

## **TOSCA - Total Operations Management for Safety Critical Activities: Industry needs for innovative methods**

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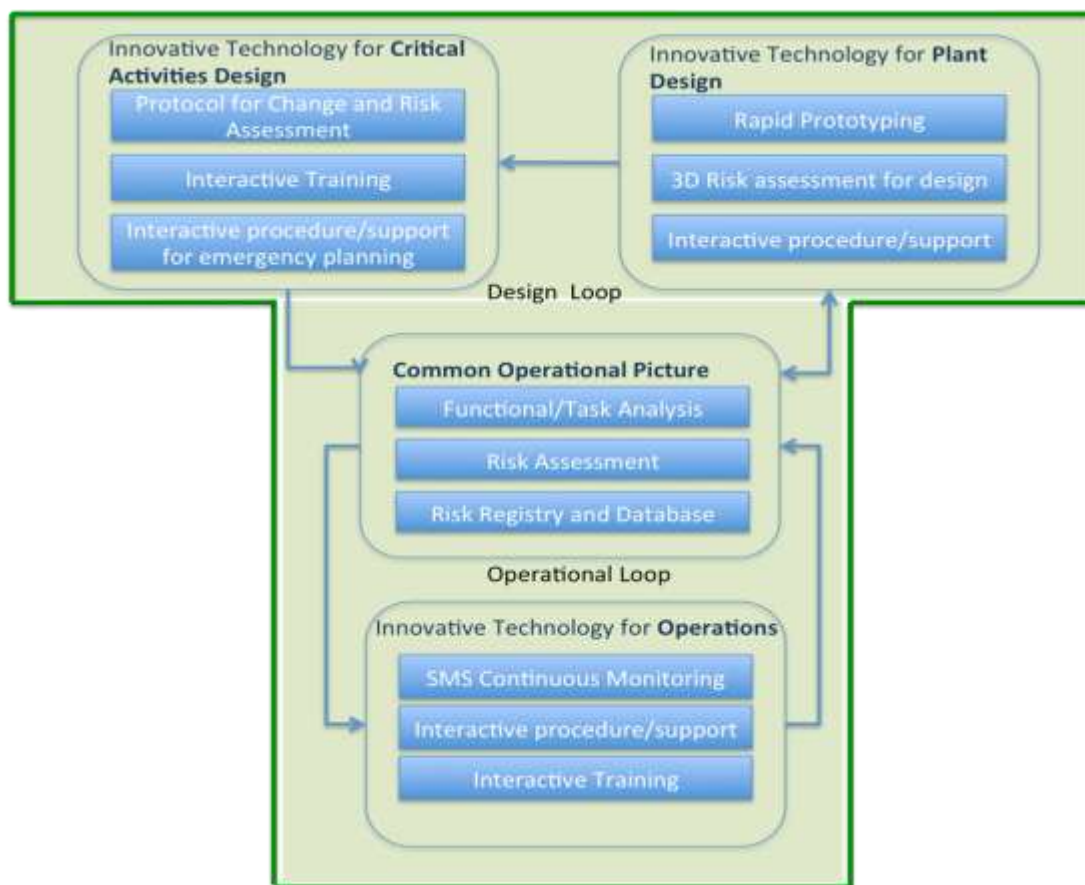
The Total Operations Management for Safety Critical Activities (TOSCA) project is a European Project aimed at an innovative approach able to integrate and enhance safety, quality and productivity. The scope of TOSCA is to work out a well-established and economically suitable framework in which the most innovative tools and techniques (advanced 3D software, virtual reality, innovative theoretical models, updated information exchange protocols etc.) are operated together in order to get advantage of the possible synergies in processing standards requirements, fulfill regulations, improve safety and enhance productivity.

