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MESSAGE MAPS FOR SAFETY BARRIER AWARENESS

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ABSTRACT

All people are exposed to risks in everyday life, but they seldom experience accidents. Therefore, people often believe that these accidents will never happen, and they do not see the risks.

By increasing the ability to notice risks, to see safety barriers, and to assess the safety barriers' performance parameters continuously, it is possible to create better risk awareness on the part of employers, managers and employees. Better risk awareness by these stakeholders will make it possible to:

- acknowledge and continuously control risks;
- discover and manage new risks;
- keep safety barriers intact;
- replace safety barriers with others, if necessary;
- monitor and maintain the quality of safety barriers.

This will contribute to maintain a high level of safety and prevent accidents.

Some pro-active accident prevention can be obtained by making people aware of the risks in a given situation, time, or place, and by enabling them to observe and judge whether the relevant safety barriers are in place and in good order. This can be considered "Situational Awareness" (SA), which is an essential competence enabling an employee to perform his/her job safely. This SA entails a number of requirements for people, work conditions, management, learning, knowledge, experience, motivation etc.

The Dutch WORM and RAM projects led to the identification of 64 types of risks and the safety barriers and performance factors linked to these risks. The Danish DanWORM project has transferred this knowledge into two sets of 17 "INFO-cards" or message maps, to be used by the employer and the employee, respectively. Such an INFO-card is developed for a specific group of risks and contains:

- What needs to be observed, what safety barriers are in place;
- What needs to be assessed, the performance parameters;
- What requires action, depending on the deficiencies that have been found.

Keywords: Risk assessment, Risk awareness, Message maps, Accident prevention, Occupational safety

BACKGROUND

The analysis of accidents is an analysis in hindsight, since it is made after the accident has happened. The accident analysis can indicate several direct and indirect causes; but to a large extent, it is the fact that the causes occur simultaneously that makes the accident happen, rather than the presence of one single cause (Rasmussen, 1997, Jørgensen, 2002). Precisely due to the fact that a single cause does not necessarily lead to an accident, but only when other causes occur at the same time, makes it difficult to point to the actual "culprit". This makes it hard to perceive causes, which in one situation mean nothing, but in another are crucial for an accident to happen.

Perhaps this is the reason why actions and choices come under scrutiny when an accident has to be explained and the "cause" located. There has been much focus on human errors and mistakes, where differentiations are made between conscious and unconscious mistakes, as well as between errors in workmanship, errors in memory, wrong choice of method, misunderstandings, and lack of knowledge (Rasmussen, 1987; Reason, 1977). This perception of the different ways in which humans make mistakes and act erroneously has been seen in a framework of explanations and conditions for why people make mistakes due to the situation and context (Reason 1997). Organization, decisions, and working conditions contribute to affecting what risks are present, but also whether the necessary barriers are present to prevent risks that lead to accidents (Reason 1997).

This brings us to consider risk understanding and risk perception as important elements for possibilities to acknowledge risks and know what dangers they hold and what consequences an accident can have. Basically, people are not particularly good at or capable of assessing their own risks (Lin et al., 2007). Some risks are assessed too high and some too low, and it seems that many other factors in our lives and surroundings affect what we understand and acknowledge. This occasionally has the effect that we misunderstand a situation that can have an accident as a consequence, or else we are simply mistaken (Lin et al., 2007). It is crucial to achieve an understanding and acceptance of the paradox that we do not understand an accident and its causes until after the accident has happened, but at the same time, an accident must be prevented before it happens. Quite often, accident prevention initiatives in enterprises comprise investigating the accidents that happen, and then acting in relation to the concrete causes evidenced by the investigation. This kind of reaction, however, has turned out to have a limited effect and, over time, practically no effect at all (Krause, 1995). A far better preventive effort is achieved when management makes the decision that it wants a higher degree of safety and a more specifically targeted effect of the safety efforts. It is even better, if the management is able to create a culture within the enterprise in which employees participate in creating continuous safety improvement (Krause, 1995; Glendon et al., 2007; Flin and Yule, 2004).

The necessary knowledge about risks and causes of accidents in such a process must be gathered from surveys and analyses of many accidents, but in such a way that the generically fundamental causes of the accidents happening can be gathered, as well as generic provisions, i.e. barriers that can prevent risks from becoming accidents. But the use of this generic knowledge is crucial for the desired results to be achieved (Krause, 1995; Hollnagel, 1999; Hale & Guldenmund, 2003).

