Securing Organizational Resilience in Escalating Situations
Development of skills for crisis and disaster management

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Abstract. Over-reliance in high-risk industries on prescriptive emergency procedures and the capacity of high-fidelity simulation has initiated the search for new steps for training in handling complex and escalating events. A theoretical framework for generic, non-domain specific competencies in proactive crisis management has been developed. The framework contains the following four categories: 1. Information Management, 2. Communication and Coordination, 3. Decision and Implementation, and finally 4. Effect Control. The ability to train the generic competencies has been studied using a crisis management training program in the context of a simulation exercise. A group of Fire Safety Engineers went through the non-domain specific training program and their performance was compared with a control group when doing crisis management exercises in their own domain. This experiment indicates that non-domain specific training improves the participants' ability to manage crises in their own domain and to evaluate their actions and shortcomings when handling complex and dynamic situations.

1 INTRODUCTION

The overall aim with this research has been to increase the understanding of resilient organizations and their characteristics. It has been suggested that in creating resilient flight-crews, increasing focus needs to be placed on awareness of, and language for, the need for generic, rather than specific or procedural competencies, for managing low-probability/high consequence events [Dekker, Dahlström, van Winsen & Nyce, 2008]. The specific aim has been to study if such generic competencies also can be applicable to manage escalating situations in other, less operator-oriented, industries and if it is possible to practice the generic competencies in such a way that the training improves peoples' handling of escalating situations in their own domain. To answer the questions a theoretical framework was needed to explain the basic concepts underlying the generic competencies. Experiments were then performed where the effects of training, focusing on the generic competencies, were studied.

2 DEVELOPING A THEORETICAL FRAMEWORK

The development of a theoretical framework aims at isolate generic, non-domain specific competencies, that can help explaining and evaluating how teams from various industries handle unexpected and escalating events.

Theory elaboration is described as: "a method for developing general theories of particular phenomena through qualitative case analysis" [Vaughan, 1992]. Using theory elaboration a theoretical framework for generic competencies has been established. A theory base considering peoples' handling of complex and dynamic systems [Janis, 1982; Dörner, 1996; Flin, O'Connor & Crichton, 2008], and decision making [Brehmer, 1992; Hutton & Klein, 1999; Mathieu, Heffner, Goodwin, Salas & et al., 2000] guided the research through five case studies from various industries. Vaughan [1992] explained how case comparison can generate contrasts that demand us to discover, reinterpret and transform our theoretical constructs.

The cases presented below represent crises from five different industries that generated considerable challenges for the organizations which had to manage the crises during their escalating phases. The first case involves the challenges of understanding signals and revising strategies. The second case highlights the use of emergency procedures. The third, and fifth, cases cover coordination at a strategic level and the fourth case coordination at an operational level.

When the main feedwater pumps at Three Mile Island tripped on March 28 1979 the increasing pressure in the reactor made a pressurized relief valve open. The valve should have closed, but did not. A control lamp in the control room that was intended to indicate that the valve had closed instead indicated that the signal had been sent to the valve to close [Kemeny, 1979]. For several hours the operators were unable to make sense of the incoming information, in hindsight showing that the valve was open and that the reactor was loosing its coolant water through the valve [Perrow, 1984]. Their main goal was probably to avoid filling the reactor with water which was known as an unwanted state. With no revision of their initial mind-set the operators were unable to establish a proactive management of the situation.

Swissair 111 crashed into the sea outside the Canadian coast on September 2 1998. When the pilots noticed smoke in the cockpit they first concluded that it was coming from the air conditioning system. The pilots initially decided to divert to Boston, but after a call from the air traffic controller whether they would rather go to Halifax, which was closer, they revised the plan and turned towards Halifax. However, what became the main goal during the entire approach towards Halifax was not the diversion itself but rather the completion of the emergency procedure for smoke into the cockpit. The procedure consisted of two checklists that were designed to help the pilots figure out the source of the smoke rather than making proactive assessments of how to get the passengers and crew on solid ground or put out a possible fire. At several times the approach was delayed in order to get more time to complete the procedure. Instead the fire spread until it reached vital systems and made the aircraft uncontrollable [National Transportation Safety Board of Canada 2003].

