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Managing Escalating Situations at Sea:

Testing and improving the value of ship-bridge simulation for maritime crisis management

Sidney Dekker, Johan Bergström, Nicklas Dahlström, Roel van Winsen, James Nyce and Kristina Helgstrand

Lund University School of Aviation

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Hantering av upptrappande situationer:
Undersökning och förädling av värdet av bryggsimulering
för hantering av maritima krissituationer

Final Report

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Summary

This final report summarises a research project conducted by researchers at the Lund University School of Aviation. In this project training of escalating situations at sea has been studied. Methods for training escalating situations needs to consider the nature of escalation and the certain demands that are raised on a team responsible for managing such events. Traditional training emphasises the use of prescriptive emergency procedures, but such procedures might be useless when managing dynamic developments of unforeseen events. By, instead of procedural drills, focusing training on generic team-competencies, such as information handling, communication and coordination, decision making, and effect control, teams are more likely to be prepared for the actual demands raised by an unforeseen and escalating event. A mid-fidelity simulation program has proven to improve such generic team-competencies in handling escalating situations. The learning gained from running the simulation program has also been used to develop guidelines in designing scenarios for training of such situations.

Content

1 Introduction

1.1 Background

Maritime accidents such as the *Estonia*, *Herald of Free Enterprise*, *Scandinavian Star* and even *Piper Alpha* have highlighted the importance of human factors, crew collaboration and coordination across vessels and agencies. In particular, these mishaps have emphasized the role of command and previous training in decision making under stress and emergency handling (Havold, 2000). Management of escalating situations, such as the crises and emergencies mentioned, as well as other situations with impact on the safety and efficiency of maritime transport, is often exceedingly difficult. Investigations of maritime accidents have often identified poor training of seafarers as a key contributing factor (Wang & Zhang, 2000). The development and validation of training that improves the management of escalating situations should thus play a central part in making progress on maritime safety. This goes especially for situations that take crews outside the routine, or beyond available written guidance (the word "crisis" is often used here to distinguish the requisite activities from "emergency management", for which routines, procedures and protocol are supposed to be available).

Research results from other domains (e.g. aviation, fire fighting, see Klein, 1998) tell us that successful management of escalating, complex situations ("crises") relies heavily on cognitive skills of the individuals involved as well as teamwork skills of the group. Among the cognitive processes that play an important role here are information processing, judgement and decision making and among the teamwork skills are communication, group interaction and leadership (Strohschneider & Gerdes, 2004). Despite their criticality, opportunities to practise these skills are often limited. High-fidelity ship-bridge simulations have made enormous inroads in improving the return on training investment with respect to technical ship handling (e.g. navigation), and, in important ways mimic the increasing technological sophistication of ship bridge systems themselves (which in turn present new error opportunities and routes to breakdown) (Lee & Sandquist, 2000, ; Lützhöft & Dekker, 2002).

However, the systematic teaching of cognitive and coordinative skills is severely underdeveloped in the maritime domain. There is in fact neither a good empirical basis for assessing the value of ship-bridge simulation (of any level of fidelity) on the teaching of these kinds of skills, nor an existing database of (or even much generic guidance on) what counts as relevant and valuable scenarios in which such skills could be practiced. While simulation is often a preferred method of training it is not widely used for training of handling escalating emergencies at sea. This lacuna was also alluded to after the grounding of the *Green Lily*, where the Marine Accident Investigation Branch (MAIB) report recommended that the Maritime Coastguard Agency (MCA) commission a research study into how bridge and engine room simulators can best be used for bridge and engine room resource management training that includes escalating emergencies and increasing levels of stress. Such studies have been slow in the making, but their need is becoming ever more apparent and critical.

One response to these problems may be a continually increased demand for more and higher levels of high-fidelity simulation. This could trap maritime training in a spiral of increased cost and lower availability of training simulators (since the huge capital investment required tends to concentrate available simulators in a limited number of centres across the world, as has happened in aviation too). Despite the face validity and visual persuasiveness of high-fidelity simulation, it is actually uncertain whether the quality of training is improved (and, critically, whether high-fidelity simulation leads to a better transfer of training to real situations) by using advanced simulators—for example when compared to traditional teaching methods and paper based scenario training already used today.

Since the market for maritime training simulators has become as important as the market for aeronautical training simulators (Cieutat, Gonzat & Guitton, 2001) these are issues that need to be considered. More systematic validation of mid-fidelity ship-bridge simulation could not only help as a counterweight to avert the spiral of increased cost and decreased availability of maritime simulators. "It is desirable that simulation fidelity and capability is sufficient to ensure the required transfer of training, but not to grossly exceed it since this would generally increase system cost with no return (see Jackson, 1993). Such a validation could also be a critical ingredient in the development of valuable and relevant scenarios that could help teach cognitive and collaborative skills, independent of the level of simulation fidelity. Part of such a training needs analysis, of course, is to begin to better specify the nature and level of cues required (and their minimum fidelity) to ensure the required transfer of training. On balance, though, what matters is not how much the simulation looks like "the real thing", but to what extent it is able to appeal to, and develop, the cognitive and collaborative skills that need to be applied in actual practice.

When it comes to the management of escalating situations, there are indications that the transfer of cognitive and procedural training to practice may in fact benefit from lower-fidelity simulations, as this removes "distracting" featurism from the training setting (Jackson, 1993). This is confirmed by experience from other domains:

> "…there is some evidence from flight simulation that higher levels of fidelity have little or no effect on skill transfer and reductions in fidelity actually improve training. Reductions of complexity may aid working memory and attention as skills and knowledge are initially acquired……Perhaps errors on the side of more fidelity reflect failed attempts to completely understand the underlying physical to cognitive mappings" (Caird, 1996)

Indeed, it is questionable how different levels of fidelity in training can be connected to different levels of learning. As Caird puts it, "for decades, the naïve but persistent theory of fidelity has guided the fit of simulation systems to training." (1996). If there is a link between simulator level-of-fidelity and training return-on-investment, then this connection is probably much more complex than the industry may think it is, depending critically on quality and relevance of the scenario and the exportability of the cognitive and coordinative skills acquired during the simulation. A distinction is sometimes made between "physical fidelity" and "functional/operational fidelity" — the latter being relevant to imparting cognitive and coordinative skills, the former for manual or physical tasks. These terms lack common definitions, however, and the distinction should be studied in much more detail.