The specific risks commonly focused on are those that can result in very serious consequences if they develop into an accident. Especially spectacular risks, where many people are exposed simultaneously, have been focused upon and of course for good reason (Lin et al., 2007). But the fact is that also the so-called banal risks causing more traditional types of accidents are very frequent and can have serious consequences for the individual (Jørgensen, 2008). Far more people die due to such banal risks than from what are often characterized as "high-risk" areas. It presents a great challenge do something about these banal risks, without neglecting the risks focused on presently (Jørgensen, 2008). Situation-specific awareness can be defined as: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley, 2000). If we do not understand what the objective of the individual is in a given situation, the information in the environment will carry no meaning. In addition, presuppositions and expectations influence the situation-specific awareness (Endsley, 2000). Actually, people should rather act on the basis of the direct information in the situation. They must be able to combine information and imagine incidents on the basis of their experiences. They must be proactive, not merely reactive. They must act from objectives and be capable of doing this with a certain degree of automatic and knowledgeable behaviour (Endsley, 2000). A tool for creating an overview of barriers as well as risks and appropriate actions, and thus heightening the situation-specific awareness, is the development of message maps (Flin et al., 2006). Message maps are developed to create an overview of the users of information and the information they need, which then enables individuals to make decisions by themselves and act according to their own needs. Message maps can also be used as a means of creating a situation-specific awareness, in a decision-making process as well as in communication and

cooperation, including establishing how managers can support this process (Lin & Petersen, 2007; Flin et al., 2006).

This tool can be used in connection with proactive accident prevention by enterprises, if it is targeted at accident risks that are tangibly present. Methods exist for creating greater likelihood that situation-specific awareness is correct, and that it will be acted upon appropriately – for example, knowing what observations to be aware of, what barriers need to be present for everything to progress properly, and what actions are required if the conditions are not as they should be. This is not meant to remove proactive prevention from managerial responsibility, but on the contrary to support managerial responsibility with concrete tools that are especially useful for small enterprises.

METHODS

The aim is to create material that can be used to promote appropriate risk awareness and also provide information about which safety barriers should be in focus and how to make sure that the same safety barriers function optimally.

This material must also be an easily accessible tool that enterprises can use to create risk awareness and proactive prevention.

The method applied uses the thinking behind Flin's development of message maps (Flin et al., 2006). presents an example of such a message map, showing a message map for the risk of "being hit by a movable object".

Hazard: Being hit by a movable object. **Barrier**: Controlling movable objects in the area		
Gather information	**Understand the information**	**Predict and react**
Where are the movable objects in the area?	Assess whether the movements could possibly hit you	Secure movable objects and their movement path
How do they move?	Assess whether the movements are varied and whether they should be adjusted	Adjust, signal, flag, communicate with your surroundings
Can their movement become uncontrollable?	Assess what could make the movements uncontrollable	Check the security devices and information to the surroundings
Can I be in the object's movement path?	Assess how I should act to not be caught in the object's movement path	Adjust your own behaviour

Table 1. Example of a message map for "being hit by a movable object

Knowledge about risks, safety barriers, and quality assessment of safety barriers come from the Dutch project, WORM/RAM/ORCA, which has identified 64 hazards through an analysis of 9,000 serious work accidents (RIVM, 2008).

A crucial element of the analyses is which safety barriers have failed and thus caused accidents. In some cases, the safety barriers are easy to assess, while in other cases, more detailed information is needed. Furthermore, it is necessary not merely to identify the safety barriers, but also to examine what qualities they have and what factors affect them. The factors that affect the quality of the safety barriers and thus influence the likelihood of an accident occurring have been termed Probability Influencing Entities (PIEs), meaning factors that can influence the likelihood of failure of a safety barrier. The idea is that if PIEs are entirely in order, then the safety barriers will be as well, and the risk of an accident happening is therefore low: on the other hand, if the PIEs are lacking, not in order or present, the safety barrier will be bad and the risk of an accident happening will be high. For each hazardous activity, the safety barriers are identified as primary and support barriers, and the PIEs are identified for each barrier.

An example of the connection between sources of danger, safety barriers and PIEs/quality parameters is shown in Table 2 (RIVM, 2008).

