TECHNOLOGY • RESEARCH HIGHLIGHTS • VISIONS • SCIENCE

295

Sociotechnical safety assessment within three risk regulation regimes

SAF€RA STARS Final report

Marja Ylönen | Ole Andreas Engen | Jean-Christophe Le Coze | Jouko Heikkilä | Ruth Skotnes | Kenneth Pettersen | Claudia Morsut

VTT

VTT TECHNOLOGY 295

Sociotechnical safety assessment within three risk regulation regimes

SAF€RA STARS Final report

Marja Ylönen & Jouko Heikkilä

VTT

Ole Andreas Engen, Ruth Skotnes, Kenneth Pettersen & Claudia Morsut

University of Stavanger

Jean-Christophe Le Coze

INERIS

ISBN 978-951-38-8528-1 (Soft back ed.)
ISBN 978-951-38-8527-4 (URL: http://www.vttresearch.com/impact/publications)

VTT Technology 295

ISSN-L 2242-1211
ISSN 2242-1211 (Print)
ISSN 2242-122X (Online)
http://urn.fi/URN:ISBN:978-951-38-8527-4

JULKAISIJA – UTGIVARE – PUBLISHER

Teknologian tutkimuskeskus VTT Oy
PL 1000 (Tekniikantie 4 A, Espoo)
02044 VTT
Puh. 020 722 111, faksi 020 722 7001

Teknologiska forskningscentralen VTT Ab
PB 1000 (Teknikvägen 4 A, Esbo)
FI-02044 VTT
Tfn +358 20 722 111, telefax +358 20 722 7001

VTT Technical Research Centre of Finland Ltd
P.O. Box 1000 (Tekniikantie 4 A, Espoo)
FI-02044 VTT, Finland
Tel. +358 20 722 111, fax +358 20 722 7001

Cover image: Shutterstock

Juvenes Print, Tampere 2017

Preface

This is the final report of the research project on Sociotechnical Safety Assessment within three regulatory regimes (SAF€RA STARS). The project was realised in cooperation between L'institute National de l'Environnement Industriel et des Risques (Ineris), University of Stavanger, and VTT Technical Research Centre of Finland Ltd (VTT), which also had the role of coordinator. In addition to this final report, a white paper (Sociotechnical systems theory and the regulation of safety in high-risk industries, VTT Technology 293) has been published: http://www.vtt.fi/inf/pdf/technology/2017/T293.pdf.

The activity and interest of the Safety and Chemicals Agency (Tukes) in Finland, the Petroleum Safety Authority Norway (PSA) and French Safety Authorities have made the STARS project possible. The SAF€RA network has had a significant role in the building of this project which has been funded by the Fondation pour une culture de sécurité industrielle (FonCSI), L'institute National de l'Environnement Industriel et des Risques (Ineris), Ministère chargé de l'écologigie (MEDDE), The Research Council of Norway, University of Stavanger, VTT Technical Research Centre of Finland Ltd (VTT) and the Safety and Chemicals Agency (Tukes).

The steering board consisting of renowned safety professionals Prof. Johan Sanne (IVL Svenska Miljöinstitutet), Prof. Gudela Grote (ETH Zürich), and Todd La Porte (Berkeley University) provided us with invaluable insight. We sincerely thank them all. In addition, we gratefully acknowledge all the people who collaborated in this work by giving their time for interviews, responding to questions in e-mails, sending research material, taking us to site visit, and reading and commenting on the draft reports.

Contents

1. Introduction

The research project on Sociotechnical Safety Assessment within three regulatory regimes (SAF€RA STARS) was financed by the Fondation pour une culture de sécurité industrielle (FonCSI), L'institute National de l'Environnement Industriel et des Risques (Ineris), Ministère chargé de l'écologigue (MEDDE), the Research Council of Norway, University of Stavanger, Finnish Safety and Chemicals Agency (Tukes) and VTT Technical Research Centre of Finland Ltd (VTT). The two-year research project was launched in the end of 2014 and ended by the end of 2016. The three regulatory regimes include the Norwegian petroleum industry and the industrial use of hazardous chemicals in Finland and in France.

The objectives of the research project were the following:

1) Explore what the shift towards a sociotechnical approach entails from a scientific viewpoint and how it affects safety management
2) Compare practices in risk regulatory regimes in terms of sociotechnical approaches to safety
3) Clarify the regulation (limits and possibilities) in ensuring sociotechnical safety in society
4) Develop an evidence-based guide on how to develop regulatory practices towards taking better into account the sociotechnical dimension of safety.

The study was motivated by accident investigations in high-risk industries, which have shown that accidents are sociotechnical by nature. Single-factor explanations for accidents are outdated. Sociotechnical means that accidents and failures are consequences of interconnections between technical deficiencies, human errors, organisational and inter-organisational problems in communication, lack of regulation etc. Technical and social systems (including organisations) and processes are interdependent, which increases complexity and the possibility of negative surprises. These observations have also led to a shift in the understanding of safety. It is increasingly seen as an emergent phenomenon and as a by-product of several interacting systems. This kind of sociotechnical systemic understanding of safety, has called for a more integrated and holistic view of safety, which has also challenged some current regulatory approaches, such as examining only compliance with regulations.

Research questions were the following:

1) What kinds of features characterize the regulatory regimes and inspection practices in Norway, Finland and France?
2) How do the regimes and inspection practices contribute to or hamper sociotechnical i.e. integrated understanding of safety?
3) How is it possible to develop regulatory practices towards taking better into account the sociotechnical aspects of safety?

In order to answer to these questions, we have drawn on accident and disaster studies, and regulation studies to provide a background for understanding demands for sociotechnical safety assessment. In addition, we have examined three regulatory regimes – Norwegian oil and gas and regulation of use of hazardous chemicals in Finland and France – as well as inspection practices in these regimes, in order to gain insights into how the regimes function in terms of sociotechnical aspects. On the basis of these examinations, we outline a set of recommendations.

This final report summarises the findings of the SAF€RA STARS project. After the introduction section 2 deals with the historical roots of the sociotechnical approach to safety and focuses on implications of a sociotechnical systems perspective on safety and regulation, highlighting some major debates and current issues for discussion. These reflections are based on the findings of the White paper – a separate report, VTT Technology 293 – that draws on the disaster, safety and regulation studies and examines the requirements for the sociotechnical approach to safety (Le Coze et al. 2017). The third section provides a brief overview of the comparison of three regulatory regimes in Norwegian oil and gas industry and in the regulation of hazardous chemicals in Finland and France. Section four discusses regulatory strategies and inspection practices with regard to sociotechnical approaches to safety. The fifth section provides some recommendations concerning taking better into account sociotechnical aspects of safety. In the conclusion section, we reflect upon the strength and weaknesses of this study and the challenges that the sociotechnical systems approach to safety will encounter as well as opportunities for it to prosper in the future.

2. Sociotechnical systems approach to safety

Sociotechnical systems thinking has its roots in the pioneering work carried out at the U.K. Tavistock Institute of Human Relations (Trist and Bamforth 1951; Emery and Trist 1960; Trist et al. 1963; Trist 1981). Researchers at the Institute reflected on the importance of adding to the technical framework of production, the so-called human factor inside a work system (industry or organisation). The researchers argued that technology could not be an independent and autonomous variable because it is strictly related to and influenced by social aspects, such as human working conditions, and political and economic structures. Thus, the term "sociotechnical" was coined to describe the reciprocal interrelations between technology and humans. The term "system" was taken from general systems theory, which describes a system as a set of elements related to each other, with functions that transform the system over time.

High-risk industries were introduced in the 1970s as a new category referring to industries, such as the nuclear, aviation, marine, and petroleum industries (Le Coze 2013). Common to these industries is that they create a potential harm to society. They can threaten the lives of a great number of people at once, and/or can endanger generations to come with their long-term radiological or toxicological effects. The rapid increase in size and number of planes or tankers, the concentration of chemical plants, the construction of nuclear power plants, etc. are probably reasons why this interest in high-risk industries has intensified over the years. High-risk industries as a new category allowed the creation of a sense of common interest for systemic issues linked with the management and governance of those industries as systems. Rasmussen's (1997) model of complex system dynamics is a well-known representative of high-risk systems.

Technological development and the increase of high-risk industries have triggered a mounting social concern: can our societies master these now ubiquitous dangerous artefacts? Ulrich Beck in Germany (Beck 1986), Barry Turner in the UK (Turner 1978), Patrick Lagadec in France (Lagadec 1982) and Charles Perrow in the US (Perrow 1984) have all expressed and shaped, in different ways and from different angles, an academic interest in the topic of high-risk systems and accidents and disasters.

Their message could not be missed, as a first wave of disasters across high-risk industries in the 1980s contributed to justifying the need for a better

understanding of the issue of safe operation of high-risk systems. Events such as Chernobyl (1986), Bhopal (1984), Challenger (1986), Piper Alpha (1988), Herald of Free Enterprise (1987) questioned society's ability to control modern engineered systems. Moreover, the repetition of disasters over twenty years later, such as Fukushima (2011) and Deepwater Horizon (2010) generated a feeling of 'déjà vu'. These accidents triggered many debates in the field of safety (Le Coze 2013). Has any progress been made? What about our safety models and theories? Are they still relevant? Have regulations failed in these cases? Should regulations be adaptive? Changes are empirical, they concern the daily operating realities of high-risk systems. In this respect, what is the difference, for example, between the regulatory and sociotechnical contexts of Piper Alpha in 1988 and Deepwater Horizon in 2010, 22 years apart? What is the difference between the regulatory and sociotechnical context of Chernobyl in 1986 and Fukushima Daïchi in 2011, 25 years apart?

Sociotechnical system safety implies that safety is a dynamic property of systems and that it is determined by context. In this perspective, safety is a continuous development, on the one hand relying on systems structured processes and formalized situations such as accident investigations, audits, inspection and meetings, and on the other hand being symbolic and related to a systems cultures, power relations and trust. The sociotechnical perspective on safety as an emergent phenomenon and a by-product of several interacting systems, and its call for a more integrated and holistic view of safety, has also challenged some current regulatory approaches, such as examining only the compliance with regulations. Similarly, sociotechnical understanding of safety has called into question accident investigations based on single-cause explanations or root-cause analysis, because there are often several interconnected factors contributing to accidents. (Dekker 2011; Dekker et al. 2011.)

Based on the findings of studies of disasters and systems' safety, we identify a knowledge framework consisting of technical and engineered systems, human factors in teams and organisations and management and control within their social and managerial but also competitive, regulative and governance environments. The following points together capture a framework for knowledge in and about sociotechnical systems (Le Coze 2016):

- **The engineering and technological view** corresponds to risk assessments performed in order to produce quantitative estimates of system performance limits and specifications. It also includes a qualitative analysis of what could possibly happen and estimates the likelihood of these events when taking into account the barriers designed to prevent or mitigate the consequences. Safety-economic studies can help justify choices.

- **The human and organisational factors view** tackles the problem of designing work situations and task completion, taking into account strength and weaknesses of humans in specific material, informational and social contexts. Recommendations for display design, functionalities, and

procedures, but also for team coordination and training are produced to buttress safe performance (in some sectors, behaviour-based safety approaches are included in this human factors perspective). In addition, organisation level aspects are relevant, including organisational cultures as shared understandings of risks, and relationships between top and middle managers concerning e.g. flow of safety critical information.

- **The managerial and strategic view** concerns the systems and processes delivering support to the safety management in companies. These include meta-rules and systems for risk assessment, learning from experience, management of change etc., activities which constitute the backbones of any systematic approach to safety and are often described in regulations and international standards. These processes can be monitored through indicators which reflect the state of the system, and are conveyed by channels of communication which produce flows of information throughout and between regulatory environments.

- Finally, high-risk industries are also strongly influenced by interactions with stakeholders (e.g. ministries, civil society). Regulatory strategies are strongly related to such issues, including risk communication, consultation strategies and approaches for system monitoring. This is the **governance and political view**, looking at the management of high-risk systems from the point of view of interactions between the media, civil society, justice, regulation and the industry.

This framework for sociotechnical safety has implications, for example when explaining why despite preventive strategies, accidents keep on happening. Firstly, there are limitations in our **engineering knowledge** of the sociotechnical artefacts that we create, especially when they reach a certain degree of complexity or innovation. As a result, the practice of risk assessment contains methodological limitations and challenges. Secondly, human cognition still defies our best **human factors models**. As a consequence, predicting human adaptive behaviours across different contexts and increasingly complex technological environment remains a challenge and will be highly problematic for a long time.

Third, managerial decisions influencing safety involve ambiguous, uncertain and imperfect situations and resources, as is well documented in the organisational literature. Therefore, a sociotechnical systems approach goes against mechanistic and generalized views of organisations and safety management, and challenges the idea that any principles can be applied perfectly, idealistically: organisations are messier than their official presentations. Fourth, interactions between civil society, the media, justice, regulators and industry can both subvert well established processes for stakeholder involvement and provide opportunities for managerial and regulatory reform. However, these interactions are not well documented in the literature. If they are studied and assessed at all, it is only as part of disaster investigations or special commission reports.

With regard to regulation, there already exists a wide range of compliance monitoring tools described and applied for regulating major accident risks in industries. Whether related to technical specifications, competence requirements or meta-rules associated with international management standards or industry best practices, these are key parts of safety regulation. However, as Andrew Hopkins argued (2007), regulators should also search for ways to move beyond compliance monitoring. Compliance monitoring can in some situations develop into a ritual that blinds an industry from being aware of developing risks. Analysing the 2010 Gulf of Mexico blowout, Hopkins (2012) claimed that the US regulator at the time lost sight of safety of the rig operation through focusing on regulatory compliance as an ultimate goal, substituting it for risk awareness within the industry.