When the tsunami struck south-east Asia on December 26 2004 the information of a large-scale crisis, possibly involving thousands of Swedish citizens, reached the Swedish authorities. However the managers rather waited for more information to come in than to act based on the available information, a phenomenon that Moats, Chermack and Dooley [2008] calls "paralysis by analysis". Even when the

information had reached all decision makers, the involved authorities were not coordinated with shared goals to guide their response operations making the Swedish authorities unable to establish any proactive strategies for several weeks. The commission that investigated the Swedish authorities' handling of the tsunami disaster criticized the authorities for not having a central crisis management function within the government offices.[The Swedish Tsunami Commission, 2005]

After a tank rupture at the company Kemira in Helsingborg, Sweden, 16 300 tons of sulfuric acid leaked out. This triggered the largest operation ever by the local rescue services. The operation came to involve ten different crisis management teams responsible for supplying different kinds of information and support to the rescue crews on site. Also eight different people had the role as incident commanders, causing confusion regarding who was the highest decision maker in the operation. Lacking communication and coordination between the management teams and commanders led to unclear goals, the same tasks made by several teams and lacking follow-ups of the situation. [Danielsson & Winnberg, 2005]

On October 2 2002 a major breakdown of the telecom system occurred in Uppsala County, Sweden. 230 000 subscribers were affected, 40 000 of which were completely cut off from the telecom network without the ability to make any phone calls, not even to the emergency services. Not having any predefined procedures for a situation where the telecom system was down, the personnel at the rescue station soon realized the severity of the situation and started to act. The crisis management team for the county was brought in by letting horns in the population centers sound (indicating important message for the public as well as a call for the staff). The team was soon gathered and without any information about the severity of the breakdown, or how long it would remain, goals for the coming 24 hours was set up and prioritized. The early formulation of explicit goals helped the management team to guide the decision-making processes in a proactive manner. The county was well prepared for the breakdown to last a lot longer when the telecommunication was back later in the evening. [Hedin Ekström, 2004]

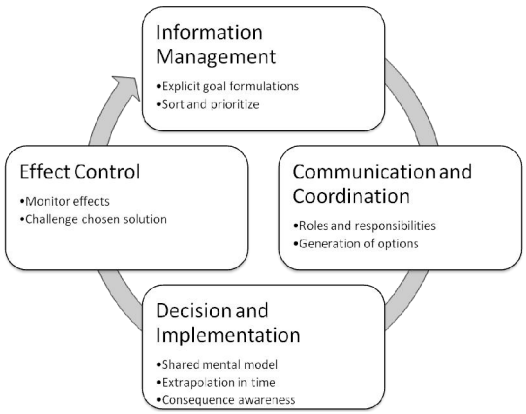

Fig. 1. A theoretical framework of generic competencies for proactive crisis management

In terms of the competencies needed for a team handling an escalating scenario, some parts of the theoretical base were able to explain key aspects of all the cases. These generic, non domain specific, competencies are shown in figure 1.

The first competence category is *Information Management*. In an escalating situation the team managing the situation is often in a situation of information overflow. To establish proactive strategies, analyses of possible developments of the situation has to be based on explicit goals [Dörner, 1996]. The ability to sort out relevant pieces of information in an information overflow may also have decisive importance for the outcome of the crisis management [Orasanu & Connolly, 1993].

In the *Communication and Coordination*-processes the roles, and their areas of responsibilities, in the team have to be robust and clear. But the roles also have to be flexible to the need of assistance for some responsibilities and call on for others [Heath, 1998].

The third competence category is named *Decision and Implementation*. In a situation of high information flow the decision-making process has to take place within every area of responsibility. To make all decisions in consensus would cost too much time. It is therefore necessary that the various ongoing decision-making processes are based on the shared goals. This is described by Fredholm & Åström [2006] as distributed decision-making based on a shared mental model.

The importance of updating the initial thesis and goals of the crisis management, based on additional incoming information, is expressed as the final competence category: *Effect Control*. The category also contains the importance of avoiding mind-sets that makes people see and interpret information that confirms the initial thesis rather than information that does not.

