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SAFETY CULTURE: A REQUIREMENT FOR NEW BUSINESS MODELS

Lessons learned from other High Risk Industries

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Abstract

Technical development and changes in global markets affects all high risk industries creating opportunities as well as risks related to the achievement of safety and business goals. Changes in legal and regulatory frameworks as well as in market demands requires major changes. Several high risk industries are facing a situation where they have to develop new business models. Within the transportation domain, e.g. aviation and railways there is a growing concern related to how the new business models may affect safety issues.

New business models in aviation and railways include extensive use of outsourcing and subcontractors in order to reduce costs resulting in for example negative changes in working conditions, e.g. work hours, employment conditions and high turnover rates.

Some negative effects of the new business models have already been observed within the transportation domain such as degraded safety culture and higher mental workload.

There are examples where a business model with several low-cost subcontractors can turn out to be much more expensive due to the need for managing risks on numerous interfaces. Other negative effects are social dumping by external contractors and loss of competence if procurement requirements are not taking quality and safety issues into account.

The paper will present some lessons learned within the transportation domain which can be useful for the nuclear industry in facing the major challenges ahead.

Assuring safety is a fundamental requirement for obtaining a license to operate a business in nuclear power, aviation and railways. Thus, safety culture is an essential requirement for a successful business and must be part of any new business model in high risk industries. In the future safety culture, management commitment to safety and leadership skills in creating safety culture will be essential. The paper will discuss how companies and public utilities are to achieve this and how the regulators are to assess this where learning across industries is a key success factor.

Keywords: safety culture, HTO, new business models, change management, working conditions

1. INTRODUCTION

1.1 Global competition and changes in legal and regulatory requirements demand extensive changes

Global markets and technical development affects all industries creating opportunities as well as risks related to the achievement of safety and business goals. Also, changes in legal and regulatory frameworks as well as market demands create a need for major changes in business models.

Therefore, high risk industries are facing a situation where they have to develop new business models. Within the transportation domain, e.g. in aviation and railways there is a growing concern how the new business models may affect safety issues since the new business models include extensive use of outsourcing and subcontractors.

The energy sector is also facing pressure to make rapid changes in business models but also in production facilities in the transition to renewable energy production. The nuclear industry is facing new legal and regulatory challenges. New reactor designs are available. The nuclear industry also has to on a large scale manage the life cycle state of phase out and decommissioning of nuclear facilities.

The new business models require changes in business strategies, management systems, work processes, employment models and working conditions. In order to ensure safety and safety culture in high risk industries new ways of working have to be developed both for companies and for regulators. Examples of such work practices from the aviation sector are regulatory requirements on cooperative oversight and risk based oversight. For example it has been suggested by the European Aviation Safety Agency (EASA) that the focus of aviation operators and regulators should be on management systems including new forms of employment, safety culture and the governance structure of the company, e.g. subcontracting and outsourcing.

Features of the new business models include using models from the private market based on markets that were previously heavily regulated or monopolistic. High risk industries rely on regulations and procedures in order to ensure safety and performance. Safety is an important part of the product delivered to the clients. Therefore features and effects of the new business models presents major challenges to safety management and safety culture in high risk industries.

The transportation sector has faced major changes in business models the last decade due to changes in regulations and market deregulations in Europe.

1.2 Challenges and changes in the energy sector

The energy industry faces major challenges. Major investments will be necessary to meet rising energy consumption as well as more stringent regulations. At the same time the utilities face pressure from customers, public opinion and legislators with respect to both climate and price issues. Deregulation and liberalisation has been ongoing since the electricity and gas markets were opened to competition across EU in 2007. The European market and its consumers demand lower energy prices at the same time as there is a need for funding major long term investment in new production facilities.

In addition, the decisions in Germany and Japan to shut down most of the nuclear reactors following the Fukushima Daiichi accident will reduce energy supply and production capacity. Reliable energy supply has to be maintained in a transition phase to renewable energy even though the electricity consumption is rising and many of the existing power plants have to be replaced.

Safety and reliability has always been an important prerequisite and not to mention a challenge for the nuclear sector and now economic competitiveness and financing, public perception and spent fuel and waste management including disposal are other major challenges.