What accidents have shown is that the companies have often mentioned before the accident that they follow procedures and standards. However, after the accident it has been revealed that it has not been possible to follow standards and procedures because of their very simplistic, descriptions of structure, which do not correspond to the reality of high-risk organisations. Indeed, one clear foundation for the field of safety is that there is always more to practices than the application of procedures and standards or processes. This is disturbing because regulations, procedures and standards remain the most common way of approaching safety from an audit and inspection point of view: relying on compliance to procedure, standard or processes to assess situations. This raises the question what is actually managed and regulated when relying on the rhetoric of compliance as a guarantee for safety, when this if far from the whole picture.

How then should one approach high-risk industries? How is it possible to get beyond the compliance strategy in regulation? What needs to be taken into account in order to approach safety in a comprehensive, integrated way? In the fifth section of this report we outline some partial answers to these questions. In the next section we present a summary of findings of comparison between the three regulatory regimes and reflect upon how the regimes hinder or contribute to sociotechnical safety assessment.

3. Sociotechnical safety assessment within three regulatory regimes

This section summarises the findings of a comparison between the regulatory regimes in three countries, namely in Norway, Finland and France[1]. In Norway the research target was regulation of the petroleum industry and in Finland and France the regulation of industrial use of hazardous chemicals. Despite the fact that all three were high-risk industries, and therefore we can assume many similarities with regard to approaches to safety assessment between the regimes, there were also some fundamental differences between them. We will also show some nuances between the regulatory regimes found in the comparison.

The data consists of interviews with professionals from the Norwegian Petroleum Safety Authority (PSA), Finnish Safety and Chemicals Agency (Tukes) and the French regulatory bodies at the regional level (Direction Régionale de l'Environnement, de l'Aménagement et du Logement). In addition, the data includes documents concerning safety requirements and reports of the regulatory bodies. The method of analysis is content analysis, based on researchers' interpretation of interviews and documents within the framework of regulatory regimes and sociotechnical understanding of safety. This comparison proceeded in three steps. The first step consisted of designing the framework. The second included examining the data of each country within the designed framework. The third phase embraced the comparison. In the analysis we frequently found complexities associated with the degree of detail for each dimension of the framework, but also their relevance for the STARS' purposes.

3.1 The STARS framework

Many dimensions are needed to describe how societies attempt to regulate risks through various institutions, chiefly by the state through public policies. Although many countries within Europe share a common background through the European Union (EU) framework, including its legislative process and directives, for each of these countries there are many specifics that must be addressed in order to sensitize each situation of risk regulation regimes properly.

[1] Please, contact the authors, if you are interested to get full reports of each country.

One required dimension is the type of risks that these countries encounter. A second is the cultural, social, and political traditions of the different nation states when it comes to translating EU-level regulations into national practices. Different risks materialize in different sociotechnical systems. In order to adequately approach risks, there is a wide range of issues to be considered. These issues include technologies and their potential scenarios, and the markets within which organisations evolve, but also the societal level of concern about these risks. Risk regulation regimes take different shapes in different countries. Each country has a history of relationships between civil society, state, science, and technological developments, as well as its own justice system, which results in very specific risk regulation regimes.

The analytical concept of a risk regulation regime refers to institutional context, laws, principles, strategies and stakeholder relationships and practices that characterize and guide regulation (Hood and Rothstein 2003; Renn 2008; Baldwin et al. 2012; Baram and Lindoe 2014). The Saf€ra Stars framework includes the above-mentioned aspects and many different potential mechanisms between the ranging in their philosophies from “command and control” to “self-regulation”. The comparison produced in this study is based on five criteria, following the works of Peter May (2002) on social regulation and Hood et al. (2001) on risk regulation regimes. These criteria are the following:

1) Industrial context,
2) States, agencies and inspectorates’ structure and relationships,
3) Governance structure beyond states, agencies, and inspectorate: industry, professional associations, unions, consultancies, NGOs,
4) Rulemaking, enforcement & compliance strategy of the state, agency, inspectorate and governance as well as
5) Liability, accountability of actors including justice (tribunals, judges, attorneys) as a specific actor in the governance.

The following graphical representation illustrates and connects these criteria visually (Figure 1). Through these five criteria differences and similarities between the regimes as well as their sociotechnical contours, including limits and possibilities are examined. The criteria refer to structural features on the macro level. In addition, we discuss inspection practices separately in this final report.

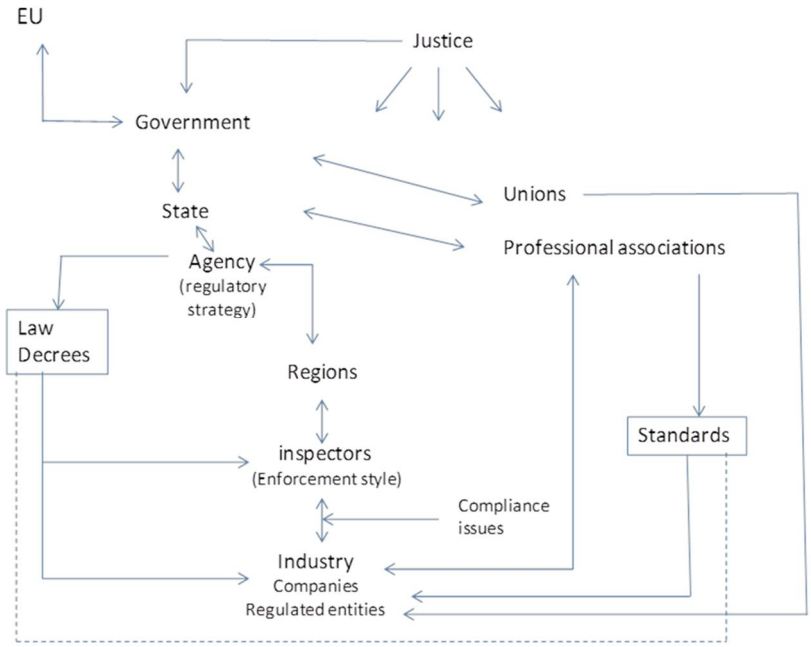

Figure 1. STARS Framework for analysis of risk regulation regimes.

3.2 Comparison of risk regulation regimes

Comparison of risk regulation regimes (RRR) between the three countries shows that the regimes are diverse and complex by nature. Simple comparison in terms of numbers or chosen descriptive features does not do justice to the diversity of the ways in which regulatory regimes are organised. For example, although the notion of enforced self-regulation and command and control indicate different philosophies, in practice, we find rather a continuum than a strict distinction. Therefore, we have tried to show the complexity and nuances of the regimes in this summary as much as possible, by relying on the framework which indicates main aspects of an RRR. Furthermore, the terminology between the countries sometimes varies for similar activities, e.g. in Finland and France, the term “inspection” is used, whereas in Norway the term “supervision” is used. In all three cases, these notions refer to the regular on-site visit by inspectors who are in charge of the control of companies’ compliance.

3.2.1 Regulated industries and their relevance to national economy

With regard to the regulated industries, we will look at the factors impacting on inspections and sociotechnical safety assessments. These factors include the

industry's relevance to the national economy, the homogeneity vs. heterogeneity of the regulated industries, and the ratio of inspectors per regulated targets.

In Norway, the petroleum industry was the largest industry and constituted 26 per cent of the net flow of Gross National Product in 2012. In Finland, the chemical industry and pulp and paper industry, which use large amounts of chemicals, together account for 39 percent of Finnish foreign export. Correspondingly, in 2014 the French chemical industry was ranked in 6th place among chemical producing countries in the world and 2nd in Europe, after Germany. The chemical sector is the largest export sector in France.

Hence, a similarity between the regulated industries is that they are important for the state's economy. From the regulatory viewpoint, the relevance of the regulated industry for the state's economy can be interpreted as triggering both an interest to find a balance between regulation (i.e. protection of human and environment from harms that accident may cause) and support to the industry. Hence, it is interesting to see how the regulation is arranged in each country, and what are the greatest similarities and differences between the regimes.

3.2.2 Diversity of installations

The largest difference stems from the fact that the Norwegian petroleum industry is relatively homogeneous compared to the industrial use of hazardous chemicals in Finland and France, where several industries are regulated. For example, in Finland and France not only the chemical industry, but also petrochemical factories, oil refineries, gas and hydrocarbon depots, fertilizer and phytosanitary products storage, explosives workshops and warehouses, pulp and paper mills, metalworking factories, glassmakers, sugar factories, distilleries, water and dangerous material treatment plants, etc., are among the regulated industries. This indicates the huge heterogeneity of regulated targets compared to the Norwegian Petroleum industry.

In France and Finland, the size and complexity of the supervised plants vary extensively from simple storages to complex production processes (such as refineries with several production lines and storage sites). In addition, all variations of ownership forms of the plants also exist: entrepreneurs, limited companies, and international corporations. Business models, organisational structures, and ownership arrangements are continuously evolving in the industry. According to Finnish safety inspectors, this challenges the current regulations and inspection practices.

3.2.3 Regulatory bodies and ratio of inspectors per installations/site

Norway is a country of five million inhabitants and considerable oil and gas resources. In 2015, Norway had 110 petroleum plants (8 of these plants were land-based plants, the rest were offshore industry. The Petroleum Safety Authority (PSA) was established in 1972 as part of the Norwegian Petroleum Directorate

(NPD). The NPD is a governmental specialist directorate and administrative body, organised under the Ministry of Petroleum and Energy. The Directorate's main task is to manage the oil and gas resources on the Norwegian Continental Shelf (NCS) and to act as advisory body for the Ministry of Petroleum and Energy. The Petroleum Safety Authority (PSA) is organised under the Ministry of Labour and Social Affairs. It became an independent agency in 2004 when it separated from the NPD. As an independent government regulator, the PSA is responsible for safety, emergency preparedness and the working environment in all petroleum activities on the NCS as well as petroleum-related plants and associated pipeline systems (PSA 2016a).

The PSA supervises around 75 permanent installations and over 40 mobile units on the Norwegian continental self. There are 8 major land-based petroleum plants and approximately 300 subsea installations. In addition, PSA is in charge of supervising about 14 000 kilometres of oil and gas pipelines (PSA 2016b).

The duties of the PSA include ensuring that the petroleum industry and related activities are supervised in a coherent manner, through own audits and in cooperation with other health, safety and environment (HSE) regulators; supplying information and advice to the players in the industry; establishing appropriate collaboration with other HSE regulators nationally and internationally; contributing actively to conveying knowledge about HSE to society in general; providing input to the supervising Ministry on matters being dealt with by the latter, and support with issues on request.

The PSA's goal is to set the terms for health, safety, the environment and emergency preparedness in the petroleum sector, following up to ensure that industry players maintain high standards in this area, and thereby contribute to creating maximum value for society (PSA 2016a).

Of its 173 employees, about 115 are involved in audits and supervision tasks. PSA's experts are involved in all kinds of activities associated with the PSA's role, for example regulatory development, planning and implementation of various activities, meetings with the industry in general, evaluation of applications for licenses (access to the field), etc. (PSA website, interviews 2015). With regard to the ratio of inspectors per regulated target, there are 115 PSA inspectors per 123 regulated targets. Considering the homogeneity of the regulated industry, the good available resources that the petroleum industry has provided to Norwegian society and to regulatory body as well as the beneficial ratio of inspectors per regulated targets, we argue that the context provides good material preconditions for the Norwegian regulatory regime to adopt a sociotechnical perspective on regulation.

Finland is also a country of about 5 million inhabitants, and as previously mentioned, both the chemical industry and the pulp and paper industry, which use large amounts of hazardous chemicals are leading export industries. In Finland, chemicals safety, i.e. use of chemicals and compliance with chemicals legislation, is supervised by the Finnish Safety and Chemicals Agency (Tukes), which was established in 1995. It operates under the Ministry of Economic Affairs and Employment. Tukes receives administrative guidance from the Ministry of Transport and Communications, Ministry of Agriculture and Forestry, Ministry of

the Interior, Ministry of Social Affairs and Health, and Ministry of the Environment. In addition, the Safety Engineering Advisory Board working under the Ministry of Economic Affairs and Employment supports the Ministry in law preparation and Tukes in the interpretation of legal requirements in unclear cases.

Tukes is in charge of supervising the large scale use of hazardous chemicals, and ensuring chemical safety and process safety i.e. how chemicals are treated in the plants. Supervising large scale hazardous chemicals is divided into three different hazard levels. Level 1 includes Seveso upper-tier plants, which consist of 129 establishments. Inspections of upper-tier plants are made annually. Level 2 refers to Seveso, lower-tier plants, which consist of 141 establishments. Inspections are made every third year. Level 3 includes nationally regulated targets, which consist of 434 establishments, and inspections are made every fifth year. In 2011 there were 704 chemicals and explosives establishments under the supervision of Tukes (Lax 2011). Division of targets into three hazard levels with different inspection frequencies divides the workload on the basis of risk potential and lightens the work load of inspectors. There are 16 inspectors in Tukes who are in charge of large-scale use of hazardous chemicals in various industries. Hence, the number of inspectors per regulated targets is rather low, which creates limits for the regulation. However, in addition to Tukes, there are other authorities, supervising the industries, ensuring e.g. that the environmental regulation, occupation safety and health and fire safety requirements are complied with.