Activity hazardous	*Primary safety barriers*	*Support safety barriers*	*Evaluation criteria – PIEs*
Work at placement ladders/ Risk of falling	1 Ladder strength	1. Type of ladder and its strength	Conditions of ladder steps
			Inspection of ladder capacity and length
			Maintenance and storage
			Cleaning
	2. Ladder stability	2. Placement and protection of the ladder	Placement on the ground
			Placement at the top, angle
			Protection against traffic
	3. User stability	3. Ability of the user to stay on the ladder	Position on the ladder
			Personal condition
			Use of both hands to hold onto the ladder
			External forces influence
			Appropriate movements

Table 2 Example of the assessment of the criteria that affect the probability of accidents, in this case working/standing/climbing on a placement ladder

Finally, it must be taken into consideration that both employers and employees need to possess risk awareness regarding risks that can lead to accidents. Most legislation places the obligation for safety with the employer, and there are also many conditions that the employer can ensure beforehand and which contribute to good and safe working conditions for employees. But it will never be possible to remove all risks, especially not the banal ones.

It is also true that many employees are on their own during much of their working hours and must be able to judge their own work situation for themselves at each point in time. It is therefore necessary to make sure that an instrument is developed that can help create risk awareness of both the employer – with regard to what he can see, understand, and act on in advance – and the employees – with regard to what they must be able to see, understand, and act on in the situation (Jørgensen et al., 2010).

RESULTS

As a consequence of the theoretical work and the results mentioned above, and inspired by “message maps”, the idea was to develop a kind of INFO card to be used for education and training regarding the different risks. These cards would contain information about the safety barriers and PIEs for each hazardous activity, and focus on both what the employer should be aware of beforehand, and what the employee should be aware of in the situation. The model for the development of the INFO cards was inspired by the work of Bellamy (Bellamy et al., 2009) about safety awareness, as illustrated in figure 1.