Until recently nuclear energy has benefited from the initial investments being paid off and from a situation where license extensions, safety upgrades and power upgrades have been economically favourable. However, recent increased supply of cheaper energy prices and lower production costs from other sources have now had a negative effect on the energy economy creating stagnation in demand and prices on several markets. Nuclear powers high upfront capital costs and long lead times for planning, licensing and construction present challenges to financing and return on investments. Global negotiations on climate change and current policies in several countries promote renewable energy and provide subsidies for renewable production. Public acceptance has been challenged by major accidents.

The nuclear industry faces challenges in all of the above areas and strives to find new business models in a situation with rapid changes in several areas. The nuclear industry has to develop its capabilities in coping with new demands from stakeholders and the market as well as accelerating changes.

The transportation domain has already experienced and confronted some of these challenges. The paper will present some of the problems identified in the transportation domain, the lessons learned as well as highlight the learning potential for the nuclear sector using examples from the European market.

1.3 Changes in the aviation and railway sectors

The aviation sector and railway sectors have seen major changes and challenges related to deregulation of the market. In 1978 the US airline market was deregulated and subsequently requiring changes in business models. The airlines in Europe were deregulated in 1987 and the railway sector in Europe was deregulated around 2010.

In 2010 the European market on air traffic control (ATC) services was deregulated.

Thus, the European transport sector has experienced a high rate of change for the past 5-10 years affecting several high risk transportation domains.

Using the European air traffic control (ATC) as an example and in particular Scandinavia, some examples of the major changes in market demands and technical development introduced in the last decade are presented below.

In 2004 the common European airspace and open skies concept was launched in an EU directive. In 2006 a new, advanced technical platform for ATC increasing the automation level resulting in major changes in work processes, work situation and staffing for air traffic controllers was launched in some European countries such as Sweden and Denmark. Furthermore, in 2009 a common airspace for Sweden and Denmark was created. In 2010 the European market was opened to competition on ATC services and in Sweden the providers of ATC services and airport services were separated into different companies. The following year in 2011 there was competition on the national Swedish market providing for all airports to procure their ATC services from suppliers of their choice. The same year EASA introduced common targets for reducing costs on ATC services in Europe. In 2014 there was a reregulation of major, state owned airports in Sweden.

In summary, in five years the air traffic control (ATC) services in Sweden has gone from a regulated market to a completely deregulated market and back to a partly regulated market.

The example presented above illustrates the rapid changes in regulation and market conditions using ATC services as an example. Other safety critical industries are being exposed to the same changes. This will of course present major challenges to business models and safety culture in transportation and other industries where safe delivery of services is the major customer value.

1.4 New business models changes the HTO system and challenges safety culture

New and rapidly changing market demands as presented above will require changes in the business models of several high risk industries. The changes will among other things affect managerial practices and working condition.

By applying a systemic view on safety and production the effects on the Human, Organizational and Technical systems (HTO) can be identified, Fig. 1.

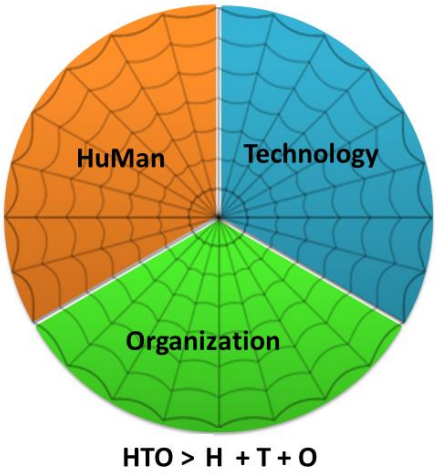

FIG. 1. Illustration of the systemic safety view and the interaction between Humans, Technologies and Organizations.

Safety culture is affected by changes in external requirements and demands. Changes in business models affect management values and strategies and also the social processes within organizations, Fig. 2.

FIG. 2. Safety culture and the relation to external demands, management commitment and social processes.

In the next sections observations of the effects of new business models on safety culture and different parts of the HTO system will be presented.