Compared to Norway and Finland, France is a much bigger country with 66 million inhabitants, and it has a strong chemical industry sector. France is characterised by several administrative echelons, i.e. national regional, departmental and communal. This also manifests itself in the regulation of hazardous chemicals. Since the 1970s, inspection of classified installations has been entrusted to the central echelon, the Ministry of Environment. The Ministry is responsible for regulations, monitoring their application, and piloting inspection services. This central administration is relayed, at the regional level, by decentralised services of the State. This mission is accomplished by the several Direction Régionale de l'Environnement, de l'Aménegement et du Logement (DREAL) under the supervision of the Direction Générale de la Prévention des Risques (DGPR) and more precisely the Service des Risques Technologiques (SRT). The inspectors of classified installations are at the regional level, and in 2013 France had 1234 inspectors. Of around 500.000 establishments subject to specific regulations counted in 2013, 44.000 were subject to authorization or registration, of which nearly 27.000 were industrial establishments. Amongst them, there were 1.200 Seveso plants, including 650 Seveso high tier, i.e. establishments potentially capable of causing a "major accident," such as a fire, explosion, or toxic leak of an order likely to cause great harm to the environment or to the population. Hence the ratio of inspectors per site in France is 1234 per 1200 Seveso plants. Table 1 crystallizes the ratio of inspectors per site in the three countries.

Table 1. Ratio of inspectors per site.

	Regulated sites	Number of inspectors	Regulatory domains
Finland (Tukes)	704	16	Chemicals safety, Process safety
France (DREAL)	1200	1234	Environment & process safety
Norway (PSA)	110	123	Safety, health and environment

There are differences between the countries with regard to the ratio of inspectors per site. However, solely looking at the number of inspectors per site does not tell the truth of the complexity and nuances of the regimes or division of labour between the regulatory bodies and other authorities as regards regulation. However, the numbers provide some understanding of the resources invested in regulation and background data for reflecting upon the possibilities to adopt sociotechnical safety assessment.

3.2.4 Educational background of inspections

In all three countries, the inspectors mainly have technical education and backgrounds. In Norway and Finland, inspectors often have experience from working in the industry. However, in Norway the industrial background of the inspectors is stronger than in Finland. In France, most of the inspectors have a university education and less experience from working in the industry when recruited, although this situation has changed during the past decade following the Toulouse disaster in 2001, which triggered an increase in the number of inspectors. Nevertheless, in all three countries the inspectors have developed specified knowledge about the industry over time. As a complement, it is worth pointing out that in Norway, the PSA supervises health, environment and safety, and thus closely overlaps with labour and environment inspectors. In France, the inspectors cover both process safety and the environment, but in Finland, Tukes inspects chemical safety and process safety. There are also different degrees of autonomy and freedom for the inspectors in the three countries, although it is difficult to conclude about this matter in the current project. In Finland and Norway, the inspectors work closely together in one unit, but in France there are many levels and the inspectors may be far removed from the top of the organisation, which leads to more autonomy and freedom for the inspectors in France, although an important effort for normalizing practices has been made.

Authority-enforced self-regulation is thoroughly reflected upon in Norway. This requires continuous building of capability among the regulators and industry. Capability building is supported by the university through education and training courses.

3.2.5 Governance structures & philosophies: Tripartite system and the issue of trust

All three countries also have a strong and active state. In France, the state has a strong status, and as mentioned, France has many administrative echelons and a bureaucratic structure. Norway and Finland are welfare states, characterized by generalized trust in other people. Mutual trust between the main actors manifests itself in governance philosophies and regulatory regimes in both countries. The regulatory regime in Finland and Norway is risk-informed, and trust- and dialogue-based.

In addition, in the Nordic countries, the working regulation is characterized by a trinity of cooperation between employers, employees, and the government, concerning economic policy, exchange of information, and consultations at different levels of industries, i.e., a tripartite system. The institutional strength of the tripartite system for the Norwegian offshore petroleum industry was fortified in 1977 when the working conditions offshore were subjected to the same legal framework as onshore. The Working Environment Act of 1977 gave employees in Norway extended privileges in general, and became a powerful instrument for offshore workers in terms of influencing safety and security regulations.

Contrary to this, the labour unions in France are able to participate in regulation and inspection of major accidents, but they have generally not been very involved. In France and Finland, it is mostly the state that controls the industry, and the unions usually stand back. In Finland, the Occupational Health and Safety Regulations are based on tripartite principles, but the major accident regulations inspected by Tukes are not. The Seveso Directives and national laws contain formal requirements for safety management systems and assessments of risks, and Tukes inspects only these requirements. In addition, it grants licenses to the industries using hazardous chemicals.

In the Norwegian petroleum industry, the tripartite system clearly expresses itself as the formal institutions facilitated by the PSA, i.e., the Regulatory Forum and the Safety Forum, which are forums for discussing overall priorities and critical issues, and developing regulations, as well as more specific and practical questions. The “Regulatory Forum” was established already in the 1980s. It is hosted by the PSA and the director in the regulatory area. The main focus of the regulatory forum is currently the creation of a strategy for future regulation. The participants include union representatives and society representatives from other coordinating bodies such as the pollution agency. Participants meet every second month, the frequency of meetings depending on current issues. Another central arena for cooperation is the Safety Forum, which discuss and follows up the relevant safety, emergency preparedness and working environment issues. These forums as institutionalized practices formalize the partnership between public agencies and industrial actors and thus constitute an important formal part of the sociotechnical structure of the petroleum system. Norway has a very active state which has gained control of the petroleum industry, and regulates the relationship

between employers and employees. Statoil has been a dominant operator in Norway, and an instrument for the governmental oil policy.

However, due to privatization of the former state-owned company Statoil, and a merger between Statoil and another major operator, Hydro Oil & Gas, the power balance in the tripartite collaboration has been disturbed. In addition to several new operators on the NCS, the role of the state has diminished during the recent years. The Norwegian offshore system is a complex ecosystem, with many actors and many interfaces between the actors.

Finland and Norway, as countries with relatively small numbers of inhabitants, are characterized by generalized trust in other people. Similarly, the regulatory regimes in both countries are based on trust. When the regulatory system is dependent on information provided by the Operator, this trust is essential because it saves resources. Trust is also enhanced by the similar education shared by the inspectors and the industrial representatives. Moreover, especially in Norway, many regulators have experience from working in the industry, which creates a trustful relationship between the industry and the regulatory body. In studies of regulation, it has been acknowledged that a too close relationship between the industry and the regulatory body may lead to a regulatory capture, i.e. to a situation, in which the regulatory body has adopted the interests of the industry. On the other hand, a too distant relationship between the regulatory body and the industry is also not beneficial to safety (Bieder and Bourrier 2013). Therefore, finding a balance between a close and a distant relationship is necessary.

3.2.6 Regimes

The Norwegian regime can be described as authority-enforced self-regulation, which means that regulators set the general requirements to which industry needs to conform. The regime explicitly emphasises the industry's self-regulation, which means that the industry is required to establish a system for identifying relevant requirements, checking that these are adhered to, implementing corrective measures if needed and reporting all these activities to the state authorities supervising offshore safety. The regime is thus function- or performance-based, i.e. the requirements are upper level requirements, which provide more leeway for the industry to decide how to meet the requirements.

At the regime level, we can depict Finnish and Norwegian regimes with the same words: risk-informed, trust and dialogue and functional-based regulation. However, below the surface level there are differences. Although the Finnish regime is closer to authority-enforced self-regulation than the command and control way of regulating, the regulators have adopted the dual role of controller and motivator. As distinct from Norwegian regulations, Finnish regulations include more site inspections, walking around the site with the aim of controlling and checking as well as verifying what has been said. In addition, Tukes grants the licenses for all plants involved in large-scale industrial handling and storage of chemicals, whereas in Norway granting licenses does not belong to the duties of the PSA.

The French regime could be described as risk-informed, command and control-based regulation, in which site inspections play an important role. The French regime has entailed very detailed command and control type regulation, but it is currently going through major changes, and during the recent years it has adopted a dialogue-based approach towards stakeholders, both Operators and civil society.

If we were to locate regimes in a line segment, where one end is command and control and the other is self-regulation, the French regime would be the closest to the command and control end of the line segment, Finland would be in the middle, though closer to the self-regulation end of the line segment and Norway would be the closest to the self-regulation end. The regimes are illustrated in Figure 2.

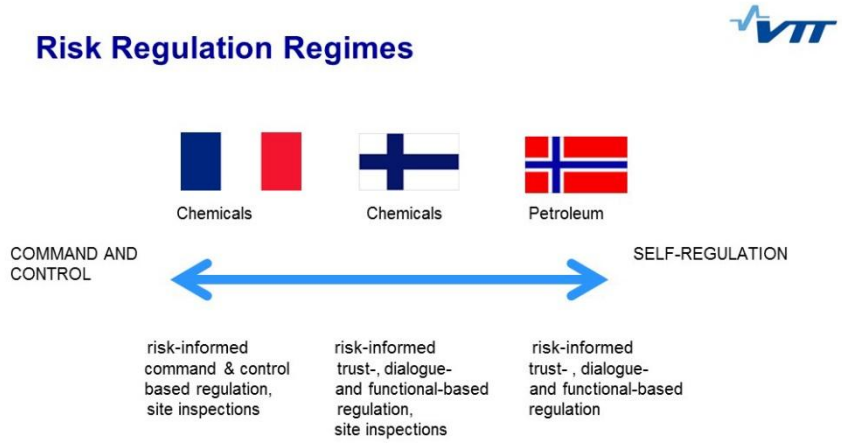

Figure 2. Regulatory regimes in three countries.

3.2.7 Disasters and regulatory evolutions

The evolution of regulations in the three countries has taken place through different phases, and often as a reactive movement in relation to specific events. Accidents have quite clearly shaped the development of the regulating regimes and inspection strategies especially in Norway and France. We indicate some of these major events, two more distant in the case of Norway and Finland, and a more recent one for France. In Norway, the Alexander L. Kielland accident in 1980, in which a semi-submersible “flotel” providing living quarters for offshore workers capsized killing 123 people, induced an overall goal of simplifying and enhancing the efficiency of risk regulation on the NCS. The accident underlined the importance of being able to establish and maintain a high level of safety with

clear regulatory boundaries. Hence, the regulatory regime that was established consisted of two elements: A single agency, at that time the Norwegian Petroleum Directorate (NPD), was assigned responsibility to draw up detailed regulations and to make overall safety and working environment assessments. Formal agreements with the pollution control authorities for the natural environment, and with the health authorities for health-related issues were also negotiated and implemented. In addition, Alexander L. Kielland was a driving force to change the Norwegian regime from a command and control type of regulation towards an authority-enforced self-regulation.

In France, a warehouse storing 300 tonnes of declassified ammonium nitrates destined for the production of fertilizer, exploded in Toulouse in 2001. Following the explosion, a new law, The Bachelot Law of 2003, was introduced to improve risk prevention of industrial accidents. The major innovation of this law was introducing the probability approach in France. When using the probability approach, the industry selects a range of scenarios representative of different possible configurations, i.e., very grave scenarios that are less probable and minor scenarios that are very probable. Before the introduction of the Bachelot Law, the industry, in practice, did not have a choice. Until this point they were obliged, to follow the requirements of public powers, who had opted for a determinist approach, i.e., retaining only the gravest scenarios, independently of their probability of occurring. The Bachelot Law established new aspects in the governance structure, by creating a committee that supports direct relations between owners, the local population and monitoring administrations.

In Finland, the Lapua Cartridge Factory explosion was an industrial disaster in an ammunition factory in Lapua in 1976, in which forty workers were killed and 60 people injured. This was Finland's worst industrial disaster, and the accident resulted in new legislation in the armaments industry which brought in stricter safety measures. During the existence of Tukes (from 1995 until now), there have not been any major accidents leading to fatalities, although, during the period 2009–2013, Tukes carried out 6 Seveso-accident investigations and one accident investigation concerning an explosion in a national license plant. Learning from accidents is continuous and also based on experience from other countries. For example, SEVESO directive triggered by severe accidents, such as Toulouse (2001), has affected national regulation and requirements.

3.2.8 Similarities and differences between the regimes

Results of the study show that, beyond the tripartite system macro difference between the countries, the theoretical dichotomies or distinctions between prescriptive and function-based regulations deriving from authority-enforced self-regulation or command and control strategies are not clear in practice. In Norway, the official regulation system is functional and internal control was made part of the safety regulation in the 1970s. The basic idea of internal control was that the industry should not limit itself to complying with straightforward regulatory obligations, but should explore new approaches to improve safety. However, the

internal safety management/internal control systems within the companies themselves have become more prescriptive, including the introduction of several industrial standards, which the companies comply with voluntarily. In France, on the other hand, the official regulation system is not described as functional. However, in practice there are similar functional elements, such as dialogue and close cooperation between inspectors and the industry as well as a safety management system requirement translated from the EU Directive. A similar situation is met in Finland.

However, there are differences between the three countries with regard to how they describe their strategy and practices. In Norway, the PSA describe themselves as performing audits, not inspections. The PSA focus on dialogue with the industry, and audit safety management systems. In Finland, the agency actually performs audits, but Tukes labels them as inspections. This is because they follow the requirements of the Seveso Directives, which uses the word inspections. Therefore, even though the Finnish and Norwegian regimes could be described with similar terms, i.e. the regimes are performance-based, trust- and risk-based, as well as dialogue-based, there are also differences between the regimes. Granting of licenses does not belong to the duties of the PSA, instead it participates in providing statements. However, in Finland, Tukes grants licenses for all plants involved in large-scale industrial handling and storage of chemicals.

Another difference between the Finnish and Norwegian regimes is that, in Finland, site inspections are common, and they include examining documents, discussions with the key persons and a walk-around on the site. One goal of these inspections is to verify what has been stated in the documents. Similarly, in France, site inspections are common. An inspection visit is when one or more inspectors go to an installation site to verify its compliance with laws and regulations related to classified installations.

Dialogue-based regulation is typical of the Norwegian and Finnish regimes, but in France, inspectors also have a tendency to prefer dialogue and avoid “breaking” their relations with the industry, and thus to maintain the cooperative climate necessary to exercise their mission. Dialogue with the industry also helps to avoid “trivialising” sanctions by giving them too often, and to avoid implementing heavy legal procedures for “minor” infractions.