1.2 Aim and objectives

The research was conducted with the following aims:

1. Experimentally test the pedagogical value of mid-fidelity ship-bridge crisis simulations on crew collaboration and decision making skills. This empirical work has been conducted through collaboration between several industries and domains as shipping and aviation. The former offers relevant context and mid-level simulation capabilities, while the latter has widely established routines and easily accessible training cycles for the checking and evaluation of collaborative and cognitive skills. It is thought that only a joint effort can generate the requisite insight for making progress on knowledge surrounding simulation for crisis management.

2. Development of new crisis scenarios and guidelines for scenario design that can be used to teach collaborative decision making skills in simulators with the aim of improving the cognitive and cooperative basis for Master and crew crisis handling. The guidance developed in this stage is generic guidelines for the construction of crisis scenarios that evoke pertinent cognitive and collaborative work, as well as inducing performance-influencing factors (e.g. stress, time limitations).

These two efforts can generate new, critical insights into the use and usefulness of maritime simulation for the management of escalating situations at sea. Of particular interest is to help the maritime industry in Sweden and elsewhere develop a greater ability to balance simulation level-of-fidelity (and thereby cost) with required transfer of training (return on investment), especially with respect to cognitive/collaborative skills. Such a focus not only produces potential safety benefits (as indicated by various investigations and previous studies) but also local opportunities for greater training effectiveness and competitiveness.

2 Method

There is general consensus in the aviation industry that specifically addressing cognitive and collaborative skills, especially in the form of CRM and MCC training, has safety benefits. This is echoed by maritime findings as well (e.g. Clemmensen, 1994). Indeed, concepts from aviation CRM have been adopted by the maritime industry in many forms, among them the SAS Bridge Resource Management (BRM) concept that has been spread widely, geographically and across industries (Offshore, 1995).

This research aims at enhance and further deepen such cross-industry fertilization and collaboration. It integrates a series of experimental validations of mid-fidelity ship-bridge crisis simulation with the easily accessible CRM/MCC training cycles in use within the aviation industry. The aim is to gauge the pedagogical benefit of mid-fidelity simulation on crews' collaborative and cognitive skills, particularly in crisis management. Lund University School of Aviation itself trains flight crews that go through the typical cycles, thus providing a flow of participants for such a validation. It is thought that such a cross-industry tactic represents a most fruitful way to generate the requisite empirical knowledge, not only because of an interconnected approach to generic non-technical skills, but also because various experimental models can be tested and modified over the course of the research project in order to finetune and maximize the pedagogical returns from mid-fidelity simulation.

2.1 MS Antwerpen, a mid-fidelity simulation

The MS Antwerpen simulation represents a new type of simulation that is rarely used in crew training. The simulation is part of a two-day emergency management training course developed by the University of Bamberg (Strohschneider & Gerdes, 2004). However, quite apart from its training purposes, the simulation can be used as a research tool for providing data on group action and interaction in escalating events.

The M/S Antwerpen is the name for the simulation of a passenger cruising vessel. The simulation is mid-fidelity. Fidelity refers to how closely a simulation imitates reality, how essentially naturalistic it is. Fidelity does not necessarily reflect the level or degree of technology. The M/S Antwerpen simulation is complex but not photorealistic or 3 dimensional. In short, it is not intended to mimic in any direct or explicit way nature or the natural world. However, all the structural and the major technical aspects of the ship are included in the simulation in an effort to approximate real maritime conditions as closely as possible. For example, conditions like passengers, sea, weather, and other traffic are also included in the simulation. All 193 of the ship's crew members and 300 passengers are simulated individually, using a coarse human-factor model (Strohschneider & Gerdes, 2004).

The simulation is designed for a group of 5 to 7 participants who act as the ship's first officers. Each participant takes on a specified role, namely: the captain, the chief officer, the chief engineer, the chief steward, the ship's doctor, the main engineer, or the navigation officer. Before the simulation begins, each participant is given general information that describes the features of the ship as well role specific information: his or her specific duties on the ship's bridge. It is the participants' task to safely navigate the ship through a stormy night in the North Atlantic. Due to the adverse conditions, and because the ship has been poorly maintained, the crew has to deal with a number of passenger-related problems and technical failures that towards the end of the simulation result in a state of emergency.

To sail the ship and handle impending events, the participants have a wide variety of options and actions available to them. They have control over the technical facilities of the ship, including maintenance and repairs. They can direct the crew and give various orders relating to the passengers (including, e.g. sending drunken passengers to their cabins, closing sections of the ship, and having passengers man the life boats). Participants do not have (are not provided with) a prescribed set list of possible responses. Instead they have to plan and execute actions as a team and deal with the possible consequences and side-effects of the actions they have chosen to initiate. The participants therefore find themselves in a dynamically developing situation – one that has a high level of uncertainty. Furthermore, they are presented with an overflow of incoming information regarding the status of the ship, its passengers and surrounding environment. Moreover, they have to deal with all this under the threat of all the conceivable emergencies that come with navigating a poorly maintained ship in very bad weather.

The total length of the simulation is approximately 3 hours, this being the average time it generally takes a group to manage the escalating events the simulation provides. The simulation program runs on a laptop and two facilitators input the crew's orders (responses) into the simulation program. All orders from the crew to the facilitators have to be written on order sheets. Verbal orders are not accepted by facilitators. Just as the participants' orders have to be on paper, incoming information on the ship's status (which the simulation provides) is provided by printouts from a portable printer positioned on the crew's table. Most of this information is the kind of information that you would expect to find on a ship's bridge (e.g. course, speed, weather conditions, radar, smoke detectors, etc.). Also, the crew may also receive additional information (printouts) such as incoming cables (from, for example, the vessel's shipping company, maritime radio communications, and signal traffic from other vessels in the vicinity), as well as messages from within the ship (for instance, passenger complaints, crew information and alarms). Because these printouts occur every minute, which equals 2 minutes of ship time, the simulation also compresses (response/reaction) time. To further increase the reality of the simulation, and to add to the crew's stress, sounds of waves and wind are played over two loudspeakers.

2.1.1 Structure of the two-day emergency management training program

Day 1 starts with a brief introduction to the M/S Antwerpen, after which the participants have the opportunity to read the general information about the ship and a short description of the various roles of the bridge's crew. They then divide up the various ship roles amongst themselves and are given very limited time to read through their role-specific materials and to receive clarification on questions they may have before the simulation starts. The first trip of the M/S Antwerpen is designed to provide an introduction to emergency management, as the participants generally have only very limited ideas and experience with such kind of situations.

For the first hour, the scenario runs smoothly. There are no alarms or emergencies. This is intended to give the participants an opportunity to become familiar with the ship and the simulation. After the first hour things slowly start to go wrong, technical failures increase in frequency, magnitude and importance, there are some passenger complaints and misbehaviour, crew problems occur, and the weather conditions deteriorate. Finally, the events that endanger the ship begin to occur so rapidly, that it becomes extremely difficult for the crew to control the situation. This almost always results in an evacuation and abandonment of the ship.

