

Assessments of safety culture – to measure or not?

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Abstract: Since the introduction of the safety culture as a concept, there have been debates on the need for establishing methods and tools for its measurement. An often heard argument in this debate is that you have to measure to be able to manage. This may be true, but one may then ask if it possible to manage something, which by many is viewed as an emergent property of a socio-technical system. The relevance of this question can further be explored in relation to the view that safety culture is connected to attitudes, beliefs and values hold by people in an organisation. The paper explores views on the need to establish methods and tools that can provide reliable and valid measurements of an abstract organisational property that is called safety culture. A conclusion of the paper is that it is doubtful that such methods can be constructed and even if that would be possible, that the use of such methods may cause more harm than benefit.

1 Introduction

Safety culture has become an important concept in managing high reliability organisations. In the nuclear field the concept was introduced by IAEA after the Chernobyl accident [1]. The introduction of safety culture led to the need to give the concept a more concise definition [2]. Further discussions brought various characterisations of safety culture and how it could be improved [3, 4]. Safety culture has recently been introduced as the basic principle in guidance for management systems [5, 6]. Definitions of safety culture have been discussed in a companion paper [7].

Since its introduction safety culture has stirred an intense debate on how it should be assessed. One line of argument has been that definitions, for example through indicators or characteristics would make it possible to measure safety culture at a facility and initiate remedial actions if it is considered to require improvements. Another line of argument has been that safety culture of an organisation is determined by attitudes, beliefs and values of members in organisations and therefore is not accessible to measurements in a strict sense.

The present paper approaches the question if it is sensible to even try to construct measuring tools or if it is more appropriate to leave assessments on a more qualitative basis. The first section of the paper discusses measuring from a theoretical point of view with the argument that measuring as interpreted both in behavioural and natural sciences is difficult to apply to safety culture. This argument is strengthened in the next section in a discussion of practical difficulties of proposed methods. The next section asks if measuring safety culture can give insight that have practical benefit. In the fourth section it is argued that measurements even may be counterproductive in an attempt to enhance safety. The final section of the paper argues that a qualitative approach with a clearly defined objective of improving organisational abilities in responding to safety threats probably is more efficient than striving for objective measurements of safety culture.

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2 The act of measuring

The act of measuring has a very distinct meaning in science. In physics for example measurements are commonly interpreted to imply a reference to an objective scale, which often can be constructed as a ratio scale. In the behavioural sciences it is more seldom that such strict requirements can be fulfilled and weaker scales are usually applied. Measurements are also connected to the concept of observability, because inherent variables in systems may sometimes be observed only indirectly from a set of measurements over time.

2.1 Scales

In measuring, the scale that is used becomes important. The simplest scale is a nominal scale that assigns labels to certain observations. An ordinal scale gives more structure by providing an ordering relation on a set of possible observations. An interval scale is ordered and has constant intervals, but it does not have a natural zero. A ratio scale is an interval scale that has a natural zero, which makes it possible to compare two measurements by a scaling constant.

Different methods have been proposed for measuring safety culture and they use different scales. For example the method proposed [8] for comprehensive safety assessments of nuclear power plants suggests to use something between an ordinal and an interval scale. This scale has been called a behaviourally anchored rating scale [9] and it has often been used for performance appraisals within organisations.

2.2 The concept of observability

Observability is an important concept of systems theory [10], which has an application to measurements. The idea is that it may not be possible to observe the state of a system directly, because some of the state components may be inaccessible. A system may still be observable if it is possible to reconstruct its state from a series of measurements collected over time. Observability can loosely be said to be a necessary condition for making measurements meaningful in the sense that they can be used to generate predictions of future behaviour of a system.

In considering systems in general it is necessary to note that a complete description of some real world system is impossible, because already its state will contain an inconceivable number of elements. Observability is therefore always restricted to some model of the system, which has been considered reliable and valid in its region of applicability.

2.3 Measuring implies interactions

A well known principle is that the act of measuring will interact with the variable that is measured. A common approach is to make that interaction as small as possible and to assess the effects of remaining influences. This general principle of interactions applies also to systems considered in the behavioural sciences. For such systems it may even be argued that already an expressed intent of measuring may influence the results obtained. Furthermore it is impossible in practice to assess how observations and interviews will interact with systems from which measurements are collected.

