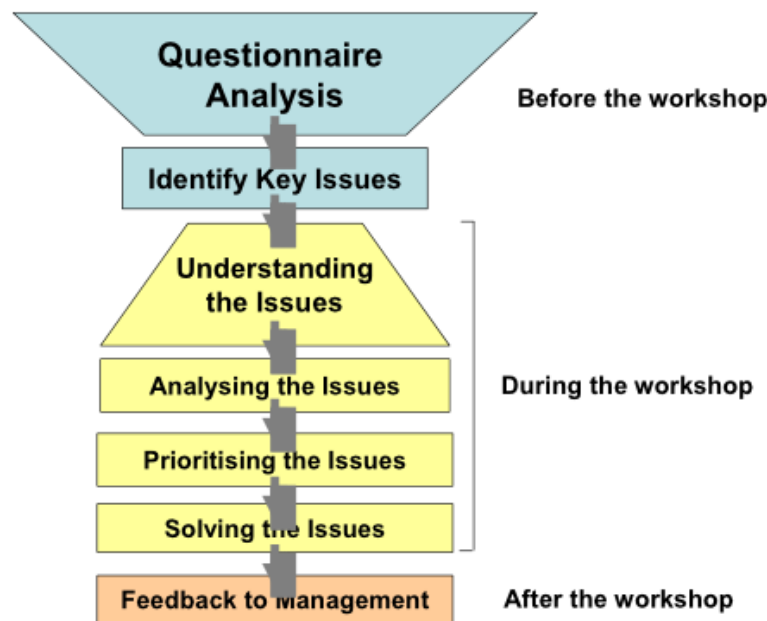


Figure 2: ANSPS analysis process (Mearns & others, 2009).

The last step is to give feedback to management by means of reporting the results. The reports will include the 'quick wins' (strong sides of the organization in terms of safety

culture), tactical short term measures (e.g. ensuring better consistency in the approach of supervisors to discipline following controller mistakes), up to medium and longer term strategic measures. Note that the final decision on what actions to implement is up to the ANSPs themselves, in particular the executive management board.

An important contribution of this approach is the detailed discussion of the validity techniques. As far as we found, this is the only approach that discusses the validity issue of workshops based on several criteria.

7.6 Loughborough University Safety Climate Assessment Toolkit – (LCSAT)

This approach by HSE is a practical tool for safety culture / climate assessment in offshore organisations. The project was carried out in collaboration with the Offshore Safety Division of the HSE, Chevron UK, Chevron Gulf of Mexico, Mobil North Sea and Oryx UK.

LCSAT is a very comprehensive tool analysing safety culture and climate by different data gathering methods such as:

- Attitude surveys and rating scales,
- In-depth, informal discussions with individuals,
- Focus groups,
- Examination of written records and databases,
- Documentation analysis,
- Direct observations.

Though it has been designed for offshore organizations, with little adjustment it can be used in other industries as well.

There are several unique features of this tool:

- the quantification of data from all methods (questionnaires, interviews, direct or indirect observations, accident, incident reports, etc.),
- the use of different dimensions for different data gathering methods: in fact, this creates difficulties as the data gathered by different methods is not comparable,
- two different types of questionnaires are available: short and long. If limited time is available, then a short form assessment can be used. This contains two of the items which best characterise each dimension of the questionnaire, thus a total of 18 items, while the long version contains 43 items,
- the confidentiality of surveys and observational methods.

Note that the majority of the tools in the available literature discuss only how to gather and assess the safety culture related data. However, there is not clear guidance on adjusting or improving the culture. This tool provides to some extent recommendations about the safety climate improvement processes, including brief details on developing action plans and a safety climate maintenance checklist.

One of the disadvantages of the tool is the data aggregation technique used for different methods. Although there are slight differences, in all data gathering methods numerical values are assigned and the average value is taken as a group decision, the results being communicated by plotted diagrams.

8. Safety Culture Assessment Tools: Nuclear Domain

While in the non-nuclear domains many tools are available both in applied and academic literature, in the nuclear domain only few tools have enough documentation allowing to analyse them thoroughly.