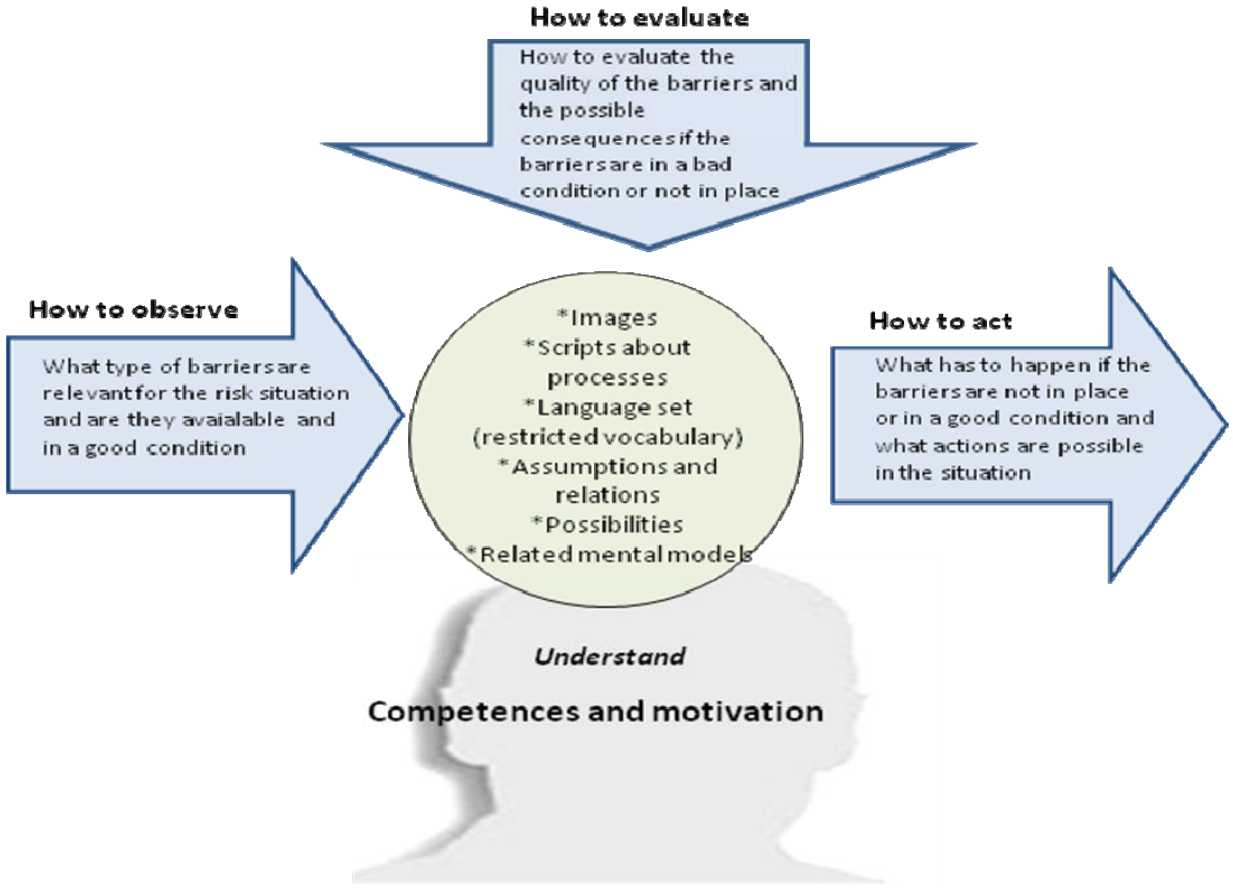

Figure 1. Model for the INFO cards and safety awareness (Bellamy 2009; Jorgensen et al., 2010).

The background for the INFO cards is an understanding of which duties are the responsibility of the employer and which must necessarily be the responsibility of the employees, who have significant independence in their work.

Management's responsibility generally is to ensure that the necessary safety barriers are provided, used correctly, maintained and controlled. The safety barriers are fundamentally linked to equipment, procedures and competencies. For example:

- The employer shall ensure that the correct equipment is in place and in order, that employees know how to use it and are motivated to use it correctly, and that each employee knows what to do and when, if the equipment fails or does not suit the task.
- The employer shall organize the work so that there is clarity about the behaviour expected from the employee, and the employer shall ensure that the employee knows what is expected and is motivated to fulfil these expectations.
- The employees shall be aware of the competencies they need when organizing their work, and shall take part in improving these competencies with regard to the job's performance when necessary.

This means that the employee shall ensure:

- That he knows which safety barriers shall be in order before he starts working.
- That he has the correct equipment, knows how to use it, and is also motivated to use it.
- That he knows the procedures, management's expectations for carrying out the work, and finally, that he has acquired the necessary competencies.
- That he takes part in communicating with the employer, when equipment, procedures, working conditions fail or are not in order, so that a solution can be found that adheres to safety requirements.

Both the employer and the employee shall be familiar with the concrete safety barriers linked to the individual types of risks and these safety barriers' function, and the consequences it will have if they are not in order.

INFO cards were made for all 64 hazards (RIVM, 2008), but in order to develop a clearer tool for the Danish project, the 64 hazards were grouped into INFO cards for 17 types of hazards (Jørgensen et al., 2010). Below is an illustration of the structure and content of an INFO card for the type of hazard called *"Falls from heights"*.

In the WORM project, this risk type is described by 12 different types of situations in which the risk of falls from heights can occur:

1. moveable ladders	7. putting up/taking down scaffolding
2. fixed ladders	8. roofs
3. step ladders	9. surfaces with a difference in level
4. rope ladders	10. fixed platform
5. mobile scaffolding	11. mobile platform
6. fixed scaffolding	12. vehicles that are standing still

These 12 different risk situations have different types of requirements and safety barriers, including legislation or guidelines. In WORM analyses, these risks fundamentally contain four generic safety barriers that involve:

1. The equipment's strength
2. Railings etc.
3. The equipment's placement and basis
4. User stability

The equipment's strength concerns the carrying capacity in relation to the actual load, and whether it is maintained, cleaned, and used correctly – e.g. are the ladder's steps in good condition and can they bear the weight of a person plus materials; or can the roof's carrying capacity handle the weight of the persons who are on it?

Railings and other protection against falls concern special safety equipment that shall ensure that employees do not fall from heights if they should misstep, stumble, or lose their balance for some other reason.

The equipment's placement and basis concerns choosing the correct equipment and using it properly. For ladders, this applies e.g. to the ladder's slope and securing; for scaffolding, it applies to the support and securing.

User stability concerns behaviour as well as the employee's physical and mental condition in relation to what is required for working at heights. It concerns how a person stands, walks and works at heights with or without tools, and how a person handles materials.