2. CHARACTERISTICS OF A GOOD SAFETY CULTURE

Research on safety culture has identified a number of characteristics of a good safety culture (e.g. IAEA 1991, 2002, Flin et al., 2000; Guldenmund, 2000; Wiegmann et al., 2004; Reason, 1997, 1998 ;Reiman & Odewald, 2009, Watson, 2013). Most of the characteristics are interrelated. Some of the important characteristics are presented below and discussed in the results section.

2.1. Safety as a fundamental value and priority

Senior management must have safety as a basic value and as a fundamental part of the business model. The importance of safety must be clear to all staff members through for example safety policies, rules and procedures.

2.2. Management commitment and leadership skills

Management must be committed to safety and make this commitment visible and transparent by providing priorities and resources for safety work and communicate the importance of safety work continuously. Leaders´ communication downwards is one of the most important management practices for workplace safety (e.g. Mearns, 2003; Mattson, 2015). This means that leaders´ communication by expressing concern for the safety of individual employee and process safety are vital in achieving workplace safety and process safety. To use storytelling to develop safety culture is an important leadership skill where the leader explains past, present and future performance in terms of coherent stories (e.g. Packer, 2016) in order to shape people´s understanding and commitment to safety.

Also management must adopt a systemic safety perspective where all members of the staff are encouraged to view safety related issues as part of a larger organizational context. This means that managers and staff members can identify their own involvement and accountability in safety issues.

2.3. Trust and just culture

Mutual trust between managers and staff must exist along with a just culture is a necessary condition for proving opportunities for learning and will also counteract complacency. A just culture requires mutual trust, a sense of fairness and justice, shared values, well developed communication and reporting systems as well as work satisfaction and motivation (e.g. Cox et al., 2006).

2.4. Learning

Learning means creating fora and systems to promote learning. This means for example reporting occurrences but also to share best practices in order to improve work processes. Also, flexibility and adaptation is necessary to cope with continuous and frequent changes in technology and in the business environment. Trust and just culture is fundamental for learning.

Examples of systems for learning are processes to identify, analyse, correct and follow up on measures taken. Systematic processes for learning means implementing processes where the organization is able to learn from both own negative and positive occurrences within their own organization as well as to learn from other companies/partners.

2.5. Accountability

This means clarification of accountabilities for safety for managers and staff where all staff has a clear view on their own accountabilities. All staff members must understand their involvement in safety work and the lines of accountability must be clear.

New business models include subcontracting and procurement where accountability and interfaces between different companies must be managed.

2.6. Communication

Structures and means for communication must exist within the organization. This means both downward communication as well as upward communication. The upward communication relates to communication from subordinates to leaders. The communication is a means of providing feedback information to superiors related to for example improvement suggestions, and work- or safety-related problems. The upward communication is important for learning.

Also, vertical communication is important for learning. Examples are exchange of work practices and occurrence report. The organization must ensure arenas and means to provide communication and information exchange in order to promote learning.

2.7. Work situation, working conditions, work processes, tools and equipment

Adequate working conditions and work environment including adequate resources and work tools are essential for ensuring safety and thus a way of communicating safety culture. This means for example assuring an adequate balance between work demands and available resources. Control of work processes and work

situation is also important. This includes for example scheduling and hours of work, staff with the right qualifications and adequate numbers. It also involves adequate tools and equipment to support the work tasks.

2.8. Safety culture and management of change

New market demands and new business models means changes. Safety culture is essential in order to uphold fundamental safety values in times of change. High risk industries are vulnerable in situations of financial difficulties when management focus often shifts from safety and quality to cost reductions. There are numerous examples where members of an organization perceive a shift in basic values from safety and quality to cost reductions. Research results show that companies with financial problems will have a lower safety performance (e.g. Bier et al. 2001).

It has been observed that safety critical organizations are more resistant to change than other businesses (e.g. Lofquist, 2011).

Also, that rapid changes in operational and organizational priorities often lead to reduced safety margins (e.g. Paries, 1995 and Amalberti, 2001).

Organizational changes are stressful for the members of the organization resulting in work related stress, lack for rest and recuperation and sleep and health problems (Greubel and Kecklund, 2011). Anticipated changes had the same effect as actual changes.