Table 8: IAEA SCART approach

Title	Safety Culture Assessment Review Team (SCART)
Year/Ref.	2008/ (IAEA, 2008).
Domain	Nuclear facilities, regulatory authorities, nuclear design organizations.
Data collection method	<ul style="list-style-type: none"> – documentation review, – behaviour observations, – interviews.
Structure	<p>Consists of a set of five key safety culture characteristics (IAEA Safety Guide GS-G-3.1):</p> <ol style="list-style-type: none"> 1. Safety is a clearly recognized value. 2. Leadership for safety is clear. 3. Accountability for safety is clear. 4. Safety is integrated into all activities. 5. Safety is learning driven. <p>The characteristics in their turn contain attributes (overall 37) that are related to safety outcomes.</p>
Assessment Method	Using 9 points scale for each question and the median method for finding the group score.
Computer Assisted	No.
Objectives	<ul style="list-style-type: none"> – gain a differentiated opinion on the organizational and business performance features of the nuclear facility which may have implications for safety, – gain an opinion on the degree of compliance with safety-related policies, processes, and procedures, – gain an opinion on the degree of formal and informal acceptance and understanding of safety-related policies, processes, and procedures, – gain an opinion on tacit social norms, beliefs, attitudes, and values of management and staff, especially, concerning their relevance to

	safety.
Description	The IAEA Safety Standards (Fundamentals, Requirements and Guides) are the basis for planning and conducting SCART missions.
Key strengths	<ul style="list-style-type: none"> – different data collection methods, – hierarchical framework for indicators, – good documentation.
Limitations	<ul style="list-style-type: none"> – the overall procedure is very time consuming and costly, – interviews focus mainly on management, – aggregation method (median) might not reflect the reality, – the scoring of attributes is based on different, possibly conflicting information.
Usage	Has been used in several nuclear power plants.

Table 9: ENEL approach

Title	ENEL and WANO Paris Centre
Year/Ref.	2006 / (ENEL Area Tecnica Nucleare, 2006).
Domain	Nuclear facilities.
Data collection method	Questionnaire.
Structure	<p>ENEL is conducting a safety culture self-assessment questionnaire aiming to identify the state of the WANO principles within an organization. WANO principles for a strong safety culture are:</p> <ul style="list-style-type: none"> – Everyone is personally responsible for nuclear safety. – Leaders demonstrate commitment to safety. – Trust permeates the organization. – Decision-making reflects safety first. – Nuclear technology is recognized as special and unique. – A questioning attitude is cultivated. – Organizational learning is embraced. – Nuclear safety undergoes constant examination.
Assessment Method	Using numerical scale for answering and the average value as a group score of WANO indicators.
Computer Assisted	No.
Objectives	<ul style="list-style-type: none"> – assess the safety culture in a nuclear facility with respect to international standards, – identify strengths and areas for improvement of safety culture at the host nuclear facility, – give recommendations and suggestions for improvement in areas

	<p>where performance falls short of international,</p> <ul style="list-style-type: none"> – provide an information regarding identified good safety culture practice.
Description	A quantitative approach for safety culture safe-assessment in nuclear facilities, though it is mentioned that also external assessment has been done inviting for example experts from WANO or IAEA. However external assessments are focused on safety assessment (such as IAEA OSART Mission) in which safety culture is covered as one part of safety assessment.
Key strengths	<ul style="list-style-type: none"> – explicitly linking questions with one or more indicators, – anonymity method.
Limitations	<ul style="list-style-type: none"> – simple aggregation method, – based only on questionnaire, – not much documentation available.
Usage	Has been used in several nuclear power plants such as in Slovensk Elektrrne and Endesa (in both ENEL has an ownership).

Table 10: SCOP approach

Title	Safety Culture Oversight Process (SCOP)
Year/Ref.	2010 / (SCOP, 2010).
Domain	Applicable primarily in the regulatory assessment and inspection activities for organizations responsible for the construction, commissioning, operation or decommissioning of nuclear installations
Data collection method	<ul style="list-style-type: none"> – documentation reviews, – behaviour observations, – interviews.
Structure	<p>Consists of a set of five key characteristics and 37 attributes as in SCART. The following functional areas are reviewed:</p> <ul style="list-style-type: none"> – Management, Organization and Administration; – Training and Qualification; – Operation and Maintenance; – Technical Support; – Operational Experience Feedback; – Radiation Protection; – Emergency Planning and Preparedness.
Assessment Method	Not specified.
Computer Assisted	No.