The basic foundation of the robustness of the Norwegian and Finnish regimes is their ability to take institutional action, facilitate information exchange, and encourage dialogue and negotiation between limited numbers of participants. In some cases, this can lead to constructive cooperation for the development of regulations and meet the requirements of professional anchoring and democracy.

As mentioned earlier, trust plays an important role in the Norwegian and Finnish regulatory regimes, and to some extent also in France. Trust can be divided into dysfunctional and functional trust. Dysfunctional trust refers to a blind or naïve trust indicating that inspectors trust what the Operators say, without conducting any checks. Functional trust, on the other hand, includes verification that things are as they have been said to be. If supervisory duties are mainly focused on auditing safety management systems, and regulators do not make site-

inspections, this may lead to dysfunctional trust. However, in both cases in Finland and Norway, regulators emphasize trust building in the long term by getting to know the regulatees. The aim of the trust building is to promote openness and to avoid dysfunctional trust.

3.3 Specific sociotechnical notions based on comparison

In this study, we have identified some factors that could contribute to sociotechnical safety assessment in regulatory regimes. These factors include extensive stakeholder involvement, capability building and training, integration of knowledge from several expert areas, trust, verification of what is stated in documents, and proactive dialogue. Factors which in turn constrain sociotechnical safety assessment include hard economic times, scarce resources, detailed inspections, disadvantageous site/inspector ratio, lack of understanding of human and organisational aspects of safety, dysfunctional trust, and lack of site inspections.

All three regimes include some factors that promote sociotechnical safety assessment, as well as factors that constrain sociotechnical safety assessment. In all countries, dialogue between the regulatory body and the regulated industries, as well as capability building efforts, serves sociotechnical ends. Capability building is most developed in Norway, due to close connections and cooperation with the academics. Norway's tripartite system and forums for safety are tailor-made to ensure wide stakeholder involvement in safety discussions. Among the three countries, Norway, with its good financial resources and networking with academics, appears to be the most advanced with regard to sociotechnical aspects.

However, there are factors that constrain sociotechnical understanding of safety in all three countries, such as a lack of understanding of human and organisational aspects of safety. The majority of the inspectors in Norway, France and Finland have technical education, and thus lack adequate knowledge of human and organisational aspects, which would be beneficial for a sociotechnical understanding of safety. With regard to Finland, the low number of inspectors in relation to the high number of Seveso plants is constraining sociotechnical safety assessment. In France, relatively detailed inspections and a focus on compliance strategy do not favour sociotechnical safety assessment.

Furthermore, some aspects make the Norwegian regime vulnerable when it comes to holistic, sociotechnical safety considerations. In Norway, audits mainly focus on safety management systems. If site inspections are not made, then there is a risk that the inspectors' understanding of relevant activities on the platforms will remain vague. In addition, many inspectors in Norway have a background from the petroleum industry. Close relationships may be beneficial with regard to safety regulation, but there is also a risk of close relationships leading to regulatory capture. Furthermore, hard economic times are a challenge to all countries and to the development of a sociotechnical view. Hence, the coin has two sides. In certain situations, close and intimate dialogue between opponents may uncover

conflicts of interest. A regime that under some circumstances possesses strength may under different circumstances suffer vulnerability. Trust is important for the tripartite system to work, but trust-based institutional structures are vulnerable. Political and economic issues can easily undermine the existing trust between the parties and immediately ruin the climate of cooperation. In such contexts, it is a demanding role for the governmental agency to act as a navigator and as a mediator. Such a role assumes a certain degree of trust from the other industrial players as well.

4. Inspection practices and sociotechnical aspects

In the previous section we provided a description of the regulatory regimes of each country and factors hindering or contributing to the adoption of a sociotechnical safety approach. This section deals with the regulatory strategy and inspection practices in the three countries and reflects on the possibilities and limits of sociotechnical aspects in these practices and contexts. There is some repetition concerning regulatory regimes and strategies that is difficult to avoid.

4.1 Regulatory strategy and inspection practices in Norway

4.1.1 Regulatory strategy

Inspection practices in Norway are based on its regulation regime, which follows the Nordic welfare model of a tripartite system of collaboration, egalitarian values, and mutual trust among the main actors. Close interactions between the Norwegian government, the oil companies, the supplier industry, and the labour unions are typical for the regulation of the Norwegian petroleum industry. In addition, shifting alliances, power relations, trust, and also distrust characterize the regulatory framework. The inspection practices of the Petroleum Safety Authority (PSA) refer to a non-blaming regulatory culture. This means that regulators are willing to find a constructive way of dealing with non-conformities. They emphasize the learning attitude rather than punishment.

Norwegian health and safety regulations have gradually adopted various mixes of management and purpose-oriented rules, including “meta-rules” for how organisations should deal with risk – such as by requiring the establishment of risk management systems comprising processes of risk assessments, administrative structures and resources, internal monitoring and audit arrangements, etc. Moreover, traditional prescriptive regulation, describing in detail how a given purpose should be achieved, is substituted with purpose-oriented regulation that largely leaves such details to the regulated party. Together, these characteristics are intended to put more responsibility in the hands of the regulated party, and at

the same time to create more leeway and flexibility as to how legal requirements should be satisfied (Kringen 2014).

Since the start of petroleum activities offshore in Norway in the 1960s, the first set of rules was designed in the tradition of industry safeguarding regulations, concentrating on practical “do’s” and “don’ts” directed to the industry carrying out the activities. Some ten years later, the same path was followed in a more detailed manner, distinguishing between drilling, production and working environment issues. Then, in the mid-1970s, a new concept was introduced in addition to the traditional approach, as internal control was made part of the safety regulation. The basic idea was that the industry should not limit itself to complying with straightforward regulatory obligations and prohibitions directly aiming at an acceptable level of safety. The industry was also required to establish a system for identifying relevant requirements, checking that these were adhered to, implementing corrective measures if needed and reporting all these activities to state authorities supervising offshore safety. This was to take place within a framework of general requirements imposed by the state in the form of “functional requirements” (Kaasen 2014).

The traditional model of regulation from above, through specified command and control rules, has been challenged in several ways. Prescriptive rules proved difficult in terms of keeping up with the dynamic technological developments and the complexity of hazards and their causes. Risks related to long-term exposures, combined effects of several hazards, psycho-social strain, etc., were not sufficiently addressed in the traditional regulations (Kringen 2014).

The term “dialogue” is frequently used to encapsulate relations between the authority and the industry. However, the term is ambiguous, as high stakes are involved for the primary duty holders in possibly compromising their reputation, including their attractiveness as (future) license holders (or contractors). Nevertheless, the basic features of the regime, notably the regulatory strategy and the tripartite framework, enjoy considerable support from all stakeholders. The system appears to be able to deal with ongoing issues in a constructive manner with relatively unquestioned legitimacy (Kringen 2014).

The role of the PSA is regulation and enforcement, but also negotiation and problem-solving within a collaborative context, including the handling of strife and conflict (Kringen 2014). The supervisory regime on the Norwegian Continental Shelf (NCS) builds on the view that a regulator cannot “inject” quality into the Norwegian petroleum sector by inspection procedures. Responsibility for operating acceptably and in compliance with the regulations rests with the industry itself. It is up to the companies to ensure quality. With this system, the regulations describe performance goals or functional requirements which must be fulfilled. The government’s job is then to describe which safety targets a company must meet, and check that it has established a management system to ensure that these goals are met. Companies have a relatively high degree of freedom to make their own choices regarding good solutions for satisfying the regulatory requirements. Accordingly, The PSA does not use the term inspections – they use the word supervision. This is not just a matter of the choice of words. The reason is that the

PSA wants to emphasize that the companies have the responsibility to comply with regulations and to conduct their work correctly.

The regulations and the supervisory system are designed to help enhance the awareness of the companies that they bear total responsibility for operating acceptably. This means that the companies are free to come up with the best solutions themselves. Mutual trust and understanding of roles and duties are a prerequisite for the PSA's ability to exercise their regulatory role in this way.

4.1.2 Supervisory practices

The Ministry of Labour and Social Affairs has provided the following guidance on how the PSA should discharge their duties:

- Supervision should be system-oriented and risk-based
- It should be a supplement to and not a replacement for internal control by the industry
- The PSA must strike a balance between their role as a high-risk/technology regulator and a labour inspection authority
- Contributing to and collaborating with companies and unions represent crucial requirements for and principles in the PSA's activities

The PSA's supervision is directed at relevant parts of a company's management system, and takes the form of audits and verifications. An audit is a planned, systematic review of parts of the management system, involving a review of documents and interviews with selected people. The intention is to establish whether the system as described conforms with reality, and whether the system provides an adequate basis for acceptable operation.

According to the PSA it is neither possible nor desirable to supervise all activities, every facility and all equipment. Risk-based supervision means that their planning gives priority to areas with the highest risk. Supervision which the PSA may have conducted in a selected area does not free the company from its duty to assure itself that all facilities, plants and equipment comply with regulatory requirements at all times. The PSA's supervision is accordingly a supplement to the company's own internal systems for inspection and control. The challenges the PSA face can be divided into major accident risk and working environment risk. No conflict exists between these two aspects, but it is important that the PSA consciously weighs the allocation of resources between them.

The PSA prepares an Annual Plan for all the audits to be performed, which is based on the overall experience of the industry and the individual companies. Other factors taken into consideration are developments in the balance of risks, injury statistics, etc. The Annual Plan is revised quarterly in order to include experience gained along the way. In 2014, 172 audits/verifications were conducted.

The PSA's supervision is most visible when they visit offshore facilities, land-based plants or fabrication sites to ensure that the companies are complying with the regulations. Supervisory activities also include:

- Meetings with the companies
- Acquiring data about accidents and incidents
- Considering company development plans
- Applications for consent to conduct various activities
- Investigating accidents

The supervision usually starts with the initial planning of a development project and continues through the design, construction, operation and possible removal phases. The ministry has delegated authority to the PSA in order to issue more detailed regulations for safety and the working environment in the industry. The PSA are also authorized to take company-specific decisions in the form of permits and consents, orders, enforcement fines, halting operations, prohibitions, exemptions and so forth. Notification of a supervisory activity, such as an audit, is usually given some time in advance, and an audit normally begins before the PSA team starts its fieldwork. These preparations often take the form of meetings with the relevant company, which usually involve both management and union representatives. Moreover, meetings are usually held with the safety delegate service when visiting an offshore facility or a land-based plant, in order to ensure that the views of the workforce are obtained. The results of these assessments are presented in an audit report, which is used as a basis for deciding how to follow up the findings made.

The PSA serves as the regulator for technical and operational safety, emergency preparedness and the working environment in all phases of the petroleum industry. The PSA has regulatory authority which covers petroleum activities on the NCS as well as petroleum-related plants and associated pipeline systems. The ministry has also resolved that the PSA will be the regulatory authority for planned gas-fired power stations, with associated pipelines, and a planned reserve gas-fired power station. The PSA experts have educational and background experience appropriate to the functions they hold. Most have a master's degree or higher, although there are also employees with a lower level of education, but with long and relevant experience in the industry. Of its 173 employees, about 115 are involved in audits and supervision tasks. PSA's experts are involved in all kinds of activities that are associated with the PSA role, for example regulatory development, planning and implementation of various activities, meetings with the industry in general, evaluation of applications for licenses (access to the field), etc.

The government has assigned the PSA the following duties:

- Through their own audits and in cooperation with other HSE regulators, to ensure that the petroleum industry and related activities are supervised in a coherent manner
- To supply information and advice to the players in the industry, in order to establish appropriate collaboration with other HSE regulators nationally and

internationally, and to contribute actively to conveying knowledge about HSE to society in general

- To provide input to the supervising ministry on matters being dealt with by the latter, and support with issues on request

The PSA's perspective on risk is based on a broad risk-uncertainty perspective. Key aspects are:

- A need for seeing beyond probabilities in risk analyses
- A need for highlighting uncertainties in the background knowledge
- A need for qualitative analyses to gain insights into important aspects of risk (Kringen 2014b)

The PSA's goal is to set the terms for health, safety, the environment and emergency preparedness in the petroleum sector, to follow up in order to ensure that industry players maintain high standards in this area, and thereby to contribute to creating maximum value for society (PSA 2015).

The PSA cooperates with a number of other government agencies that have independent supervisory authority in the petroleum industry. This collaboration is formalized through various arrangements and agreements. There are constant exchanges of experience and plans, including the coordination of supervision activities where this is natural and appropriate. The PSA is responsible in the offshore petroleum industry for coordinating the work of other agencies which have an independent regulatory responsibility for health, safety and the environment.

These coordination arrangements involve no changes to the formal authority of the various agencies to take decisions pursuant to prevailing legislation and delegated powers. The PSA has also entered into agreements with other government agencies which do not have an independent responsibility in the petroleum industry. These provide the PSA with support in areas where they do not have the capacity to develop the necessary expertise themselves.

4.2 Regulatory strategy and inspection practices in Finland

4.2.1 Regulatory strategy

The regulatory strategy that directs the activities of the Safety and Chemicals Agency has been defined as "*risk-based, proactively preventive supervision and visible communication*" (Tukes 2007; 2013). The following five strategic points contribute to the main strategy that aims towards increasing the effectiveness of the regulatory body. Firstly, *risk-based prioritization of supervision operation* means focusing supervision, communication, research and development in the areas where the risks are highest. The Seveso Directive classifies the establishments purely on the basis of the potential consequences (hazardousness and amounts of chemicals). Tukes aims to take into account the current safety

status of an establishment. Secondly, *proactively preventive communication* means providing information, guidelines and education to the operators as well as public reporting on the results of the supervision, and raising public debate. Thirdly, *workable and up-to-date regulations* will be ensured by collecting information on the regulations from the customer feedback and the observations of the inspectors. Proposals for the changes to the regulations are made on this basis. (Tukes 2007; 2013.) The two other strategic choices concern the research and development, and international cooperation.