Therefore the ability of an organization to deal with changes and hold onto basic values and assumptions regarding safety culture will be vital for long term business survival.

3. METHOD

The effects of new business models in high risk industries will be presented related to some aspects of the safety culture areas as presented in the previous section.

The results presented in the paper have been derived from case studies performed in the railway and aviation domains and are also based on MTO Safety´s extensive experience working in high risk industries. Due to confidentiality issues the observations presented are anonymous.

4. RESULTS

4.1. Safety as a fundamental value and priority

Studies from the aviation domain show that safety can remains a stable, basic value at the operational level of a high risk industry in times of change.

However, the same study showed that basic values on senior management level seemed to have shifted towards cost reductions and economy. This effect seems to be

more salient when senior management is less knowledgeable about the operational level.

As for the railway domain, observations indicate that for the operational staff, extensive pressure on cost effectiveness and production, may challenge safety as a core value and basic assumption. Operational decisions drift towards giving higher priority to keep the production ongoing rather than to adhere to safety rules.

There are several examples from aviation and railways, of members of the organization perceiving that core values are shifting from safety to economy and cost reductions. It is perceived that senior management communication and behaviour emphasizes cost effectiveness rather that safety and quality.

The management task in times of change is to improve effectiveness and revenue in a short time span. In many cases the downward communication from senior management emphasizes cost reductions rather than safety and quality. Members of the organization may become confused regarding what the core values are related to safety.

This confusion seems to more salient in organizations coming from a long period of stable external demands and entering a period of changes aiming at mainly cost reductions without systematically including improvement of safety and development of work processes.

The nuclear sector has now entered a situation with major rapid changes and focus on cost reductions and can therefore expect that safety as a fundamental value can be challenged. A major task for senior management is to communicate and uphold safety culture in times of change. The quote below illustrates this challenge.

”achieving safety under deregulation is a particularly demanding task that requires intensive management skills and dedication … safety can be managed even under deregulation. But it takes total commitment, special know-how, a highly disciplined work force and exemplary skill by management.” (Neuschel, 1988, page 109).

The consequences of not managing safety culture as a core value and priority in times of change is that the safety margins are reduced and decisions are taken at all levels of the company based on costs reductions as the first priority and safety and quality is given lower priority.

4.2. Management commitment and leadership skills

Introduction of new business models are driven by changes in external demands and in most cases demands on cost reductions and efficiency. Results from a questionnaire study has shown that staff members most often perceive that high level management give higher priority to economy and to cost reductions than to safety. The same study showed that high level management perceive that they give equal priority to communicating safety and economy.

The results illustrate that senior level management in times of change does not show enough commitment to safety to support the basic safety values. This may affect the decision making process on all organizational levels. There are several examples of decisions being taken leading to major accidents or events where the decision to reduce minor costs will lead to major losses. Examples from the nuclear domain are decision on reducing test programs when installing new equipment in nuclear power

plants in order to cut costs. Another example is the decision to reduce testing on the cement job on the blow out preventer leading to the Deepwater Horizon accident (e.g. Hopkins, 2011).

Various studies (e. g. Arvidsson et al., 2006) have also shown that high level management perceive safety culture as better than staff members on lower levels of the organization. These results show that the perception of management and staff on safety culture differs.

It is therefore important that management understands that the cost reduction messages sent out in times of change are very powerful in challenging the safety as a basic organizational value. Therefore management must develop their skills in continuously communicating the safety message in times of change and to repeatedly monitor how staff members perceive the safety message. Safety as a core business value must therefore be made more salient in senior management communication.

Examples of improved ways of communication are making management visible to the staff and increase communication and follow up. Storytelling where past, present and future is explained is a powerful tool (e.g. Packer, 2016).

Safety culture will be challenged when the organization is exposed to a major negative event. When a company faces a crisis such as being involved in a major accident senior management has to take systematic and active measures to uphold safety culture and restore self-confidence in the organization. If a major accident happens senior management must provide a common story to explain the causes of the accident, measures taken and restore self-confidence in the staff members. An important task for managers is to explain this event to the staff, in order to debrief, cope, communicate and restore the organizational balance and self-confidence. It has been observed, both in the aviation and maritime domain that as companies lose self-confidence after a major event, safety as a basic value will be challenged.