One approach to the problem of interactions in measuring safety culture may be found in the field of action research. In this approach an assessment is always seen as an intervention, which for instance could mean that an assessment team would engage in a common problem solving exercise together with the target organisation. In such an exercise it would be

expected that safety culture would be discussed from different angles, but measurements in a strict sense would not be collected.

2.4 What do we actually measure?

Variables to be measured are in the behavioural sciences defined using natural language, which means that there is an inherent ambiguity in the object of measurements. This ambiguity is reflected in the debate about definitions of safety culture and it has been seen in discussions of safety culture versus organisational culture and safety culture versus safety climate. The inherent ambiguity of natural language may also influence measuring instrument such as surveys and interviews, where respondents are asked to give their opinions about various statements such as organisational practices, management approaches, team building, etc.

Another difficulty with measurements in the behavioural sciences has to do with using people as measuring probes. People will express opinions and not undisputable facts. Opinions are again sensitive to many uncontrollable variables. Finally people have a tendency to try to stand out in a favourable light, which may introduce a systematic bias.

3 Proposed measuring methods

Different approaches for measuring have been proposed. One straightforward method is to sample opinions of a selected group of people towards a set of issues. Such surveys generate quantitative measures at a specific time. Another measuring method is to use a set of characteristics that are assessed in relation to a qualitative ranking scale. These methods can generate semi-quantitative ratings, which may or may not be weighted together to a single number. Finally solely empirical methods have also been proposed for analysing data from interviews.

3.1 Safety climate surveys

Questionnaires and surveys are used as instruments to assess the safety climate in organisations. In this connection it is important to note the distinction between safety climate and safety culture, because surveys are not believed to penetrate to deeper layers of culture. Safety climate surveys have shown to provide factors that are difficult to replicate in spite of the fact that most studies identify senior management as one important factor [11].

When surveys are used it is important that the instrument is tested on a small sample of individuals from the organisation to ensure that questions are understood and relevant. The analysis of a survey can be carried out using factor analysis. Surveys usually include the possibility for free format comments. Unfortunately however, no good methods seem to exist for analysing such comments, in spite of the fact that they often provide insights into the organisational culture. Safety climate surveys have the benefit of being a relatively inexpensive method of getting opinions from a whole organisation.

3.2 Comparisons with a norm

A straightforward way to assess organisational performance is to compare actual work practices with some more or less explicit norm. This is the standard procedure used in quality audits and the results are typically expressed on a three point nominal scale termed *no objection*, *observation* and *deviation*. The difficulty here is that no accepted norm for safety culture exists and it is even doubtful that such a norm can be constructed.

The so called SCART methodology [12] as developed by IAEA relies on an assessment of a total of 37 attributes divided among five characteristics. This method may become an emerging norm for assessing safety culture. It is based on guiding documents that IAEA has developed over the years. The method has so far been applied at two missions, one in South-Africa and one in Spain. The method seems however to need further development before it is applied to a wider collection of plants [13].

3.3 Assessments without a pre-specified model

Assessments within the behavioural sciences are considered to be empirical when they do not rely on any pre-specified model for establishing relations between observations and performance. A typical instrument used for this purpose is semi-structured interviews, which are transcribed and analysed. This approach has sometimes been referred to as grounded theory [14].

Assessments do not necessarily have to be performed in a series of individual interviews. Another possibility is to use group discussions in for example focus or system groups. These methodologies are however more directed towards problem solving than pure performance assessment. The benefit of a group discussion is that members of the group can trigger each other, which makes it easier to bring up salient issues for in depth discussions.

3.4 Methodological issues to consider

In addition to the issues discussed above there are also other methodological issues to consider before assessments of safety culture are undertaken. If interviews are used as the major data collecting method, the selection of informants becomes important, because the number has always to be restricted. The simple way of just picking people at random is not practical, because managers are then most likely underrepresented in the sample as compared with the impact on safety culture they apparently have.

Another issue to be decided on is how outliers should be handled, because in any organisation there are people who have opinions that could not be considered to be characteristic for the organisation as a whole. More generally this issue is connected to the variability in the responses. Are the samples coming from different populations within the organisation and what kind of distributions can be expected in these populations? Finally it is evident that any aggregation of the data collected to characterise the whole organisation may be misleading.

3.5 Using a combination of assessment methods

A common recommendation is to use several different methods in the assessment of safety culture. This approach has sometimes been called triangularisation and can provide additional confidence in the data collected. The most common approach is to start with a survey to identify issues to be investigated in more detail for example by using semi-structured interviews.