Proactively preventive communication, international cooperation and a focus on research and development promote multi-actor, multilevel and multidisciplinary discussion and therefore contribute to an extended integrated view over the risks and safety that can be seen as enhancing the sociotechnical view of safety. The strategy itself manifests the sociotechnical or pre-sociotechnical aspects of safety.

Most inspectors have permanently allocated set of supervised plants. The typical number of plants per inspector is between 70 and 100. Some of the inspectors have smaller number of supervised plants due to other tasks such as development projects and cooperation projects. The plants to be supervised are allocated to inspectors mainly on a geographical basis, and based on the work load rather than on the basis of the type of industry, type of technology or size. This means that an inspector has a wide variety of different plants to supervise. The education and earlier experience of the inspectors is mainly technical or chemistry-related. Recently some inspectors have been hired having academic safety management education from a technical university. Specific inspector education or training is not arranged. Instead, Tukes itself trains and familiarise the inspectors with their work. New inspectors are mentored and trained by the unit and as a part of their work. Continuing training on different topics is arranged for all inspectors. Working experience of current inspectors is distributed rather evenly over a wide range between 6 months and 30 years. According to the inspectors, they benefit greatly from the fact that they receive support from other inspectors and from the whole group in cases in which the supervision policy requires clarifications.

4.2.2 Inspection practices

Tukes inspection is, in practice, a safety management (system) audit at a site, and inspection typically takes one day. Specific technical inspections (e.g. for pressure equipment) are carried out by inspection service companies, which are supervised by Tukes. In Finland, site inspections are common, and they include examining documents, discussions with the key persons and a walk-around on the site. Hence, the format of Tukes inspection is broad. In general, the inspection attempts to discover evidence of how the safety management system is implemented and working. Hard evidence is preferred, for instance a record or a document, but interviews and discussions are also utilised as indicating material. An inspector's overall view of the performance of the regulatee's safety management system is based on discussions with the operator and the personnel. This requires

interpretations, and according to the inspectors, interpretations are difficult to present in official inspection documents. This may be due to their own technical or chemistry-related educational background. Such education does not provide sufficient theoretical, conceptual or methodological tools to interpret and explain the performance of humans and organisations, or to recognize connections between different human and organisational aspects. Hence, this is one point where the sociotechnical safety assessment faces challenges.

There is a formal common agenda for the inspections but the focus may differ especially on annually inspected larger plants. The operator selects the plant representatives for the inspection. The inspector writes a report in which the required actions with schedules and deadlines are presented. The safety of the plant operations is assessed on the basis of the regulations as well as a specific evaluation form, which consists of seven different areas. The topics of the assessment are (Lax and Kylmämaa 2012):

a) Awareness of regulatory requirements
b) Management and personnel commitment
c) Risk assessment and decision making (management of changes)
d) Technical implementation and functionality
e) Instructions for and assessment of operations
f) Competence and training
g) Managing emergencies and deviations.

Each topic is evaluated on a scale from 0 to 5, where 0 indicates serious deficiencies, 1 indicates essential deficiencies, 2 indicates demand for developing, 3 indicates fairly good practices, 4 indicates good practices, and 5 indicates proactive development. The status of the numerical assessment is informative for the operator. The report written on the basis of the inspection and safety assessment includes the results of numerical assessment, required actions and improvement suggestions. A score of 3 or higher means that no actions are required. In addition, the inspectors use this numerical information to decide whether inspection frequency should be increased, or can be reduced, from the basic inspection frequency.

As Figure 3 shows, the maturity concerning safety management processes and practices (and culture) on average follows the hazard level.

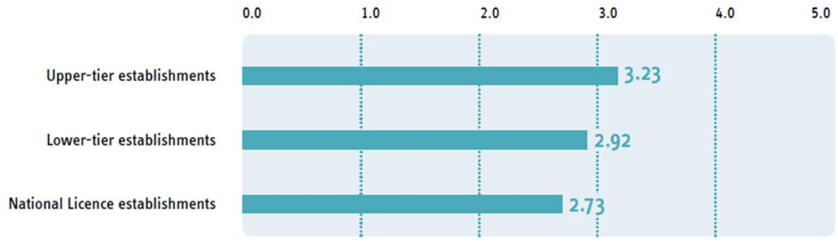

Figure 3. Tukes safety assessments – Overall grade averages according to the extent of operations (Lax and Kylmämaa 2012).

Certain tendencies in the quality of safety management have been observed:

1) The business focus matters. Companies having chemical processing as their core business tend to be more aware of the hazards and have better up-to-date safety management tools, processes and attitudes for chemical safety. Companies which do not have chemical processing as their core business tend to take handling of the chemicals less seriously, even though they may have as significant amounts of as hazardous chemicals as chemical plants have. These companies include for example the paper and pulp industry and metal surface treatment plants.
2) The resources matter. An industrial plant which belongs to a multinational corporation usually has better resources to take care of safety even in times of austerity. In purely national companies safety may be more easily affected by poor economic situation, and even in good times the lack of available resources and knowledge may limit certain safety management activities – especially documentation and formal risk assessment.
3) Management sets the tone. Multinational corporations usually have their own safety culture and practices which are based on the origin of the corporation and affect safety orientations of the national sites and companies. In small companies, the situation tends to be personified. The owner and manager of the company may have a highly business-oriented and risk-taking attitude and thus easily discount safety activities as unnecessary or even harmful for business. These kinds of observations as such represent a need for sociotechnical safety assessment.

4.2.3 The role of the inspector

The role of the inspector is that of a controller, but also of a motivator and “godfather” or “godmother” in the sense that they provide guidance and try in a constructive way to encourage licensees to comply with the rules. There are different expectations towards the inspectors. As a safety authority Tukes needs to

supervise chemical safety, and by the same token, inspectors are expected to support the industry, as Tukes works under the Ministry of Economic Affairs and Employment, which promotes economy and employment. This may cause some tension between different interests in specific events, even though in general safety is seen as the uppermost goal for the regulation. It should be noted that until 2012, it was especially mentioned in the decree that authority was allowed to accept exceptions to the safety requirements on the basis of “unfair costs or substantial difficulties”. In 2012 this clause was removed from the decree (855/2012). Inspectors regard themselves as a partner in cooperation rather than as an adversary. The common mission is to search for solutions to ensure safety.

Building trust between the authority and the operator is considered as an essential factor, since the inspections are carried out with very limited resources and they are based on the information provided by the operator. Inspectors do not see that a conflict would exist between the common safety improvement interest and the ultimate power of the authority to set requirements. Typically, long-term inspector-operator relationships enable the building of trust. However, because of the rather infrequent contacts, the relationship between the inspector and the company representatives rarely becomes very close. With regard to the enforcement, administrative force in the form of conditional imposition of a fine and even the temporary cancellation of the license can be used when necessary but these are exceptions. Recently the criteria for applying this force have been clarified and it has also been slightly more used. Tukes is also heading towards more risk-informed execution of their inspection activities. This means that more effort is put on the objects which are evaluated as being riskier on the basis of their current state of safety management (in addition to the hazardousness and the amount of chemicals, which they handle).

In addition to inspections, supervisory activities also include:

- Informative meetings with the companies
- Acquiring data about accidents and incidents
- Investigating accidents

The Seveso Directive does not set any obligations concerning accident investigation. However, all major accidents meeting certain criteria must be reported to the EU. According to Finnish law, Tukes is obliged to investigate all major accidents at Seveso installations that fulfil the reporting criteria to EU. License holders in turn are obliged to report all major chemicals-related accidents to Tukes, which evaluates the reports and asks for more information if needed. If an investigation is deemed necessary in order to identify the root causes of the accident or to prevent similar accidents, Tukes is obliged to carry out an investigation (Laki 390/2005, 99 §). The investigation does not seek to assign criminal accountability (Heinimaa 2015). During 2009–2013, Tukes carried out six Seveso-accident investigations and one accident investigation of its own accord concerning an explosion in a national license plant. In addition to supervisory duties, Tukes acts as an authorizing body handling license applications. The

license includes specific terms for operation, which are then supervised by inspectors.

New challenges in inspections relate to new business models, organisational structures and ownership arrangements, which are continuously evolving in industry. The future challenges also include increasing outsourcing of activities. The inspectors found these factors to be challenging from the point of view of the regulation, interpretations and practices.

4.3 Regulatory strategy and inspection practices in France

There are three major changes, which have occurred in France concerning the regulatory body, its personnel and the practices of the regulatory body. Firstly, a huge increase in the number of personnel of the regulatory body has occurred since 1968, when France had only 14 inspectors. In 1995 there were 581 inspectors and by 2014 the number had increased to 1306. The increase has been motivated by the establishment of the regulatory body in 1973, and later in 2001 the AZF disaster. Secondly, the recruitment channels of a regulatory body have become more versatile. Earlier the primary path was an external competitive exam for those holding degrees from specific schools, “Ecoles des Mines”, which were originally founded to provide training to operate mines and associated industries. Nowadays the inspectors’ initial education and professional careers are more diversified than earlier. Thirdly, inspections have been separated from the enhancement of economic development. This is a relatively recent change. During the 1980s and the 1990s, the regional administration, named DRIRE, was responsible both for inspection and for industrial development. However, at the end of the 1990s, the Ministry of Ecology decided to separate these two missions in practice: DRIRE engineers could no longer exercise these two conjoint missions. After 2010, these two missions were even more clearly separated into two distinct administrations: DREAL for inspection and DIRECCTE for industrial development. Fourthly, the role of an inspector has been changed from a technical expert, who practices his mission without any recourse to the law, towards the regulator role. Regulatory control has started to play a more significant role.

4.3.1 Regulatory strategies and inspection practices

As mentioned above, the inspection and the mission of industrial development were separated in the beginning of 2000s, by the Ministry of Ecology. In addition, the Ministry decided to increase the number of inspectors and to reinforce their training. Moreover the Ministry decided to proceduralise activities by publishing detailed methodological guides on different themes. It expected to reinforce inspectors’ expertise, to provide support for training new recruits and to better monitor and homogenize inspection practices. Furthermore, the Ministry decided to specialise inspectorate, in order to provide more specialized services, but at the same time it encouraged the inspectorate towards more collective operations by

acknowledging that there are competences that cannot be individually mastered, but can be achieved in cooperation by exchanging knowledge between inspectors.

The inspectors have three main activities today: 1) the production of a specific regulatory framework, 2) the surveillance of installations and 3) the provision of information to civil society, operators and other stakeholders. The first activity includes studying various regulatory documents and studies that the operators of installations must submit to the administration, at each stage of the installation's life-cycle (design, modification, cessation, change of ownership etc.) or at each regulatory requirement (new or updating framework, periodic reviews), and requiring, in most cases, complementary risks studies or additional prevention measures.

Concerning the prevention of major accidents, the inspector reviews the safety case produced by the operator and produces, in turn, the "prefectoral order" applied to this individual establishment. This sets the conditions for developing and operating the installation, operating conditions during start-up, malfunction or temporary shut-down, etc., safety measures and actions to be taken, the state in which the site will have to be placed in case of a total definitive shutdown of the installation for installations moved to new sites, etc. This is a tailored prescription, which translates the measures into a document which complies with the law.

The second main mission includes the control of installations. An inspection visit is when one or more inspectors go to an installation site to verify its conformity with the laws and regulations related to classified installations. Most of the time, the objective of the inspection is to verify that the site is following the conditions of its operation – called "prescriptions"– that are listed either in the prefectoral order specific to the installation, or in the ministerial order concerning the relevant sector of industrial activity.

The Ministry distinguishes different types of visits. According to the number of inspectors mobilized and the time spent preparing, conducting and reporting on the visit, there are "in depth" visits, when several inspectors are mobilized and the time dedicated to the visit is significant, and "short" or "prompt" visits when expended resources are more limited. Depending on the amount of information given beforehand to the operator, there are "announced" visits when the owner has been informed at least 48 hours in advance and "unannounced' visit when the owner has not been notified. According to the theme of the inspection, there are "targeted" inspections that study a precise subject (such as implementing a safety management system or deploying an emergency plan, for example) and "unspecific" inspections that bear on several different subjects. On the other hand, there are also inspections bearing on "planned" themes in the context of an annual or multi-annual programme (in relation to national and regional priorities) and more "circumstantial" inspections that are activated following unforeseen events (such as complaints, accidents or cessations of activities).

The third and last activity, which is communications and dialogue with civil society, operators and other stakeholders, is an increasingly time consuming task. The recent French "Bachelot Law", which was approved in 2003 following the Toulouse disaster in 2001, brought, from this point of view, an important change,

because it created a new local information and orchestration structure, called CLIC (Comité Local d'Information et de Concertation). Created in all industrial basins having at least one "upper tier" Seveso plant, these structures have the role of informing interested parties of the risks in the basin and debating on the means to be employed to prevent and reduce those risks. These occasions allow direct relations between owners, the local population and collectives, and monitoring administrations. One of their primary missions was, originally to participate in the elaboration of technological risk prevention plans (PPRT), of which the function was to evaluate and map risks (in relation to sources of danger, vulnerable zones, dreaded accident scenarios), then to define measures to be taken in terms of urban planning (constructability of the ground, development standards) and the organisation of emergency operations.