Objectives	<ul style="list-style-type: none"> – provide a systematic approach to the identification and collection of information relevant to the licensees' safety culture; – inform the regulatory activities with regard to the safety culture in licensees' organizations; – identify and highlight the safety culture issues at organizational level; – identify and highlight the predominant safety culture; characteristics and attributes affected in a certain functional area; – provide the basis for recommendations and suggestions regarding the improvement of safety culture in licensees organization.
Description	The SCOP has been initiated with support from the IAEA with the aim of improving nuclear safety and emergency preparedness in Romania.
Key strengths	<ul style="list-style-type: none"> – different data collection methods, – good user guideline, – thorough analysis of each indicator.
Limitations	<ul style="list-style-type: none"> – time consuming, – high complexity, – not clear guidelines about data analysis.
Usage	Has been used in nuclear facilities in Romania and Bulgaria.

Table 11: NEI NSCA approach

Title	Nuclear Safety Culture Assessment (NSCA)
Year/Ref.	2009 /(Nuclear Energy Institute, 2009).
Domain	Nuclear Power Plants.
Data collection method	<ul style="list-style-type: none"> – documentation review, – observations, – interviews, – questionnaire.
Structure	<p>Is based on INPO principles for a strong safety culture which are the same as in WANO (see ENEL approach). The proposed nuclear safety culture process is comprised of nine distinct process elements:</p> <ul style="list-style-type: none"> - Process Inputs - Nuclear Safety Culture Monitoring Panel Sources - Site Leadership Team - Communication - Regulatory Oversight. - Corrective Actions - Other Input - Site Response - External Input
Assessment	Not specified.

Method	
Computer Assisted	Pre-assessment automated survey.
Objectives	To have a comprehensive view of the safety culture by having three different types of assessment methods: self, independent and third party.
Description	Based on the evaluation against INPO principles and attributes (8 principles and 35 attributes in total).
Key strengths	<ul style="list-style-type: none"> – self, independent and third party assessments, – based on different data gathering methods.
Limitations	<ul style="list-style-type: none"> – the self-assessment is based on INPO principles evaluation, independent and third party are based on different model, – the results of self, independent and third party assessments are difficult to compare, – the scoring rules are inconsistent.
Usage	Has been applied in 15 power plants in the US ,Technatom Spain, etc.

Table 12: INEL approach

Title	Idaho National Engineering Laboratory (INEL)																				
Year / Ref.	1993 / (Ostrom & others, 1993).																				
Domain	Nuclear Industry and others.																				
Data collection method	Separate interviews with employees and managers, questionnaire, accident statistics, documents reviews.																				
Structure	<p>Consists of 19 safety culture categories:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Individual Responsibility</td> <td>Safe Processes</td> </tr> <tr> <td>Safety Thinking</td> <td>Safety Management</td> </tr> <tr> <td>Priority of Safety</td> <td>Safety values</td> </tr> <tr> <td>Safety Awareness</td> <td>Teamwork</td> </tr> <tr> <td>Pride and Commitment</td> <td>Excellence</td> </tr> <tr> <td>Honesty</td> <td>Communications</td> </tr> <tr> <td>Leadership and Supervision</td> <td>Innovation</td> </tr> <tr> <td>Training</td> <td>Customer Relations</td> </tr> <tr> <td>Procedure Compliance</td> <td>Safety Effectiveness</td> </tr> <tr> <td>Facilities.</td> <td></td> </tr> </table>	Individual Responsibility	Safe Processes	Safety Thinking	Safety Management	Priority of Safety	Safety values	Safety Awareness	Teamwork	Pride and Commitment	Excellence	Honesty	Communications	Leadership and Supervision	Innovation	Training	Customer Relations	Procedure Compliance	Safety Effectiveness	Facilities.	
Individual Responsibility	Safe Processes																				
Safety Thinking	Safety Management																				
Priority of Safety	Safety values																				
Safety Awareness	Teamwork																				
Pride and Commitment	Excellence																				
Honesty	Communications																				
Leadership and Supervision	Innovation																				
Training	Customer Relations																				
Procedure Compliance	Safety Effectiveness																				
Facilities.																					
Assessment Method	Descriptive Statistics.																				
Computer Assisted	No.																				

Objectives	Develop safety culture assessment most important norms by employees' full participation, as well as a methodology to assess the identified norms.
Description	Based on Kaplan safety norms survey.
Key strengths	<ul style="list-style-type: none"> – thorough analysis of safety culture norms development, – based on different data gathering methods, – compares results from different methods, – identifies subcultures based on different departments, – generic tool.
Limitations	<ul style="list-style-type: none"> – the scoring system, – the aggregation method (mean, median).
Usage	West Valley-Nuclear, Chem-Nuclear Geotech, etc.