The work that has been performed and is presented in this paper aims at defining the needs of the industry regarding the development of an integrated methodology for assessing safety, quality and operations management. As the most appropriate method the execution of surveys and interviews has been chosen in order to assess the present situation of the industrial installations handling toxic and flammable substances. The major parts of both the interview guide and the surveys were the following: a) safety management system; b) risk assessment process and c) proposals to improve risk assessment. Questions related to the safety management system concern organisation, resources, documentation and communication, design, management of changes, monitoring, safety performance indicators and commitment of personnel. The risk assessment process covers questions on methods used such as hazard identification, accident sequence determination, consequence assessment, human factor analysis and risk quantification. Finally proposals to improve risk assessment include questions concerning the use of virtual reality methods for training and visualisation of critical activities.

Keywords: Integrated risk assessment, survey and questionnaire for safety

### **Introduction**

The Total Operations Management for Safety Critical Activities (TOSCA) project is a European Project within the context of the 7th Framework Program aimed at an innovative approach able to integrate and enhance safety, quality and productivity. The scope of TOSCA is to work out a well-established and economically suitable framework in which the most innovative tools and techniques (advanced 3D software, virtual reality, innovative theoretical models, updated information exchange protocols, etc.) are operated together in order to get advantage on the possible synergies in processing standards requirements, fulfil regulations, improve safety and enhance productivity. The different modules comprising the TOSCA Total Safety Management (TSM) framework illustrated in Figure 1 are the following:



**Figure 1:** TOSCA Total Safety Management Framework

### Common Operational Picture

The Common Operational Picture is the information and knowledge about the operational system used to support risk assessment and safety management. It may be represented in different ways but should be accessible to all stakeholders involved in a project in order to analyse and communicate risk, and to support training and procedure design. At present the work has been concentrating on understanding the current state of the art in tools and methods used to represent the system being analysed, the tools used for risk assessment, and the form the risk registry whenever present may take. This is done so as to highlight what aspects of the above safety critical issues organisations may need to improve.

### TSM for Design

This section is seeking to understand how risk is assessed at the design stage, specifically through formal risk assessment techniques, dynamic risk modelling techniques, and rapid prototyping. Dynamic risk modelling involves the development of a model of risk to calculate risk levels, compute performance indicators, and perform sensitivity analysis of risk mitigation measures. Rapid prototyping involves the creation of a representation (physical or virtual) of a system or component for evaluation purposes. The scope is to understand how organisations may need to improve risk assessment at the design stage.

### TSM for Critical Activities

The critical tasks considered are the phase of a project when major changes may be introduced to an organisation, and this section seeks to understand how such changes are managed in order to reduce risk. Some organisations may have a formal protocol to follow for managing change, while others may simply use existing channels of communication and/or training. In the questionnaires an attempt was made to understand how organisations manage safety in defining and designing critical tasks and what their future needs are for improvement in this area.

### TSM for Operations

This section focuses on monitoring and management of risk during the operational phase. What is needed is a clearer understanding of how risks are currently monitored, for example through incident reporting or safety performance indicators (SPIs), how training is used to manage risk in the operational phase, and how changes are communicated outside of major projects/commissioning.

The main objective of TOSCA project is to deliver a “ready to apply” integrated methodology that comprises a modelling approach, an integrated set of methods and supporting IT tools for total performance management in all phases of design, operation, maintenance activities that are carried out by plant personnel or subcontractors. In order to achieve this objective, a thorough survey of end-user needs has been attempted so as to frame the pursued goal of the project. The work that has been performed and is

presented here aims at defining the needs of the industry regarding the development of an integrated methodology for assessing safety, quality and operations management. In the first place, the partners examined the possibilities to gather the pieces of information needed. As the most appropriate method the execution of surveys and interviews has been chosen in order to assess the present situation of the industrial installations handling toxic and flammable substances. This has covered all the range from methods, standards and best practices used for safety, to quality and operations management. After this short introduction the paper continues with section 2 that presents the evaluation of SMEs needs as collected from literature while section 3 presents the methodology for gathering the end-users needs which are presented analytically in section 4. Finally section 5 concludes the paper.