MANAGEMENT			
Hazard: Fall from heights Includes staying and working on all forms of ladders, scaffolding, platforms, differences in level, roofs etc.			
Barrier types	**Observe/investigate**	**Understand/interpret and evaluate**	**Act/perform**
The equipment's strength	Observe whether theequipment is in order, cleaned and maintained. Investigate what equipment is needed for the tasks and its carrying capacity. Investigate whether there is a need for other equipment for the tasks. Observe whether employees give feedback when the equipment is not in order. Observe employee behaviour and use of the equipment.	Evaluate whether the carrying capacity and construction are appropriate to the task. Evaluate the maintenance condition. Evaluate the need for remedial measures. Evaluate the need for information to employees. Evaluate the need for special instruction. Evaluate the need for motivating initiatives for the employees.	Ensure faults are rectified and remove defective equipment. Inform employees about which equipment they must use and which equipment is defective or being repaired. Ensure there are procedures for the work and for cleaning and maintenance. Motivate and instruct employees about how they work at heights, and what feedback they must give when they find that things are not in order.
Railings	Observe the need for railings. Observe the railing quality. Observe whether railings are mounted correctly and in good maintained condition.	Evaluate accessibility, maintenance, strength and set-up of railings. Evaluate the motivation to ensure maintenance of the railing quality. Evaluate the need for special instruction. Evaluate the need for motivating initiatives for the employees.	Ensure that deficiencies are rectified. Inform employees about how they shall behave. Motivate and instruct employees about how you want them to behave when railings are lacking or are not in order.
The equipment's placement and basis	Observe the equipment's placement and basis. Observe the possibility that external circumstances can affect the equipment. Observe the need for special measures for protection. Observe employees ability to protect the equipment. Check approval of the equipment.	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance. Evaluate employees' ability and motivation to set up and use equipment correctly.	Ensure that deficiencies are rectified. Inform employees of the correct method and ensure that it is used. Instruct on setup, securing, foundation, placement, etc. Motivate employees to comply with procedures.
User stability	Observe employees' state of health before they are sent to heights. Observe the weather before the task starts. Observe the employees' behaviour towards footwear, free hands.	Evaluate whether employees are OK. Evaluate whether employees can handle the task. Evaluate whether employees know how their behaviour should be when working at heights. Evaluate employees' motivation to exhibit safe behaviour.	Ensure instructions/agreements are clear. Ensure there is a good division of responsibility and tasks. Create positive motivation for safe behaviour. Ensure there is a consequent attitude toward violations.

EMPLOYEE			
Hazard: Fall from heights Includes staying and working on all forms of ladders, scaffolding, platforms, differences in level, roofs etc.			
Barrier types	**Observe/ investigate**	**Understand/interpret Evaluate**	**Act/perform**
The equipment's strength	Observe whether the equipment is in order, cleaned and maintained. Investigate what equipment is needed for the tasks and its carrying capacity. Investigate whether there is a need for other equipment for the tasks.	Evaluate whether the carrying capacity and construction are appropriate to the task. Evaluate the maintenance condition. Evaluate the need for remedial measures.	Ensure that deficiencies are rectified. Ensure that the correct equipment comes into use. Remove defective equipment. Inform the employer and possibly colleagues, if the conditions are not in order. Follow the given instructions and procedures.
Need for railings	Observe the need for railings. Observe the quality and strength of the necessary railing. Observe whether the railing is mounted correctly and is in good maintained condition.	Evaluate accessibility, maintenance, strength and set-up of railings.	Ensure that deficiencies are rectified. Inform the employer and possibly colleagues, if there are deficiencies and what measures are necessary. Follow the given instructions and procedures.
The equipment's placement and basis	Observe the equipment's placement and basis. Observe the possibility that external circumstances can affect the equipment. Observe the need for special measures for protection. Check approval of the equipment.	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance.	Ensure that deficiencies are rectified. Inform the employer and possibly colleagues, if there are deficiencies and what measures are necessary. Follow the given instructions and procedures.
User stability	Observe your state of health before you work at heights. Observe the weather before the task starts. Observe the need for particular behaviour, including footwear and free hands to hold on with.	Evaluate your own ability to work at heights. Evaluate whether you can handle the task. Evaluate which behaviour is needed in the task for your and your colleagues' safety Evaluate methods of transport of materials and tools that shall be used for working at heights.	Know the necessary instructions/agreements. Know who has the responsibility and tasks. Ensure there are aids to lift materials and equipment, so you have one hand free to be able to hold on. Carry out the task with safe and professional behaviour.