Table 13: EBSCA approach

Title	Event-based Safety Culture Assessment (EBSCA)
Year / Ref.	2004 /(Balfanz & others, 2002), (Schot & others, 2004).
Domain	Nuclear Industry.
Data collection method	<ul style="list-style-type: none"> – Event documentation analysis, – Interviews, – Workshops.
Structure	Based on accident, incident analysis.
Assessment Method	<ul style="list-style-type: none"> – "cause complexes" are classified and quantified due to their frequencies, – events are assigned weights to related to "cause complexes", – events are given relevance weights in relation with plant safety, – the final score is decided by multiplying the two weights scores.
Computer Assisted	Partially.
Objectives	Aimed at identifying organizational and management factors concerning the failure causes and at drawing conclusions about the safety culture in an NPP from events.
Description	The assessment of plant operations by root cause analysis of real events ("Event-orientated Safety Culture Assessment"), called "indirect-fact driven assessment".
Key strengths	<ul style="list-style-type: none"> – based on thorough discussion of events and causes; thus many hidden, intangible details will be identified.
Limitations	<ul style="list-style-type: none"> – should have convincing reasons that the events are related with safety culture, – many patterns are not related with events thus they won't be

	given any attention.
Usage	Nuclear power plants in Germany.

8.1 Safety Culture Assessment Review Team (SCART)

SCART is the latest approach of IAEA to assess the safety culture of nuclear facilities (nuclear power plants, regulatory authorities, nuclear design organizations). The IAEA Safety Standards (Fundamentals, Requirements and Guides) are the basis for planning and conducting SCART missions. SCART is intended to be conducted by a team of reviewers with direct experience in assessment and enhancement of safety culture in nuclear facilities. In SCART the following distinct levels of responsibility are considered:

1. Members of Boards of Directors;
1. Chief Nuclear Officers and Executive Officers;
2. Station Directors and senior managers at nuclear facility level;
3. Middle-level managers (operative nuclear facility level);
4. First line supervisors (team level, managing face to face groups);
5. Shop floor level (operators, maintenance staff, technicians, etc.).

The SCART framework consists of a set of five key safety culture characteristics, and a number of attributes that are related to safety outcomes. The attributes are short descriptions of a specific organizational performance or attitude in a nuclear facility, which, if fulfilled, would characterize this performance or attitude as belonging to a strong safety culture. The 37 attributes of the five safety culture characteristics are the assessment variables in SCART reviews. The data gathering during the SCART mission is based on three methods: interviews with managers and staff, behaviour observations, and review of documentation. In addition, it can be decided to use questionnaires as an optional supplementary method.

One of the main advantages of SCART is its comprehensiveness in analysing and assessing the safety culture by different data gathering methods.

However, the multidimensionality results also in some drawbacks that are quite noticeable to mention. In particular, SCART is very time consuming, both the Pre-SCART mission (6 months) and the SCART mission itself. Indeed, to conduct a full process with documentation reviews, observations of behavioural changes, interviews, and optional questionnaires, and afterwards to analyse all available information to be able to score each attribute, is very time consuming as well as very costly.

One drawback of SCART is the statistical method used to evaluate the final score of each attribute based on several reviewers' evaluation. For example suppose we have five reviewers (SCART has a restriction of having from four to six reviewers). To make things simple, suppose 3 of the reviewers give a score equal to three and the other two reviewers evaluated the same concept by a score equal to nine. If we take the median, the result is three. However, there is a big gap between the reviewers' evaluation: thus the final result does not reflect the reality. Another weak point of SCART is its scoring

system. For each attribute the reviewer has to come up with a single numerical value. However, if we explore the required steps to evaluate an attribute, the credibility of the given score becomes arguable. For example, for the attribute 'The high priority given to safety is shown in documentation, communications and decision making' the reviewer needs to analyse five statements from IAEA specific guidance, has to answer four guiding questions, two questions about expectations, five questions about meetings, two questions about media-based communication, and three questions about decision making. So, the reviewer has to revise the interviews taken the same day from the employees in the facility, has to revise the documentation reviews and behavioural observations results related to that specific attribute, has to analyse 20 statements and questions, and at the end give a single numerical score. This evaluation structure leads to high approximation which is not desirable in high risk industries.

Several other drawbacks can be found in the NRC revision of SCART such as:

- Interviews are often too focused on the management.
- Questions are not clearly linked with the attributes.
- There is no clear guidance on how to handle conflicts between different evaluations.
- The questionnaire-based survey is left as an optional choice.

Despite the drawbacks of SCART, it is very comprehensive approach and can be a good guide to develop a new tool of safety culture assessment.