## Evaluation Needs of SMEs Collected from Literature

The majority of studies in the literature have found that SMEs potentially face higher level of risk compared to large enterprises. Apart from inevitable mistakes/errors, another safety concern in SMEs is safety organization and comprehensibility of their safety management systems. Several factors have been spotted that explain the poorer safety performance of SMEs compared to larger enterprises. Key factors affecting safety issues in SMEs are: lack of resources, burden of compliance with regulations and codes, poor relationships with regulatory agencies, absence of workers' representation, fewer opportunities for on-the-job training and difficulties in implementing Safety, Health and Environment (SHE) practices. In general, the main characteristics of SHE management in SMEs include: the use of oral communications, limited knowledge of SHE codes of practice and regulations, a tendency to place SHE responsibility with workers, poor knowledge of long-term health effects, hazard controls decided by daily practices rather than comprehensive risk assessment. SME managers tend to work long hours and devote much time to most pressing issues; hence, there is less time and energy for 'non-core' tasks, which often happen to be SHE related, (Mayhew, 1997). An extract from literature regarding SHE management needs of SMEs is summarized in Table 1. Additionally, SMEs do not apply systematic SHE regimes and risk assessment methods in their organizational systems. There are many reasons for this approach such as lack of understanding and competence, lack of financial resources, lack of support from the local authorities and apparently cumbersome risk methodologies.

**Table 1:** SHE management characteristics that affect safety in SMEs (Arocena, P. and Nuñez, I. 2010)

SHE management characteristics	Findings in manufacturing SMEs (Spain)
Planning of preventive actions	One third of firms put in practice specific risk prevention measures
Monitoring of prevention programs	Emphasis on reactive measures (e.g. injury reduction)
Coordination of prevention and business activities	Reliance on the safety specialists rather than the larger workforce
Safety documentation and estimates of annual injuries	A quarter of companies did not even calculate an incidence index
Emergency preparedness	Emergency procedures existed in many sites but not reviewed
Safety training	Insufficient effort in training
Safety information for workers	Half of the companies did not provide information following plant changes
Participation by workers	Very poor participation by workers
Prevention of ergonomic and psychosocial risks	More attention to risks from lack of ergonomic than psychosocial risks
Size of teamwork in risk analysis	Risks from new equipment analyzed by prevention unit only.
Inter-firm cooperation	Largely ignored

The following factors can motivate SMEs to put capital investment into the health and safety:

- Interpreting SHE issues as an integral part of doing 'good business';
- Maintaining reputation;
- Achieving higher productivity;
- Keeping within the law, hence avoiding disciplinary actions from government;
- Avoiding cost of accidents;
- Containing insurance costs;
- Meeting client demands;
- Being a 'good' employer.

However, risk assessment methodologies should be practical and user-friendly to SMEs so that safety assessors can learn them easily and apply them during safety critical activities. Formal risk assessment methods are useful but there is a need to enhance their

resilience in order to support front line operators in improving their knowledge of risks and in providing feedback to hierarchy of an organization. On top of that, specific indicators should be provided for monitoring how successful the safety interventions are for the management of change. The tools should demonstrate that there is some intrinsic benefit to the business of the SMEs. This is important because developing SHE interventions for heterogeneous types of SMEs is difficult since they are hard to reach and not easily motivated if the intervention has few evident benefits. In NOHSAC report, Legg et al. (2009) recommended that, for SHE programs to be successful, managers and consultants in SMEs should:

- Focus on a particular industrial sector or risk;
- Combine health and safety with other management goals;
- Combine active interventions with practical documentation and tools;
- Measure adequacy of SHE program by evaluations of their effects afterwards;
- Ensure active involvement of different actors (employers, employer associations, workers, trade unions) in SHE program planning and implementation.

For this reason IT tools of risk assessment are needed together with the virtual reality simulations of the working environment. Many European SMEs are using complex technologies and operate in a competitive environment which increases 'variability' in the way that operations are carried out daily.