After the first simulation, the participants are usually very much aware of the shortcomings in their teamwork and their handling of the situations onboard. They need some time to evaluate and digest the disappointment of sinking the ship. At this point, participants are asked to reflect upon their experiences and especially to re-evaluate team goals in the simulation, the group's handling of information, decision making, and assessment of critical situations. After these discussions, which provide the participants with considerable knowledge of and insight into emergency management, participants are instructed about the basic dos and don'ts of emergency management (Strohschneider & Gerdes, 2004).

The next day starts with more lectures about managing escalating situations. Special attention is given to the most relevant topics of high-risk-environment trainings, such as team structure, distribution of workload, communication, development of shared mental models, and the development of proactive strategies (Strohschneider & Gerdes, 2004). The day's work is intended to increase the participants' sense of competence when dealing with an emergency situation.

After the lectures the second M/S Antwerpen simulation starts. Participants are given some time to divide up the roles, read through the role-specific materials again, and make other kinds of preparations. The second trip is a little shorter than the first trip (approx. 2.5 hours); it is designed to give the participants the opportunity to practice the knowledge and procedures they have gained so far. The ship and its condition is similar to the first trip, however, the scenario differs. The sequence of events (emergencies) the participants have to deal with starts earlier and the workload is higher (Strohschneider & Gerdes, 2004). Towards the end, once again, events (emergencies) cascade and escalate but this time they are designed to be easier for participants to handle. This is done to give the participants a chance to end the simulation more successfully than they did the first time.

After this trip, an evaluation takes place that focuses on the changes in the group's behaviour and performance between the first and second trip. In this debriefing, the same topics are covered as after the first trip. As before, an interview protocol is used. Data regarding the participants' personal experiences and learning processes is also elicited.

2.1.2 Development of the training program during the project

A consequence of having used the M/S Antwerpen simulation with different groups is that incrementally a steady practice, almost procedure, of running the entire training program has been established. The tools, equipment and paperwork used for the program is now prepared and pre-packed in bags before the facilitators travel to the site where the training program is to be performed. On site, it takes less than an hour to set up the equipment for the data collection, i.e. computer, simulation program, printer, camera, microphone and paperwork. The instructions, presentations and lectures are prepared and practiced to a level where they easily can be adjusted to the specific demands of a group and available time. Also, in-simulation practices, as how to set up the simulation screen and use shortcuts, have become fine-tuned, standardized and documented. General principles of how to interpret certain frequently used orders, when to provide the participants with particular information and how to react to events that challenge the software of the simulation have been agreed upon.

Preparations, routines, guidelines and checklists have been documented in a facilitator file in order to ensure the successful use of the simulation as a training and research tool for this project. The transfer of experience of using the simulation to future facilitators has not been a focus in previous use of it. The improved facilitator documentation increases the training value of future use of the simulation, and as the simulation may be used as a wide-spread training product in the maritime world it is necessary to make it accessible for new facilitators.

Participant information materials have been controlled and revised to remove inconsistencies, and ambiguities. Comments from participants with maritime knowledge and experience have made it possible to replace incorrect use of maritime words and concepts, partly influenced by the simulation's roots in a German language version. An example of this is that the roles have been renamed, as it was learned that the correct titles are Chief Officer and Chief Engineer, instead of First Officer and First Engineer as stated in the original material. A vast number of changes have been made in regards to clarify steps to be taken to achieve actions in the simulation which are equivalent with certain orders in maritime operations. One example is that according to the original participant information it was possible to use a "General alarm" command in an emergency situation. This command does however not exist in the simulation and thus made it overly easy for participants (but very difficult for facilitators) to evacuate the ship. Corrections such as those exemplified above may improve the face-validity of the simulation as they are performed in order to avoid confusion or frustration for the participants. Also, with the experience from the sessions with fire safety engineers and the inclusion of a project team member with fire safety engineering competence the descriptions of the fire fighting equipment and associated systems have been improved.

The experiences from this project indicate that not only corrections themselves but ambitious work on "expectation management" is an important means to ensure that inconsistencies or ambiguities do not detract from the "willing suspension of disbelief" (Pertraglia, 1998) that is necessary for participant acceptance of the simulation. "Expectation management" then does not necessarily mean that the physical fidelity of a simulation has to be improved; corrections of information, adjustments of procedures or explanations of features in it can be as effective in ensuring acceptance.

Increased understanding of the mindset of the participants during the simulation prompted measures to not over-focus on the main events causing the most drastic escalation in the simulation. Since this event normally is the same in the sessions (to ensure consistence in the research setup) other plausible events with potentially grave consequences for the safety of the passengers, crew and ship had to be inserted in the simulation scenarios. The new scenario events represent categories such as media contacts, passenger complaints, staff injury, criminal activity and terrorism. These, or rather the illusion of them, are indicated in the simulation more than directly presented to the participants. Some of the events are low workload events some may create higher workload. Besides making the simulation less predictable these added events also reduce one of the vulnerabilities of the simulation, namely information being spread among different participant groups, and therefore risking running the simulation with groups that know what will happen.

Another reason for adding extra events lies in the idea that these assist participants in recalling the state of themselves and their group as they respond to the post-simulation questionnaire. In particular the markers of low and high workload periods are important for the research questions regarding operational phase shifts. Some added scenarios have been added simply to be regarded as unimportant by the participants. One example of this is the addition in the second scenario of an event where some caged birds are discovered in a cabin. This is a minor and non-important event when considered properly. Since it is introduced during an idle period and followed by more consequential events it does however have very interesting effects on the workload and priorities of the participating group. Even when considering that being careful with the introduction of new events is of great importance we can conclude that the addition of events that has been performed in the project has been successful.

The new scenario events introduced have successfully added to the credibility and complexity of the simulation. The new events have also been presented and discussed with professor Strohschneider and appreciated as an innovative and constructive step in the development of the simulation. With these new events there should not be room for further additions of new events.

With the development of a theoretical framework to explain generic competencies for proactive crisis management, see chapter 4.1, the lectures were updated so that the theoretical education followed the concept of the framework. This makes the concept of the generic competencies run through the entire program from theoretical education to the self-evaluation after each session.

2.2 Collecting data on crew collaboration and decision making skills

To be able to successfully evaluate team collaboration during the mid-fidelity simulations, as well as potential training transfer effects from the mid-fidelity simulations to participants normal domain, an evaluation method had to be developed as a part of the research project.