4.3. Trust and just culture

Among airlines it has been observed that lack of trust and just culture prevents pilots from reporting safety occurrences. It is suggested that this is related to the management style being too focused on cost reduction, not considering its consequences (Jorgens et al, 2015).

Business models and management styles that involve blame culture may result in crew members not reporting occurrences or being afraid to report safety issues that have been observed.

Also, changes in behaviour where pilots not acting on pilot authority in situations where such action is called for has been observed. Some airlines´ management styles include blame culture, for example by non-renewal of contracts when staff legitimately applying safety procedures and according authority. Such management styles are in total contradiction with safety culture as well as provisions and regulation on Crew Resource Management (CRM) and Safety Management Systems (SMS).

The European Aviation Safety Authority (EASA) calls for effective means of ruling out the possibility of a management style overruling provisions and regulations on CRM and SMS. It has been suggested that this can be achieved by regulations addressing management styles and safety culture.

4.4. Learning

In situations with cost reductions the learning abilities of the organization may be impaired. Observations from organizations introducing new business models have shown that cost reductions in many cases will remove opportunities for informal learning and exchange of information by reducing opportunities and arenas where staff members can meet and discuss in order to improve their work process. For example meetings where knowledge and interpretation of new rules can be discussed and meetings where staff members in different locations can learn from each other are reduced.

Also, new business models and cost reduction puts more focus on reactive learning, where only occurrence reports are used for learning. Also, systemic views on safety and performance are not applied. There is no process for ensuring learning from best work practices. If learning is mostly based on reactive practices it will impair the organizations ability to develop resilience capabilities (e g Hollnagel et al, 2011, Lindvall et al., 2015).

Impaired learning processes can also be related to complacency where a good safety level is taken for granted and the need for safety improvements is not identified.

Also, extensive subcontracting and procurement will result in information and learning not being shared and forwarded to the client. Extensive use of subcontracting will also lead to loss of competence in the client organization.

A phenomena that impairs the learning process has been observed. It can be defined as an explanatory culture meaning that the organization wants to give up their own sense of accountability by trying to whitewash their own involvement and accountability related to negative events and criticism. Such a disinclination to acknowledge and analyse important events will severely impair the organizations ability to learn. Other characteristics are to seek out explanations and confirmation on why change is not necessary.

It has also been observed that subcontractors are reluctant to report occurrences for different reasons. One reason may be in fear of losing a contract and another that a new business opportunity has been identified. Management has to be vigilant on these issues and for example have a systematic process for monitor and collect report from subcontractors. Thus, enhancing the competence level and learning within client organizations.

4.5. Accountability and the effects of outsourcing and subcontracting

New business models in railways and aviation include extensive use of outsourcing and subcontractors in order to reduce costs by procuring products and services. In order to be competitive many suppliers try to reduce costs by changing work hours, employment condition etc thus leading to impaired work conditions. This will affect human performance, e.g. work hours leading to inadequate rest and recuperation will impair performance.

Accountability will be discussed related to the client and the subcontractors. It has been observed in both railways and aviation that the number of subcontractors can be very large, in some cases more than ten levels of subcontractors. In the railway domain the infrastructure manager is required by European directives and national legislation to assure that all subcontractors are working according to the requirements in the infrastructure managers Safety Management System (SMS). Many mangers state that control in cases with more than ten levels of subcontracts is not achievable.

In procurements many clients rely on formal contract terms. However, it is difficult to manage such a contract in times of change where contracts and terms can get outdated quickly. Therefore the client and the supplier must continuously monitor and manage the contracts in order to change and redistribute accountability and activities.

If there are many levels of subcontractors this is a major task and almost impossible to monitor. In for example the aviation domain it has been observed that when the number of interfaces to be managed becomes so many that it will get very expensive to subcontract. Also, when the number of hand over points increases the number of errors related to communication and hand over will also increase. Also, not sharing learning and occurrence reports in several layers of subcontractors will impair learning.