## Methodology of data collection

In order to collect end-users needs two streams of work have been followed: a) on the one hand the development of an interview guide and the execution of a significant number of interviews at the end-users' premises by the partners of the consortium and b) on the other hand the development of an on-line survey tool (questionnaire) to be remotely completed by interested end-users together with the elaboration of the data collected (a still on-going procedure) along with the organisation of three workshops, one with representatives of the industrial communities and two with the project partners. The present situation regarding the use of methods of safety, performance and operations management has been assessed within the major hazards industry. 23 interviews and 18 on-line surveys have been performed in industrial companies with special emphasis on SMEs. Industrial needs regarding the use of recently developed methods, available within the scientific community, have been assessed. To this end, the industry and the scientific community have been brought together in workshops and industrial visits, where original data have been collected and are presented in this paper.

### Interview guide presentation

The interview guide has been jointly prepared specifically for the project. A short description of each questionnaire section is given below.

#### *Section One: General Questions*

These questions were designed to give some insight in to the organisation and its approach to safety assessment and safety management. Understanding the framework organisations use to approach risk assessment and safety management allows us to better understand user needs for the project.

#### *Section 2: Common Operational Picture*

The Common Operational Picture is the information and knowledge of the operational system that is used to support risk assessment and safety management. It may be represented in different ways but should, ideally, be accessible to all stakeholders involved in a project in order to analyse and communicate risk, and to support training and procedure design. The questions in this section were designed to help understand the current tools and methods used to represent the system being analysed, the tools used for risk assessment, and the form the risk registry takes. We also wanted to capture information about what aspects organisations would like to improve.

#### *Section 3: TSM for Design*

This section is seeking to understand how risk is assessed at the design stage, specifically through formal risk assessment techniques, dynamic risk modelling techniques, and rapid prototyping. It was also required how organisations would like to improve risk assessment at the design stage.

#### *Section 4: TSM for Planning and Commissioning*

The planning and commissioning phase of a project is when major changes may be introduced to an organisation, and this section seeks to understand how such changes are managed in order to reduce risk. Some organisations may have a formal protocol to follow for managing change, while others may simply use existing channels of communication and/or training. These questions were designed to understand how organisations manage safety during planning and commissioning phases and what their future needs are.

#### *Section 5: TSM for Operations*

This section focuses on monitoring and management of risk during the operational phase. The questions were designed to understand how risks are monitored, for example through incident reporting or safety performance indicators (SPIs), how training is used to

manage risk in the operational phase, and how changes are communicated outside of major projects/commissioning. Future needs of organisations in these areas were also required.

### On-line questionnaire

The on-line questionnaire for the user-needs survey aimed mainly at the enlargement of the end-users' community to be analysed so as to depict better the needs of the European SMEs. It has been created in two versions, a Greek one and an English one and it has been available on line (<http://tosca.ipta.demokritos.gr/>)

## Results and discussion

### End user needs collected throughout the interview process

Figure 1 shows the types of companies involved in this study. In total, 23 interviews were conducted. The majority were working in the process industry, following by manufacturing companies. A small number of companies in the energy sector were interviewed, and the views of two regulators were collected.