While studying teams handling the mid-fidelity simulation in the beginning of the project it became clear that the evaluation tool had to be flexible when evaluating teamwork efficiency. The tool could not be a counting of markers like the number of briefings held by the team, because briefings are not themselves markers of efficient collaboration. Briefings used to make all participants updated on all incoming information will soon make the team members overloaded with information and unable to make decisions. Briefings used to share information about the latest decisions made and to update the team goals and processes are however important means to establish a proactive management of the escalating situations.

The method developed is a qualitative method in which measures taken, and statements made, by the participants are categorised into the four categories of the model developed to explain generic competencies for proactive crisis management, see chapter 4.1. The qualitative data is then discussed in a holistic evaluation of the participants' ability to establish an efficient and proactive team work process in terms of the generic competencies.

The method can be used as a tool to evaluate team performance during the mid-fidelity simulations and compare teams from various industries. The method has also proven useful to study training transfer effects from the mid-fidelity simulation to the participants' ordinary domain, see chapter 4.2.

The collection of the data is made while watching the simulation sessions (during the sessions and afterwards watching the video recordings made) as well as during debriefing sessions in which the teams get to reflect upon their chosen strategies and the resulting handling of the upcoming situations. From the beginning of the project it was believed that self-evaluation questionnaires after each session would provide interesting data. However the questionnaires developed have probably been using concepts that are too hard to grasp without further explanation and clarification. The debriefing sessions proved to be a much more useful tool for self evaluation. An example is the question if the team stated explicit goals during the simulation. Participants tent to rate their statements of goals really high in the questionnaire without being able to exemplify any such goals in the following debriefing session. Because the concept of team goals might be unknown to the participants further knowledge is needed before such a self evaluation can be an efficient measure to evaluate generic team competencies.

2.3 Development of new scenarios and guidelines

The data gathered during this research project has been used as an empirical basis for the development of generic guidelines that could be used for simulation of on-board crises with the specific purpose of training coordinative and cognitive skills. Questions that have been addressed include what level and fidelity of cues are necessary to trigger or evoke relevant cognitive and coordinative behaviours. Also, which performance-influencing factors can help trigger stress or other responses that may impair decision making or cognitive functioning?

As this project has progressed a knowledge base has grown on what could serve as ingredients in meaningful crisis scenarios. Deliverables include guidelines for scenario that can be used at various levels of fidelity to train cognitive/coordinative crew skills.

3 Execution of the research project

3.1 Establishing a theoretical framework

Early into the project it became clear that an extraction of generic properties of team skills in handling escalating situations was needed for several reasons. For the validation of mid-fidelity simulation as tools for training cognitive and collaborative team skills an evaluation tool to study training transfer aspects from the mid-fidelity simulation program was needed. A theory elaboration resulted in a theoretical framework outlining generic competencies for proactive crisis management, see chapter 4.1. It is a concrete framework that is easily explained and understood. In the theoretical elements of the training program the lectures are now developed to cover the concepts of the theoretical framework. Training evaluation and debriefing discussions are performed based on the framework structure. Also the generic competencies are useful in presenting and marketing the mid-fidelity simulation program to various industries.

3.2 Data collections with pilot students and instructors

The research project started by providing the MS Antwerpen simulation to pilot students at the Lund University School of Aviation. Six pilot student teams were given the training and an evaluation of training transfer between the mid-fidelity simulation and the pilot students' following Multi Crew Cooperation training.

Later one team of pilot instructors went through the training program and expressed positive opinions about the training concept.

3.3 Data collections in the maritime domain

3.3.1 Chalmers department of Shipping and Marine Technology

Contacts with Margareta Lützhöft at the department of Shipping and Marine Technology at Chalmers University of Technology led to a presentation of the research for the Human Factors Research Group. It was agreed that three groups of maritime students would be made available for data collection. The groups contained senior students, mainly from the master mariner and naval engineering program. Most of the students had seafaring experience limited to that included in their education while some had many years of experience on fishing vessels.

The groups were positive in regards to the training and found it relevant for their future professional roles. A number of comments have indicated that the training provides an appreciated "learning by doing" –approach not found in other courses. The students had enough knowledge to provide further input on potential improvements of the realism of the simulation, but not experience enough to be disturbed by such inconsistencies.
At Chalmers there has been great interest in the simulation. It has been decided that the students participating in the training will be credited for it as a part of their Crowd and Crisis Management course.

3.3.2 World Maritime University

After initial contacts and two meetings at the World Maritime University (WMU) to present the research, a data collection at WMU was planned together with Professor Takeshi Nakazawa as part of the course on maritime training and training technologies.

The data collection was made in March 2007. This was the first time ever that the M/S Antwerpen was to be used on participants with specific maritime domain knowledge.

A group of seven students who were all experienced seafarers was assembled for this data collection. In particular the roles of the captain and chief engineer were filled by students with great professional experience from working in these positions, however, besides the role of the ship's doctor, all the roles were played by students with actual first hand experience in that role. The seven participants were all from different countries and represented the diversity found in the maritime world.

The group was appreciative of the training and considered it relevant for maritime operations. With their experience they did reveal inconsistencies in the simulation that need to be either corrected in the software or should be adapted in the participant information. Professor Nakazawa and a PhD-student at WMU were present during the training. They found the training relevant and interesting and proposed additional data collections at WMU. Professor Nakazawa proposed a comparison between an experienced and a less experienced group in order to study the relation between experience and management of escalating situations.

3.3.3 SAS Flight Academy, Bridge Resource Management representatives

The Manager of Business Development, together with two instructors from the Bridge Resource Management unit at SAS Flight Academy visited Lund University School of Aviation to participate in a demonstration of the M/S Antwerpen simulation in August 2006. The visit was requested by SAS Flight Academy and the visitors found the simulation an interesting tool for training crews on ships to manage escalating situations and other situations, e.g. complex technical problems that require intensive cooperation, emergencies, and crowd control situations. Cooperation regarding the use of M/S Antwerpen for research with BRM-participants as subjects and on using the simulation for crew training will be further discussed.

The demonstration of M/S Antwerpen for SAS Flight Academy Bridge Resource Management representatives led to further contacts and to an invitation to present a demonstration of the mid-fidelity simulation concept for participants in a Bridge Resource Management Workshop Leaders Seminar at SAS Flight Academy in April 2007. At this seminar twenty participants from different countries gathered, all with seafaring experience as masters, engineers, pilots or in other professional maritime roles. The majority of the participants found the demo an interesting alternative for training, in particular in regards to crowd and crises management.