4.3.2 Developments in regulations and related inspections challenges

The Seveso II Directive brought about a first regulatory change by imposing the implementation of safety management systems (SMS). Those of the most dangerous establishments (generally equivalent to "upper tier") have the obligation to implement an SMS, based on the danger study. Another law, called the Bachelot Law following the disaster of AZF disaster in 2001, was enacted to improve risk prevention of industrial accident. The law introduced human safety barriers and the probability approach. Earlier the safety cases were based solely on determinist logic. The Bachelot Law of 2003 and the ministerial order of 29 September 2005 were a major turning point in requesting that safety cases be established in relation to three parameters: probability, gravity and kinetics. Once accident scenarios have been identified, the owner must then reduce risks at their source, by reflecting on operations and successive measures of risk control leading to the reduction of the probability of dangerous phenomena or decreasing their effects, following a logic of defence in-depth. These "safety barriers" can be of a technical nature, but also of a human nature, and can intervene in prevention or in protection (to limit the effects of a dangerous phenomenon and its consequences on potential targets). Finally, the owner is asked to evaluate, for each of these barriers, its performance level based on its effectiveness, response time and confidence level related to its architecture or probability class.

However, some difficulties can be identified in each case. Concerning the safety barriers, it appears that inspectors consider the technical barriers as less unsure and safer than human barriers. Human factors are associated with negative connotations, such as failures, errors or negligence. The operators who work in these establishments are very rarely seen as "reliable agents" who are able to detect and control the trickiest situations, but are mostly seen, on the contrary, as "unreliable agents" making mistakes and causing accidents. Some inspectors also think of "necessary violations", e.g. operators, who sometimes break safety rules in order to meet production imperatives. With regard to safety management systems, it appears that inspections are often staying on a "paper inspection". In each case, several reasons are cited by inspectors to explain this, such as lack of

time. Concerning control of the management systems, the inspectors are mostly proceeding in two successive stages: a first stage “in the room”, which allows the inspector to verify whether documents meet the regulatory requirements, and then a second stage “in the installations”, which allows them to verify whether procedures are being correctly implemented, known and complied with. As many inspectors have noted, the first stage “in the room” is very time-consuming for several reasons. Firstly, because reading of the documents takes place during the visit itself and not before, and so the inspectors have only one day to read all the documents in the room and then, proceed to the necessary verifications in the installations. Secondly, because the behaviour of the industrialist can intentionally or unintentionally complicate or slow down the work of the inspector, by not providing the required documents or by providing too many documents. In order to avoid the trap of the “paper inspection”, the inspectors generally limit their inspection to only one item of the safety management system. However, this is not always sufficient and they often run out of time for the visit of the installations.

In order to explain their poor trust in “human factors” or their tendency to perform “papers inspections”, many inspectors also noted the “competence issue”. The inspectors mention that they are above all engineers. Engineering issues are central to their training, their job, their practice and their identity. They are already accustomed to judging the adequacy of technical safety equipment, both in their regulatory framework mission and in their inspection mission. And even if recent changes in the French legislation encourage them also to engage in the judgment of the adequacy of human actions or organisational measures, the inspectors do not feel qualified for this with regard to their background. Hence, lack of human and social science education is one factor that maintains poor trust in human factors and a tendency towards paper inspections.

In addition to the lack of human and social science education, a lack of clear criteria for judging has been acknowledged among the inspectors. Concerning technical equipment, their judgement is based on a set of “specific”, “objective” and “hard” criteria and it is rather easy for them to say whether equipment is compliant or not. Concerning human actions or organisational measures, however, things are different because they do not have the same criteria for judging. They have to observe or question operators “on the job” on more unfamiliar and improvised issues and they consider their criteria for judging as too “fuzzy”, “soft” and “subjective” because of the room for interpretation left to the discretion of each inspector.

Some inspectors also mentioned, although more rarely, the problem of discontinuity in the surveillance of establishments. The problem is that to be really competent on sociotechnical issues, it is necessary to have not only a good knowledge of the issue in general, but also of the inspected establishment in particular, that is its activities, its hazards, its regulatory framework, its technical characteristics, its economic or social situation, its history and its projects. In addition, inspectors meet with two types of difficulties: firstly, they are mostly changing positions every two or three years; and secondly, they sometimes have to come with or replace a colleague in a completely unknown establishment.

Another challenge that the inspectors mentioned is the tension between controlling and advising. Earlier (mid 1960s – mid 1980s), the role of the inspector was technical expertise. The inspector had an advisory role and dialogued with the industrial representative, rather than menacing him with sanctions. In the following era (mid 1980s – end 1990s), regulatory control took on a much more significant role. In the current era, many inspectors think that their role is only limited to the regulatory control of compliance.

Some French inspectors, who have a particularly long career in the classified installations, or those who have previously worked in other inspectorate bodies, such as nuclear or occupational health and safety, or worked in the industry itself, appear to be more sensitive to sociotechnical safety aspects. These previous experiences, particularly in nuclear and occupational health and safety, have taught them to go beyond the documents and installations review, and regulatory requirements, to study the real work situations, by observing and questioning operators.

4.4 Conclusions: Inspection practices as contributing to and hampering sociotechnical safety assessment

With regard to regulatory strategy, tripartite strategy with collaboration between the Petroleum Safety Authority (PSA), industry and unions is typical of Norway. In addition, the PSA has adopted a non-blaming regulatory culture. This means that regulators aim at finding constructive ways to solve the non-conformities or deviations from the regulations. They emphasise a learning attitude and avoid a police-like role. In addition, meta-rules or purpose-oriented regulation that leaves the regulatee with relatively wide freedom of choice to meet the requirements, characterizes the PSA's regulatory strategy. Furthermore, supervision is system-oriented and risk-based and it should supplement the internal control of the industry.

Finnish regulatory strategy is defined as risk-based, proactively preventive supervision and visible communication. Inspections are focused on the areas where the risks are highest. The Safety and Chemicals Agency (Tukes) emphasizes proactively preventive communication by providing guidelines to the operators and by reporting the results of the inspections to the public. Tukes has also emphasised research and development as well as international cooperation as part of the regulatory strategy. The aforementioned factors contribute to the multi-actor, multilevel and multidisciplinary interaction, which are relevant in sociotechnical safety assessment. However, the large number of supervised plants and the small number of inspectors is a clear challenge with regard to the development of sociotechnical safety assessment.

By contrast, in France the regulatory strategy has moved especially in the beginning of 2000 towards a more detailed, proceduralised regulatory strategy in the form of detailed methodological guides. Even though this appears to contradict the sociotechnical safety assessment requirements, there are also tendencies,

which contribute to sociotechnical aspects. For instance the number of inspectors has increased and their training has been developed. In addition, specialisation of inspectors and cooperation between the various experts is supported at the Ministry level. Moreover, emphasis on dialogue with civil society, Operators and other stakeholders is a factor, which is beneficial to sociotechnical safety assessment.

With regard to inspection practices, there are similarities between the countries. Oversight of the safety management systems is at the core of inspections, or supervision, in all countries. In addition, verification of what the regulatee has said is common to all three countries. Similarly, site inspections are made in all the countries. However, in comparison to Norway, site inspections are more common in Finland and France, meaning walking around on the site to verify the regulatee's compliance with laws and regulations as well as to better understand the reality of an organisation.

However, a difficulty in the oversight of safety management systems was identified by French inspectors. Due to the lack of time and often the large amount of paperwork to be checked, inspectors do not have adequately time to spend on site walking, which would be relevant to gain understanding of the reality of the plant. Therefore, inspections may easily remain as "paper inspections". In addition, the French inspectors mentioned a lack of continuity in the surveillance of establishments as a challenge. A feature common to French inspectors is that they change positions every second or third year, which does not contribute to the development of long-term trust relationships between the regulator and the regulated targets. In addition, knowledge about the specifics of the establishment cannot be gained when the regulated targets vary according to the changing position of the regulators.

Both French and Finnish inspectors expressed problems related to human and organisational factors. When assessing an organisation's performance, it is easier to refer to hard facts rather than to soft facts, such as discussions with the operators and their interpretations. A lack of clear criteria for judging human factors is missing. Hence the education of the inspectors has implications for their ability to analyse, conceptualise and understand the human and organisational aspects.

With regard to the role of inspectors, the Finnish inspectors have adopted the role of both controller and motivator. In France inspectors acted in the 1960s-1980s more as advisors than nowadays. Since the 1990s inspectors have adopted the role of a controller, based on the new regulatory strategy that emphasised proceduralisation, i.e. more detailed supervision of steps through which the regulatory requirements are achieved. By the same token, the role of inspectors is also that of controllers, in Norway, even though the regulatory strategy is non-blaming and the inspectors focus on dialogue in the supervision, and the industry's self-regulation is emphasised. Hence, ensuring compliance with the regulations plays a relevant role in Norway, Finland and France.

Based on France's example, it appears that the career path plays a significant role as regards inspectors' ability to take into account sociotechnical aspects.

Particularly, inspectors who have worked in the industry, or in other regulatory bodies, are more capable of going beyond the regulations and of understanding the reality of an organisation. Hence, versatile experience is a contributing factor with regard to sociotechnical safety assessment.

In conclusion, the collaboration of inspectors with different authorities and various experts as well as with civil society organisations contributes significantly to broader understanding of the situation of the regulated organisation. Similarly, site inspections provide a better view over the reality of an organisation than does checking paper documents only. Both of these methods contribute to a holistic understanding of the situation of the regulated target.

5. Recommendations to improve the regulation towards taking better into account the sociotechnical phenomena

One of the questions which this study aims to answer is how to develop regulatory practices towards taking better into account the sociotechnical dimension of safety. Providing recommendations is not an easy task for various reasons. Firstly, regulatory bodies, their cultures, regulatory strategies and practices differ from each other. Secondly, structural aspects, including social and political context as well as financial or material resources are different, and hence recommendations that work in one regulatory context do not necessarily work in others. Thirdly, it is possible to distinguish between different levels of recommendation, low level and high-level recommendations, both of which encounter challenges (Dekker 2006). Low level recommendations targeted to individuals or small groups are easy to implement but not necessarily effective at the system level, whereas high-stream recommendations, embracing structural decisions, resources and technologies may encounter difficulties because they require structural changes that are not easy to implement.

Acknowledging the difficulties, we distinguish between three levels of recommendations. The first one is linked to macro level referring to legislation and resources provided by society to regulation. The second, meso level is connected to organisation of the regulatory body and its design of inspection strategies. The third, micro level includes inspector's practices. Often all these levels, namely resources, inspection strategies and individual inspector's practices are linked together: working practices are dependent on the upper level resources, principles and strategies.

We will focus in our recommendations on those aspects that are relevant from the sociotechnical viewpoint and to which the studies on accidents and safety, as well as our study, provide support. Our recommendations are targeted both to the regulatory bodies and to the regulated industries. Mainly our recommendations relate to organisation level, design of inspection strategies and inspection practices, although, organisation level recommendations are not isolated from the macro level questions, such as legislation, resources, mandates or cultures. All

recommendations are interlinked. In addition, after each recommendation we have provided a set of questions for inspectors to be investigated.

5.1 Recommendations concerning the regulated organisation

5.1.1 Attention to external pressures in organisation

Sociotechnical oversight of safety would require holistic understanding of the organisation's situation. This means that it is also important to understand the external pressures that affect the organisation. Often little attention, if any, has been paid to the economic pressures and their safety impacts despite the fact that studies on accident investigations have shown that external pressures, notably pressures related to production and economy, have been contributing factors in accidents. According to Dechy et al. (2016) Llory (2015) examined 100 industrial accidents and found that similar root causes recur, one of which is production pressure. Similarly, in the case of BP Texas City, investigations showed that cost-cutting pressures seriously degraded infrastructure, and management failed to assess the impact of cost and staff reductions on safety (Hopkins 2008; Griffon 2016). By the same token, Finnish inspectors have observed that small companies with relatively scarce economic resources easily set economic aspects in the first position at the cost of safety. Hence, attention to external pressures is crucial in the enhancement of sociotechnical safety assessment.

By the same token, sometimes positive things, such as expansion of the plant can trigger changes in an organisation's strategies, and these factors can have effects on safety. Senior managers may be too focused on enhancing business through expansion and forget safety effects. Hence, not only economic pressures but also expansion endeavours may have safety significant implications, which need to be examined thoroughly. This kind of task may go beyond the normal inspection practices and daily routines of regulated industry. Another difficulty is that economy related data can be secret and not available for inspectors. However, at least at general level economic aspects needs to be dealt with if emphasis is given to sociotechnical thinking.

For inspectors the questions to be investigated are:

- What kinds of economics or production pressures have been identified by managers?
- What kinds of implications do the production pressures or expansion of the company have for the safety?
- How are the effects of economic and production-related pressures on safety mitigated?

5.1.2 Attention to safety effects of organisational and technological changes

Organisations may respond to external pressures by changing the organisational structure. All kinds of changes, even if they are expected to be beneficial for the organisation may have effects on safety. Technological changes affect people's work, competences and organisation. For example, technological changes may require new competences, and they may lead to deterioration of old but relevant competences. Hence, organisations should evaluate carefully the effects of technological and organisational changes on safety. When organisational structure is complex, change management becomes challenging. Changes in roles and responsibilities of one function or unit are reflected in other functions, workloads of people and organisational culture. In addition, changes require updates of guides and documents, which is a time-consuming but important task (Reiman and Oedewald 2009). Furthermore, it may be difficult to anticipate the effects of change on everyday practices, because everyday practices are more than simply following the guides. In any case, in order to enhance sociotechnical safety assessments, inspectors could encourage organisations to pay attention to changes and reflect upon their possible effects.

Questions to be investigated:

- How does the organisation identify the effects of changes on its different functions?
- Who are responsible for identifying the effects?
- What kinds of experts and cooperation are required in order to identify efficiently the effects?
- How does technology/change affect competences, roles, responsibilities, and work practices/work processes/work load and interaction between the people in an organisation?
- How are the possible negative effects of changes mitigated?