3 TRAINING THE COMPETENCIES USING A CRISIS MANAGEMENT SIMULATION

To evaluate the possibility to train the generic competencies, and use the theoretical framework as an evaluation tool, an experiment was made at the Swedish Rescue Service Agency's school in Revinge, Sweden. A crisis simulation exercise was used to train the generic competencies in two experiment groups.

The simulation used allows five to seven participants to assume different roles on the bridge of a vessel caught in a stormy night on the Atlantic Ocean [Strohschneider & Gerdes, 2004]. During the simulation different events occur that increasingly demand that the participants establish strategies to apply generic competencies to prevent the situation from escalating beyond their control. The simulation provides information to the participants in the form of computer printouts. Beyond blueprints and maps there is no visualization of the simulation and the participants are not equipped with any predefined strategies for managing upcoming situations. The simulation is part of a two-day training program which also includes lectures, discussions and debriefing sessions.

From a course with 23 Fire Safety Engineers, on a year-long training program to become incident commanders in rescue services, half received the two-day program before scheduled emergency management team training on their course. During the simulation data collections were made in regards to the students' abilities to use generic competencies. Data collections were also made during the emergency management training, i.e. where they were performing within the boundaries of their own domain. Differences in the use of generic competencies between those engineers who had received the two-day program and those who had not were

observed and analyzed.

The two experiment groups were not successful in handling the simulated vessel during the crisis management simulation exercises. None of the groups established any strategies to handle the information overflow, did not state any explicit goals, did not establish any successful strategies for distributed decision making and were not flexible in their roles. Shortly into the simulation the teams' performance could be described as normal operations-behavior, focusing on what to do to solve current problems based on their urgency rather than trying to refocus on how to create structures and strategies to solve problems based on an assessment of their importance. However both teams did improve their performances at the second day's exercise and expressed that the exercise had been useful for their training.

During the following emergency management team training an increased ability to apply generic competencies was demonstrated by the experimental groups compared to the control groups. The experimental groups established shared mental models based on clearer formulations of roles and with a mandate for decision making within the different roles. The control groups were hardly aware of roles in any sense beyond labeling group members and their decision making processes were characterized by gathering the groups for briefing sessions as soon as any new information was received, instead of sort and distribute the incoming information to the team members based on their roles. The experimental groups followed up on how ordered tasks were performed while the control groups ordered work to be performed and then took no action to ensure that the orders were carried out. The use of the generic competencies made the experimental groups able to establish more proactive processes than the control groups which rather were stuck in the inability to sort, prioritize and distribute information and tasks. A summary of the observations made during the staff exercises is shown in table 1.

Table 1. A comparison between the groups that had received the simulation training program and the control group's performances at the staff exercises

The experimental groups	The control groups
Indistinct roles at high information flow	Hardly any roles
Showed proactive tendencies	No proactive tendencies
Not all decisions taken in consensus	Briefing sessions as soon as any new information was coming in
Clear team-leader and team-moderator	Who answers the phone is selected by chance
Tasks were performed	Thematic vagabonding
Some explicit goals	No explicit goals

The most significant difference between the groups was however observed during the debriefing sessions. During these the control groups commented their own performance with "In real life one has predefined procedures and roles for situations like this" and "I don't know if more sharply defined roles would have made us more effective". The experimental groups performed far more qualified analyses of their performance and their shortcomings. Their statements showed understanding of the

need for generic competencies and the difficulties in establishing strategies for applying them. A summary of the observations made during the debriefing sessions is shown in table 2.

Table 2. Differences in reasoning at the debriefing sessions after the staff exercises.

The experimental groups	The control groups
Identifies the problems in doing other peoples' work	No understanding for the importance of roles
Discusses the difficulties in formulating explicit goals and the benefits from doing so	Believes implicit goals are capable of guiding the management
Discusses the difficulties in being proactive	Wrongly believes that some actions were proactive
Generally good in evaluating their own actions	Express believes that in real life there are predetermined roles and procedures for all situations

4 DISCUSSION

This experiment indicates that non-domain specific training of escalating situations improves the participants' ability to manage crises in their own domain and to evaluate their actions and shortcomings when handling complex and dynamic situations. The potential to apply this sort of training in various industries, that demand rapid and well structured response to escalating situations, is great although more research and further testing is needed. However, as a part of the overall aim to increase the understanding of resilient organizations and their characteristics non-domain specific simulation have already proved to be an effective tool.