To collect a deeper understanding of the culture within an organisation it is however necessary to follow it from the inside during extended periods of time [15]. This would also have the benefit of assessing changes over time.

4 Is it meaningful to measure safety culture?

This question has to be approached in relation to the intent of measuring. The usual intent is to improve, which involves control for something better. The concept of controllability therefore becomes important. A ratio scale would be ideal if the intent is to allocate efforts to be spent for improvements. If a two times better safety culture is obtained by doubling the resources spent in its improvements, this could for example be considered as a fair deal. If measurements on an ordinal scale is obtained from two facilities, they could point to the facility, where organisational development should be started. If the measurement consists of a profile of deviations from an expected norm, this information would be useful in building an action programme to improve the safety culture.

4.1 The concept of controllability

The aim of measuring safety culture is at least partly based on the saying "You can't manage if you can't measure". Applied to safety culture this statement carries an implicit assumption that it would be possible to manage safety culture provided that it can be measured. Because management has to do with the control of a socio-technical system necessary conditions for successful control are the following:

- there has to be a goal for the control action,
- one has to be able to determine the state of the system to be controlled,
- it should be possible to influence the system in a way that moves it towards the goal,
- one has to have a model of how the system behaves in response to control actions.

The first of these conditions implies that we know what a "good" safety culture is. The definition of safety culture in terms of characteristics and attributes aims apparently to achieve that. The second of the conditions is connected to observability as discussed above. The third condition is the condition of controllability as defined in systems theory and it is doubtful if this can hold in a system, where control actions are exercised by people through people. Finally the fourth condition also seems difficult, because we do not have good models of how safety culture can be influenced.

4.2 Emergent properties

Many scholars talk about organisational culture as an emergent property. This is to stress that means for managing culture is meagre. Organisational culture is sometimes seen as something the organisation is and not what it has. Organisational culture has to do with attitudes, beliefs and values that people have and they are therefore difficult to control.

The notion of emergent properties carries an implicit understanding that they develop without conscious control actions. It may even be argued that our understanding of the drivers of some emergent property is deficient, i.e. there is no model available that could be used to predict how they would develop in certain situations. This suggests that safety culture may not be a measurable property at all.

4.3 Is there only one safety culture?

Discussions of safety culture sometimes give an impression that an organisation has one safety culture. A more thorough consideration of available literature shows that this is not necessarily true, because in any organisation there may be different subcultures. It is also a recognised fact that different groups of people within an organisation are influencing safety in different ways. These conditions also aggravate the problem of aggregation. How should different subcultures and different impacts on safety be aggregated to arrive at a measurement

of safety culture that applies to the whole organisation? Most of the guides for assessing safety culture have recognised this problem by stating that that numerical ratings of safety culture has limited meaning and that one should not drive the rating to a single number [16].

4.4 To improve safety or safety culture

The intent of assessing safety culture of an organisation is usually a concern for safety. Safety culture is one of several contributors to safety and it is evidently practical to concentrate on one larger area of contributors at a time. One may however ask if it is necessary to obtain a reliable and valid measurement of safety culture in order to improve safety. Such a measurement may serve as an alarm for more detailed investigations to be made, but also other indicators of a deteriorated safety may serve this purpose.

A single measurement of safety culture does neither seem to be useful, because improvements would require more accurate information on where problems are. This would actually propose that qualitative indicators collected from different areas that are known to influence safety may be a better approach.

4.5 Is safety culture sufficient for safety?

Safety culture, in the ways the concept has been defined, can be considered as a necessary condition for safety. The more difficult question is whether or not it can be considered as a sufficient condition. If safety culture is understood as encompassing all human activities that are involved with designing, constructing, operating, maintaining and decommissioning nuclear power plants it may perhaps be argued that it is. Such a definition of safety culture seems however too broad to be practical.

It is not likely that sufficient conditions for safety will be found, because there are not only things that we know that we do not know, but also things that we do not know that we do not know. It may still however be interesting to speak about necessary conditions for safety. Among such conditions one may identify important technical requirements, staff knowledge and skills as well as certain organisational practices. The consideration of necessary conditions for safety may actually have an important application in the construction of safety indicators [17].

5 Dangers in measuring safety culture

In building methods and tools measuring for safety culture, one may finally ask if such attempts could be counterproductive in some situation. If doubts regarding the reliability and the validity of such measurements can be expressed at least the efforts of obtaining them are seem to be wasted. A more important question is concerned with possible unintended consequences of trying to obtain such measurements.