8.2 ENEL and WANO Paris Centre Safety Culture Assessment Tool

ENEL is the biggest energy company in Italy and it is present in over 23 countries in Europe, North America and South America. Biannually ENEL is conducting a safety culture self-assessment questionnaire aiming to identify the state of the *World Association of Nuclear Operators* (WANO) principles within an organization. WANO principles for a strong safety culture are listed in Table 9. Note that most principles are the same as SCART characteristics even if they are formulated slightly differently.

A total of 40 questions are designed to conduct the survey. To each of the forty questions there is a weight assigned with respect to one or more of the eight WANO principles. Average values are calculated for each question using the five possible answer values. The resulting matrix of the average values and weights builds up a picture of the organizational profile with respect to the WANO safety culture principles.

For anonymity an email drop box is used. We want to mention here that anonymity is very important for safety culture surveys as the responders feel not comfortable to answer certain questions if they are sure that their identity is easy to identify (which is the case in small groups where only by demographic features and some basic details it is easy to find the identity of the respondent). On the other hand the anonymity should be insured in a way that each respondent answers only once: thus there is no fear of having

fake multiple answers from the same user (this problem might arise with computer assisted tools).

This approach is interesting for connecting each question with safety culture principles with different degrees. This is missing in other approaches, and, in fact, if we take for example the attributes of SCART, even though they are formulated to be independent, the interview questions, for example, are related with different attributes in different degrees.

However, even with the interesting framework of ENEL questionnaire, its evaluation algorithm is very simple (assigning numbers for each answer then taking the average). Another limitation of this approach is choosing only questionnaires as a data gathering method, which will give a rather shallow view of the real safety culture of an organization.

8.3 Safety Culture Oversight Process (SCOP)

As in SCART, the SCOP assessment is based on IAEA Safety Guide GS-G-3.1 characteristics and attributes. SCOP is designed as a supplementary tool for the inspectors to conduct safety culture assessments in licensees' organizations.

SCOP combines two approaches: compliance based regulation and proactive approach. The compliance based verifications are the inspections by which the regulatory authority checks if the provisions of the regulations are fulfilled by the licensee. Usually this kind of inspections are finalized with dispositions; this is because every time when the requirements are not met, all the efforts shall be made to bring the facility back into the license boundaries. The proactive approach, on the other hand, is considered when practices, organizational aspects, procedures, etc. are observed and evaluated with the aim of identifying areas for improvement. This type of assessment finalizes with recommendations and in particular cases also with dispositions. These kinds of assessments are usually convenient for the facilities because they are independent assessments even if they come from regulatory authorities.

The SCOP review process includes the following:

1. assessment of nuclear safety and management systems documentation,
2. process oriented inspections (operation, maintenance, training, etc.),
3. field routines (plant walk downs and checklists to verify configuration for different systems and the normal range for certain parameters important for nuclear safety),
4. system inspections (i.e. checking test results, tendencies, abnormal conditions),
5. examinations and interviews of control room staff and of plant managers,
6. participation in meetings with the licensees' representatives.

To guide inspectors the following steps are provided within SCOP approach:

- for each attribute of each characteristic the review areas are listed (all functional areas are listed in Table 10),
- for each attribute and for each review area all the necessary documentation to be reviewed is listed,
- for each attribute and for each review area the types of observations are provided (i.e. types of meetings or trainings to observe),
- for each attribute and for each review area a number of questions are provided to be asked during interviews,
- for each attribute and for each review area a number of criteria are listed to help inspectors to make their judgments.

The drawbacks of SCOP are the same as for the SCART. However, SCOP is a very good guide for conducting safety culture interviews. As far as we found, it has the most detailed and complete documentation about safety culture assessment with interviews.

8.4 Nuclear Safety Culture Assessment (NSCA)

The US Nuclear Energy Institute (NEI) NSCA approach is conducted not only by a self-assessment, but also by independent or third party assessment by increasing the sample size of interviews and observations, adding more team members who are not site employees, and providing additional focus on the areas of concern. Note that, self-assessment is based on three data gathering methods: questionnaire based survey, interviews and observations; whereas independent and third party assessment are based only on interviews and observations. The documentation review is conducted as a pre-assessment step.

For the self-assessment, half of the team is from the site and the other half from the site's fleet, corporate offices, or other utilities. For an independent assessment, there are no site members. Not more than a half may be from the site's fleet or corporate offices, and the rest from outside the company. For the third party assessment, all must be from outside the company. A behavioural scientist is suggested for an independent assessment and required for a third party assessment.