5.1.3 Promotion of safety culture within the regulated industry

The following citation expresses complex regulatory reality and the need for sociotechnical safety assessment:

"One difficulty arises, when there are lot of old plants, constructed a long time ago, and licenses were approved in the 1970s or 1980s. The operation of some plants has been halted, and new installations have been made, owners have changed, some new installations have been built and old ones have been removed, and some new processes and chemicals have been taken into use. Then the current situation does not correspond to what is required in the current legislation. It requires balancing, deciding what is the sufficient level." (Interviewee, Finnish inspector)

The case described refers to a complex situation. The regulated target has gone through several changes related to plants, organisation, technology, human resources, and chemicals. When the situation is complex and challenging, it is not

possible simply to rely on current regulations. It is necessary to go beyond the compliance. How is it possible to guarantee safety in the situations similar to that described above? How can an organisation's potential for acting safely be enhanced?

One relevant answer would be the development of safety culture thinking in an organisation. The safety culture concept was launched in the nuclear domain after the Chernobyl nuclear accident (1986). The concept has become popular and widely used and several frameworks have been introduced (IAEA 2012). The lessons learned from the Davis-Besse incident (2002) and the Fukushima accident (2011) put more emphasis on safety culture in the successful performance of a plant. We argue that it would be beneficial to adopt relevant aspects from the existing safety culture frameworks, both in the regulatory body and in the high-risk industries.

A safety culture perspective, developed at VTT Technical Research Centre of Finland Ltd, has focused on an organisation's functions and capabilities that are relevant in maintaining and enhancing the organisation's potential for safe operation. The Design for Integrated Safety Culture (DISC-model) describes normative criteria for good safety culture (Reiman and Oedewald 2009). These criteria consist of six items: safety is a genuine value in an organisation, which is reflected in decision-making and daily activities; hazards and core task requirements are understood thoroughly; safety is understood as a complex and systemic phenomenon; the organisation is mindful in its practices; responsibility for the safe functioning of the entire system is taken; activities are organised in a meaningful way. These six criteria form an inner layer of the model, whereas the outer layer consists of the functions of the organisations, such as change management, safety management, work conditions management, work process management, which can have direct or indirect influence on an individual's and the organisation's performance in terms of safety.

Adoption of safety culture thinking takes time. It builds on the grounds of organisational culture understood as shared values, attitudes and practices. It requires resources and the commitment of the organisation's senior management to the safety culture approach and its development, including continuous training so that every member of the organisation will internalize it.

Benefits of the safety culture would be the following. Firstly, when truly internalized, safety culture thinking contributes to the common understanding of safety as a primary value that cannot be overridden by production pressures. However, safety should not be seen as an opposite to successful business but as a precondition for it. Safety is taken into account in the decisions and everyday practices at the organisation. Secondly, members of the organisation understand hazards and each one is aware of his/her own tasks and their effects on safety. Thirdly, when safety is understood as complex and systemic phenomenon, an employee cannot simply lean on compliance with the regulations but is motivated to consider interconnections of social and technological aspects i.e. sociotechnical aspects. Fourthly, members of an organisation have a mindful attitude towards emergent risks. Fifthly, in any kind of change situations, for example in

organisational change situations, responsibility is taken for the entire system. Sixthly, the organisation is structured in a meaningful way, so that core functions work together neatly and safety is integrated in all activities, and the organisational structure supports efficient and safe functioning. If those aspects work, then they support sociotechnical safety thinking.

Safety culture approach can be criticized for leading to a simplistic understanding of culture as something that can be designed. We acknowledge that national or organisational cultures cannot be designed. However, if we regard safety culture in an organisation as mindfulness, as the employee's ability to understand how his/her work is related to safety, or as how the organisation's activities are arranged in a manageable way, we can think that these things can be trained and steered to some extent. And although safety culture does not resolve problems related to a sociotechnical systems understanding of safety (Reiman and Rollenhagen 2014), it is a partial solution to sociotechnical safety assessment, because people's mindfulness in their work is closely affected by their performance and by their relationship with the technical devices. Similarly, technological development affects employees' competences to deal with the devices.

We argue that safety culture would be a relevant answer to the complex situation in companies, and in complex projects with long supply chains. When, owner of the project has responsibility for the safety, adoption of safety culture thinking makes it more mature to be in responsible. Similarly supplier organisation that is often responsible for sub-suppliers, should have a good safety culture. When regulatory bodies, have many regulated targets and scarce resources, and when the regulated industry has faced several structural, organisational and technological changes, the answer to the requirement for efficient and sociotechnical safety assessment, is that the licensee/operator adopts safety culture thinking. Only then does the responsibility for safety rest clearly with the licensee/Operator. Hence the adoption of good safety culture could be a minimum requirement for high-risk organisations to obtain a license to operate.

Questions to be investigated:

- How safety is understood by employees and taken into account in their daily activities?
- How hazards and core task are understood?
- How safety is taken into account as complex and systemic phenomenon in an organisation?
- How are activities in an organisation arranged?
- How the responsibility for the safe functioning of the entire system is arranged?

5.2 Recommendations concerning the system and organisation level

Often recommendations concern both system and organisational level and it is difficult to distinguish between them, because the boundaries are blurred. If we think of organisations themselves as system of systems, then also the previously presented recommendations could be dealt with here.

5.2.1 Understanding the overall situation and potential dangers in the organisation

Hopkins (2012), after an analysis of the Gulf of Mexico accident (2010) claimed that the US regulators lost sight of safety of the rig operation by focusing on regulatory compliance as the ultimate goal, which substituted risk awareness. Risks related to functioning of an organisation are so complex that in addition to technical aspects it is important to have an understanding of potential dangers that organisations and humans may create in the overall safety of a whole system. The achievement of a broad understanding of the organisation's situation and inter-organisational relationships requires cooperation between several experts and from different levels of organisations. Inspectors can develop capabilities to gather and interpret data at several layers of functioning of an organisation. This would enable a discussion with regulated industry about the extent of changes which affect their modes of operating.

Good practice that can be borrowed from the nuclear industry context is the practice, according to which the inspectors from different technical expert areas make observations during the inspections and report them to a common database. The human and organisational experts within the regulatory body can then use those observations to examine whether there are weak signals that could be interpreted as compromising the safety culture of a regulated organisation. Even though the technical experts are not trained to analyse human and organisation factors, they can bring relevant observations from their own technical field, which relate to human and organisational factors. It is a task of organisational experts to analyse those observations and gather more data if needed. For instance event reports focusing on technical explanations or human errors may reveal lack of understanding of organisational features and pressures that have contributed to the event.

If the regulated company has a separate safety management department and safety professionals, one risk may be that these professionals are somehow isolated from the shop floor practices, and therefore their capability to understand the reality of shop floor practices is limited. In addition, if safety section is separated from other sections of a company, it does not contribute to integration of safety aspects to other functions in an organisation. Hence, it is important to ensure that the safety management is closely connected to the other functions of the organisation.

Questions to be investigated:

- Do the regulators have a mandate to oversee the different functions of the organisation?
- Do the regulators have adequate financial and human resources, and competences to oversee broadly the organisation's functions?
- How is it possible to guarantee efficient cooperation and exchange of information between the different experts in the organisation?
- Who are responsible for gathering and analysing the relevant information gathered from different functions of an organisation?
- How is it possible to guarantee that the safety management department does not remain isolated from the other functions of the organisation and from the shop floor level?

5.2.2 Attention to the competence in analysing human and organisational aspects

As the findings of this study show, the majority of inspectors have a technical education, and therefore they lack competence in analysing human and organisational aspects. Therefore, we recommend three options for tackling this problem.

Option 1. Change the system so that the sociotechnical approach is introduced: change in the law, access to data granted, trained and expert inspectors available.

Option 2. Provide specialist training to supply some inspectors with the expertise to perform this kind of assessment from time to time when needed, while retaining their ability to perform inspections with technical inspectors.

Option 3. Rely on external firms which can perform sociotechnical assessment on request.

Questions to be investigated:

- How the regulation is understood in society?
- How in the current social, political and economic situation one can best enhance sociotechnical safety assessment?
- How to guarantee that the human and organisational experts are included in discussion of sociotechnical safety assessment?

5.3 Recommendations: concluding remarks

Due to the complex realities of regulated organisations, the focus on compliance with regulations can never be a sufficient means for ensuring safety. By the same token, all the recommendations provided here are only partial answers to the need for improvement of sociotechnical safety assessment. However, we argue that the recommendations presented here, even though they do not appear to be totally new, are necessary steps towards sociotechnical safety assessment. There is considerable variation in the degree to which different industrial sectors have adopted them.

Recommendations included attention to external pressures in the organisation, attention to the safety effects of organisational and technological changes, understanding the overall situation and potential dangers in the organisation, promotion of safety culture within the regulated industry, or system level recommendations concerning changes in laws to enhance sociotechnical understanding of safety. All the previously presented recommendations contribute to the possibility to go beyond the narrow compliance perspective. They provide first steps towards a strategy for sociotechnical safety assessment.

Even though an active strategy for sociotechnical safety assessment can be developed in a series of steps, the sociotechnical safety assessment is not a mechanical, easy process to attain or govern. A broader discussion about the regulation and its role in society is needed. In addition, discussion about whose competences and expertise are needed in sociotechnical safety assessment and how to guarantee that all relevant parties are included in the assessment, would be crucial.

6. Conclusions and discussion

The objectives of this study were to compare the practices in Norwegian, Finnish and French risk regulation regimes in terms of sociotechnical approaches to safety and to clarify the limits and possibilities of regulation in ensuring sociotechnical safety. Other objectives were to develop an evidence-based guide on how to develop regulatory practices towards taking better into account the sociotechnical dimension of safety and to investigate what the shift towards a sociotechnical approach entails from a scientific viewpoint, and how it affects the management of safety (Le Coze et al. 2017).

Increasing complexity of the high-risk industries with interconnectedness of technical and social systems has given rise to a need for a broader, integrated understanding of safety. Especially accident investigations have shown that accidents are often the outcome of several failures, and for this reason it is not meaningful to look for a single root cause of accidents. In addition, it is not possible retrospectively to trace back the causes, because the situation after the accident is never the same as it was before the accident. If accidents are the outcome of several interconnected systems, then safety should also be understood as an emergent phenomenon and as an outcome of structures, processes and actions of several systems and actors. The question arises: how is it possible to improve regulations in order to enhance better understanding of sociotechnical systems safety?

This is a pioneer study in the sense that no comparison between these regulatory regimes has been made previously, nor in terms of sociotechnical safety assessment. The study does not provide exhaustive answers regarding the enhancement of sociotechnical safety assessment, but rather a reference point for future discussions and studies on the topic. The findings of this study can be reflected upon in other high risk industries, as well as in various regulatory bodies, bearing in the mind that culture and context play a crucial role in any development of sociotechnical assessments.

The findings of this study reveal strengths and vulnerabilities of all three regimes. The Norwegian regime can be described as risk-informed, trust- and dialogue-based as well as functional-based, authority-enforced self-regulation, which means that regulators set the general requirements which industry should meet. The strength of the Norwegian regime is a strong stakeholder involvement

and adopted capability building among the industry and the regulatory body. The tripartite system and forums for safety are tailor-made to ensure strong stakeholder involvement in safety discussions. Among the three countries, Norway, with its good financial resources and networks with academics, appears to be the most advanced with regard to sociotechnical aspects. However, there are vulnerabilities in the Norwegian regime; for example political and economic issues can easily weaken the existing trust between the parties and undermine the climate of cooperation. Similarly, the win-win principle between safety and economy in financially poor times is difficult to obtain and to maintain.

The Finnish regime can be described almost with the same words as the Norwegian regime, although the Finnish regime is less authority-based self-regulation compared to the Norwegian regime. The strength of the Finnish regime is in its emphasis on proactively preventive communication, meaning providing information, guidelines and training to the operators as well as public reporting on the results of the supervision and increasing public debate. These factors contribute to multi-actor, multilevel and multidisciplinary interaction, which are relevant in sociotechnical safety assessment. However, the heterogeneity and large number of supervised plants and the small number of inspectors is a clear challenge with regard to the development of sociotechnical safety assessment.

The French regime could be described as risk-informed, command- and control–based regulation. The strength of the French regime is in the development of a dialogue-based approach with civil society, operators and other stakeholders. By contrast a weak point is the command and control type of regulation, which is at variance with sociotechnical safety regulation. Similarly, the fact that inspectors need to change their position every second or third year undermines their possibility to acquire detailed knowledge about the specifics of the establishment. This maintains knowledge asymmetry between the Inspectors and the regulated industries.

Common to all countries is the fact that the majority of inspectors or supervisors have a technical education. The biased educational background of inspectors means that they do not have the competence to observe human and organisational aspects. However, the inspectors who have previously controlled in other inspectorate bodies, or those who have worked before in the industry itself, appear to be more sensitive to sociotechnical issues.

Another factor common to all regimes is that they are focused on compliance aspects, which means that sociotechnical thinking is not yet fully adopted. Perhaps the most relevant issue facing the sociotechnical safety assessment is that despite acknowledgment of the complexity of high-risk industries and the need to develop sociotechnical systemic understanding of safety, many actors in the high-risk industries do not fully understand what this would require with regard to resources, culture and area of competence.

Recommendations provided in the report represent the first steps towards a strategy for sociotechnical safety assessment. In addition to these recommendations, it is of major importance to reflect on the sociotechnical context and how regulation can retain its independence while at the same maintaining

trustful relationships and cooperation with the industry. By the same token, it is necessary to open a broad discussion about the role of regulation in society and its importance, especially when there are relevant deregulation pressures in society. Another discussion topic could entail questions about the actors and experts on which sociotechnical safety regulation should be based. We hope that the findings and recommendations of this study will inspire serious discussion in the high-risk industries and among the regulatory bodies about sociotechnical safety assessments and how to enhance them for the benefit of the industry, society and safety.