5.1 Reliability and validity

A common requirement in the behavioural sciences is that measurements should be reliable and valid. The reliability requirement means that different persons performing a measurement should get the same results and the validity requirement that the measuring method should measure what it is supposed to measure. The first requirement sets conditions on objectivity, which may be difficult to reach. The second requirement seems at least to require some common agreement of what safety culture is.

Reliability and validity of safety culture measurements is also connected to the use of insiders or outsiders in making the assessments. One argument is been that the assessors should be independent from the organisation they are assessing. This requirement is commonly used in quality audits, but an independence requirement will become unpractical if it is driven to absurdities. If insiders are doing the assessment they will have the benefit of understanding organisational practices, but they may have the impediment of being too near to the practices to be able to stay neutral in their assessments. A usual recommendation is therefore that assessments should be carried out as a suitable combination of self-assessments and external reviews.

5.2 The danger of success

A danger in aiming for scores characterising the safety culture in an organisation is that they may take the focus off more open ended considerations of safety. If a facility has produced good performance over a period of time, it is understandable, but certainly not acceptable if vigilance against safety threats will decrease. For well performing plants the major challenge in maintaining a good safety seems to be how to maintain vigilance and avoid complacency.

Success may have a negative influence on the nuclear industry at large. The track record of nuclear power is since its introduction half a decade ago is good, but two major accidents were required to reach our present safety thinking. We have to be aware of and plan for the possibility of surprises. It has actually been suggested that complex interconnected systems that their development depend more on surprises than on known drivers [18].

5.3 Regulatory oversight

Regulatory oversight is an important component in building safety at the nuclear power plants [19]. Already the requirement to explain why a plant can be considered safe invites to a second thought and has the benefit of sharpening the arguments. It is also clear that a regulator has the obligation to intervene if the safety has deteriorated. This may be interpreted that the regulator should assess the safety culture, but this is not necessarily true, because a judgement that safety is not good enough can be based on more direct evidence.

A problem with regulatory assessment of safety culture is connected to trust. Most methods to assess safety culture use interviews and questionnaires, which cannot provide a true picture of the organisation if the respondents consciously are trying to give "correct" answers to questions. Therefore the more or less explicit threat to shut down a badly performing plant will most likely at least in a hostile regulatory climate, bring deceit and delusion into a regulatory assessment of safety culture.

5.4 Closing the model of safety culture

The IAEA definition of safety culture through characteristics and attributes has achieved widely spread acceptance. If it will become a de facto norm, it should be protected from fundamentalism that may stifle further discussions of the meaning and content of safety culture. One may naturally argue that these characteristics and attributes are general enough to encompass also other concepts, but this would imply a contradiction with the original intent of defining the characteristics and their attributes.

Another commonly seen effect is that concepts with time tend to acquire their own special interpretations. Such a development is more likely if the concepts get a strong institutional backing, which they have obtained through IAEA. It would be important to ensure a

continuous influx of new insights and models in understanding how safety is built at the nuclear plants, which also implies a continued discussion of what safety culture is about.

6 Assessing without measuring

If safety culture should not be measured it does not mean that it should not be assessed. Assessments can be systematic even if they do not place collected observations in relation to a specified yardstick. An assessment can be purely subjective and connected to a specific assessor, who is considering observations good or bad with respect to safety. Assessments can be given the overall goal to identify things to improve and things that may be considered as good practices. This specific goal has also the benefit of putting the assessor and the assessed in the same boat.

6.1 Assessment efforts

The expected effort in carrying out an assessment of safety culture is an important practical factor to consider. A general assumption is that more efforts spent will make an assessment richer and more accurate. Because resources are finite it is important to allocate available resources in such a way that the largest benefits are obtained with the smallest costs. This would suggest different levels of screening, where alarms on one level would initiate a more thorough investigation on the next level of accuracy.

One may divide between screening done voluntary at the facilities and screening done by the regulator. At the facilities such screening should be integrated in the normal planning and follow up activities that take place at different organisational levels in the power companies. For the regulator a straightforward solution is to define suitable indicators to be followed on a continuing basis [20]. The regulatory site inspectors should be closely involved in those activities.

6.2 Safety indicators

Safety indicators have been suggested as a simple and economic method to do the first level of screening. Several systems are in use and a general view is that they are performing mostly according to expectations. One common complaint is however, that most indicators are lagging in the sense that they summarise past safety performance. A recent number of Safety Science summarised present views on performance indicators, which by large indicates that additional research will be needed [21].