In the aviation domain tightly coupled, interacting computer networks supplying services to airports as well as to air traffic control, can be managed and maintained by several different companies creating numerous interfaces. There are examples where a business model with several low-cost subcontractors can turn out to be much more expensive due to the need for managing risks on numerous interfaces. Other negative effects are social dumping by external contractors and loss of competence if procurement requirements are not taking quality and safety issues into account.

The privatization of the UK rail network is very complex and involves many companies. Many sources believe that the privatization of the rail infrastructure management led to the deterioration of the tracks and was potentially the cause of a several fatal crashes.

In summary, high risk industries are complex systems. New business model increases complexity by adding more subcontractors. Rapid rate of change will reduce control in such systems.

4.6. Communication

Communication has been discussed previously, in relation to management commitment, learning etc.

4.7. Working conditions, work processes and equipment

New business models in the airline industry introduces new hazards related to different employment models, increased mobility of pilots, safety-critical services provided by non-certified service providers and long term leasing. Longer work hours, increased insecurity in employment and reduced social security due to flagging out of airlines to low cost countries ("rule shopping") has been the effect.

In many cases the subcontracting trend among airlines makes the pilots employment status versus the airlines so weak, that pilots often refrain from acting upon their authority with regard to flight safety regulations and issues (e.g. illness, fatigue and fuel) (Jorgens et al, 2015).

Examples from both the aviation and railway domain show cost cutting, shortage of staff and lack of replacements in case of absences lead to staff in safety critical positions perceive pressure to go to work even when they are sick.

Examples from the Swedish railways shows that after deregulation and privatization there are major differences between companies with regard to working conditions, retirement age and work organization.

The new business models means higher workload and clear cut backs related to the employees working conditions. Thus, there is an increased risk that higher work demands and cut backs on resources will lead to an unbalance between demands and resources the resulting in impaired work performance, stress and health problems among employees in safety critical positions. The slack in the demand-resource balance is reduced thus making the organization less resilient.

4.8. Safety culture and the management of change

New business models means rapid changes in goals and mission often related to increased competitiveness and cost reductions. In high risk industries where management focus is on economy story and not paying enough attention to the messages related to safety and quality. In our experience, major changes related to deregulation and cost reductions are often done too fast without adequate planning and preparation resulting in lack of control of the consequences as well as inadequate control of the interfaces have to be managed. There are many examples where control of safety and quality are having a negative effect on safety as well as on business performance.

Therefore, programs and skills for managing changes are particularly important in high risk industries.

A change process is stressful for the organizations and its members and in turn concerns of the members of the organization must be manage in order to uphold safety and performance in times of change or crisis.

Operational staff in high risk industries are more resistant since their safety work is based on procedure and technologies where deviations may result in accidents. These organizations are therefore more resistant to changes (Arvidsson, Johansson, Ek & Akselsson, 2006). Introducing changes in these organizations to cope with rapid

changes in external demands is therefore more difficult. Communication, participation and trying to achieve consensus is therefore important for a successful change in this organizational culture.

Therefore change management in safety critical industries has to be directed towards developing and refining work processes focusing on safety, quality and efficiency. Change management must be done by use of a systematic process.

5. CONCLUSIONS

The paper has presented challenges to safety culture when introducing new business models in high risk industries such as transportation. These businesses have gone through major changes related to cope with market requirements, regulatory demands and new legislation.

The changes have challenged safety culture and affected the interaction between the Human, Technical and Organizational systems. It is likely that the changes in general have or will have a negative effect on the organizations safety performance.

The nuclear industry is presently facing many challenges and there are important lessons to be learned from transportation and other areas of industry.

In conclusion, focus on safety culture and HTO interactions are essential in order to ensure nuclear safety and cope with the challenges ahead. A strong, solid and sustainable safety culture will be a necessary investment in order to manage changes in a complex system. The nuclear industry must have a clear strategy for development of safety culture in a period of change. This means that the international community as well as the national regulators must set and enforce a clear performance standard related on managing safety culture in times of change.

In addition, safety must be explicitly included in the core business values.

The rate of change in high risk industries has to be controlled and managed. Rapid changes in high risk industries will lead to increased complexity and possible loss of control.

Stakeholder requirements and external demands will be important to ensure nuclear safety in the future. Management and leadership knowledge and skills on safety culture will be essential to manage nuclear safety in a life cycle perspective.