DISCUSSION

Part of the Danish project has been to develop an easy-to-use tool to help an enterprise register the activities that comprise the different tasks, including the risks that are innate to the tasks as well as the condition of the necessary barriers during the execution of the activities. The objective of the Danish project, however, is to make it easy for small enterprises to gain control of safety. Combining the investigation of a trade to learn how the tasks are being done with the Dutch data and knowledge of barriers and PIEs for concrete risks, constitute a good basis for creating objective-specific message maps for concrete trades. This creates the opportunity to be very specific about what is important for small enterprises to focus on as well as what the employees should learn and know, namely how to assess risks in their daily, often very diverse, work processes.

The Danish investigation has also made it obvious that it is necessary to distinguish what is expected that the employer must handle; what must be taught and instructed; and finally, what the individual employee must take care of to achieve a higher level of safety. This is supported by several other research results, which indicate that it is not until safety is prioritized and created in cooperation between employer and employee that a low risk of accidents is continually achieved.

Proactive prevention can then be assisted by using such tools as message maps or INFO cards. These can be part of the empirical data that must form at the core of proactive prevention.

How these results are to be transferred afterwards to both small and large enterprises is still not determined. This leaves a key question not answered by this project. Especially small enterprises do not have much awareness or interest in the safety problem. They themselves declare that they are doing fine and do not really have time for other tasks than those demanded of them by their clients. Implementation therefore relies on communication.

REFERENCES

Bellamy L., 2008, “Raising Situation Awareness of Major Hazard Safety Barriers - Barrier Intelligence”, not yet published

Endsley M.R. and Garland D.J., 2000,” Situation Awareness Analysis and Measurement”, Mahwah, N.J.: Lawrence Erlbaum Associates

Endsley M.R., 2000, “Theoretical Underpinnings of Situation Awareness: A critical review”, Lawrence Erlbaum Associates

Flin R., Yule, S., Paterson-Brown, S., Rowley, D., Maran, N., 2006, “The Non-Technical Skills for Surgeons (NOTSS) System Handbook v1.2” University of Aberdeen, Scotland

Flin R., Yule S., 2004,”Leadership for safety: Industrial experience”, Qual Saf Health Care 13 (suppl II), pp 45-51

Glendon A.I., Clarke S.G., McKenna E.F., 2007, “Human Safety and Risk Management”, second edition, Taylor & Francis

Hale A. & Guldenmund, 2003, ” Barriers and Delivery Systems”, Worm paper, mangler hvor det kommer fra

Hollnagel E., 1999,”Accident Analysis and Barrier Functions”, Project TRAIN, IFE

Jørgensen K. 2002, ”En taxonomi for Arbejdsulykker – en systematisk beskrivelse af årsagssammenhæng” [En taxomony of work accidents – a systematic description of causality], BYG-DTU report R-027, Denmark

Jørgensen K., 2008, “The dominance of accidents caused by banalities”, EVENT ANALYSIS AND LEARNING FROM EVENTS, 26th NeTWork Workshop, Steinhoefel near Berlin, August 28 -30, 2008

Jørgensen K., Duijm N., Troen H., 2010, ”Accident prevention in SME using ORM”, *Safety Science*, vol 48, issue no 8, pp 1036-1043

Jørgensen K., Duijm N., Troen H., 2010, ” Risk assessment and prevention of accidents at work”, DTU Management, Report 4, 2010, Kgs. Lyngby, Denmark

Krause T.R., 1995,”Employee-Driven Systems for Safe Behavior – Integrating Behavioral and Statistical Methodologies”, Van Nostrand Reinhold Staff, ITP, USA

Lin I., Petersen D.D., 2007, “Risk Communication in Action – The tools of message mapping”, EPA/625/R-06/012, United States Environmental Protection Agency, Cincinnati, USA

Rasmussen J., Duncan K., Leplat J., 1987, “New Technology and Human Error, John Wiley & Son, New York

Rasmussen J., 1997; “Risk Management in a Dynamic Society: A modeling Problem”, *Safety Science*, vol 27, no 2/3, pp 183-213

Reason J., 1997, “Managing the risks of organizational accidents”, Ashgate Publishing Company, USA

RIVM, (2008), “The Quantification of Occupational Risk - The development of a risk assessment model and software, Ministry of Social Affairs and Employment, The Netherlands