These independent and third party assessments are ad hoc and usually do not build on the same model as the self-assessments, resulting in different scales and the difficulty in comparing the two assessments. This is often the case because self-assessments commonly use the INPO nuclear safety culture model of principles and attributes, whereas the independent or third party assessments are conducted around specific issues and the NRC's nuclear safety culture components and aspects.

Whatever the type of assessment, it is only one process input among others as shown in Figure 3. For each input, there are data (e.g., deficiencies, violations, or weaknesses)

which can be reviewed in combination with data from other inputs to conclude if there is a nuclear safety culture problem.

Each input includes assessing the data against the INPO principles and attributes and reporting their results to the site leadership team on a periodic basis. The identified problems are sent into the site's corrective action program where they are assessed to find their significance level. In addition, root cause analyses are conducted, and both apparent and root cause analyses include an assessment against the INPO principles and attributes. The monitoring process assumes reviewing emergent issues that could impact safety culture and report the conclusions to the team who is responsible to address relevant issues and to plan appropriate actions.

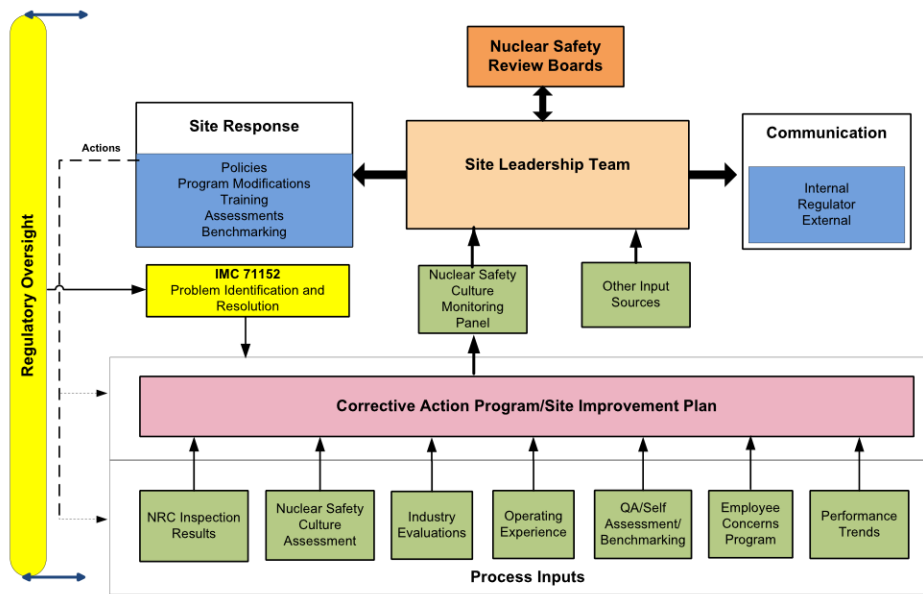


Figure 3: NSCE structure (Nuclear Energy Institute, 2009)

In general, NSCE is a very comprehensive approach for safety culture assessment based on several data gathering methods, as well as several assessments from different time frame perspectives.

8.5 Idaho National Engineering Laboratory (INEL)

Though this approach (Table 12) is relatively older, we included it in our review as it has unique features that might be interesting for researchers working on the development of new tools.

A noteworthy point in this approach is the choice of the procedure to decide the safety culture important norms. Namely, three different techniques are used. First, the employees are asked to write their imaginary ideal safety culture along with the real situation in the organization mentioning how far it is from the ideal case. Second, the

managers write down their own safety credo: how they would like their employees to understand safety issues. Third, the safety culture norms have been developed based on the results of the first two steps as well as on literature review.

Overall 19 categories have been identified as an output of these three methods. In addition, 88 statements have been developed and each statement is linked to one safety culture category. The five-point numerical scale can be used to evaluate each statement. The respondents can skip a statement, and it is stated that the data of non-responded statements are also important to understand the general tendency within an organization related with a certain statement.

All responses are assembled into four groups: positive answers, negative answers, neutral answers and non-respondents. The authors emphasize the importance of considering non-respondents as they indicate that either participants have never been asked to participate in the survey, or they could not (or did not want) participate.

For data analysis descriptive statistics are used (e.g. mean, median, non-respondents percentage, and frequency of responses). The results are analysed for the departments separately; thus in case of heterogeneity of the certain safety culture norms, the subcultures are discovered and analysed further. Note that, if two departments do not have similar results for some statements, the possible reasons are not obvious as the departments can have completely different targets and functionality.