In a workshop, held together with SAS Flight Academy, guidelines for writing an application case were discussed. Divided into three groups BRM instructors were asked to outline the process of developing cases for training, as well as the contents of such cases. The workshop initiated the work with developing scenario guidelines for team-training of escalating situations, see chapter 4.3.

3.4 Data collections in other domains

3.4.1 Lund University Security Group

In March 2007 The Lund University Security group were given the MS Antwerpen training program. The group consisted of staff at the Division of Buildings responsible for, and actively involved in, work with security and safety at Lund University, i.e. responsible for theft and workplace safety as well as terrorism and accidents at the chemistry department. Contacts with the manager of safety and security at Lund University led to opportunities to present the research project at the Division of Buildings as well as at a meeting of other managers of security and safety at universities or colleges in southern Sweden. After these presentations a training session/data collection was planned.

This session, being the first non-aviation group participating in the project, worked as the launch session for an improved version of the M/S Antwerpen training concept, including new scenario events, instructions and documentation as well as the introduction of a questionnaire. The group that was assembled for the data collection consisted of seven persons with designated tasks in regards to the management of security and safety at the university.

The group was very satisfied with the training they received. The manager of safety and security considered it a useful and valuable training event and claimed that the training provided a cost-effective alternative to the full-scale crisis management training scenarios performed every five years. These involve a number of high level decision-makers within the university as well as journalists and other people playing different roles as part of an enactment of a major crisis. The M/S Antwerpen was considered to provide an important alternative for training in particular for those who are designated as replacements for positions in the crisis management group and do not get to participate in the full-scale training events.

3.4.2 Fire Safety Engineers

An extensive data collection was made during the autumn of 2007 when 23 Fire Safety Engineers participated in a training transfer study. 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 results of the study are outlined further in see chapter 4.2.

3.4.3 A municipal crisis management staff

During spring and autumn of 2008 a Swedish municipal crisis management staff of 23 people went through the MS Antwerpen training program. The staff was divided into four teams that individually received the training program. The teams responded well to the training and expressed belief in the methodology of moving the municipal personnel to the fictive cruise vessel bridge.

After the last training session all participants were called up by the crisis management director of the municipality to give some feedback. The crisis management director later reported in a letter to the municipal managing director and the chairman of the municipal executive board that all participants found the training positive and developing.

3.4.4 Air Traffic controllers

In autumn 2008 one groups of air traffic controller students and one group of air traffic controller instructors, both from the air traffic controller education centre Entry Point North, went through the MS Antwerpen training program. This was a pilot study to test the concepts in the domain of air traffic control and to test the possibility to incorporate the mid-fidelity simulation into more comprehensive crisis management courses to be developed at the air traffic controller education centre Entry Point North.

Both teams' background from air traffic control had effects for their handling of the situations at the simulated vessel bridge. They soon established strategies for sorting and canalising information. They were also rapid in their decision making, rather making early decisions and later correct and revise them than waiting for more information to be gathered. The participants of both teams also received a lot of information by overhearing the ongoing conversations while working on their own tasks. However neither the students nor the instructors reflected on their processes. The moderator role (distributing the incoming information) was selected by chance (the one closest to the printer) and they remained sitting in their chairs working with the material on the table. This proved insufficient when the situation escalated.

Both teams responded well to the training and expressed great belief in incorporating such training to crisis management courses offered to air traffic controllers. More evaluation of this pilot study will be made after this final report is due.

4 Results

4.1 Generic competencies for proactive crisis management

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, p.175). 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 (Rasmussen, Brehmer & Leplat, 1991, ; Brehmer, 1992, ; Cannon-Bowers, Salas & Converse, 1993, ; Hutton & Klein, 1999, ; Mathieu, Heffner, Goodwin, Salas & et al., 2000) guided the research through five case studies from various industries. Vaughan (1992, p.176-177) 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. (NTSB 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. (SOU 2005:104)

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)

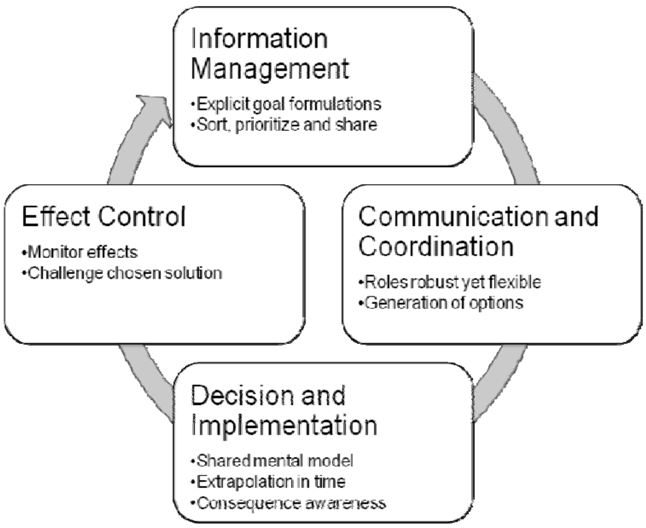

Fig. 1. A theoretical framework of generic competencies for proactive crisis management

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.

4.2 Validation of mid-fidelity simulations for training generic competencies

A total of 22 teams have gone through the two day education program in handling unexpected and escalating situations using the mid-fidelity simulation MS Antwerpen. The teams have been representatives from six different domains (aviation, marine, rescue services, municipal crisis management, air traffic control, university safety group). Three teams have also received a shortened demo-version of the simulation. In all teams we have received support for the idea of lowering the fidelity level to focus on generic rather than technical skills. In all teams members have also expressed a belief in an improvement of their generic skills in handling an unexpected and escalating event.

4.2.1 Training effects

A highly successful pilot study, funded jointly by LUSA and the University of Bamberg, was conducted at Lund with the MS Antwerpen simulation in November 2004, and later presented to key participants in the BRM groups run by SAS Flight Academy in Stockholm. In this pilot study, pedagogical returns from the MS Antwerpen simulation were measured during MCC training at LUSA, which showed a clear benefit from the collaborative and decision-making skills imparted during the MS Antwerpen exercises. The observations during this pilot study showed how the MS Antwerpen generates novel kinds of opportunities to practice cognitive and cooperative skills that are highly relevant for managing escalating situations in any safety-critical domain. The response from the participating training crews was overwhelmingly positive, both because of the training experience in itself and the importance of the training for their future work as managers of complex, safety-critical processes in the transportation industry. This response also served as strong indicator of the generality and domain independence of CRM-principles imparted during mid-fidelity simulation.