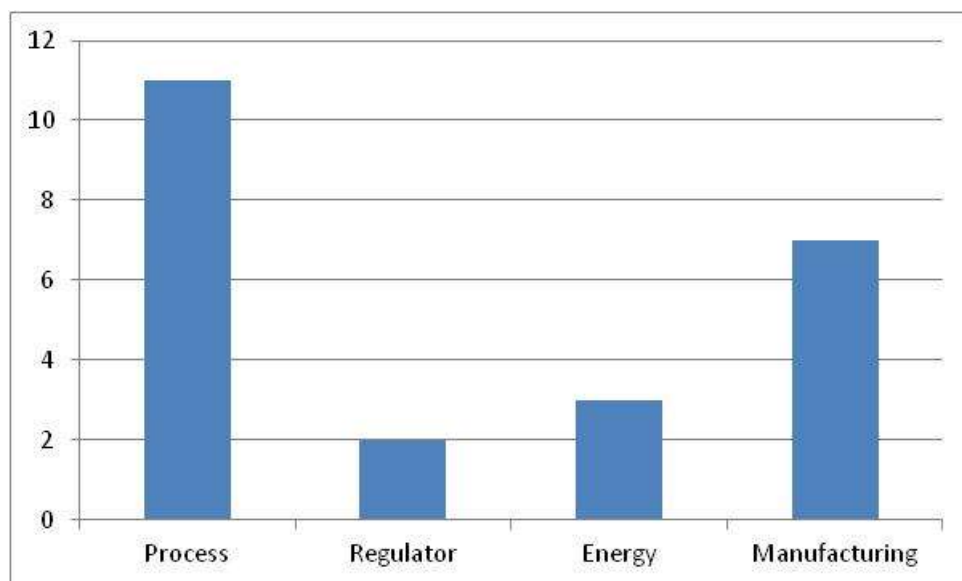


Figure 2: Industries responded via interviews

Overall, nine of the 23 companies interviewed were Small or Medium Enterprises (SME). Four were SMEs at a local level, i.e. the plant from which the interviewee came operated as an SME but was owned by a larger parent company. As mentioned above, two regulators were also interviewed, and the remaining eight were larger companies.

### Common Operational Picture and Risk Assessment Process

The first area in which a need emerged is to take into account human factors. Eight participants indicated that their risk assessment would benefit from greater inclusion of the tasks and activities of their operations and maintenance staff. A view emerged that too often risk assessments focus only on the processes and technology, and not on human and organisational factors. Involving those same end users in the risk assessment process was suggested as one way of achieving this. Increased availability of detailed, specific data to support risk assessments was raised by seven interviewees as a need. This included detailed information on the plant operations, processes, and environment as well as technical information on hazards sources, consequences and failure rates. Seven interviewees raised a need for better technology to support risk assessments. Ideas included using VR to illustrate major hazards before embarking on a complex activity, electronic updates for risk registries and Standard Operating Procedures, 3D models of sites and electronic collection of daily operational information to support the management of process safety. Electronic systems supporting risk assessment were seen as adding benefits in terms of better monitoring and control of safety management. Other ideas raised by one or more interviewees included the need to provide SMEs with a more comprehensive portfolio of risk assessment tools and methods, and for a central repository of the applicable regulations and standards to make it easier for SMEs to access. A feedback loop to management to act on safety information from operations was also seen as important. Finally, some comments were made about the need for risk assessment to be simple, but meaningful and beneficial, focusing on real risks.

### Risk Assessment in Design

Eight interviewees described a need for undertaking risk assessments earlier in the design phase to allow safety improvements to be made to the design. This was seen as reducing the reliance on training and organisational control measures, giving a direct benefit in reduced training costs. However, the participants noted that methods used in the design phase must be less time consuming than currently available methods. There was also a desire to include operational and human factors in the analysis at the design phase to facilitate a better risk based design review. It was noted that this information is often not available at the design stage. Other needs

relating to the design phase included better sharing of lessons learned from previous projects, access to reference experts, and intelligent software for performing HAZOPs and HAZIDs.

### *Change Management*

Communication emerged as a need within the area of change. In particular, communication of risk assessments to staff and the reasons for the changes was highlighted. One company was interested in developing eLearning for this purpose. Training was a second area of interest to the companies surveyed. A benefit was seen for an environment in which personnel could try out new equipment or safety procedures. Simulation and 3D tools were suggested by the interviewees as technologies of interest in this area. In general, there was a need for a better change management process in many companies. Temporary changes which are not fully controlled and may become permanent were a particular area of concern. Interviewees highlighted that a management of change process should be simple and should provide support for contractors. The interviewees were also keen to involve operations staff in the change process in order to benefit from their knowledge and expertise.