One approach towards leading safety indicators may be to start with a set of necessary conditions from which one can obtain a reasonable model of how safety is constructed. The necessary conditions would then suggest a set of variables that may be assessed as precursors for safety. An assessment could then be obtained using an ordinal scale and several variables could be combined to set an alarm level.

6.3 Peer reviews

Peer reviews have been used at an increasing rate at nuclear power plants in the world. Peer reviews that have found established forms within the nuclear community and are offered by WANO and IAEA as a service for member organisations. The peer reviews are built on the idea that people who have personal experience from their own work at a nuclear power plant can make an assessment of work their colleagues do. The peer review does not in principle

build on any explicit model of how safety is constructed, but the guidance for team members that have been developed over the years will contain at least an implicit model.

The important thing is that peer reviews are not expected to come up with quantifications connected to their assessment. The recommendations that are created in the peer review are qualitative and give indications of areas where improvements are possible. However, even if this is the general aim, the human urge to obtain a grade in assessments has sometimes introduced a counting of the number of recommendations given as some overall grade.

6.4 Support for self-reflection

Early guidance on safety culture from IAEA stressed self-assessments as a tool for improving safety performance [22]. This is certainly correct, because any improvement of safety within an organisation has to rely on an internal understanding of identified problems and a willingness to improve. One observation from nuclear power plants is that it seems difficult to close the loop from identified problems to their solution. One reason for this difficulty may lie in the need to bring an issue from an analytic framework to innovative deliberations where viable solutions are sought.

Self-assessments and self-reflections are important, because initiatives for improvements should to be efficient come from the organisation itself. One may naturally argue that organisations may be forced to change due to external causes, but such cases are often traumatic and may cause shorter or longer periods of decreased performance.

6.5 Other areas to assess

So far the discussion above has mainly been focusing on safety culture loosely defined within the characteristics and attributes as defined by IAEA. One important question to ask is if these are sufficient for a comprehensive assessment, or if there are other characteristics and attributes that may be necessary to assess. One area that seems somewhat unfairly treated is documentation. One may naturally argue that two of the attributes mention documentation, but in comparison with the importance of correct and user friendly documentation this seems to be on the lower side.

Another observation is that characteristics and attributes proposed by for instance IAEA and WANO differ. To some extent this may be considered natural, because WANO may have better access to internal material at the facilities than IAEA. What kind of consequences this will have in the future development of assessment methods of safety culture is difficult to foresee,

6.6 An open ended definition of safety culture

Finally one may ask if there is a need for an exact definition of safety culture if the main target of assessments should be various precursors to safety. On the other hand it is clear that safety culture will remain an important concept in safety thinking. When safety culture is discussed in groups of people, it becomes evident that everyone understands the concepts in slightly different ways. Such discussions also seem to broaden the understanding of contributors to safety within the group. Based on these observations, it may actually be beneficial not to give the "correct" definition of safety culture, but rather to let an understanding of the concept emerge in a group discussion on how safety is constructed.

Another benefit to proceed without an exact definition of safety culture is that it will legitimate a broader discussion of what is meant with the concept and how indications of its

existence may be observed [23]. One may even argue that the present focus on safety culture has moved from an earlier focus on system design to a focus on people and organisations. If this change of focus would imply that a blame for safety problems is more likely to be placed on humans and organisations and not on badly designed systems it may be a path that we do not want to tread.

7 Conclusions

As a conclusion it is both theoretically and practically doubtful that measuring methods for safety culture can be constructed. Furthermore it even seems likely that attempts to measure safety culture may cause more harm than benefits. This conclusion does however not imply that assessments of safety culture are futile if they are performed in a prudent way.

Ideally safety culture assessments should be carried out as an interaction between an assessment team and a host organisation and it should be aimed at the creation of an awareness of potential safety threats and it could be seen as a joint learning exercise. If this can be achieved the assessment team and the host organisation has a common goal in the assessment. This interaction will also enhance the possibilities of successful improvement actions, because safety concerns are communicated directly to the organisation.

It can be argued that refraining from too detailed definitions of characteristics and attributes, makes it more likely that the concept of safety culture is adapted to local language and practices, which in turn is important for the creation of an understanding of necessary preconditions for safety. This implies that safety culture should be considered in a more open-ended way as compared to many efforts today. We actually believe that safety culture is a too important and useful concept to be wasted on simplistic measuring activities.

8 References

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