Concluding, INEL has an interesting approach for establishing the safety culture norms and important statements corresponding to the organization. However, the statistical analysis used in the approach is not descriptive enough and data aggregation is very simple.

8.6 Event-based Safety Culture Assessment (EBSCA)

This method is different from the other approaches discussed in this report as it is based on the assumption that the root causes of incidents or near misses in complex industries give indications of deficiencies in safety culture.

Figure 4 shows the general structure of the entire process of safety culture assessment by taking into account possible events.

- In advance examples of possible causes called *cause complexes* are defined on the aspects of safety culture.
- The set of significant events which are related with safety culture is chosen.
- From the events' reports, the appropriate data is elicited and an analysis is done.
- Interviews are conducted with plant experts for further details and background information about the events, and for clarification of the underlying cause triggering the events.
- The identified causes are assessed and classified in terms of their organisational and management impact.

- Experts assess the degree of relevance of the events with respect to the identified cause complexes.
- The frequencies of the events and the related causes are depicted in a graph to communicate the results.

An interesting classification of NPPs safety culture assessment methods is discussed in (Balfanz & others, 2002), (Schot & others, 2004) :

- The assessment by interviews with plant management and operators to get direct (subjective) information about the plant safety culture called "direct-subjective assessment".
- The assessment of plant operation by root cause analysis of real events ("Event-orientated Safety Culture Assessment"), called "indirect-fact driven assessment".

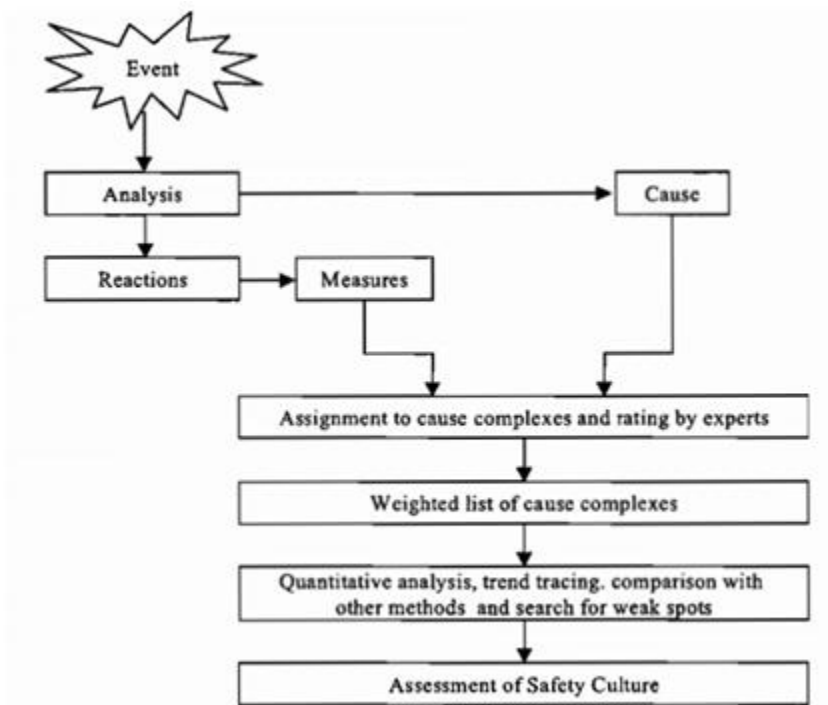


Figure 4: EBSCA general structure (Schot & others, 2004)

It is mentioned also that both approaches are accompanied by high uncertainties, but of different types. However, the two approaches can complement each other to give a more realistic picture of the state of safety culture, respectively to reduce the uncertainties of the general approach.

9. Applicability Recommendations

There is very little research done to compare different tools in terms of their usage degree and their practical implications. All available tools, both in academic and applied literature, have unique features targeting different issues. It is therefore not easy to formulate preferences of one tool over another. We shall rather give recommendations about the practical implications of the tools depending on specific requirements and objectives.

IAEA's SCART method can be a good guide for conducting safety culture assessment based on several data gathering methods. However, the multidimensionality leads also some drawbacks such as time consuming, high complexity, high cost. It is a good framework, but has some limitations (mentioned before) that need to be taken into consideration.

SCOP has similar structure as SCART, but has more data gathering methods. The limitations of SCOP are the same as for SCART. SCOP is a very good guide, if one wants to conduct safety culture assessment based on interviews. Both SCART and SCOP are applied in the nuclear industry, but both can be adjusted to be applied in other domains.