Acknowledgements

The steering board consisting of renowned safety professionals Prof. Johan Sanne (IVL Svenska Miljöinstitutet), Prof. Gudela Grote (ETH Zürich), and Todd La Porte (Berkeley University) has given us invaluable insight. We greatly thank them all. In addition, we gratefully acknowledge all the people who collaborated in this work by giving their time for interviews, responding to questions in e-mails, sending research material, taking us to site visit, and reading and commenting the draft reports.

References

Baldwin, R., Cave, M., & Lodge, M. 2012. Understanding Regulation. Second Edition. New York. Oxford University Press.

Baram, M., & Lindoe, P.H. 2014. Modes of risk regulation for prevention of major industrial accidents. In Lindoe, P.H., Baram, M., & Renn, O. (Eds.) Risk Governance of Offshore Oil and Gas Operations. New York. Cambridge University Press.

Beck, U. 1986. Risk Society: Towards a New Modernity. London. Sage.

Dechy, N., Rousseau, J.-M., Dien, Y., Llory, M., & Montmayeul, R. 2016. Learning Lessons from TMI to Fukushima and Other Industrial Accidents: Keys for Assessing Safety Management Practices. IAEA – International Conference on Human and Organizational Aspects of Assuring Nuclear Safety – Exploring 30 Years of Safety Culture. Vienna, 25th February 2016.

Dekker, S. 2006. The Field Guide to Understanding Human Error. Adelshot, UK. Ashgate.

Dekker, S. 2011. Drift into failure. From hunting broken components to understanding complex systems. Adelshot, UK. Ashgate.

Dekker, S., Cilliers, P., & Hofmeyr, J.-H. 2011. The complexity of failure: Implications of complexity theory for safety investigations. Safety Science, 49(6), pp. 939–945.

Emery, F.E., & Trist, E. 1960. Socio-technical systems. In Management Sciences, Models and Techniques, vol. 2. London. Pergamon Press.

Griffon, M. 2016. Lessons Learned from the US Chemical Safety and Hazard Investigations Board presented at The IAEA International Conference on Human and Organizational Aspects of Assuring Nuclear Safety – Exploring 30 Years of Safety Culture. Vienna, February 24th 2016.

Heinimaa, T. 2015. Improving the safety of Seveso-establishments in Finland by developing the accident investigation process (in Finnish). Licensiate Thesis. Tampere University of Technology. 146 p. + 47 app.

Hood, C., & Rothstein, H. 2003. The Government of Risk. New York. Oxford University Press.

Hood, C., Rothstein, H., & Baldwin, R. 2001. The government of risk: Understanding risk regulation regimes. New York. Oxford University Press.

Hopkins, A. 2007. Beyond compliance monitoring: new strategies for safety regulators. Law & Policy, 29(2), 210–225.

Hopkins, A. 2008. Failure to learn: the BP Texas City refinery disaster. Sydney, NSW. CCH.

Hopkins, A. 2012. Disastrous Decisions: The Human and Organisational Causes of the Gulf of Mexico Blowout. Sydney, NSW. CCH.

IAEA. 2012. Safety culture in pre-operational phases in nuclear power plant Projects. Safety reports series 74. Vienna. International Atomic Energy Agency.

Kaasen, K. 2014. Safety Regulation on the Norwegian Continental Shelf. In Lindøe, P.H., Baram, M., & Renn, O. (Eds.) Risk Governance of Offshore Oil and Gas Operations. New York. Cambridge University Press. Pp. 103–131.

Kringen, J. 2014. Liability, blame, and causation in Norwegian risk regulation. Journal of Risk Research, 17(6), pp. 765–779.

Lagadec, P. 1982. Major technological risk – an assessment of industrial disasters. London. Pergamon Press.

Laki 390/2005. 2005. Laki vaarallisten kemikaalien ja räjähteiden käsittelyn turvallisuudesta. (Finnish law on the safe handling of hazardous chemicals and explosives.)

Lax, S. 2011. Authority supervision of chemical plants in Finland (in Finnish). M.Sc. thesis. Tampere University of Technology. 62 p. + 17 app.

Lax, S., & Kylmämaa, H. 2012. Good practice for enhancing process safety. Tukes. ISBN: 978-952-5649-47-5 (pdf), 978-952-5649-46-8 (printed). 20 p.

Le Coze, J.C. 2013. New models for new times. An anti-dualist move. Safety Science, 59, 200–218.

Le Coze, J.C. 2016. Managing the unexpected. In Moller, N., & Hanson, S. (Eds.) Handbook of safety principles. London. Routledge.

Le Coze, J.C., Pettersen, K., Engen, O.A., Morsut, C., Skotnes, R., Ylönen, M., Heikkilä, J., & Merlele-Coze, I. 2017. Sociotechnical systems theory and the regulation of safety in high-risk industries – White paper. VTT Technology 293. Espoo, Finland. VTT. http://www.vtt.fi/inf/pdf/technology/2017/T293.pdf

May, P.J. 2002. Social Regulation. In Salamon, L.M. (Ed.) The Tools of Government: A Guide to the New Governance Handbook. New York. Oxford University Press. Pp. 156–187.

Perrow, C. 1984. Normal Accidents, living with high risk technologies. New York. Basic Books.

PSA. 2016a. The Petroleum Safety Authority. http://www.psa.no/role-and-area-of-responsibility/category916.html (accessed 23 June 2016).

PSA. 2016b. The Petroleum Safety Authority. http://www.psa.no/about-supervision/category888.html (accessed 23 June 2016).

Rasmussen, J. 1997. Risk management in a dynamic society: a modelling problem. Safety Science, 27(2–3), 183–213.

Reiman, T., & Oedewald, P. 2009. Evaluating safety critical organizations – emphasis on the nuclear industry. SSM 2009:12. Available at: www.stralsakerhetsmyndigheten.se

Reiman, T., & Rollenhagen, C. 2014. Does the concept of safety culture help or hinder systemic thinking in safety? Accident Analysis and Prevention, 68, 5–15.

Renn, O. 2008. Risk Governance. Coping with Uncertainty in a Complex World. London and New York. Earthscan.

Trist, E.L., & Bamforth, K.W. 1951. Some social and psychological consequences of the longwall method of coal-getting: an examination of the psychological situation and defences of a work group in relation to the social structure and technological content of the work system. Human Relations, 4(1), 3–38.

Trist, E.L., Higgin, G.W., Murray, H., & Pollock, A.B. 1963. Organisational Choice. London. Tavistock.

Trist, E.L. 1981. The Evolution of Socio Technical Systems. Occasional Paper, 2, 1–67.

Tukes. 2007. Tekninen turvallisuus ja luotettavuus. Tukesin strategia 2015 (Tukes strategy 2015). Helsinki. Tukes. 17 p.

Tukes. 2013. Turvallisuus- ja kemikaaliviraston (Tukes) toiminta- ja taloussuunnitelma vuosille 2015–2018. Helsinki. Tukes. 12 p.

Turner, B.A. 1978. Man-Made Disasters. London. Wykeman.

Series title and number

VTT Technology 295

Title	**Sociotechnical safety assessment within three risk regulation regimes** SAF€RA STARS Final report
Author(s)	Marja Ylönen, Ole Andreas Engen, Jean-Christophe Le Coze, Jouko Heikkilä, Ruth Skotnes, Kenneth Pettersen & Claudia Morsut
Abstract	This final report summarises the main results of the research project on Sociotechnical Safety Assessment within three regulatory regimes (SAF€RA STARS). The objectives of the project were the following: 1) Explore what the shift towards a sociotechnical approach entails from a scientific viewpoint and how it affects safety management, 2) Compare practices in risk regulatory regimes – Norwegian oil and gas, hazardous use of chemicals in Finland and France – with sociotechnical approaches, 3) Clarify the regulation (limits and possibilities) in ensuring sociotechnical safety 4) Develop an evidence-based guide on how to develop regulatory practices towards taking better into account the sociotechnical safety. It's a question of pioneer study in the sense that there is no comparison between these regimes made before, and not in terms of sociotechnical safety. Findings show strengths and vulnerabilities of all three regimes. Norway appears to be the most advanced with regard to sociotechnical aspects. The strength of Norwegian regime is large stakeholder involvement and adopted capability building among the industry and the regulatory body. However, vulnerabilities in the Norwegian regime relate to political and economic issues, which can easily weaken the existing trust between the parties and undermine the climate of cooperation. The strength of the Finnish regime is in its emphasis on proactively preventive communication, meaning providing information, guidelines and training to the operators. However, the heterogeneity and large number of supervised plants and the small number of inspectors is a clear challenge with regard to the development of sociotechnical safety assessment. The strength of the French regime is in the development of a dialogue-based approach with civil society, operators and other stakeholders. Weak points are the command and control type of regulation and the fact that inspectors need to change their position every second or third year. Development of sociotechnical safety assessment would require a broad discussion about the role of regulation in society.
ISBN, ISSN, URN	ISBN 978-951-38-8528-1 (Soft back ed.) ISBN 978-951-38-8527-4 (URL: http://www.vttresearch.com/impact/publications) ISSN-L 2242-1211 ISSN 2242-1211 (Print) ISSN 2242-122X (Online) http://urn.fi/URN:ISBN:978-951-38-8527-4
Date	March 2017
Language	English, Finnish abstract
Pages	56 p.
Name of the project	Sociotechnical safety assessment within three risk regulation regimes
Commissioned by	
Keywords	Sociotechnical, safety, risk regulation regime, compliance
Publisher	VTT Technical Research Centre of Finland Ltd P.O. Box 1000, FI-02044 VTT, Finland, Tel. 020 722 111

Julkaisun sarja ja numero

VTT Technology 295

Nimeke	**Sosiotekninen turvallisuuden valvonta kolmessa riskiregiimissä** SAF€RA STARS -loppuraportti
Tekijä(t)	Marja Ylönen, Ole Andreas Engen, Jean-Christophe Le Coze, Jouko Heikkilä, Ruth Skotnes, Kenneth Pettersen & Claudia Morsut
Tiivistelmä	SAF€RA STARS -projekti käsitteli sosioteknistä turvallisuuden arviointia kolmessa riskienhallinnan regiimissä – Norjan öljy- ja kaasuteollisuudessa sekä vaarallisten kemikaalien valvonnassa Suomessa ja Ranskassa. Sosioteknisyys merkitsee kokonaisvaltaista, tekniset ja sosiaaliset seikat huomioivaa lähestymistapaa turvallisuuteen. Tutkimuksen tavoitteena oli 1) tarkastella, mitä siirtymä sosiotekniseen lähestymistapaan merkitsee tieteellisestä näkökulmasta ja miten se vaikuttaa valvontaan, 2) vertailla riskienhallinnan regiimejä ja sosioteknisyyden toteutumista niissä, 3) selvittää valvonnan rajoituksia ja mahdollisuuksia sosioteknisyyden varmistamisessa ja 4) kehittää tutkimustuloksiin perustuvia suosituksia sosioteknisyyden huomioimiseksi valvonnassa. Kyse on uraauurtavasta regiimien vertailusta sosioteknisyyden näkökulmasta. Tutkimustulokset osoittivat regiimien vahvuudet ja heikkoudet sosioteknisyyden toteutumisen suhteen. Norja on kaikkein pisimmällä sosioteknisyydessä. Sen vahvuutena on kolmikantajärjestelmä ja laaja osanottajajoukko, joka osallistuu turvallisuuden kehittämiseen erilaisilla foorumeilla. Toisaalta poliittiset ja taloudelliset ongelmat voivat heikentää vallitsevaa luottamusta laajan toimijajoukon välillä ja rapauttaa yhteistyön ilmapiiriä. Suomen valvonnan vahvuutena on ennaltaehkäisevä kommunikaatio, ohjeiden, tiedon ja koulutuksen tarjoaminen teollisuudelle. Suomessa valvontaa heikentävät valvontakohteiden suuri lukumäärä ja vastaavasti valvontaviranomaisten vähäinen määrä. Ranskan valvonnan vahvuutena on dialogin kehittäminen kansalaisyhteiskuntaan päin ja heikkoutena valvojien nopea urakierto, joka ehkäisee syvällisen tiedon syntymistä valvontakohteista. Norjan ja Suomen regiimit ovat riski-, luottamus- ja dialogiperusteisia. Norjassa korostuu valvottavien itsevalvonta. Ranskan regiimiä luonnehtii yksityiskohtainen noudattamisen valvonta. Sosioteknisyyden kehittäminen edellyttää laajaa keskustelua valvonnan merkityksestä ja turvallisuuden monimutkaisesta luonteesta.
ISBN, ISSN, URN	ISBN 978-951-38-8528-1 (nid.) ISBN 978-951-38-8527-4 (URL: http://www.vtt.fi/julkaisut) ISSN-L 2242-1211 ISSN 2242-1211 (Painettu) ISSN 2242-122X (Verkkojulkaisu) http://urn.fi/URN:ISBN:978-951-38-8527-4
Julkaisuaika	Maaliskuu 2017
Kieli	Englanti, suomenkielinen tiivistelmä
Sivumäärä	56 s.
Projektin nimi	Sociotechnical safety assessment within three risk regulation regimes
Rahoittajat	
Avainsanat	Sosioteknisyys, turvallisuus, regiimi, noudattaminen
Julkaisija	Teknologian tutkimuskeskus VTT Oy PL 1000, 02044 VTT, puh. 020 722 111

Sociotechnical safety assessment within three risk regulation regimes

SAF€RA STARS Final report

ISBN 978-951-38-8528-1 (Soft back ed.)
ISBN 978-951-38-8527-4 (URL: http://www.vttresearch.com/impact/publications)
ISSN-L 2242-1211
ISSN 2242-1211 (Print)
ISSN 2242-122X (Online)
http://urn.fi/URN:ISBN:978-951-38-8527-4