Another study of the training transfer from the mid-fidelity training program to the participants normal domain was conducted with Swedish Fire Safety Engineers. 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-behaviour, 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

4.2.2 Benefits from lowering the level of fidelity

The main advantage from lowering the level of fidelity in simulator training has proven to be the shift of focus from training of technical skills and procedures to training of the generic competencies in proactive crisis management. The research results indicates that by leaving out features like visual reference systems, gauges, bottoms and emergency procedures, the training is focused on the generic team competencies that are needed in an escalating situation characterized by uncertainties. By removing the opportunity to focus on instrument readings and control settings the participants in the M/S Antwerpen sessions are put in a situation where their most useful tools are those of understanding the behaviour of themselves and their group.

If no training opportunities exist in which individuals can disconnect from the constant reification and elaboration of their normal operational activities, the ability to respond effectively may remain inextricably anchored to (and fundamentally limited by) known and rehearsed roles, duties and procedures (as shown powerfully in Weick, 1993). High-fidelity simulation is normally a costly and restricted resource primarily used to train and emphasise such roles, duties and procedures. Lower-fidelity simulation can complement high fidelity simulation and serve as an important resource in the creation of resilient operators. In the research we have conducted, it seems to force participants to confront the interpersonal and goal-oriented demands of managing unanticipated and escalating situations. These are exactly the work elements that seem to be lost or hidden behind the procedural specifics fostered by high-fidelity training and operational experience. In addition, the limited costs connected to using lower-fidelity simulation could increase availability and frequency of training sessions.

Studies of aviation accidents and the use of lower-fidelity simulation reveal a disconnect between the fidelity (or photorealistic faithfulness) of a simulation and its validity (how the skills it develops map onto situations in the target environment). Lower-fidelity simulation allows the development of the sorts of generic problem-solving skills presented in chapter 4.1. These skills (and the confidence that comes from successfully deploying them in settings other than the target environment) could contribute significantly to the development of resilient crews in ways that reliance on considerably more costly and more high-fidelity (photorealism) training cannot. Traditional assumptions about simulation tend to portray both role and context as though they are natural, unalterable facts. This message seems to be implicit in almost all attempts at "realistic" simulation. We would, however, argue that this conveys exactly the wrong message if we want individuals and workgroups to be adaptive and capable of creative, appropriate improvisation—skills which can be practiced and learnt effectively in lower-fidelity simulations to complement the procedural skills gained from high-fidelity simulation. These simulations, by design, can lead participants to rethink their normal roles and behaviour, which in turn can help develop more adaptive and flexible competencies, strengthening operator and system resilience in the face of unanticipated and escalating situations.

4.3 Guidelines for scenario-based training

In the early stage of this project a workshop was held in which experienced BRM instructors were asked to outline how to write an application case. That workshop together with the data collections made in the project has made us able to isolate some principles for scenario-based training.

A scenario that helps people prepare better for escalating situations should have the following elements:

First, it needs to heed the escalation principle:

Escalation Principle: The concept of escalation concerns a process – how situations move from canonical or textbook to non-routine to exceptional. In that process, escalation captures a relationship - as problems cascade they produce an escalation of cognitive and coordinative demands which brings out the penalties of poor support for work (Woods & Patterson, 2003, p.2).

This means that the scenario needs to contain the following (see also Woods & Patterson, 2003):

- **There is a cascade of effects in the monitored process**. A fault should produce a time series of disturbances along lines of functional and physical coupling within the process. These disturbances produce a cascade of multiple changes in the data available about the state of the underlying process

- **Demands for cognitive activity need to increase as the problem cascades.** More knowledge potentially needs to be brought to bear. There should be more to monitor. There is a changing set of data that people should integrate if they want to get a coherent assessment of what is going on. People need to be forced to generate candidate hypotheses evaluate them. People's assessments may need to be revised as new data comes in. Actions to protect the integrity and safety of systems need to be identified, carried out, and monitored for success. Existing plans need to be modified or new plans formulated to cope with the consequences of anomalies. Contingencies need to be considered in this process. All of these multiple threads challenge control of attention and require practitioners to juggle more tasks.

- **Demands for coordination need to increase as the problem cascades**. As the cognitive activities escalate, the demand for coordination across people and across people and machines rises. Knowledge may reside in different people or different parts of the operational system (and can in part be planted as such by the one designing the scenario). Specialized knowledge and expertise from other parties may need to be brought into the problem solving process. Multiple parties may have to coordinate in order to implement activities aimed at gaining information to aid diagnosis or to protect the monitored process. The trouble in the underlying process must require informing and updating others – those whose scope of responsibility might be affected by the anomaly, those who may be able to support recovery, or those who may be affected by the consequences the anomaly could or does produce.

- **The cascade and escalation should be a dynamic process**. A variety of complicating factors can occur which move situations beyond canonical, textbook forms. The concept of escalation captures this movement from canonical to non-routine to exceptional. The tempo of operations must increase following people's recognition of a triggering event and then needs to be synchronized by temporal landmarks that represent irreversible decision points (i.e. if people have moved beyond them, there is no way back).

In addition, in order to maximally utilize the escalation scenario, and enhance people's generic abilities to handle it, the scenario should:

- Try to force people beyond their learned roles and routines. The scenario can contain problems that are not solvable within those roles or routines, and forces people to step out of those roles and routines.
- Be very difficult to handle if people do not share in mental bookkeeping of what has been done (by whom and when).
- Contain a number of hidden goals, at various times during the scenario, that people could pursue (e.g. different ways of escaping the situation or de-escalating it), but that they have to vocalize and articulate in order to begin to achieve them (as they cannot do so by themselves).
- Contain possible actions of which the consequences are both really important and really hard to foresee (and that might significantly influence people's ability to control the problem in the near future). This can force people into pro-active thinking and articulation of their expectations of what might happen.

- Be able to trap people in locking onto one solution that everybody is fixedly working towards. This can be done by garden-pathing; making the escalating problem look initially (with strong cues) like something the crew could already familiar with, but then letting it depart (with much weaker cues) to see whether the crew is caught on the garden path and lets the situation escalate.
- Or the scenario, by creating so much cognitive noise in terms of new warnings and events, should be able to trip people into thematic vagabonding—the tendency to redirect attention and change diagnosis with each incoming data piece, which results in a fragmentation of problem-solving.

5 Conclusions

Based on the results the conclusions of this project are summarized in the following points:

- Establishment of strategies to apply generic team skills, such as information sorting based on shared and explicit goals, coordination/communication among robust jet flexible roles, distributed decision making in a dynamic environment and effect control, can have a decisive importance for the crisis management process in a team.

- High-fidelity simulation is normally a costly and restricted resource primarily used to train and emphasize known and rehearsed roles, duties and procedures, or can trap people in those roles, duties and procedures which may keep them from exploring alternative problem-solving configurations.