### *Monitoring*

The primary need for monitoring of safety management was for more and improved data. In particular, the need for more leading indicators was highlighted and one company is interested in balancing quantitative and qualitative data, including operator reporting data. The data collected should be linked to the risk assessment performed. Companies also suggested that they need to improve their ability to analyse and act on the safety data they collect, including better classification of the data and ICT support.

### *Enhancing Training*

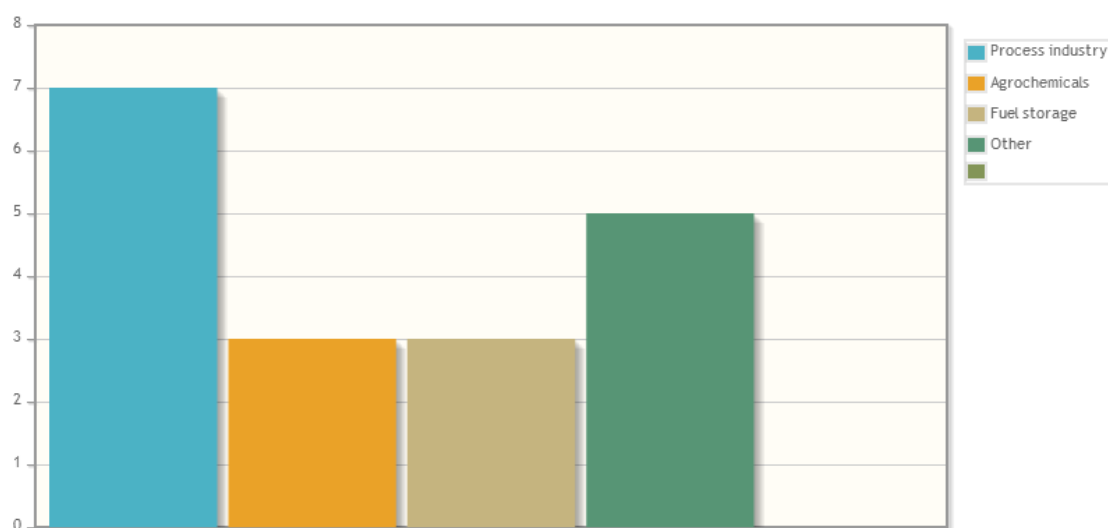
The needs expressed regarding training fall broadly in to two categories: the topics or areas to be covered by training and the format for delivering training. Areas that interviewees identified as requiring improved training included training on the importance of safety critical assets, procedures for safety critical tasks, good practices, safety and risk awareness, alarm management and emergency response. One company was concerned about how to facilitate the transfer of knowledge from retiring experienced staff to new engineers. Another particular concern for interviewees was facilitating training for contractor staff. The types of training in which interviewees were interested included eLearning, cascaded training from management to supervisors to operators, animations, and simulation/ virtual reality. One benefit of eLearning which was highlighted was the ability to track and control communications and training. It is also flexible, allowing it to be deployed across different sites.

### *Communications*

Similarly to training needs, the interviews revealed a desire to use more ICT in communications to staff. With respect to safety management, interviewees saw a need to make staff more aware of the risks entailed in their operations and to implement learning from experience. Visual approaches to communications, as opposed to written communications, were suggested as an approach by one interviewee.

## **End user needs collected from the on-line survey**

Figure 1 presents the type of companies involved in this part of the study. In total, 18 companies completed the on line questionnaire, seven process industries, three agrochemicals, three fuel storage and five other companies. Overall ten companies (out of the 18) were SMEs and seven of them had less than 250 employees.



**Figure 3:** Industries responded via on-line questionnaire

The results collected from the online survey are highly compatible with the ones collected from the face to face interviews. More specifically, the following end user needs were collected from the on-line survey.