ENEL is an interesting method to develop questionnaires, as each question is related with some WANO indicators to a certain degree. However, the scoring and aggregation method is rather simplified.

INEL is a good guide for developing the most important indicators, attributes, principles of safety culture that best suit the specific organization. It shows also how to involve employees in different stages of the safety culture assessment process.

NSCA has been successfully applied in several nuclear power plants in the US. It's an interesting approach of combining several types of assessments such as self, independent and third part. Based on both qualitative and quantitative assessments, it gives an in-depth view of the safety culture state.

EBSCA is an alternative approach and, if used with one of the approaches listed in this study as a complementary tool, might give very reliable results.

HMRI has a scenario-based strategy, and we consider it as the most comprehensive method to conduct interviews. It has several valuable features making it an attractive tool. First, it has the flexibility to assess only one indicator of safety culture, if required. This is a useful feature for reassessment of safety culture focusing on the indicator which was found the most vulnerable during the previous assessment. Second, scenarios and evidence points help to have a deeper and more thorough view of the culture. Evidence points provide more details before answering the question, thus the answer will be more realistic and reliable. Third, the use of the pocket cards and the overview diagrams are supplementary tools to be used in the interviews, and obviously, they help providing summarized and visual representations of the process.

Another tool used in railways is the RSSB questionnaire based survey. The computer assisted program of the RSSB tool released in 2011 is very informative and user friendly, both for conducting the survey, as well as for interpreting the results. An interesting feature of this tool is its possibility of having assessment analysis of different roles such as engineers, managers and train drivers. It can be a good guide to include the concept of sub-culture in the safety culture tools.

The Keil Centre Maturity[®] Model (KCMM) is very different from the other tools. It uses only workshops for data collection and is a good guide for safety culture continuous improvement follow up. It is based on a ten element model of the safety culture with five levels of maturity to each element. It generates improvement actions as an output and includes normative data in the form of the five levels of safety culture maturity.

The Loughborough University Safety Climate Assessment Toolkit (LSCAT) provides the possibility of identifying sub-cultures that could be used to understand the safety attitude and perceptions of people having different levels of responsibility.

10. Conclusions

There is a growing concern about safety culture issues within the nuclear industry, as well as in other high risk organizations. The aim of this study was to give a general overview of the current tools of safety culture assessment used in different domains.

The results of the review revealed that the majority of attempts to define and assess safety culture have arisen outside the nuclear industry even though the term itself has been first introduced in the nuclear field. Several comments are noteworthy to mention as concluding remarks. There is a considerable disagreement among researchers, both within and across industries, as to how safety culture should be defined and whether safety culture is fundamentally different from the concept of safety climate or not. There is no agreement neither cross industry, nor within the same industry about the terminology used for the formulation of the main concepts, nor the number and the concepts themselves.

For this review, we chose the tools that have unique features and that can be useful when one needs to develop a new tool, or even to use one of the listed tools. The tools vary considerably from one another in several dimensions such as the content, target domain, overall length, the data gathering methods, the anonymity level, the available information, validity evidence degree, etc. All of the instruments have distinctive strengths and limitations. We hope that an awareness of some of the differences between the tools and their limitations will make it easy to choose the desired tool or to develop a new one.

Note that, as a result of this study we designed a new tool for safety culture assessment to be used in SCK●CEN. In the modelling of our tool we used several features (scenario

driven questions, accident/incident based analysis, the linking of each question to the main norms of safety culture, etc) from the tools that we discussed in this review.

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List of the abbreviations

AHRQ - Agency for Healthcare Research and Quality
ANSPS - European Air Navigation Service Providers
ASCOT - Assessment of Safety Culture in Organizations Team
EBSCA - Event-based Safety Culture Assessment
EDF - Électricité de France
HMRI - Her Majesty's Railway Inspectorate
HRO - High Reliability Organization
IAEA – International Atomic Energy Agency
INEL - Idaho National Engineering Laboratory
INSAG - International Nuclear Safety Advisory Group
LSCAT - Loughborough University Safety Climate Assessment Toolkit
NEI - US Nuclear Energy Institute
NPP – Nuclear Power Plant
NRC - Nuclear Regulatory Commission
NSCA - Nuclear Safety Culture Assessment
INPO - Institute of Nuclear Power Operations
RSSB - Rail Safety and Standards Board
SCART - IAEA Safety Culture Assessment Team
SCMM - Safety Culture Maturity® Model (Keil Centre)
SCOP - Safety Culture Oversight Process