- Lower-fidelity simulation can complement high-fidelity simulation and serve as an important resource in the creation of resilient operators, particularly when those are faced by escalating situations, where the pace of activities, their criticality and information processing demands all go up.

- Lower-fidelity simulation seems to force participants to confront the interpersonal and goal-oriented demands of managing unanticipated and escalating situations. These are exactly the work elements that seem to be lost or hidden behind the procedural specifics fostered by high-fidelity training and operational experience.

- The limited costs connected to using lower-fidelity simulation could increase availability and frequency of training sessions.

- We should be sceptical about the often taken-for-granted relationship between the fidelity (or photorealistic faithfulness) of a simulation and its validity (how the skills it develops map on to situations in the target environment).

- Traditional assumptions about simulation tend to portray both role and context as though they are natural, unalterable facts. This message seems to be implicit in almost all attempts at 'realistic' simulation. The conclusion from this research project is however that this conveys exactly the wrong message if one wants individuals and workgroups to be adaptive and capable of creative, appropriate improvisation – skills that can be practiced and learnt effectively in lower-fidelity simulations to complement the procedural skills gained from high-fidelity simulation.

- Scenarios designed to create learning opportunities in handling escalating situations needs to heed the escalation principle. Such scenarios should also force people beyond learned roles and routines, demand a mental bookkeeping of decisions made, contain hidden goals and difficulties of foreseeing effects of actions as well as the ability to trap people in locking on to one solution that the entire team is fixedly working towards.

- Scenarios that cover the principles mentioned above can lead participants to rethink their normal roles and behaviour, which, in turn, can help develop more adaptive and flexible competencies, strengthening operator and system resilience in the face of unanticipated and escalating situations

6 Making the results available

The progress made in this project has continuously been made available to a broad public, through research sources such as articles, book chapters and reports, but also after being invited to hold presentations in various contexts and industries.

6.1 Published papers and reports

6.1.1 Articles published in scientific papers

Dahlström, N. (2008). Pilot training in our time - use of flight training devices and simulators. *Aviation*, 12(1), 22-27

Dahlström N., van Winsen R. D., Dekker S. W. A., & Nyce J. (2007). Fidelity and Validity of Simulator Training. Accepted for *the Theoretical Issues in Ergonomics Science*

Dekker S. W. A, Jonsén M., Bergström J., & Dahlström N. (2007) Learning from faliures in emergency response: A series of empirical studies. Accepted for *the Journal of Emergency Management*

6.1.2 Book Chapters

Dekker, S. W. A., Dahlström, N., van Winsen, R., & Nyce, J. M. (2008). Crew resilience and simulator training in aviation. In: E. Hollnagel, C. Nemeth, & S. W. A. Dekker (Eds.). *Resilience Engineering Perspectives: Remaining sensitive to the possibility of failure*. Aldershot, UK: Ashgate Publishing Co.

6.1.3 Reports

Bergström J. (2008), *Generella kompetenser för krishantering – tillämpningsområden och träning,* rapport 5104, Ergonomi och Aerosolteknologi, Lunds Universitet, Lund

6.1.4 Conference Proceedings

Bergström J. Dahlström N. & Petersen K. (2008), *Securing Organizational Resilience in Escalating Situations: Development of skills for crisis and disaster management,* Presented at the 3rd Symposium on Resilience Engineering, October 28-30, Antibes Juan-Les-Pins

Dahlström N. (2006), *Perspectives on pilot training and selection*. Proceedings of the Second Arab-African Aviation Conference and Exhibition. 4-6 December, Tripoli, Libya

Dahlstrom N. (2006). *Pilot training in our time - use of flight training devices and simulators.* Proceedings of Recent research and design progress in aeronautical engineering and its influence on education, 11-12 October 2006, Tallinn, Estonia

6.2 Presentations

Managing of escalating situations
Presentation to be held at "Transportforum" -Swedish National Road and Transport Research Institute's annual conference, January 8-9 2009, Linköping

New Perspectives in Patient Safety - Is the pilot a better doctor?,
11th World Congress on Controversies in Obstetrics, Gynaecology and Infertility, November 27-30 2008, Paris

Is a common operating picture worth striving for in the Swedish crisis management system?,
Presentation at the Young Researchers' Seminar, November 18-19 2008

Securing Organizational Resilience in Escalating Situations
Seminar with representatives from the Framework for Risk and Vulneriability Analysis (FRIVA) at Lund University, October 20, 2008

Tillsammans mot högre höjder - Patient- och flygsäkerhet mot samma mål
4th Swedish National Conference on Patient Safety, September 17-18 2008, Stockholm

Crisis Management Training Based on a System Perspective
Seminar with representatives from Lund University-departments concerned with research on various aspects of risk, September 08, 2008

The Realities of Implementing CRM in Airline Operations
Presentation at the workshop Human Factors in Aviation, Graz, June 22, 2008

More Procedures Wont Increase Safety
Breakfast seminar at Chalmers Lindholmen, June 4, 2008

How should we get people to do what they are supposed to??
Course for managers with responsibility for explosive materials, Competence Centre for Energetic Materials, 6 May 2008, Örebro

Organizational resilience in escalating situations
Presentation for SAAB Training Systems, 29 February 2008, Lund

Generic competencies for crisis management, M/S Antwerpen
Presentation for the Swedish National Defence College, 21 February 2008, Lund

Development of skills for crisis- and disaster management
Presentation for researchers at the Lund university's department for Fire Safety Engineering and Systems Safety, 14 February 2008, Lund

Training generic competencies for crisis management
Estonian annual meeting of aviation, 15 November 2007, Pühajärve

Parallels between Aviation and Patient Safety
Regional Conference on Patient Safety, Lund University Hospital, 8 November 2007, Lund

Errors in understanding of human error
Seminar for instructors for nuclear operators, Nuclear Safety and Education, 6 November 2007, Studsvik

Safety and error - based on work with aviation safety
Cambrex (Chemical Industry) Annual Safety Day, 19 October 2007, Karlskoga

How should we get people to do what they should do?

Course for managers with responsibility for explosive materials, Competence Centre for Energetic Materials, 15 October 2007, Örebro

Human error and safety
Patient Safety Course, University Hospital of Malmö, 15 October 2007, Malmö

Safety and error
Crew Resource Management course for the Swedish Armed Forces, 12 October 2007, Ljungbyhed

Training of escalating crises with simulation
Seminar on Learning for Rescue Services, 2 October 2007, Karlstad

Cooperate, lead and decide
Meeting of development group for leading and coordination, 13 September 2007, Revingehed

Safety Culture in Aviation
Maritime Administration Seminar – Safety Culture in the Maritime Industry (MARAD 2007), World Maritime University, 27-29 August 2007, Malmö.