The theoretical framework explaining generic competencies for proactive crisis management was a useful tool for contextualizing statements made, and strategies chosen, by the observed teams in their managing of the escalating situations. The framework could also be a useful tool for development of new programs and methods for managing and training of escalating situations in numerous industries like aviation, ship management, health care and the nuclear industry.

The framework is an early model based on five cases. Further case studies are needed to study whether the same framework could be useful in describing the competences needed to maintain organizational resilience in operations where various management teams and organizations are not predefined, but rather an emergent phenomenon, rooted in the complexity and dynamics of the situation. Triangulation using additional case studies and training experiments could reveal additional competencies that need to be considered and added to the framework.

In future development of training programs in handling complex and dynamic systems the need for the development and training of generic competencies, in contrast to drilling prescriptive plans and procedures, needs to be emphasized. The theoretical framework for generic competencies could help guiding such processes.

REFERENCES

Brehmer, B. (1992). Dynamic decision making: Human control of complex systems. *Acta Psychologica*, *81*(3), 211-241.

NTSB (2003), Aviation Investigation Report A98H0003, Quebec

(2005), Sverige och tsunamin - granskning och förslag (SOU 2005:104), Stockholm

Helsingborg stad - Brandförsvaret (2005), Undersökning av räddningsinsatsen vid olyckan på Kemira Kemi AB, Helsingborg 4-7 februari 2005, Helsingborg

Dekker, S., Dahlström, N., van Winsen, R. and Nyce, J. (2008). Crew Resilience and Simulator Training in Aviation.In E. Hollnagel, C. Nemeth, P. and S. Dekker (Ed) *Resilience Engineering Perspectives, Remaining Sensitive to the Possibility of Failure,* pp. 119-126. Aldershot, Ashgate Publishing Company. **1**.

Dörner, D. (1996). *The Logic of Faliure*. New York: Metropolitan Books.

Flin, R., O'Connor, P. and Crichton, M. (2008). *Safety at the Sharp End, A Guide to Non-Technical Skills*. Aldershot: Ashgate Publishing Company.

Fredholm, L. and Åström, M. (2006). Räddningsledning och beslutsfattande.In L. Fredholm and A.-L. Göransson (Ed) *Ledning av räddningsinsatser i det komplexa samhället,* pp. 113-126. Huskvarna, NRS Tryckeri.

Heath, R. (1998). Dealing with the complete crisis-the crisis management shell structure. *Safety Science*, *30*(1-2), 139-150.

The Swedish National Defence College (2004), Teleavbrottet i Uppsala 2002 - Infrastrukturell sårbarhet, Stockholm

Hutton, R. and Klein, G. (1999). Expert Decision Making. *Systems Engineering*, *2*(1), 32-45.

Janis, I. (1982). *Groupthink, Psychological Studies of Policy Decisions and Fiascoes*. Boston: Houghton Mifflin Company.

Pergamon Press (1979), Report of The President's Commission on the Accident at Three Mile Island, New York

Mathieu, J., E., Heffner, T., S., Goodwin, G., F., Salas, E. and et al. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, *85*(2), 273-283.

Moats, J., B., Chermack, T., J. and Dooley, L., M. (2008). Using Scenarios to Develop Crisis Managers: Applications of Scenario Planning and Scenario-Based Training. *Advances in Developing Human Resources*, *10*(3), 397-397.

Orasanu, J. and Connolly, T. (1993). The reinvention of decision making.In G. Klein, J. Orasanu, R. Calderwood and C. Zsambok (Ed) *Decision making in action: Models and methods,* pp. 3-20. Norwood, Ablex publishing corporation.

Perrow, C. (1984). *Normal accidents : living with high-risk technologies / Charles Perrow*. New York: Basic Books.

Strohschneider, S. and Gerdes, J. (2004). MS: ANTWERPEN: Emergency management training for low-risk environments. *SIMULATION & GAMING*, *35*.

Vaughan, D. (1992). Theory elaboration: the heuristics of case analysis.In C. Ragin and H. Becker (Ed) *What Is a Case?: Exploring the Foundations of Social Inquiry,* pp. 173-202, Cambridge University Press.