REFERENCES

[1] AMALBERTI, R., The paradoxes of almost totally safe transportation systems. Safety Science, 37, 109-126 (2001).

[2] ARVIDSSON, M., JOHANSSON, C.R., EK, Å., & AKSELSSON, R., Organizational climate in air traffic control: Innovative preparedness for implementation of new technology and organizational development in a rule governed organization, Applied Ergonomics, 37, 119-129 (2006).

[3] BEIR, V., M., JOOSTEN, J. K. & GLYER, J. D., Effects of Deregulation on Safety: Implication Drawn From the Aviation, Rail, and United Kingdom Nuclear Power Industries, NUREG/CR-6735 (2001).

[4] COX, S., JONES, B. & COLLINSON, D., Trust Relations in High-Reliability Organizations. Risk Analysis, 26:5, s 1123-1138 (2006).

[5] FLIN, R., MEARNS, K., O'CONNOR, P. & BRYDEN, R., Measuring safety climate: identifying the common features, Safety Science 34, 177-192 (2000).

[6] GREUBEL, J. & KECKLUND, G., The Impact of Organizational Changes on Work Stress, Sleep, Recovery and Health. Industrial Health, 49 (2011).

[7] GULDENMUND F.W., The nature of safety culture: a review of theory and research. Safety Science 34, 215-257 (2000).

[8] HOLLNAGEL, E., PARIÉS, J., WOODS, D. D., & WREATHALL, J. (Eds.)., Resilience engineering in practice. Farnham, United Kingdom: Ashgate Publishing (2011).

[9] HOPKINS, A., Risk-management and rule-compliance: Decision-making in hazardous industries. 49 Safety Science 110-120 (2011).

[10] IAEA, Safety culture. Safety series No. 75-INSAG-4. International Atomic Energy Agency, Vienna (1991).

[11] IAEA, Safety culture in nuclear installations: Guidance for use in the enhancement of safety culture. IAEA TECDOC-1529. International Atomic Energy Agency, Vienna (2002).

[12] JORENS, Y. GILLIS, L., VALCKE & DE CONINCK. Atypical forms of employment in the aviation sector. European social dialogue, European commission (2015).

[13] LINDVALL, J. , KECKLUND, L., ARVIDSSON, M. "Measuring and visualizing resilience: A railway example", (11th International Symposium on Human Factors in Organisational Design and Management (ODAM), Copenhagen, Denmark (2014).

[14] LOFQUIST, E.A., Doomed to fail: A case study of change implementation collapse in the Norwegian civil aviation industry. Journal of Change management, 11:2, pp 223-243 (2011).

[15] MATTSON, M., Promoting safety in organizations. Doctoral thesis. Stockholm: Stockholm University (2016).

[16] MEARNS, K., FLIN, R., FLEMING, M. & GORDON, R., Human and organizational factors in offshore safety (REPORT OTH 543). Suffolk: HSE Books, Offshore Safety Division (2003).

[17] NEUSCHEL, R., P.,The Servant Leader: Unleashing the Power of Your People. London, Northwestern University Press (1988).
[18] PACKER, C., Storytelling and safety culture. Cherrystone management Inc. Deep River, Ontario, Canada (2016).
[19] REASON, J., Managing the risks of organizational accidents. Aldershot, Brookfield (1997).
[20] REASON, J., Achieving a safe culture: theory and practice. Work and Stress, 12, 293–306 (1998).
[21] REIMAN, T & OEDEWALD, P., Evaluating safety-critical organizations - emphasis on the nuclear industry. Strålsäkerhetsmyndigheten 2009:12 (2009).
[22] WATSON, J., Nine values for safety culture. Professional Safety, 58, 11, p. 37 (2013).
[23] WEICK, K., E., The vulnerable system: an analysis of the Tenerife air disaster. Journal of Management, 16, 571–593 (1990).
[24] WIEGMANN, D. A., ZHANG, H., VON THADEN, T. L., SHARMA, G, & GIBBONS, A. M., Safety Culture: An Integrative Review. The international journal of aviation psychology, 14, 117–134 (2004).

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