### *Common operation picture*

An important constrain expressed by end-users is the inability to handle accident scenarios that cause difficulties in sharing common understanding in emergency situations. Oral or written description of an emergency situation is not always sufficient. Visualization of accident scenarios can offer significant help in apprehending what is regarded as an emergency. In close relation to the above-mentioned problem are the “communication” difficulties among employees. These difficulties are referred to as discrepancies between people with different conception of the same object. For example, safety managers and field workers may have different perception of what an emergency situation is, owing to their different experience and knowledge. This can be facilitated by a VR paradigm. Concerning Auditing activities VR can be used for proving the safety level of the plant in the presence of inspectors. The same can be valid for insurance companies surveying the plant or quality control inspectors. The same (VR) tools could be used in the facilitation of an information campaign addressing neighbouring communities and have the common “risk-aversion” way of thinking, in occasions where this attitude may be extreme.

### *Main SMS challenges for a SME*

Safety Management itself aims at enhancing safety level and identifying best practices for the various processes and procedures in the company. Some significant challenges are the following:

- To prevent accident occurrence
- To mitigate consequences in case of an accident occur
- To set barriers for ensuring the plant normal operation
- To set barriers for limiting accident propagation
- To identify weaknesses of the emergency plans
- To identify problematic procedures in normal operation which have a potential to lead to an accident
- To better do work planning – to allocate critical tasks to adequately qualified operators and resources according to the actual needs.
- To identify training needs and modify accordingly the training activities
- To evaluate personnel response in case of emergency
- To evaluate/increase personnel safety awareness
- To evaluate/increase personnel skills and level of knowledge regarding activities ensuring normal operation of the plant.
- For better understanding of critical situations and rare activities

### *Added value of the TOSCA proposed toolkit*

The added value of the TOSCA proposed toolkit was thought significant by the respondents in emergency situations or accidents, where VR tools could offer a valuable contribution for simulation of these situations through an interacting interface, enabling thus the evaluation and/or the improvement of the personnel skills and at the same time of the emergency plans. When infrequent activities (like, start up or shut down procedures) or rare ones (substitution of equipment or specific maintenance) are in concern, VR tools could be used for training operators or evaluating procedures & operators skills and knowledge in an effective, low-cost and safe tool whereas these activities cannot be tested in the real plant or encompass a high level of risk for the site. It seemed that VR tools had some acceptance among end-users regarding Safety management and Audit activities too.

## **Conclusions**

The work that has been performed has aimed at defining the needs of the industry regarding the development of an integrated methodology for assessing safety, quality and operations management. In the first place, the partners examined the possibilities to gather the needed pieces of information; as the most appropriate method the execution of surveys and interviews has been chosen in order to assess the present situation of the industrial installations handling toxic and flammable substances. This has covered all the range from methods, standards and best practices used for safety, to quality and operations management. Various questions have been raised from the end-users about the innovative character of the proposed technology. Some of them referred to the form of the final tool (software and hardware) and the cost that this entails. Moreover, user-friendly interface and limited resources (both in human effort and cost) are desirable characteristics of the toolbox. According to the literature review, SMEs do not apply systematic SHE regimes and risk assessment methods in their work systems. As a result TOSCA partners should motivate SMEs to invest in safety management and show them that there is a business case for safety. TOSCA risk assessment methodologies should be practical and user-friendly to SMEs so that safety practitioners can master them easily and apply them during safety critical activities; formal risk assessment methods are useful but there is a need to adopt a resilience –based approach in order to support front-line operators in improving their knowledge of risk. TOSCA tools should provide specific indicators for monitoring how successful the safety interventions are during change management. End-users (and especially SMEs) are not always familiar with modern technologies (such as VR technology) and this could be a possible constrain they have to be overcome before using the new technology. It is in the

interest of TOSCA consortium then to create a user-friendly tool. End-users are also reluctant in changing well-established techniques and methods even for a new one more promising one with a clear added value. It is the task of TOSCA community to help promoting new technologies, as the VR technology proposed. Moreover, end-users have expressed vivid interest in learning more about the new VR technology proposed by TOSCA.

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