Human Error – Models and Management
International Summer School on Aviation Psychology, arranged by University of Graz, 1-6 July 2007, Graz, Austria.

Can we still learn from aviation?
Annual meeting for the Society in Europe for Simulation Applied to Medicine, 18-20 June 2007, Copenhagen, Denmark.

Security at a high level – experiences from the world of aviation
Security conference for universities and colleges, arranged by Gothenburg University, 19-20 April 2007, Gothenburg.

Research and practical experiences
Crew Resource Management Workshop, arranged by Swedish Network for Human Factors, 16-17 April 2007, Linköping.

Safety at a high level – working with safety in aviation
Patient safety workshop, arranged by the Scania Region, 23 March 2007, Barsebäck.

CRM for examiners – update, role of the examiner, assessment and TEM
Presented at the annual meeting for flight examiners, arranged the Swedish Civil Aviation Authority, 31 January 2007, Arlanda

Managing escalating situations - A new training approach
European Aviation Training Symposium, 13-14 November 2006, Berlin. (Together with Johan Lundstrom of SAS Flight Academy.)

Training of CRM-skills with mid-fidelity simulation
Presented at the Nordic Flight School Seminar, 12-13 October 2006, Ljungbyhed

Safety and Security Synergy – using aviation experience for a safe and secure future
"Security takes off", arranged by the Southern chapter of the Swedish Computer society, 9 October 2006, Malmö

6.3 Teams trained using the MS Antwerpen mid-fidelity training program

An important part of making the research results available to various industries is to provide the kind of training that in this research is suggested to be an efficient way to practice the generic team competencies in handling unexpected and escalating crisis. A total of 22 teams have, as this final report is due, gone through the two day training program in establishing strategies for the generic competencies in proactive crisis management, to handle unexpected and escalating situations, using the mid-fidelity simulator MS Antwerpen. In addition three teams have received a shortened demo-version of the simulation program. The teams are presented in table 3, below.

Table 3. Teams that have trained using the MS Antwerpen simulation

Domain	Team	Number of teams	Date of data collection	Remark
Aviation	Pilot students	6	2004-2006	
Aviation	Pilot instructors	1	1-2 November 2007	
Marine	Professional sea farers at WMU	1	29-30 March 2007	
Marine	Maritime students	3	26-27 April, 3-4, 24-25 May 2007	
Marine	BRM-instructors	2	18 April 2007	Demo sessions
Marine	Stena Line, Crowd and crisis management course	1	30 May 2007	Demo-session
Rescue Service	Fire Safety Engineers	4	16-17 August, 5-6 September, 6-7, 10-11 December, 2007	
Municipality	Municipal crisis management staff	4	26-29 May, 7-10 October, 2008	
Air traffic control	ATC Students	1	26-27 November 2008	
Air traffic control	ATC instructors	1	25, 28 November 2008	
Civil security	Lund University security group	1	8-9 March 2007	

6.4 Making industries use mid-fidelity simulation in their training programs

The aim of the cooperation with the air traffic controller education centre Entry Point North is an incorporation of the MS Antwerpen training program into the context of a more comprehensive crisis management course that Entry Point North will offer to operators in the air traffic control sector as well as others. The simulation sessions performed at Entry Point North were the first step in making that happen by evaluating the concept in the domain.

For some time Maersk Training Centre has been interested in incorporating the MS Antwerpen training into a course that they could offer maritime stakeholders. They have previously been in contact with Professor Stefan Strohschneider and a demo session has been held. We are now invited to do another and more extensive demo, giving the entire two day program to representatives from the training centre so that they can evaluate their future possibilities for incorporating the training into their business.

Previous contacts with Chalmers Lindholmen resulted also in contacts with the Carnival UK Group, including cruise shipping companies as P&O Cruises, Cunard Line, Princess Cruises, Ocean Village and the Yachts of Seabourn. The Carnival UK Group is currently building up a training department and they are interested in further contacts. This cooperation could result in us giving mid-fideilty crisis management training to their bridge-personnel.

In contacts with representatives from the UN World Food Program they showed a great interesting the possibility to receive our crisis management training program.

7 Further research

This research project has resulted in guidelines for scenario design when developing training programs for escalating situations. As a method, mid-fidelity simulation has been validated for training of escalating situations. One obvious next step is to help the industry in developing programs and courses for training sea crews in handling escalating emergencies. That work has begun in contacts with sea training organizations as well as training organizations in other industries. Our role will be to assist the industries in implementing our research findings into their training concepts and provide them with pedagogic tools, such as mid-fidelity simulation programs.

The findings from our research could be used in the development of new mid-fidelity simulation training programs. During the progress of this project a number of possible simulation-features that could improve training of escalating situations have been recognized (e.g. vague indications, hidden goals, goal-conflicts, trapping people in locking on to certain solutions, several types of possible escalations). In MS Antwerpen such features are not driven by the simulation itself but rather by the facilitators who add such features and responses to the output of the simulation. Having the ability to, in a future research project, develop a new simulation tool for team-training of escalating situations would make us able to implement such features into the simulation program itself.

This project has initiated research and development, as well as the validation of tools for the evaluation of teamwork efficacy in handling escalating situations. It has given rise to interesting questions, and of course offers room for further testing and improvement. Such improvements should be integrated in potential developments of new training concepts. The research project has also raised several questions for future studies, among them:

- What is really the nature of the cognitive and coordinative mechanisms that help teams detect, and respond to, anomalies, particularly escalating situations? Can we begin to map the knowledge aspects, attentional dynamics and strategic factors that go into people's ability to handle escalation well?

- What is the role of new technology and the potential for such technology to create data overload in escalating situations (particularly with respect to technology aimed at "joined situation awareness" or "common operating picture " in various fields of practice, e.g. emergency response)?

- What is the basis (both in terms of sensitivity to the need as well as the decision criterion for acting on this perceived needs) for teams to call in extra resources, additional expertise in escalating situations (given that such expertise is in principle available in their operating domain)?

- Are there long-term benefits associated with team-training (particularly generic skills) in escalating situations, or do these skills have a limited shelf-life, requiring regular proficiency-checking and updating?

- What are ways in which generic skills for escalating situations can be effectively evaluated, especially when an entire team is involved in creating success and failure—not just an individual's skills?

- Are the skills taught for handling escalating situations easily exportable by individuals to other teams that they may be working with in future situations?

These, and doubtlessly other, questions form an exciting basis for further work in this important area.

8 References

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